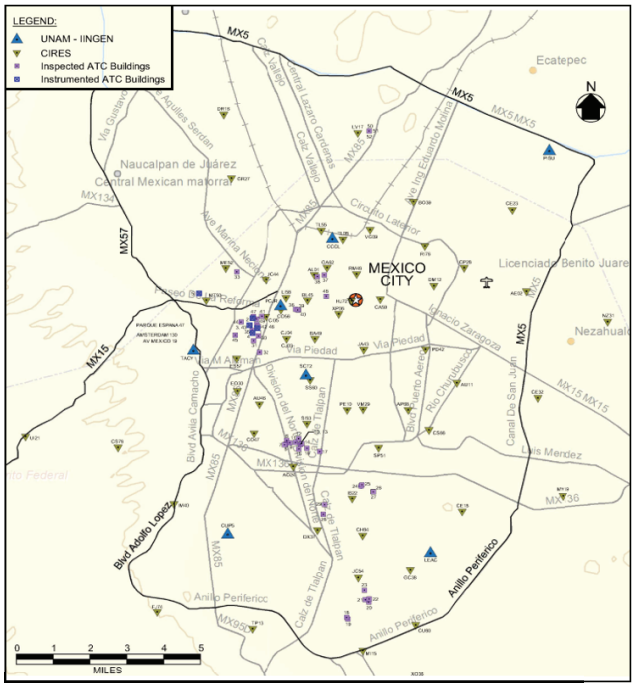
ATC 141

September 19, 2017 Puebla-Morelos, Mexico earthquake:

Seismological and structural observations by the ATC reconnaissance team



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Project management and administration are carried out by a full-time Executive Director and support staff. Project work is conducted by a wide range of highly qualified consulting professionals, thus incorporating the experience of many individuals from academia, research, and professional practice who would not be available from any single organization. Funding for ATC projects is obtained from government agencies and from the private sector in the form of tax-deductible contributions.

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Cover illustration: Location map of UNAM and CIRES recording stations (triangles) and ATC observed and instrumented buildings (squares).

ATC-141

September 19, 2017 Puebla-Morelos, Mexico Earthquake: Seismological and Structural Observations by the ATC Reconnaissance Team

by

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Preface

Immediately following the September 19, 2017 magnitude-7.1 earthquake in Mexico, the Applied Technology Council (ATC) established a team to collaborate with local and international agencies, engineers, architects, and researchers to understand the impact of the earthquake in Mexico City and observe building and infrastructure performance. The on-site team was primarily supported by the ATC Endowment fund, which was established in 1989 with a purpose to support projects of critical interest to structural engineering design practice, research, and education. Additional support was provided for instrumentation by the National Science Foundation (NSF) Grant #1810899.

This report is a compilation of the data and observations compiled by both on-site and off-site teams in October 2017 and shortly thereafter. The report is expected to serve as a basis for future research projects studying the behavior of buildings to the earthquake conditions in Mexico City.

The contents of this report are the result of collaboration by universities (State University of New York at Buffalo, National Technical University of Athens, University of Greenwich, Universidad Nacional Autónoma de México, Rensselaer Polytechnic Institute, Universidad Michoacana de San Nicolás de Hidalgo, and Aristotle University of Thessaloniki), private engineering firms in the United States (Gilsanz Murray Steficek, WSP, Degenkolb Engineers, Forell/Elsesser Engineers, IDS Group, and Rutherford + Chekene), private engineering and architecture firms in Mexico (TEN Arquitectos, Grupo Colinas de Buen , PEI Diseño Estructural S.A. de C.V., Grupo Rioboo, Kali Design), and agencies and organizations in both Mexico and United States (Centro de Instrumentación de Registro Sísmico, Sociedad Mexicana de Ingenería Estructural, A.C., and Earthquake Engineering Research Institute).

ATC is indebted to the on-site leadership of Ramon Gilsanz and Rodolfo Valles Mattox, and off-site leadership of Sissy Nikolaou. Ramon Gilsanz and Sissy Nikolaou also served as co-editors of this report. The team members who participated in on-site information collection in Mexico City are Ramon Gilsanz, Esteban Anzola, Russell Berkowitz, Homero Carrion, Evangelia Garini, Laura Hernández, Saif Hussain, Afshar Jalalian, Insung

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Chapter 1
Introduction

On September 19th of 2017, a magnitude-7.1 earthquake struck the states of Puebla and Morelos in Mexico. The event caused severe localized damage and the collapse of over 40 buildings in Mexico City, located approximately 120 km away from the epicenter. Over 16 million people felt strong shaking, with 1 million being very strongly shaken, and an estimated death toll of more than 500 people.

The Applied Technology Council (ATC) brought together and deployed to the field an interdisciplinary team of seismologists, structural and geotechnical engineers, tasked with performing reconnaissance and collecting building design and strong ground motion information. The team arrived in Mexico City on October 10th, 2017 and worked with local agencies and academic institutions for one week.

1.1 Project Objective

The objective of the team was to collect design information and performance observations for a large group of buildings to help advance the knowledge and practice of earthquake engineering. This information can also be used to enhance and validate existing and ongoing ATC projects related to seismic design and evaluation of reinforced concrete buildings.

1.2 Scope

The ATC team documented earthquake effects of 70 buildings, ranging 1 to 25 stories high, most of which were constructed of reinforced concrete with masonry infill walls. Where possible, the team collected structural drawings and geotechnical data. The degree of detail in the observations depend on accessibility: The team had interior access to 21 buildings that were observed in detail; the remaining 49 buildings were either observed from the exterior due to limited access, or in passing as they were of general interest as additions to the body of Mexico City building performance data.

Microtremors were recorded using monitoring instruments installed at 7 buildings during the ATC visit and a second visit by University at Buffalo researchers funded by the National Science Foundation. For these buildings, periods of the first 3 modes of vibration were identified.

Local agencies UNAM (National Autonomous University of Mexico) and CIRES (Center of Instrumentation and Seismic Records) collaborated with the ATC team and provided 71 (unprocessed) strong ground motion records with 3 components each (2 horizontal and vertical) from the main event. The horizontal components of the provided raw strong motion recordings were processed by the ATC team. In addition, site-specific ground motions at the ground surface were derived for each ATC-observed building by performing one-dimensional (1D) equivalent-linear amplification analyses for simplified soil columns, representative of the code-specified seismic zones.

Figure 1.2.1 shows a map with the locations of the observed and instrumented buildings and recording stations.

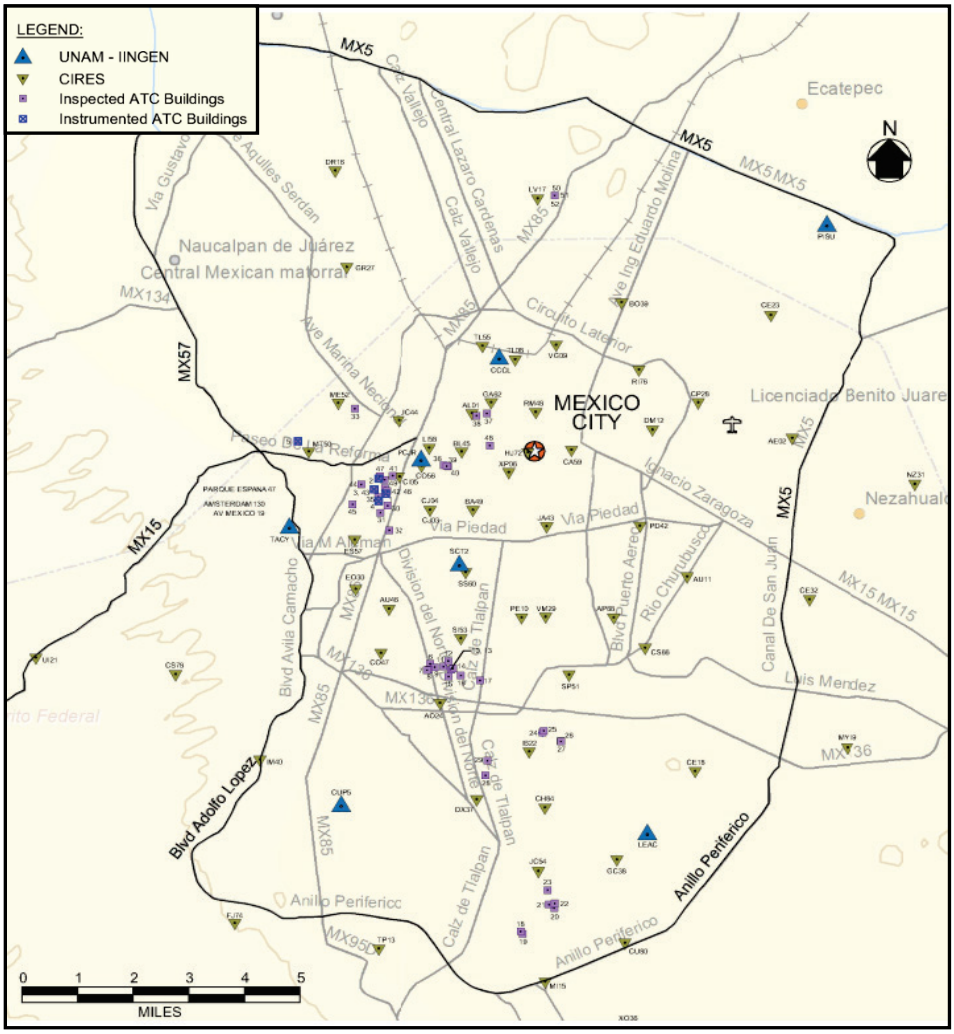


Figure 1.2.1 Location map of UNAM and CIRES recording stations (triangles) and ATC-observed and instrumented buildings (squares).

1.3 Report Organization

This report presents the information collected by the ATC team during site visits conducted in October 2017 in the following chapters:

Chapter 2 presents seismotectonic setting and historic seismicity of Mexico, including information on the most relevant seismic events to the Puebla-Morelos earthquake.

Chapter 3 presents seismological observations with 71 strong ground motion records from the main event that were provided to by UNAM and CIRES.

Chapter 4 describes instrumentation methods and observations at 7 buildings to record microtremors and identify main vibrational characteristics.

Chapter 5 presents the geologic setting in the vicinity of Mexico City.

Chapter 6 presents reconnaissance observations for 70 buildings, including extent of damage, structural, nonstructural, geotechnical, and foundation observations. Information includes geotechnical characterization of inspected sites, including site response analyses for simplified representative profiles for code-specified zones, to derive generalized acceleration response spectra at the ground surface. Also included are maps showing structural and geotechnical characteristics of inspected sites, including the number of stories of buildings, predominant site soil periods, code-specified seismic zones, and results of post-earthquake safety evaluation conducted according to the ATC-20-1 methodology (ATC, 2005).

Chapter 7 presents a summary of observations including recommendations for further studies for selected buildings.

Appendices A and B present acceleration, velocity, and displacement time histories, acceleration response spectra, and summary tables of peak recorded values, epicentral distance and site conditions at ground motion recording stations managed by UNAM and CIRES, respectively. Lists of references and project participants are also included.

All photographs without attribution to a specific source were taken by the ATC Team during field work. Any references to the photographs should reference this report.

Chapter 2
Tectonic Setting and Historic Seismicity

2.1 Tectonic Setting

Located on the convergence of four large tectonic plates (North American, Cocos, Caribbean, and Pacific) and a microplate (Rivera), as illustrated in Figure 2.1.1, Mexico is one of the world's most seismically active regions. Most of the country lies on the North American tectonic plate, but the Pacific Ocean floor off southern Mexico rests on the Cocos plate. A map of the ocean floor reveals a deep underwater trench, as shown in Figure 2.1.2, running along the southern coast of Mexico, defining the boundary between the Cocos and the North American plates. The Cocos plate moves to the northeast, toward the North American plate, at a rate of 61 mm/yr (USGS, 2017a). The two tectonic plates meet off the southern shore of Mexico, forming a deep underwater trench that runs parallel to the shoreline. This area along the Pacific coast is called the Middle American Subduction Zone and it is where most of the seismicity occurs (Singh et al., 1985; Gardi et al., 2000; Payero et al., 2008). Additional tectonic activity along the edges of the Rivera and Caribbean plates also affects Mexico.

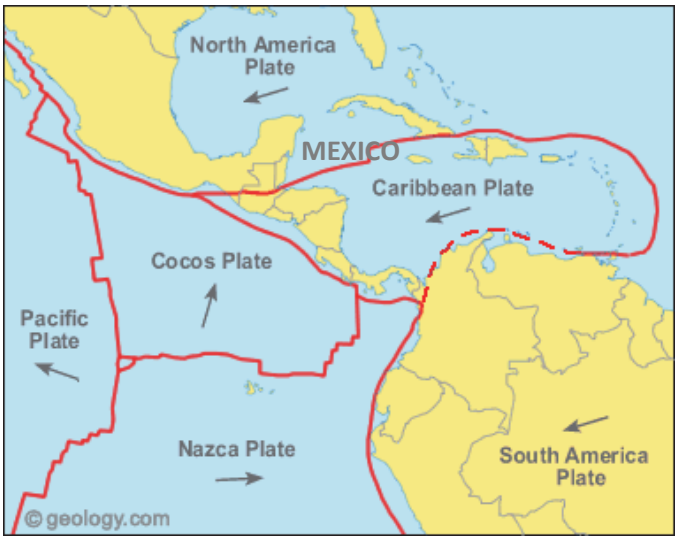


Figure 2.1.1 Plate tectonics in the Mexico region (from geology.com, 2018).

Because the oceanic crust is relatively dense, when the Pacific Ocean floor encounters the lighter continental crust of the Mexican landmass, the ocean floor descends beneath the North American plate, creating the deep Middle American trench along Mexico's southern coast (Ferrari et al., 2000). Thus, the westward-moving landmass is slowed and crumpled, creating the mountain ranges of southern Mexico and generating earthquakes near the southern coast. As the oceanic crust is pulled downward, it melts, with molten material forced upward through the weaker continental crust, creating a region of volcanoes across south-central Mexico (Benz et al., 2011).

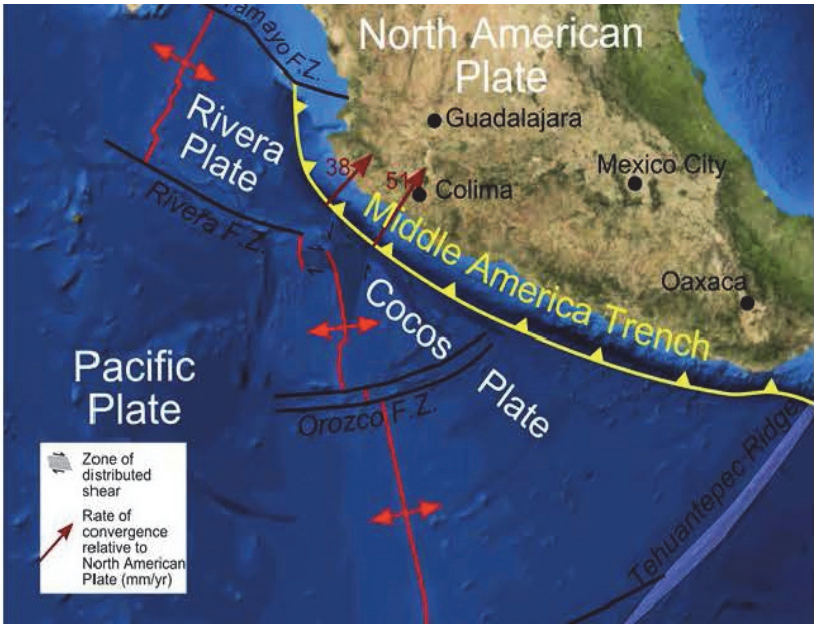


Figure 2.1.2 NASA map of ocean floor with a deep underwater trench along the south coast of Mexico, and Cocos and North American plates boundary (Pardo and Suarez, 1995; DeMets and Wilson, 1997).

Figure 2.1.3 is a model of the subducting slab by the Caltech Tectonic Observatory (2009; based on the work of Perez-Campos et al., 2008). The slab descends beneath the continental crust at a shallow angle, and then levels off to nearly horizontal. Below Mexico City, it plunges steeply into the mantle and ends abruptly at a depth of about 500 km. This abrupt termination may be due to an earlier tear, before that part of the ocean floor subducted.

As the Cocos plate subducts under the North American plate, the primary forces are compressional due to the collision. However, several historic Mexican earthquakes have been caused by extensional (normal) fault movement that is typically observed as the underlying Cocos plate descends into the mantle after subducting underneath the North American plate. This

also appears to be the case for the September 19, 2017 moment magnitude (M_w) 7.1 Puebla-Morelos earthquake, caused by normal faulting at a 50-km depth. Focal mechanism solutions show that the earthquake occurred on a moderately dipping fault. Within a radius of 250 km from the 2017 hypocenter, the region has experienced another 19 events of magnitude (M) 6.5 or higher in the previous century, most of which occurred to the south, near the subduction zone interface at the Pacific coast. As shown in Fig. 2.1.4, the epicenter of the 2017 M_w7.1 Puebla-Morelos earthquake was 120 km southeast of Mexico City, about 55 km south of the city of Puebla, and 12 km southeast of Axochiapan, Morelos.

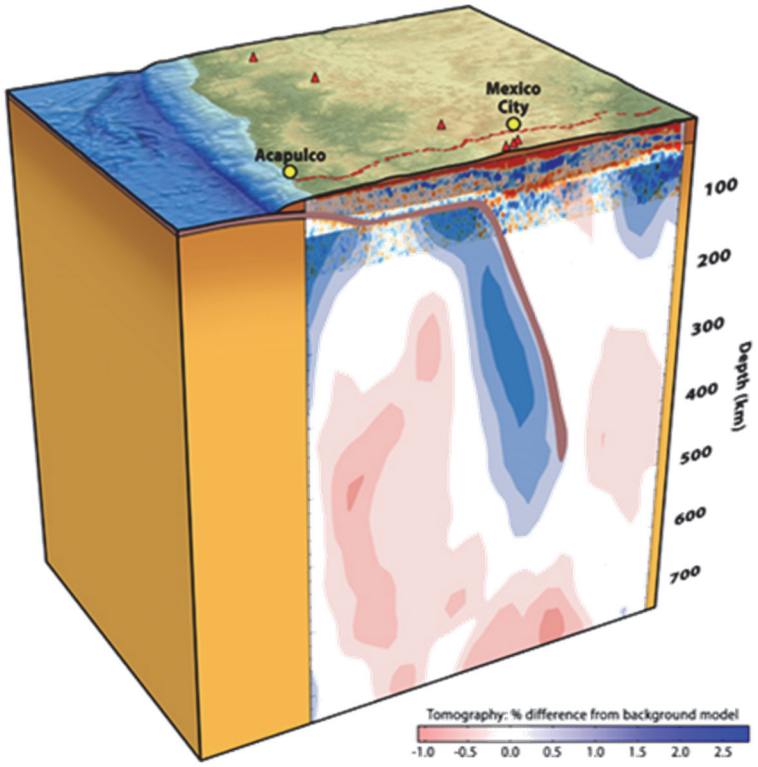


Figure 2.1.3 Model of subducting slab in Mexico (Caltech, 2009).

The 2017 event occurred near the plate boundary between the Cocos and North America plates. The location, depth, and normal-faulting mechanism indicate that this is likely an intraplate event, within the subducting Cocos slab, rather than on the shallower megathrust plate boundary interface (USGS, 2017a). Figure 2.1.5 shows the Cocos plate being pushed under the North American plate with extensional forces observed in the underlying plate that is bending and breaking off into the mantle (Cruz-Atienza et al., 2017).

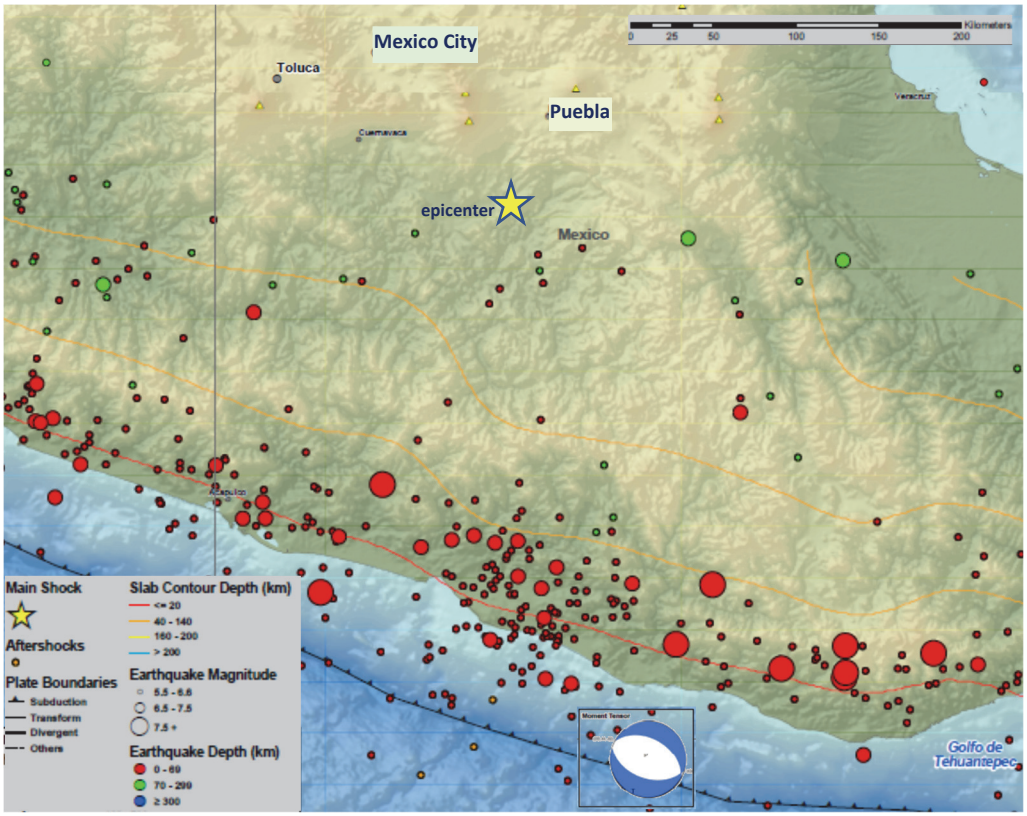


Figure 2.1.4 Epicenter of the M_w7.1 Puebla-Morelos event and aftershocks (USGS, 2017b).

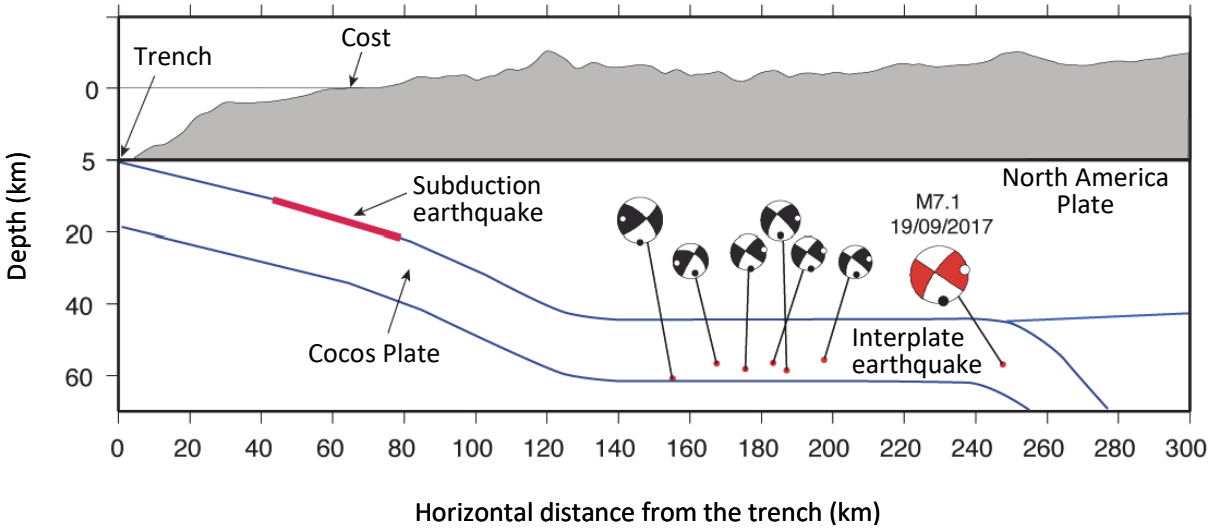


Figure 2.1.5 Hypocenter of the M_w7.1 Puebla-Morelos event of September 19, 2017 (in red) and of other regional earthquakes associated with normal faulting (Cruz-Atienza et al., 2017).

2.2 Historic Seismicity

2.2.1 Overview

Mexico City is subject to earthquakes and other natural hazards such as floods and volcanic eruptions. It is located on a unique volcanic high plateau at about 2,240 m above sea level, bound by volcanic sierras, alluvial fans and plains (Figure 2.2.1, Flores-Estrella et al., 2006).

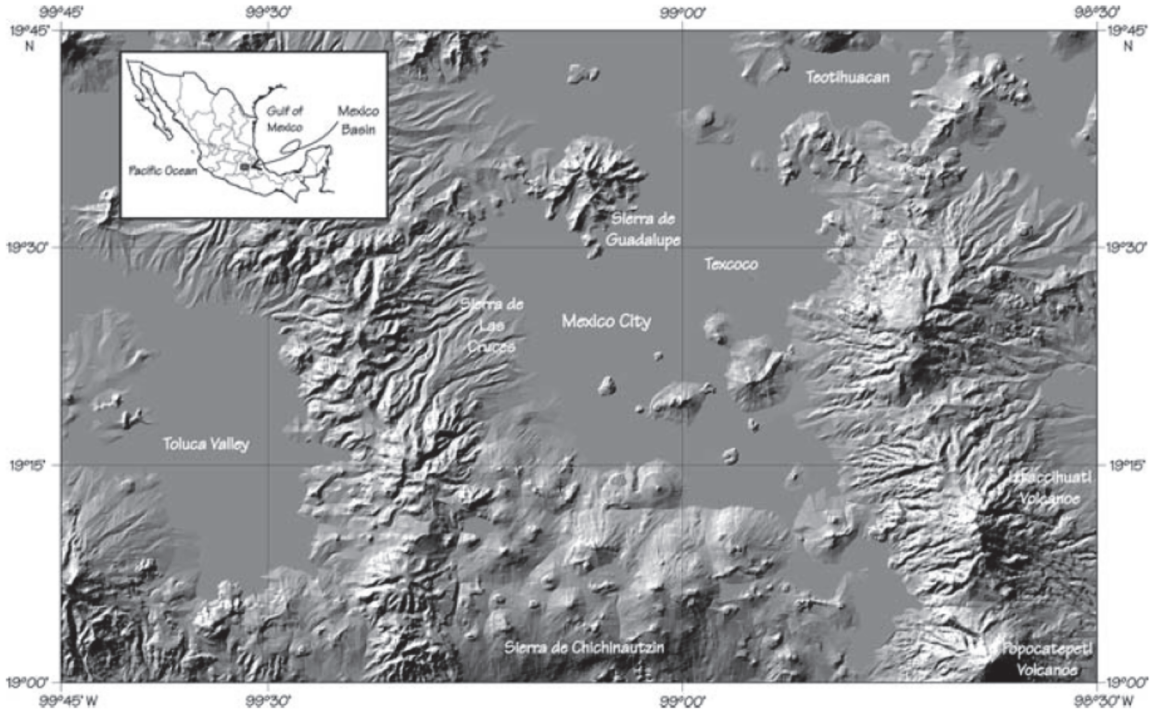


Figure 2.2.1 Mexico basin and its digital elevation model (modified from Flores-Estrella et al., 2006, based on Instituto Nacional de Geografica e Informatica, INEGI).

The U.S. National Geophysical Data Center (NGDC, 2018) reports at least 105 earthquakes of magnitude M6 or higher since 1787, 39 of which were followed by tsunamis, with historic records indicating over 30 earthquakes from 1523 to 1787 associated with death toll and significant destruction. Figure 2.2.2 shows regional earthquake and volcanic events from 1900 to 2010 from the global Centennial Catalog (Engdahl and Villaseñor, 2002) and the USGS tectonic activity map (Benz et al., 2011). In the figure, major earthquakes of magnitude over M7.5 are labeled by the year of occurrence. Sections A-A' and B-B' reflect earth structure profiles with focal depth and volcano eruptions. The most recent events larger than M4 from 1990 to 2017, are presented in the map of Fig. 2.2.3 by the Mexican Seismological Service (SSN, 2018).

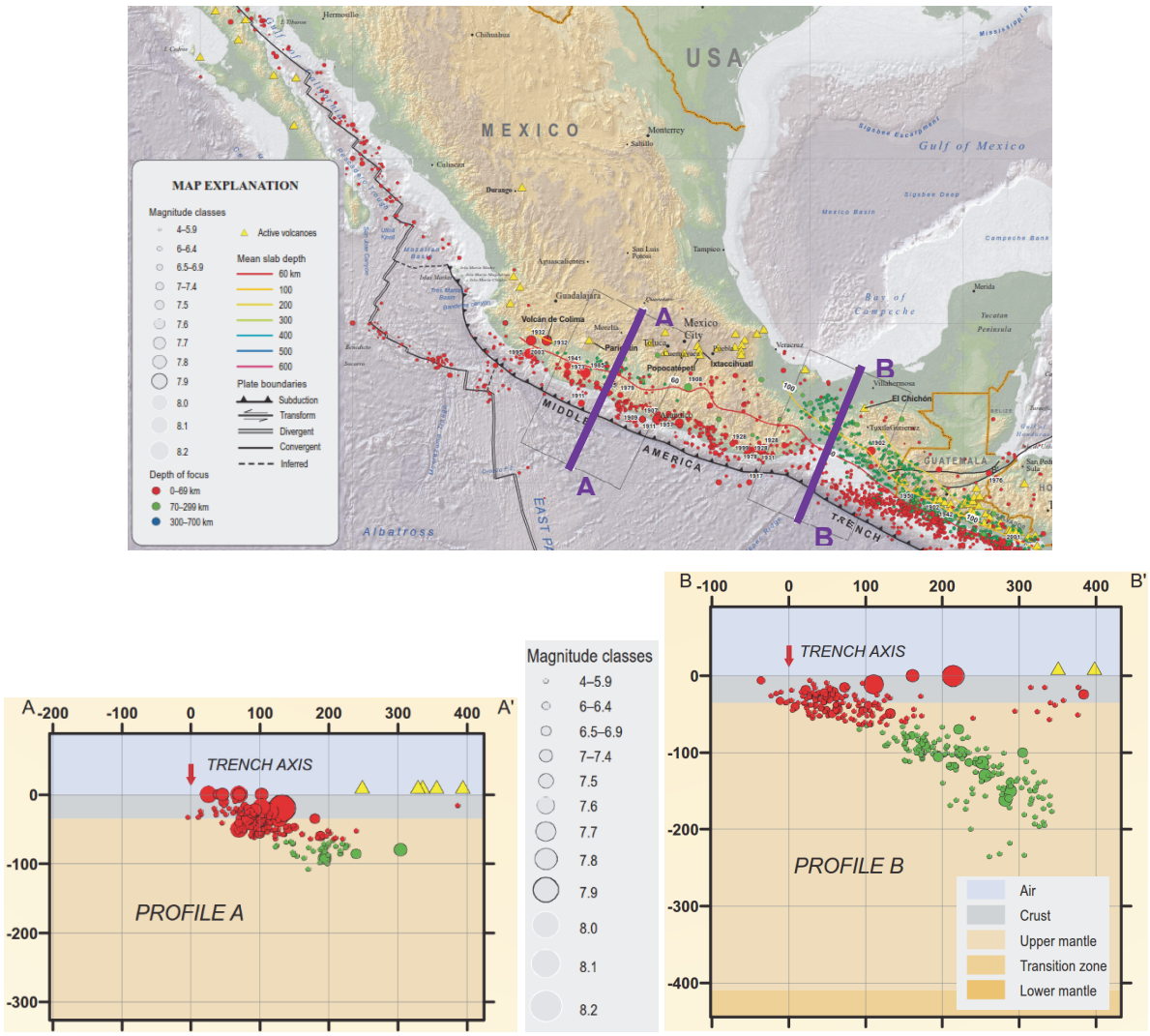


Figure 2.2.2 Top: Seismicity of Mexico and vicinity (1900-2010). Bottom: Sections A-A′ and B-B′ with triangles indicating active volcanoes and circles indicating seismic events (Benz et al., 2011).

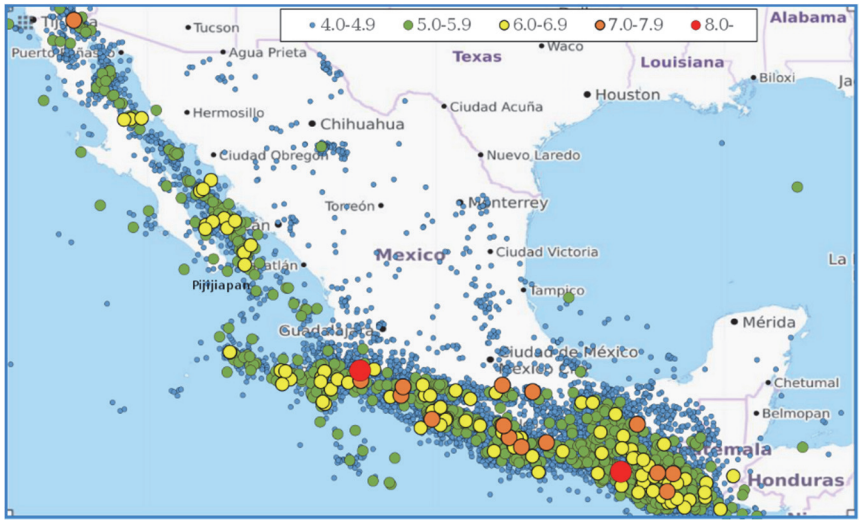


Figure 2.2.3 Regional earthquakes over M4 from 1900-2017 (SSN, 2018).

2.2.2 Major Historic Events

Historic events with magnitude over M6 from 1787 to 2017 are summarized in Tables 2.2.1 and 2.2.2 (NGDC, 2018) with details for selected significant events following in this section.

Table 2.2.1 Historic Events with Magnitude Greater than 6 from 1787 to 2017 (NGDC, 2018)

Date			*Time*	*Location*			*Parameters*			*Deaths*		*Damage*		*Collapse*	
Year	*Mo*	*Dy*	*UTC*	*Name*	*LAT*	*LON*	*D (km)*	*M*	*MMI*	*No.*	*Dscr.[1]*	*$M*	*Dscr.[2]*	*No.*	*Dscr.[3]*
1787	3	28	17:30	San Marcos	16.5	-98.5		8.3					3		3
1787	4	3	15:30	San Marcos	15.5	-97		7.3					2		
1806	3	25		Jalisco	18.9	-103.8		7.5			3				
1818	3	31		Mexico	19.1	-103.6		7.5							
1820	5	4		Guerrero	17.2	-99.6		7.6					3		
1834	3	14		Acapulco	16.8	-99.9		7							
1837	8	9	21:30	Acapulco	16.86	-99.88		6.5							
1837	10	18	21:00	Mexico City	19.45	-99.15		7							
1837	11	22		Guadalajara	20	-105		7.5							
1845	4	7		Mexico City	17	-100.6		8					2		
1852	11	29		North Mexico	32.5	-115.5		7							
1870	5	11		Oaxaca	15.4	-96.3		7.9		24	1		3		3
1875	2	11		San Cristobal de la Barranca	20.7	-103.4		7.5							
1887	5	3		Bavispe	31	-109	80	8		44	1		3		3
1897	6	5		Oaxaca	17	-96.3		7					3		
1897	6	20		Tehuantepec	16	-95		7					2		2
1899	1	24	23:43	Guerrero-Oaxaca	17	-98	60	8.4					3		
1900	1	20	06:33	Mexico	20	-105	10	7.4					1		
1900	5	16	20:12	Near Coast of Jalisco	20	-105	60	7.8							
1902	1	16		Guerrero	17.6	-99.7		7		2	1		2		
1902	9	23	20:18	Venustiano Carranza	16.6	-92.6	100	7.8					3		
1902	12	12	23:10	Baja California	29	-114	60	7.8							
1903	1	14	01:47	Off Coast of Guerrero	15	-98	33	7.7							
1906	4	10	21:22	Revilla Gigedo Islands	19	-113.8	60	7.5							

Table 2.2.1 Historic Events with Magnitude Greater than 6 from 1787 to 2017 (NGDC, 2018) (continued)

Date			Time	Location			Parameters			Deaths		Damage		Collapse	
Year	Mo	Dy	UTC	Name	LAT	LON	D (km)	M	MMI	No.	Dscr.[1]	$M	Dscr.[2]	No.	Dscr.[3]
1907	4	15	06:08	Guerrero	17	-100	60	8.3		8	1		2		3
1907	10	16	14:57	Gulf of California	28	-112.5	60	7.7							
1908	3	26	23:03	Guerrero	18	-99	80	8.1					2		
1908	3	27	03:45	Guerrero	17	-101		7.5							
1909	7	30	10:51	Acapulco	16.8	-99.8		7.8					3		3
1910	9	24	03:00	Oaxaca	16.8	-95.9		6.9	9				2		
1911	6	7	11:02	Michoacan	17.5	-102.5	11	7.9		45	1				
1911	12	16	19:14	Near Coast of Guerrero	17	-100.7	50	7.6	4						
1912	11	19	13:18	Central Mexico	19.9	-99.8		7.8					3		
1914	3	30	00:41	Chiapas	16.8	-92.2	150	7.5							
1917	12	29	22:50	Near Oaxaca Coast	15	-97	33	7.7							
1920	1	3	21:48	Veracruz	19.26	-96.97		7.8	10	648	3		2		
1921	4	30	11:04	Near Coast of Jalisco	19.7	-104.3		7.7							
1925	11	16	11:54	South Mexico	18.5	-107	80	7							
1928	2	10	04:39	Oaxaca	17.8	-97.6	100	7.7					3		
1928	3	22	04:17	Oaxaca	15.67	-96.1	60	7.7							
1928	4	16	21:26	Oaxaca	17.75	-97.1		7.8					1		
1928	6	17	03:19	Oaxaca	16.03	-97.036	35	7.7		4	1		2		
1928	10	9	03:01	Oaxaca	16	-97	60	7.6							
1931	1	15	01:50	Oaxaca	16.1	-96.8	50	7.9	10						
1932	6	3	10:36	Near Coast of Jalisco	19.5	-104.25	60	8.1	10	400	3		3		3
1932	6	18	10:12	Central Mexico	19.45	-103.632	54	7.9	10				2		
1932	6	22	12:59	Central Mexico	19	-104.5		6.9					3	400	3
1934	11	30	02:05	Jalisco	18.5	-105.5	5	7					3		
1937	7	26	03:48	Central Mexico	18.8	-97.5		7.7		34	1		2		
1937	12	23	13:17	Guerrero	16.7	-98.5	60	7.5		4	1				
1941	4	15	19:09	Michoacan	18.9	-102.9	60	7.9	7						
1943	2	22	09:20	Guerrero	16.7	-101.5	60	7.5	7	11	1		3		

Table 2.2.1 Historic Events with Magnitude Greater than 6 from 1787 to 2017 (NGDC, 2018) (continued)

Date			*Time*	*Location*			*Parameters*			*Deaths*		*Damage*		*Collapse*	
Year	*Mo*	*Dy*	*UTC*	*Name*	*LAT*	*LON*	*D (km)*	*M*	*MMI*	*No.*	*Dscr.*[1]	*$M*	*Dscr.*[2]	*No.*	*Dscr.*[3]
1948	12	4	00:22	Maria Madre Island	22	-106		6.9		4	1		3		
1950	11	17	19:28	Guerrero	16.5	-100.4		6.8	11				2		
1950	12	14	14:15	Acapulco	16.48	-98.22	50	7.5	5				3		
1951	7	9	00:04	Oaxaca	16.1	-96.8	50	6.2		1	1		2		
1954	2	5	15:17	Chiapas	17.3	-92.6	100	6.2		6	1	17	3		
1956	1	8	07:11	Guerrero	17	-99.5		6.5					3		
1957	7	28	08:40	Acapulco	16.5	-99.1	25	7.9	7	65	2	25	4		3
1959	5	24	19:17	Oaxaca	17	-96.3	100	6.8					3		
1959	8	26	08:25	Gulf of Campeche	18.3	-94.4		6.9		25	1		3		3
1962	5	11	14:11	South Mexico	17.2	-99.6	40	7	8	4	1		2		2
1962	5	19	14:58	South Mexico	17.2	-99.5	33	7.2		3	1		2		2
1964	7	6	07:22	Guerrero	18.3	-100.4	100	7.4		78	2		3		
1965	8	23	19:46	Mexico City	16.3	-95.8	28	7.8		6	1		1		
1968	8	2	14:06	Oaxaca	16.5	-97.8	36	7.5	7	18	1	2.4	2		
1973	1	30	21:01	Farias	18.48	-103	43	7.5		56	2		2		2
1973	8	28	09:50	Veracruz	18.27	-96.6	84	6.2	7	600	3		3		
1976	6	7	14:26	Mexico City	17.4	-100.64	45	6.4					2		
1978	3	19	01:39	Acapulco	17.03	-99.74	36	6.6		1	1		2		
1978	11	29	19:52	Oaxaca	16.01	-96.591	18	7.7		9	1		2		
1979	3	14	11:07	Guerrero	17.81	-101.276	49	7.6		5	1	30	4	200	3
1980	6	9	03:28	NW Mexico	32.22	-114.985	5	6.4	5	1	1		2		
1980	10	24	14:53	Huajapan de Leon	18.21	-98.24	72	6.4	9	300	3	5	2		3
1981	10	25	03:22	Michoacan	18.05	-102.084	33	7.3		9	1		3		
1982	6	7	10:59	Guererro	16.56	-98.358	34	7	6	9	1		2		
1983	1	24	08:17	Oaxaca	16.15	-95.232	57	6.7	7				2		
1985	9	19	13:17	Michoacan	18.19	-102.533	28	8.1	9	9500	4	4000	4		4
1985	9	21	01:37	SW Coast Mexico City	17.8	-101.647	31	7.6	6		2		2		
1989	4	25	14:29	Mexico City	16.77	-99.328	19	6.8	6	3	1		2		
1995	9	14	14:04	Guerrero	16.78	-98.597	23	7.4		3	1		2		
1995	10	9	15:35	Jalisco	19.06	-104.205	33	8		49	2		2		2
1996	2	25	03:08	Off Coast Guerrero	15.98	-98.07	21	7.1							

Table 2.2.1 Historic Events with Magnitude Greater than 6 from 1787 to 2017 (NGDC, 2018) (continued)

Date			Time	Location			Parameters			Deaths		Damage		Collapse	
Year	Mo	Dy	UTC	Name	LAT	LON	D (km)	M	MMI	No.	Dscr.[1]	$M	Dscr.[2]	No.	Dscr.[3]
1997	1	11	20:28	Michoacan	18.22	-102.756	33	7.2		1	1		2		
1998	2	3	03:02	Oaxaca	15.88	-96.298	33	6.3					2		
1999	6	15	20:42	Puebla-Morelos	18.39	-97.436	70	7		20	1	226.8	4		
1999	6	21	17:43	Guerrero	18.32	-101.539	69	6.3					3		
1999	9	30	16:31	Oaxaca	16.06	-96.931	61	7.5	8	35	1	164.8	4		
2003	1	22	02:06	Villa de Alvarez	18.77	-104.104	24	7.5	8	29	1		3	2005	4
2004	1	1	23:31	Guerrero	17.49	-101.303	29	6.1					1		
2007	4	13	05:42	Guerrero	17.3	-100.198	34	6	5				1	2	1
2010	4	4	22:40	Baja California	32.3	-115.278	4	7.2		2	1	1150	4		
2010	6	30	07:22	San Andres	16.4	-97.782	20	6.2		1	1				
2011	12	11	01:47	Guerrero	17.84	-99.963	54	6.4		2	1		2		
2012	3	20	18:02	Guerrero	16.49	-98.231	20	7.4	8	2	1		3	800	3
2013	8	21	12:38	Mexico: Acapulco	16.92	-99.381	12	6.2					1		
2014	4	18	14:27	Guerrero	17.55	-100.816	24	7.2					1		
2014	5	8	17:00	Tecpan	17.39	-100.656	24	6.4					1		
2014	7	7	11:23	Guatemala	14.74	-92.409	60	6.9		53	1		1		1
2014	7	29	10:46	Oaxaca	17.84	-95.524	95	6.3		1	1		1		
2017	9	8	04:49	Chiapas	15.07	-93.715	70	8.1		98	2		4	5000	4
2017	9	19	18:14	Puebla - Morelos	18.58	-98.399	51	7.1		369	3		4	226	3
2017	9	23	12:53	Oaxaca	16.74	-94.946	9	6.1		5	1		1	11	1

Table 2.2.2 Description Index for Deaths, Damage, and House Losses for Historic Events with Magnitude Over M6 from 1787 to 2017 (NGDC, 2018)

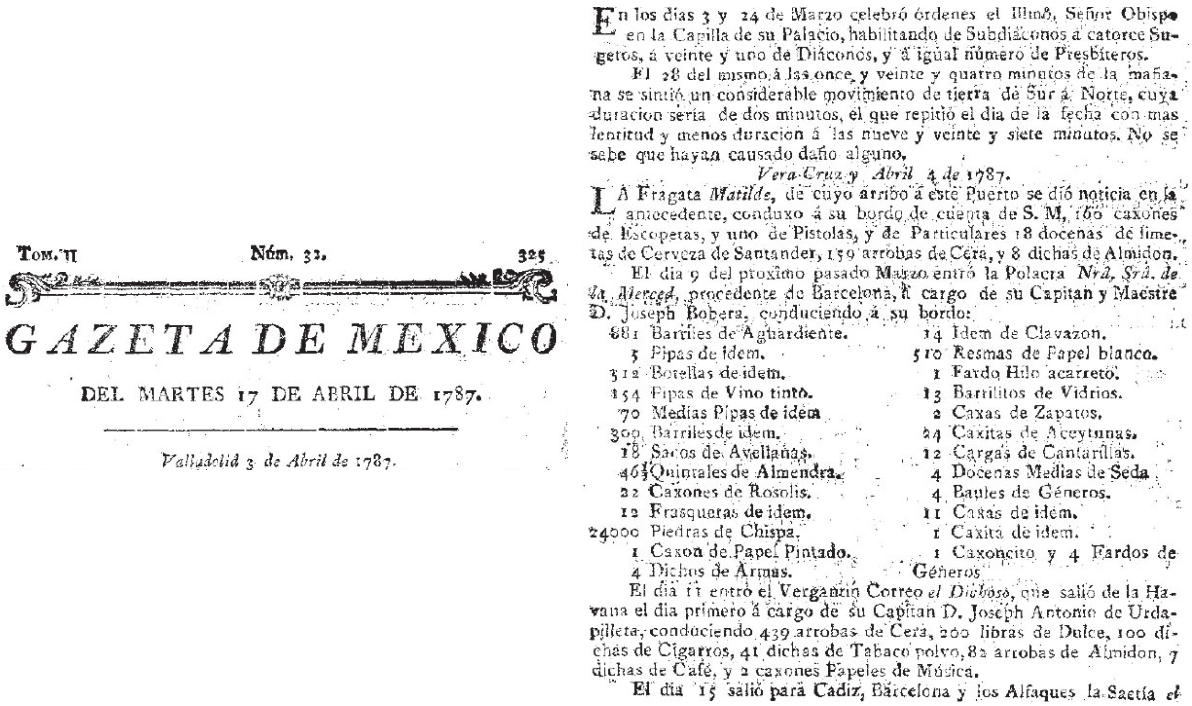
			NOAA Description Index				
ID	Category	Unit	0	1	2	3	4
1	Deaths	Number	0	1-50	51-100	101-1000	>1000
2	Econ. Damage	1990 USD	0	< 1 M	1 - 5 M	4 - 24 M	> 25 M
3	Homes Losts	Number	0	1-50	51-100	101-1000	>1000

2.2.2.1 1787, March 28, M_s8.3 (est. Intensity >VIII)

The M_s8.3 event, known as the 1787 New Spain or San Sixto earthquake, took place along the Mexican subduction zone, with an epicenter near San Marcos, affecting the city and the coasts of Oaxaca, Guerrero, and Michoacán (Sánchez and Farreras,1993). It was felt for 6 to 7 min in many locations (Soloviev and Go, 1975), destroying towns and devastating districts (Milne, 1911). The earthquake was followed by a large tsunami reported at the south coasts of Mexico.

According to reports in the Gazeta de México newspaper (Figure 2.2.4), the government building suffered damage that forced the local politicians who were meeting at the time to go out and gather in the main square open space, where aftershocks followed. The prison was in ruins and about 220 prisoners moved to the center of the building asking for help and were saved by the authorities (Biblioteca Nacional de España, 2018). The earthquake had an estimated Modified Mercalli Intensity [MMI] of at least VIII and estimated moment magnitude of M_w8.6, and was followed by 35 aftershocks with apparent magnitude over M_w7.0 up to April 3rd (Soloviev et al., 1975), three of which caused extensive damage in Oaxaca (Suárez and Albini, 2009). The estimated 450-km long ruptured fault segment also broke during events of more moderate magnitude (M_w7 to M_w8) and relatively short recurrence periods of about 30-40 years, showing similarities to the rupture in the 1906 M8.8 Ecuador-Colombia (Suárez and Albini, 2009), and the 2016 M_w7.8 Muisne, Ecuador earthquakes (Nikolaou et al., 2016).

The 1787 event was the most intense earthquake in recent history in Mexico, causing dome and temple collapses, following patterns observed in 1931, 1999, and 2017 (Figure 2.2.5). The temple of San Francisco was one of the most damaged buildings. For fear of the towers collapsing in the days following the main shock, religious icons were transferred to the convent of Santo Domingo. Indeed, on April 3rd, a major aftershock caused one of the towers of the San Francisco temple to collapse, inducing severe damage to the Cathedral and the La Merced convent, as well as collapse of already damaged buildings (Biblioteca Nacional de España, 2018).



TOM. II Núm. 32. 325

GAZETA DE MEXICO

DEL MARTES 17 DE ABRIL DE 1787.

Valladolid 3 de Abril de 1787.

En los dias 3 y 24 de Marzo celebró órdenes el Illmô. Señor Obispo en la Capilla de su Palacio, habilitando de Subdiáconos á catorce Sugetos, á veinte y uno de Diáconos, y á igual número de Presbíteros.

El 28 del mismo á las once y veinte y quatro minutos de la mañana se sintió un considerable movimiento de tierra de Sur á Norte, cuya duracion seria de dos minutos, el que repitió el dia de la fecha con mas lentitud y menos duracion á las nueve y veinte y siete minutos. No se sabe que haya causado daño alguno.

Vera-Cruz y Abril 4 de 1787.

LA Fragata *Matilde*, de cuyo arribo á este Puerto se dió noticia en la antecedente, conduxo á su bordo de cuenta de S. M. 160 cañones de Escopetas, y uno de Pistolas, y de Particulares 18 docenas de limetas de Cerveza de Santander, 159 arrobas de Cera, y 8 dichas de Almidon.

El dia 9 del proximo pasado Marzo entró la Polacra *Nrâ. Srâ. de la Merced*, procedente de Barcelona, á cargo de su Capitan y Maestre D. Joseph Bobera, conduciendo á su bordo:

681 Barriles de Aguardiente.	14 Idem de Clavazon.
5 Pipas de idem.	510 Resmas de Papel blanco.
312 Botellas de idem.	1 Fardo Hilo acarreto.
154 Pipas de Vino tinto.	13 Barrilitos de Vidrios.
70 Medias Pipas de idem	2 Caxas de Zapatos.
300 Barriles de idem.	24 Caxitas de Aceytunas.
18 Sacos de Avellanas.	12 Cargas de Cantarillas.
46½ Quintales de Almendra.	4 Docenas Medias de Seda
22 Caxones de Rosolis.	4 Baules de Géneros.
12 Frasqueras de idem.	11 Caxas de idem.
24000 Piedras de Chispa.	1 Caxita de idem.
1 Caxon de Papel Pintado.	1 Caxoncito y 4 Fardos de
4 Dichos de Armas.	Géneros

El dia 11 entró el Vergantin Correo *el Dichoso*, que salió de la Havana el dia primero á cargo de su Capitan D. Joseph Antonio de Urdapilleta, conduciendo 439 arrobas de Cera, 200 libras de Dulce, 100 dichas de Cigarros, 41 dichas de Tabaco polvo, 82 arrobas de Almidon, 7 dichas de Café, y 2 caxones Papeles de Música.

El dia 15 salió para Cadiz, Barcelona y los Alfaques la Saetía *el*

Figure 2.2.4 Article of April 17, 1787 appearing in the *Gazeta de México* newspaper, regarding the great 1787 earthquake and tsunami in the Oaxaca coasts (Biblioteca Nacional de España, 2018).



Figure 2.2.5 Pattern of domes and temple collapses in Oaxaca observed in 1787 and followed in the 1931, 1999, and 2017 earthquakes (Biblioteca Nacional de España, 2018).

As Suárez and Albini (2009) suggest in Figure 2.2.6, the rupture zones of the 1937 M7.5, 1965 M_s7.8, 1968 M7.5, 1978 M_s6.6, 1982 M_s7.0, and 1996 M_w7.1 along the Oaxaca coast coincide with the rupture area from the 1787 New Spain earthquake. A massive tsunami followed the earthquake, that *"injured and left 11 fishermen hanging from 5-m trees on a high hill, which was 1.5 leagues (about 6.3 km) from the coastline"* (Núñez-Cornú et al., 2008). The wave heights were more than 4 m and 18 m at some areas of Acapulco and Corralero, respectively, and at least 2 m at locations in Jamiltepec and Tehuantepec.

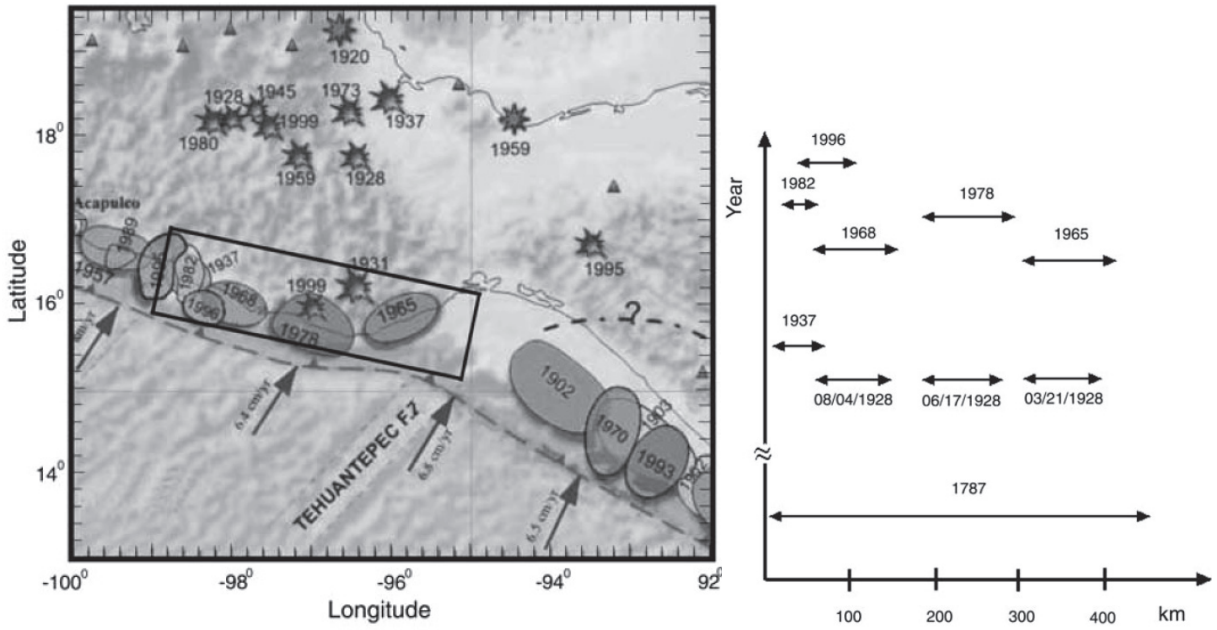


Figure 2.2.6 Seismicity of southern coast of Guerrero and Oaxaca in the 20th century (top) with rupture lengths (bottom) of the largest recorded and the 1787 New Spain events (Suárez & Albini, 2009).

2.2.2.2 1985, September 19, M_s8.1 (Intensity IX)

The 1985 Michoacán earthquake struck in the morning of September 19th (13:17:50 UTC) off the coast of the Mexican state of Michoacán, with magnitude M_s8.1 and MMI of IX (Figure 2.2.7). The main shock was followed by a second M_s7.7 earthquake two days later and a M_s7.0 aftershock six months later, on April 30th 1986. Although some damage occurred in the epicentral area, by far the greatest impact was to Mexico City approximately 350 km from the epicenter (Figure 2.2.7). The main earthquake is considered the second largest earthquake along the Middle America trench (Glass, 1989) with devastating impact to the capital. Official estimates placed the final death toll at 10,000 people (Encyclopedia Britannica, 2018), but the actual death toll could be as high as 45,000, per the National Geophysical Data Center (NGDC, 2018). More than 30,000 people

were injured and 50,000 were left homeless, with 3,000 buildings destroyed or severely damaged (Haber, 1995), and a total cost of $4B (U.N., 1985).

The main shock occurred in a region of tectonic tension between the North American Plate and the subducting Cocos Plate (Figure 2.2.7). The expansion of this subduction zone is part of the mid-America trench known as the Michoacán seismic gap (Figure 2.2.8), where seismic energy had been accumulating since the 1911 event. The strike of the fault plane was computed at 100° with a north-east dip of 18° (Priestly and Masters, 1986), with a total offset along the dislocation of 2.3 m, with approximately 1 m of uplift along the coast (Anderson et al., 1986).

Earthquake damage to buildings was extensive, particularly to those with 6 to 15 stories; however, very few buildings less than 5 or over 15 stories suffered serious damage. The heavy impact on 6- to 15-story buildings was due to resonance of the lakebed sediments with the predominant period of shaking and with the fundamental period of the buildings. In many cases, either the upper floors or only one floor collapsed, leaving the other floors relatively undamaged, often leading to pancake-type story collapse (Figure 2.2.9). In cases where the bottom floors were parking garages, lobbies or large shopping areas, soft story collapses were observed.



Figure 2.2.7 Epicenter of the 1985 Michoacán earthquake, approximately 350 km away from Mexico City. Also shown is the subduction zone off the coast of Mexico (Encyclopedia Britannica, 2018).

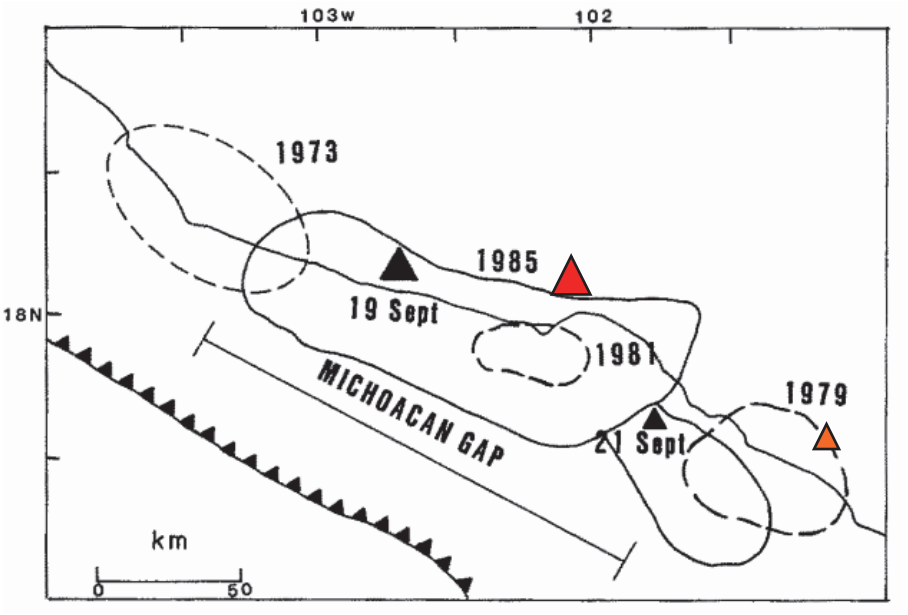


Figure 2.2.8 The Michoacán seismic gap and the 1985 M_s8.1 and M_s7.7 rupture areas (Glass,1989).



Figure 2.2.9 Pancake building collapse in the 1985 Michoacán earthquake (Beck and Hall, 1986).

Damage was localized to the center of the city, as shown in Figures 2.2.10 and 2.2.11, leaving the rest of the metropolitan city unscathed. However, the damage in the affected area was extensive: in the historic part of the city (Cuauhtémoc), 258 buildings completely collapsed, 143 partially collapsed, and 181 were substantially damaged.

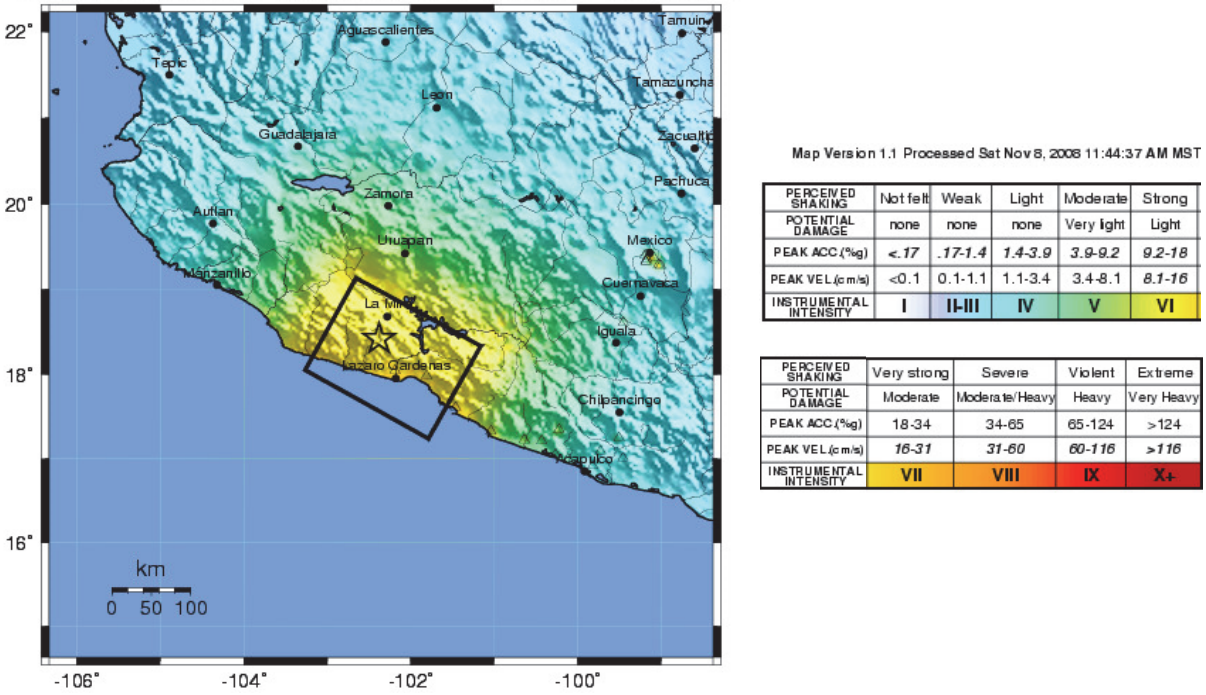


Figure 2.2.10 1985 Michoacán earthquake Shakemap (USGS, 2008).

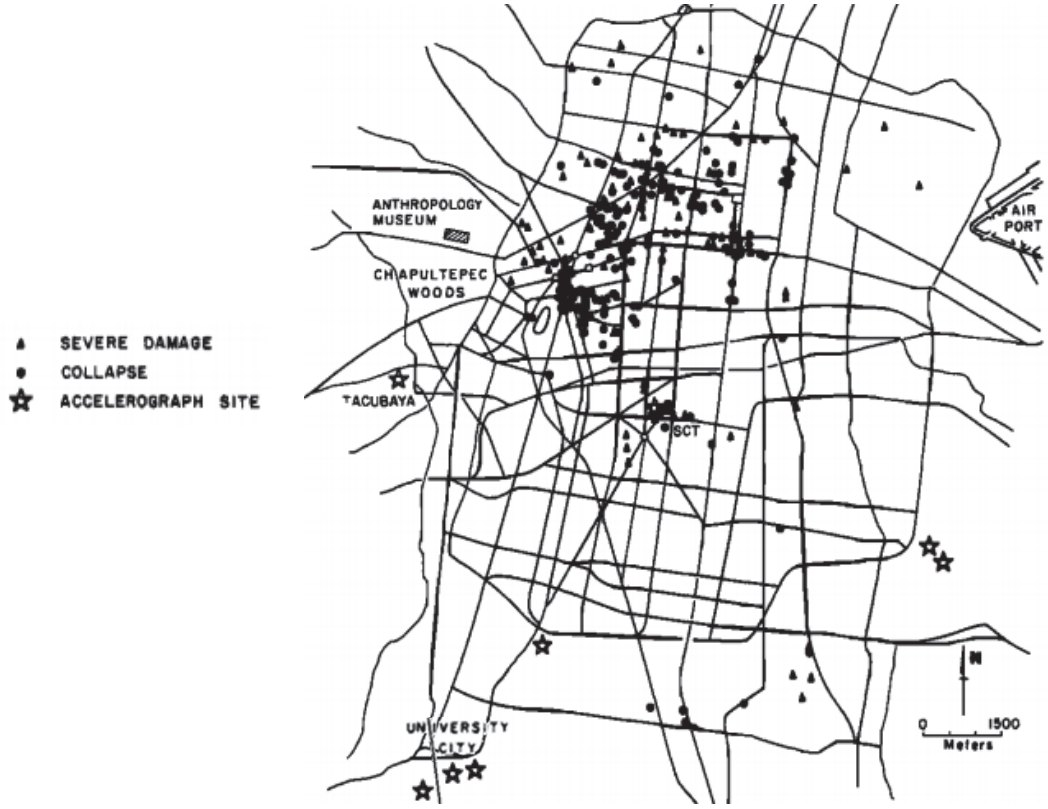


Figure 2.2.11 Distribution of severe structural damage in the center of Mexico (Beck and Hall, 1986).

The tallest building in the city at the time was 44-story Torre Latinoamericana. The building did not sustain damage from the earthquake, making it a *"silent witness of the history and the tragedy that has surrounded the Aztec capital"* (Flores, 2011). The building had also not sustained any damage in the 1957 M7.9 earthquake; this earned it the title of "the tallest building ever exposed to a huge seismic force" by the American Institute of Steel Construction (AISC).

The resilient behavior of this structure can be attributed to its design. The structural system shown in the inset of Fig. 2.2.12 is a symmetrical moment-resisting frame with heavy built-up H columns, wide flange composite beams, and rigid riveted connections (Tomlinson and Boorman, 2001). The bearing pressure on the rigid, 361-pile raft was reduced by the 13-m deep basement. The concrete piles were driven 34 m below the ground surface to extend into the deeper stiff clays and dense sands (Gioncu and Mazzolani, 2013). The soil-structure-foundation interaction increases the fundamental building period, shifting it further away from the site response period, which has helped avoid resonance phenomena and associated damage.

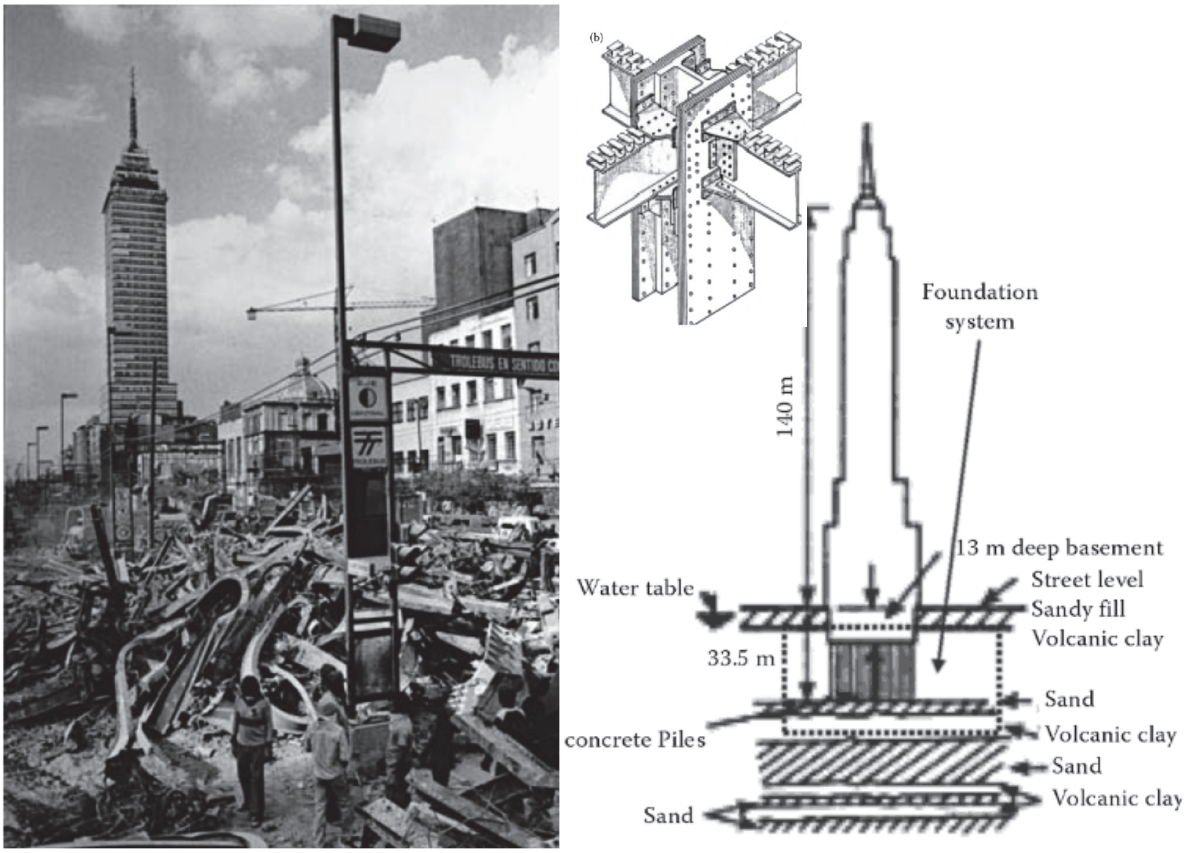


Figure 2.2.12 Left: The Torre Latinoamericana building surrounded by city ruins in the aftermath of the 1985 Michoacán earthquake (photo by A. Garay; Flores, 2011). Right: Foundation and structural system (Tomlinson and Boorman, 2001; Gioncu and Mazzolani, 2013).

2.2.2.3 1999, June 15, M_w7.0 (Intensity IV)

On June 15, 1999 at 15:42 local time, a M_w7.0 earthquake struck near Tehuacán, Puebla. The location of the 1999 Puebla earthquake indicates that it is generated by fracturing of the continental lithosphere caused by the process of subduction (Vanek et al., 2000), and is thus is an intraplate earthquake. Figure 2.2.13 shows the epicenter and its distance from the subduction zone, with felt intensity shown on the USGS map of Fig. 2.2.14.

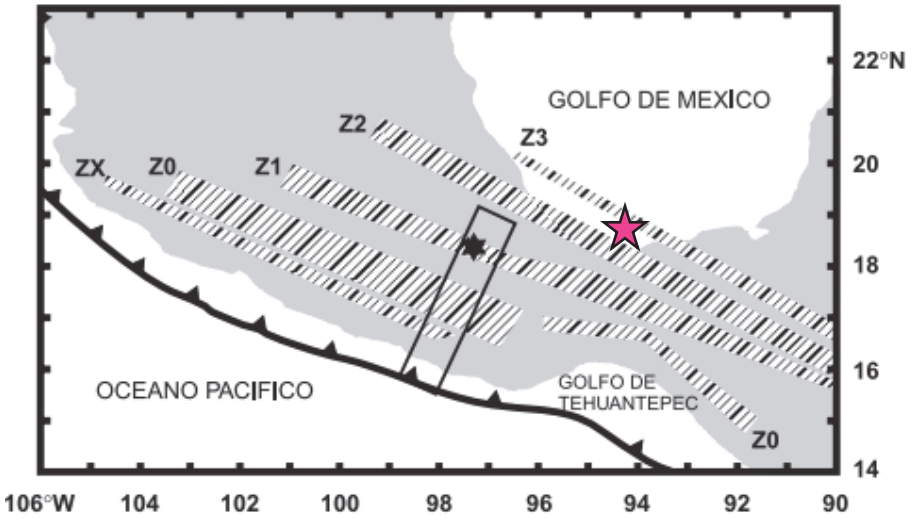
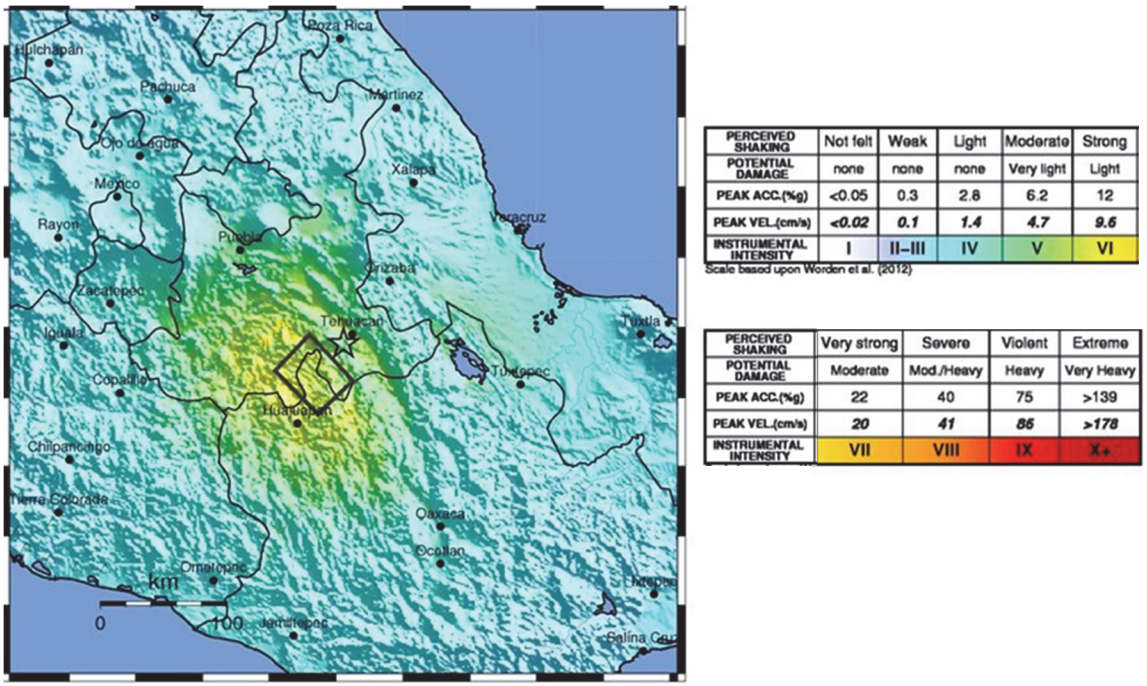


Figure 2.2.13 Epicenter of the 1999 M_w7 Puebla intraplate earthquake (Vanek et al., 2000)



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong
POTENTIAL DAMAGE	none	none	none	Very light	Light
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI

Scale based upon Worden et al. (2012)

PERCEIVED SHAKING	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	22	40	75	>139
PEAK VEL.(cm/s)	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	VII	VIII	IX	X+

Figure 2.2.14 Intensity map of the 1999 M_w7 Puebla earthquake (USGS, 1999).

Fifteen people were reported dead, 5,306 houses were destroyed, and 15,688 were partially damaged (Bitrán-Bitrán, 2001). Many colonial monuments and more than 280 churches sustained damage, including 16 monasteries (Fig. 2.2.15). The Puebla state was declared a disaster area, with collapses that included the Puebla City Hall. Landslides and bridge damages closed traffic routes near Tehuacán (Figures 2.2.16 and 2.2.17).



Figure 2.2.15 The Santiago Xochiteopan church, damaged in 1999 (colonialmexico.com, 2017).



Figure 2.2.16 Bridge damage near Tehuacán in the 1999 Puebla earthquake (Pestana et al., 2002).



Figure 2.2.17 Landslide on road from Tehuacán to Huajapán de León after the 1999 M_w7 Puebla earthquake (EERC, 1999).

2.2.2.4 2017, September 7, M_w8.2 (Intensity IX)

On September 7, 2017 at 23:49:19 local time, a M_w8.2 earthquake struck Mexico (Mayoral et al., 2017) with intensity IX (USGS, 2017b, with an epicenter about 133 km southeast of Pijijiapan in the Chiapas state (Figure 2.2.18) and hypocentral depth of 58 km. The earthquake occurred merely 12 days before the M_w7.1 Puebla-Morelos earthquake covered in this report. Although the locations, depths, and normal-faulting mechanisms for both 2017 events indicate that they are intraplate events within the subducting Cocos slab, rather than on the shallower megathrust plate boundary interface, the two events are likely not related to each other (Becker, 2017). A small- to moderate-size tsunami was generated by this seismic event along the Pacific coast. In the far field, the maximum tsunami amplitudes were less than 0.35 m, which was the measured amplitude in Owenga, Chatham Islands, in New Zealand's Pacific Tsunami Warning Center (Wilson et al., 2017).

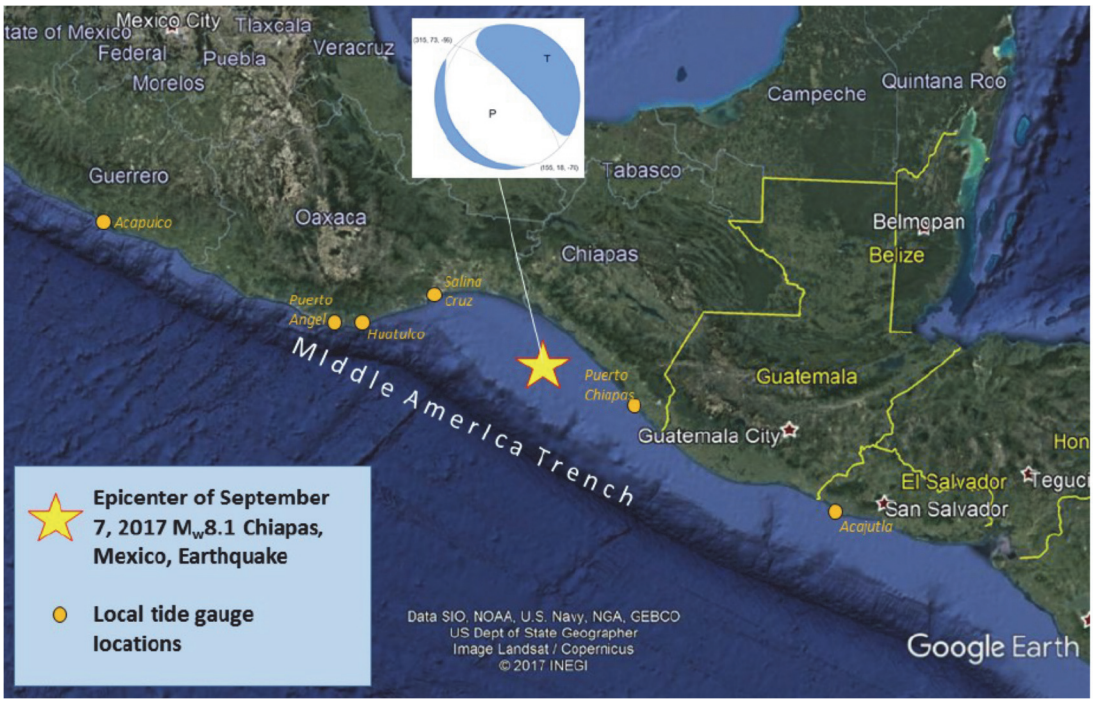


Figure 2.2.18 Map of the epicentral area of the M_w8.2 Chiapas earthquake, with USGS moment tensor diagram and locations of tide gauges (Wilson et al., 2017).

As the largest earthquake of the 20th century (Fig. 2.2.19) and second strongest in the country's history (second only to the 1787 M_s8.3 San Sixto earthquake), this event affected Mexico City, South Mexico, and portions of Guatemala.

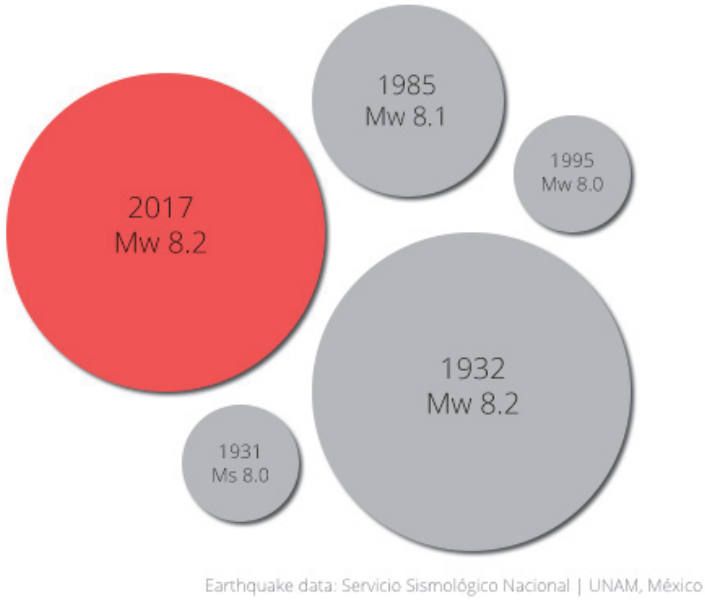


Figure 2.2.19 Largest earthquakes in Mexico in the 20th century, up to the M_w8.2 Chiapas earthquake of 2017 (Servicio Sismologico Nacional, 2018).

The Learning From Earthquakes (LFE) Program of the Earthquake Engineering Research Institute (EERI, 2017) reported that hundreds of schools were damaged and one collapsed in the Chiapas, Oaxaca, and Mexico City area (Figure 2.2.20). Severe geotechnical effects including landslides, ground movement, building settlements, site and topographic effects were observed (Mayoral et al., 2018).



Figure 2.2.20 Collapse of a hotel in the state of Oaxaca (EERI, 2017).

This was the first major event in Mexico where social media played a big role in the emergency response, reconnaissance and recovery, as the extent and types of damage in different areas of the affected areas were well reported. The established early warning system gave the residents of Mexico City 86 seconds of warning (EERI, 2018). Despite the use of technology to prevent loss of life, the event resulted in over 100 deaths, 300 injuries, 57,000 collapsed buildings, 210,000 damaged buildings, and 450,000 displaced people (Earthquake Report, 2017).

The fact that the Middle American Trench megathrust did not rupture indicates that the stress along this subduction zone within the Tehuantepec seismic gap may remain unreleased. This leads to the following considerations: (1) historical and paleo-seismic events should be examined to identify if past large earthquakes ruptured the megathrust without rupturing subsidiary faults; and (2) potential for multiple earthquake sources should be included within complicated tectonic boundaries, such as the one off the coast of Chiapas, in regional seismic hazard analyses (Wilson et al., 2017).

Chapter 3
Ground Motions

3.1 Seismological Observations

The M_w7.1 earthquake struck the Puebla area of Mexico on September 19, 2017 at 1:14pm local time (18:14 UTC), exactly 32 years to the day after the devastating M_s8.0 1985 Michoacán earthquake, and 12 days after a M_w8.1 earthquake offshore of Chiapas. The main shock occurred as the result of normal faulting at a depth of approximately 50 km within the subducting Cocos plate, rather than on the shallower megathrust plate boundary interface between the Cocos and North American plates, as shown in Figures 3.1.1 and 3.1.2.

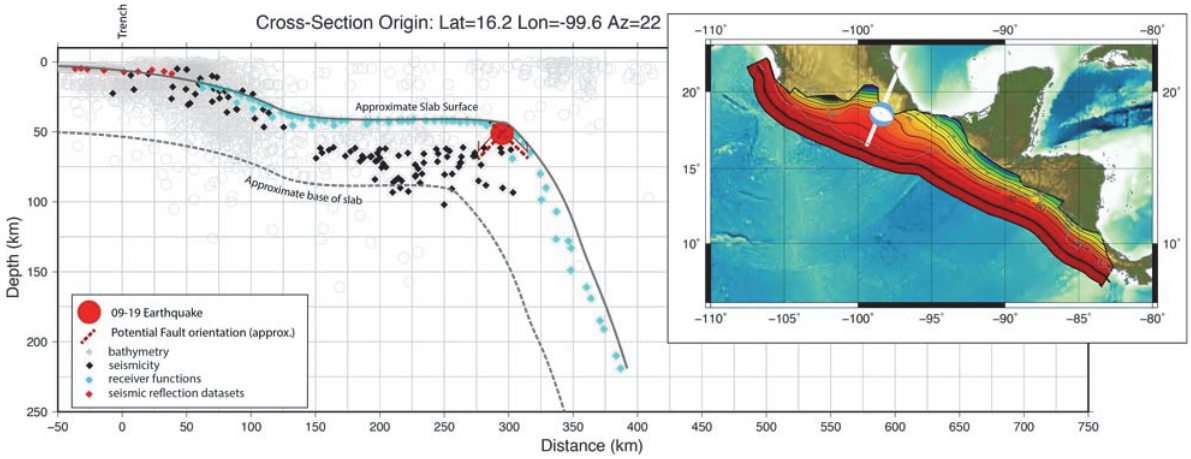


Figure 3.1.1 Cross section of the mechanism of the September 19th, 2017, M_w7.1 Puebla-Morelos earthquake within the Cocos plate (USGS, 2017).

The USGS estimates that over 1 million people felt very strong shaking and more than 15 million felt strong shaking from this earthquake, according to the USGS "Did You Feel It" and PAGER maps. Figure 3.1.3 shows the ShakeMap of Modified Mercalli Intensity (MMI) levels reflected with color-coded contours, and an accompanying table with key engineering parameters, including expected potential damage, Peak Ground Acceleration and Velocity (PGA and PGV), to each MMI level.

The seismological parameters as estimated by SSN (2017), the United States Geological Survey (USGS, 2017), and the Global Centroid-Moment-Tensor (CMT) catalog (available at: https://www.globalcmt.org/CMTsearch.html; last accessed May 11, 2020) are shown in Table 3.1.1 (IRIS, 2017b).

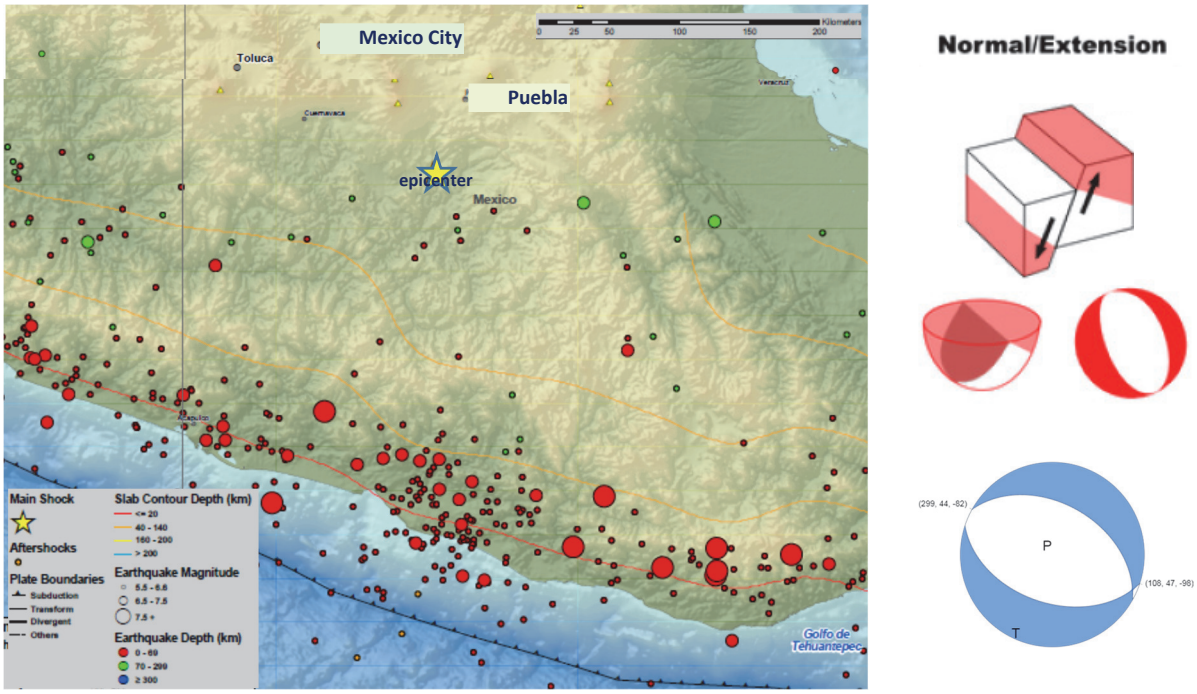
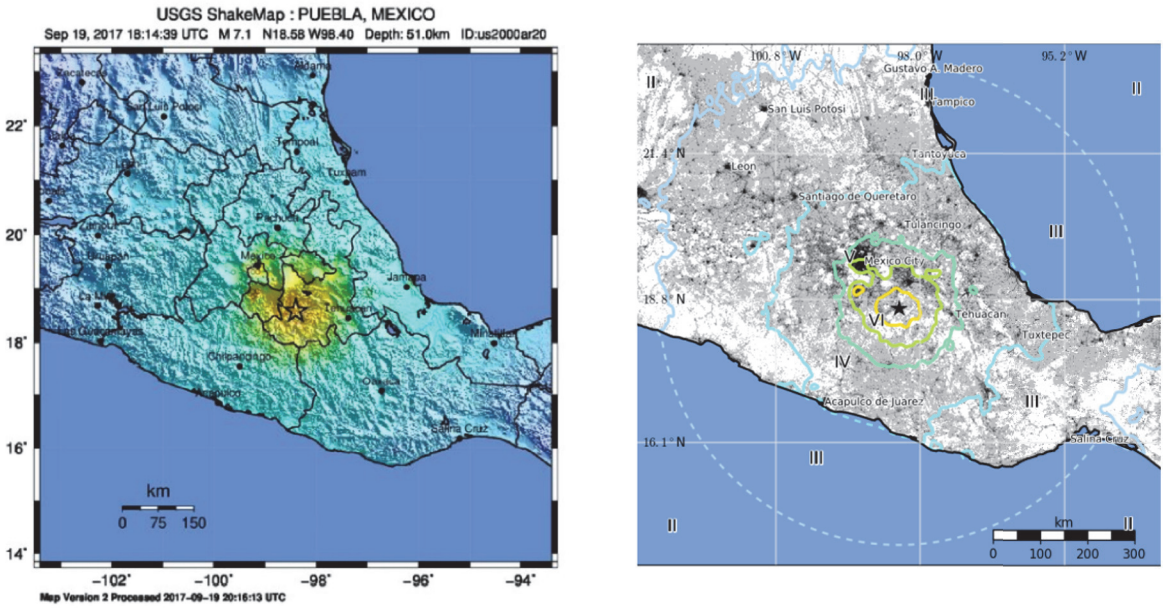


Figure 3.1.2 Left: Epicenters of the M_w7.1 Puebla-Morelos event and its aftershocks. Right: Focal mechanism with tension (T) and pressure (P) reflecting the minimum and maximum compressive stresses (USGS, 2017; IRIS, 2017a).



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Figure 3.1.3 USGS PAGER map (left) and table correlating population exposed to shaking with corresponding MMI intensity levels (right) from IRIS (2017a,b).

Table 3.1.1 Seismological Parameters for the Main 9/19/17 Event by SSN, USGS, and CMT

			Location			
Catalog (Agency)	*Date (mm/dd/yyyy)*	*Univ. Time*	*LAT*	*LON*	*Depth (km)*	*Magnitude M_w*
SSN	9/19/2017	18:14:40	18.3353°	-98.6763°	38.5	7.1
USGS	9/19/2017	18:14:38	18.550°	-98.489°	48.0	7.1
CMT	9/19/2017	18:14:47	18.550°	-98.489°	52.7	7.1

The main event was followed by multiple aftershocks. A summary of aftershocks with magnitude over M_w3.0 for the seven days following the event is shown on Figure 3.1.4. The seismological parameters for major aftershocks (above M_w5) of the 9/19/19 event, as estimated by SSN (2017), are documented in Table 3.1.2 (SSN, 2017).

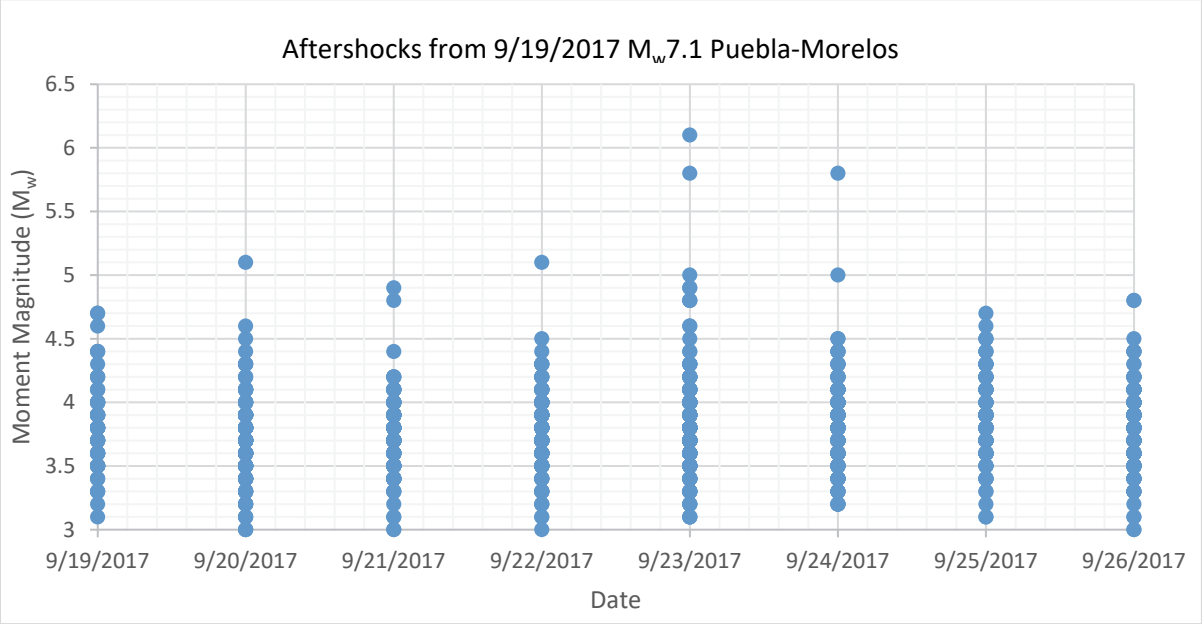


Figure 3.1.4 Recorded aftershocks during the 7 days following the 9/19/19 event (SSN, 2017).

Table 3.1.2 Seismological Parameters for Major Aftershocks (over M_w 5) Based on SSN (2017)

Date (mm/dd/yyyy)	UNIV. TIME	LOCATION		DEPTH (km)	MAGN M_w
		LAT	LON		
9/20/2017	10:39:26	18.3353°	-98.6763°	52.4	5.1
9/22/2017	5:33:45	23.5463°	-108.63°	14.4	5.1
9/23/2017	10:38:05	15.2525°	-94.586°	35	5.8
9/23/2017	12:53:04	16.496°	-95.146°	22	6.1
9/23/2017	14:31:47	16.4523°	-94.9925°	10.0	5
9/24/2017	10:06:08	15.0823°	-94.3375°	15.8	5.8
9/24/2017	23:29:31	15.5395°	-94.5627°	16.1	5

3.2 Strong Ground Motion Records

3.2.1 Instruments

This report presents data for 71 strong ground motion records of the main September 19, 2017 event within Mexico City. The CIRES center (Centro de Instrumentación y Registro Sísmico, A.C.; or Center for Instrumentation and Seismic Recording Civil Association), provided 64 of the ground motion records from their RACM accelerographic network (Red Accelerográfica de la Ciudad de México) at the stations shown in the left panel of Figure 3.2.1. An additional seven records at stations shown in the right panel of Figure 3.2.1 were provided by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico).

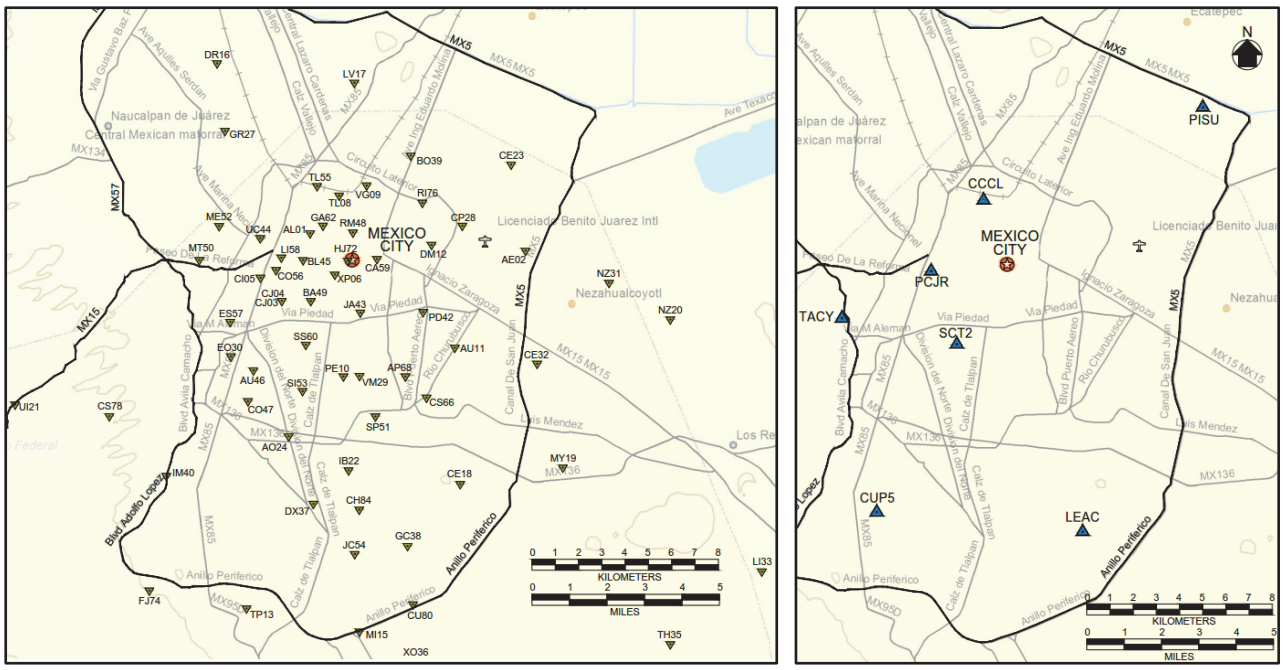


Figure 3.2.1 Spatial distribution of strong ground motion stations by CIRES (left) and IINGEN UNAM (right) in Mexico City.

3.2.2 IINGEN UNAM Network—Instituto de Ingeniería

The seven IINGEN UNAM stations record data using instruments mostly by Kinemetrics (Altus K2 system), as well as by Trimble (REFTEK 130-SMHR). The typical Kinemetrics instrument consists of an Altus K2 digital recorder and an EpiSensor triaxial force-balance accelerometer (FBA ES-T), with a dynamic range greater than 114 dB, timing accuracy to ±0.5 ms with its synchronized sampling with GPS system, and utilizes a 10 MB PCMICIA memory card. The REFTEK accelerometer has a 24-bit resolution ADC (analogue-to-digital converter) and a low-noise FBA, and utilizes GPS receiver for time base (±10 μsec accuracy). The Trimble REF TEK 130-SMHR, used only at one station (TACY) of the network, meets the USGS Advanced National Seismic System (ANSS) specifications for urban area strong motion stations. The Kinemetrics models Granito (at LEAC) and Basalto (at PCJR) are obsolete as of 2015 and will no longer be supported after 2020 (Kinemetrics, 2018). Figure 3.2.2 shows the two types of instruments, with details in Table 3.2.1, including recorded PGA (X, Y, Z components) and epicentral distance from the September 19, 2017 main event. The table provides the orientation of the horizontal components (X, Y).



Figure 3.2.2 Accelerometers used in the IINGEN-UNAM network: Kinemetrics—K2 (left; Hofstra Group, 2017) and RefTek 130-SMA (right; Trimble, 2017).

Table 3.2.1 List of the IINGEN UNAM Strong Motion Stations, with PGA Values for the Records of the Main Event

Station	Instrument Type	Geographic Coordinates		Elevation	Epicentral Distance	Bearing		PGA (g)		
		Latitude	Longitude	(m)	(km)	X	Y	X	Y	Z
CCCL	K2	19° 26' 59.49"	-99° 8' 16.51"	2231	N/A	N10E	N80W	0.087	0.075	0.042
CUP5	ALTUS-ETNA	19° 19' 48.86"	-99° 10' 51.87"	2240	209	ENN	ENE	0.056	0.060	0.035
LEAC	GRANITO	19° 19' 21.89"	-99° 5' 51.51"	2243	71	-	-	0.159	0.199	0.051
PCJR	BASALTO	19° 25' 22.11"	-99° 9' 32.8"	2240	392	N65E	N25W	0.101	0.096	0.055
PISU	K2	19° 29' 8.52"	-99° 2' 56.4"	2240	103	N75W	N15E	0.099	0.097	0.025
SCT2	K2	19° 23' 40.9"	-99° 8' 55.24"	2240	121	N90E	N00E	0.093	0.092	0.043
TACY	130-SMA	19° 24' 16.22"	-99° 11' 42.89"	2240	101	N00E	N90E	0.060	0.064	0.035

3.2.3 CIRES Network—Centro de Instrumentación y Registro Sísmico

The CIRES network records 3-component acceleration time series with a predominant sampling rate of 100 Hz (time step of 0.01 s), and sometimes of 200 Hz (time step of 0.005 s). The equipment, shown in Fig. 3.2.3, consists of a grounded metallic cabinet, a triaxial accelerograph with range of 0.5g (with NS-EW orientation), data acquisition card RAD (Digital Accelerometric Recorder) with 12-bit resolution. Data are stored in a PCMCIA (Personal Computer Memory Card International Association) with standard 1 Mb memory, battery, charger, and solar panel. Details are provided in Table 3.2.2, including PGA values from the main event, with X and Y referring to north-south and east-west bearings, respectively.

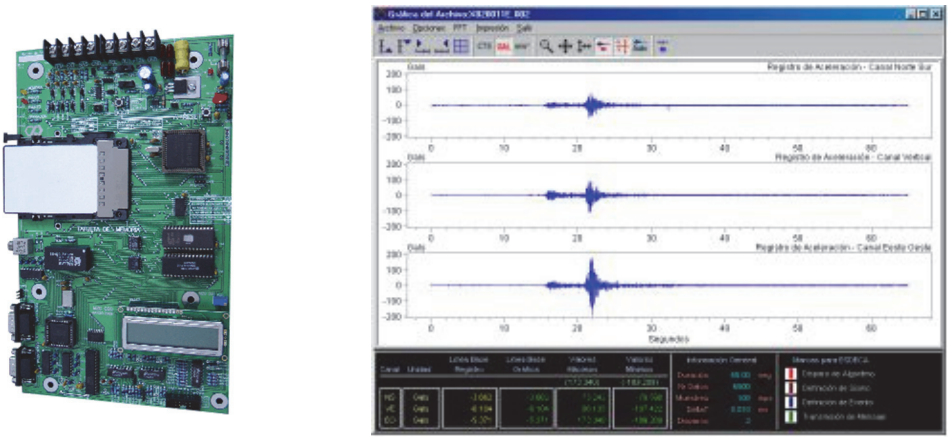


Figure 3.2.3 Strong ground motion instrumentation at the CIRES network: Digital Accelerometric Recorder RAD (left) and software output (right) (CIRES, 2017).

Table 3.2.2 List of the CIRES Stations with PGA Values for the Records of the Main Event

Station	Instrument Type	Geographic Coordinates		Elevation	Epicentral Distance	PGA (g)		
		Latitude	Longitude	(m)	(km)	X	Y	Z
AE02	RADESD	19° 25' 44.4"	-99° 3' 30.24"	2232	120	0.098	0.117	0.043
AL01	RAD_IO14	19° 26' 8.16"	-99° 8' 43.08"	2232	123	0.119	0.111	0.041
AO24	RADESD	19° 21' 28.8"	-99° 9' 14.04"	2235	116	0.108	0.122	0.049
AP68	RADESD	19° 22' 51.24"	-99° 6' 24.48"	2232	116	0.117	0.137	0.083
AU11	RADESD	19° 23' 30.84"	-99° 5' 12.84"	2234	117	0.074	0.092	0.036
AU46	RADESD	19° 22' 59.52"	-99° 10' 5.16"	2233	119	0.079	0.097	0.034
BA49	RADESD	19° 24' 34.92"	-99° 8' 42"	2233	121	0.091	0.115	0.031
BL45	RADESD	19° 25' 31.08"	-99° 8' 53.16"	2232	122	0.104	0.117	0.040
BO39	RAD_IO14	19° 27' 55.08"	-99° 6' 16.92"	2232	125	0.079	0.097	0.025
CA59	RADESD	19° 25' 32.88"	-99° 7' 5.88"	2233	121	0.085	0.092	0.036
CE18	RADESD	19° 20' 23.28"	-99° 5' 4.92"	2240	111	0.074	0.052	0.030
CE23	RADESD	19° 27' 42.84"	-99° 3' 51.12"	2233	123	0.053	0.061	0.027
CE32	RADESD	19° 23' 8.88"	-99° 3' 13.32"	2233	115	0.082	0.078	0.036
CH84	RADESD	19° 19' 48"	-99° 7' 31.44"	2234	112	0.152	0.230	0.085
CI05	RAD_IO14	19° 25' 6.96"	-99° 9' 55.08"	2233	122	0.116	0.116	0.052
CJ03	RAD_IO14	19° 24' 34.92"	-99° 9' 24.12"	2233	121	0.114	0.100	0.037
CJ04	RAD_IO14	19° 24' 35.28"	-99° 9' 23.76"	2233	121	0.126	0.099	0.035
CO47	RADESD	19° 22' 17.04"	-99° 10' 13.08"	2247	118	0.073	0.096	0.031
CO56	RADESD	19° 25' 17.4"	-99° 9' 32.4"	2233	122	0.112	0.116	0.055

Table 3.2.2 List of the CIRES Stations with PGA Values for the Records of the Main Event (continued)

Station	Instrument Type	Geographic Coordinates		Elevation	Epicentral Distance	PGA (g)		
		Latitude	Longitude	(m)	(km)	X	Y	Z
CP28	RADESD	19° 26' 18.6"	-99° 5' 2.04"	2240	121	0.092	0.136	0.083
CS66	-	19° 22' 22.08"	-99° 5' 53.88"	2247	115	0.136	0.109	0.060
CS78	RADESD	19° 21' 56.16"	-99° 13' 34.32"	2430	120	0.089	0.057	0.059
CU80	RADESD	19° 17' 37.68"	-99° 6' 13.32"	2232	107	0.147	0.172	0.043
DM12	RADESD	19° 25' 52.32"	-99° 5' 46.68"	2232	121	0.089	0.092	0.042
DR16	RADESD	19° 30' 1.8"	-99° 10' 58.44"	2233	131	0.072	0.079	0.026
DX37	RAD_IO14	19° 19' 55.92"	-99° 8' 38.04"	2240	113	0.191	0.126	0.053
EO30	RADESD	19° 23' 18.6"	-99° 10' 37.92"	2236	120	0.069	0.084	0.035
ES57	RADESD	19° 24' 6.12"	-99° 10' 39"	2242	121	0.072	0.086	0.029
FJ74	RADESD	19° 17' 56.4"	-99° 12' 36"	2240	112	0.094	0.093	0.051
GA62	RADESD	19° 26' 18.6"	-99° 8' 24.36"	2232	123	0.099	0.086	0.034
GC38	RADESD	19° 18' 57.96"	-99° 6' 21.24"	2233	109	0.128	0.127	0.044
GR27	RAD_IO14	19° 28' 28.92"	-99° 10' 46.92"	2238	129	0.086	0.122	0.046
HJ72	RADESD	19° 25' 30.36"	-99° 7' 48.36"	2232	122	0.092	0.098	0.041
IB22	RADESD	19° 20' 42"	-99° 7' 46.92"	2234	113	0.121	0.164	0.047
IM40	-	19° 20' 34.08"	-99° 12' 11.52"	2365	116	0.091	0.071	0.069
JA43	RADESD	19° 24' 19.08"	-99° 7' 30"	2234	119	0.084	0.108	0.049
JC54	RADESD	19° 18' 46.8"	-99° 7' 37.92"	2237	110	0.225	0.208	0.061
LI33	RAD_IO14	19° 18' 23.04"	-98° 57' 47.16"	2238	104	0.141	0.116	0.067
LI58	RADESD	19° 25' 34.68"	-99° 9' 24.84"	2233	123	0.098	0.092	0.052
LV17	RAD_IO14	19° 29' 35.16"	-99° 7' 39"	2233	129	0.125	0.106	0.026
ME52	RADESD	19° 26' 17.88"	-99° 10' 55.2"	2238	125	0.064	0.074	0.032
MI15	RADESD	19° 17' 0.24"	-99° 7' 31.08"	2237	107	0.211	0.136	0.056
MT50	RADESD	19° 25' 31.08"	-99° 11' 24"	2234	124	0.048	0.059	0.030
MY19	RADESD	19° 20' 45.96"	-99° 2' 35.88"	2237	110	0.122	0.114	0.087
NZ20	RADESD	19° 24' 9.72"	-99° 0' 0"	2232	115	0.149	0.145	0.074
NZ31	RAD_IO14	19° 25' 0.12"	-99° 1' 28.92"	2234	117	0.112	0.100	0.034
PA34	RADESD	19° 12' 5.76"	-99° 2' 56.76"	2240	95	0.085	0.087	0.061
PD42	RADESD	19° 24' 19.8"	-99° 5' 58.92"	2234	119	0.085	0.098	0.043
PE10	RADESD	19° 22' 51.24"	-99° 7' 54.48"	2232	117	0.103	0.127	0.032
RI76	RADESD	19° 26' 50.28"	-99° 6' 0"	2232	123	0.053	0.074	0.025
RM48	RADESD	19° 26' 9.24"	-99° 7' 40.8"	2232	123	0.062	0.080	0.039
SI53	RADESD	19° 22' 31.08"	-99° 8' 53.88"	2235	117	0.132	0.181	0.058
SP51	RADESD	19° 21' 56.16"	-99° 7' 8.04"	2234	115	0.079	0.102	0.039
SS60	-	19° 23' 34.8"	-99° 8' 49.2"	2254	119	0.099	0.108	0.042
TH35	RAD_IO14	19° 16' 42.96"	-99° 0' 0"	2238	102	0.194	0.190	0.060
TL08	RADESD	19° 27' 0"	-99° 8' 0.96"	2232	124	0.084	0.083	0.031
TL55	RADESD	19° 27' 12.96"	-99° 8' 33"	2232	125	0.084	0.071	0.034
TP13	RAD_IO14	19° 17' 31.92"	-99° 10' 14.88"	2265	110	0.062	0.068	0.053
UC44	RADESD	19° 26' 1.32"	-99° 9' 55.44"	2234	124	0.128	0.127	0.043
UI21	RAD_IO14	19° 22' 12"	-99° 15' 51.12"	2540	122	0.076	0.081	0.036
VG09	RAD_IO14	19° 27' 14.04"	-99° 7' 21"	2233	124	0.122	0.104	0.037
VM29	RAD_IO14	19° 22' 51.96"	-99° 7' 31.08"	2234	117	0.087	0.097	0.037
XO36	RADESD	19° 16' 15.96"	-99° 6' 8.64"	2232	105	0.127	0.177	0.052
XP06	RADESD	19° 25' 11.28"	-99° 8' 7.08"	2232	121	0.083	0.110	0.032

3.2.4 Strong Motion Records

All the strong motion recordings provided (seven from IINGEN and 64 from CIRES), yielding a total of 71) were processed following the PEER procedure (Ancheta et al., 2013; Kishida et al, 2016) and are provided with this report. The vertical component is not part of this report, based on the specific purpose of the ATC reconnaissance mission, so only the horizontal components are shown. For signal processing, SAC2008 was used (Goldstein et al., 2003; Goldstein and Snoke, 2005).

The following briefly outlines the procedure: Accelerometric recordings were first subjected to standard corrections (demeaning and detrending). From the corrected time series, pre-event noise windows and strong-motion windows were extracted on a record-to-record basis. For engineering purposes, the entire signal was considered (P waves, S waves and strongest surface and coda waves), rather than only S waves. Time windows were tapered and Fourier transformed, and only amplitudes were kept. The Nyquist frequency based on the predominant sampling rate of 100 Hz is 50 Hz. Considering a minimum signal-to-noise ratio of 3, record-specific corner frequency values were assigned for low-pass and high-pass filtering through visual inspection of the two horizontal components. Filter corner choice was then fine-tuned with the aim of producing acceptable displacement time histories. A 4-pole Butterworth filter was applied (2 passes) to acceleration time histories, and from these, velocity and displacement time series were computed through integration of the tapered waveforms.

Appendix A presents the processed ground motions exhibits for each station. Each exhibit includes a map indicating the station location; filtered time histories of horizontal acceleration, velocity, and displacement; acceleration response spectra for 5% damping, and a summary table with key information of peak ground acceleration, velocity, and displacement (PGA, PGV, PGD), Arias intensity, and station shear wave velocity average at the top 30 m, Vs_{30}, where available.

Chapter 4
Instrumentation

4.1 Instrumentation Program Overview

The instrumentation program comprised pairs of accelerometers installed in two opposite corners of selected floors of buildings to measure the horizontal acceleration in the two perpendicular axes and capture the translational and torsional modes of vibration. The selected instrumentation locations allow the identification of the modal frequencies of buildings and the modal shapes along the height of buildings. The obtained modal properties can be used to validate numerical structural models, as well as simplified empirical equations used in practice to estimate the period of actual buildings. For this purpose, the ATC team instrumented five buildings between October 11th and 14th, 2017, and two additional buildings were instrumented during a second trip of Dr. A. Stavridis funded by the National Science Foundation (NSF Award #1810899) in January 2018. Modal information is presented for each building in Section 4.5.

The instrumented buildings had different structural systems, including reinforced concrete (RC) frames and shear walls, as well as steel columns designed for gravity loads. All seven buildings included masonry infills at varying densities and configurations in their floorplans. The structural damage varied from non-visible for three buildings to severe, with two of the buildings declared unsafe to occupy per the assessment by local engineers. Four of the buildings were constructed in the 1970s and were retrofitted after the 1985 earthquake (by adding RC shear walls or steel rings around columns); while the other three were constructed after 2000. Detailed information for the seven buildings is provided in Table 4.1.1.

For six of the buildings, multiple stories of each building were instrumented. In Campos Eliseos 200 the team only had access to one floor. A summary of the observed damage and the locations of the sensors are provided in Table 4.1.2. More details for each building are provided in the following sections of this chapter, together with information on the instruments and methods used.

Table 4.1.1 Structural Details of ATC-Instrumented Buildings

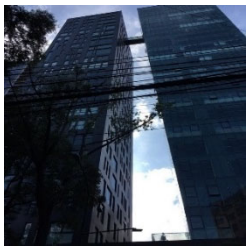
Location	*Coordinates*					*Irregularities**	
Address	*Lat.*	*Long.*	*# of Stories*	*Construction Era*	*Structural System and Infills*	*Hor.*	*Vert.*
Av. Mexico 19	19.4142	-99.169	14	1970s	Shear walls in one direction, infilled RC frames in the other.	-	-
Cozumel 52	19.4184	-99.171	9	1970s	Initially an infilled RC frame and waffle slabs, RC shear walls were added 1980s.	2	-
Parque Espana 47	19.4151	-99.172	7	2000s	Eccentric RC shear walls, gravity steel columns, waffle slabs. Few confined infills.	1*	3
Amsterdam 130	19.4117	-99.171	5	2000s	Eccentric RC shear walls, steel frames, steel deck slabs. Limited infills.	1*	-
Campo Eliseos 200	19.4279	-99.193	24	2010s	RC frames, ribbed slabs, occupied floors probably include infills.	2	-
Martin Mendalde 1755	19.3627	-99.172	9	1975	RC frames and shear walls. Significant number of infills.	5	-
Escuela Primaria Erasto Valle	19.3806	-99.210	4	1970s	RC frames with masonry infill walls. A staircase and some infills were removed due to ongoing repairs.	1a	-

*Assessment based on ASCE/SEI 7-10 Tables 12.3-1 and 2 (ASCE, 2010).

Table 4.1.2 Instrumented Buildings: Damage Observations

Building	*Observed Damage*	*Vacancy Status*	*Instrumented Floors*	*Photo*
Av. Mexico 19	Extensive diagonal cracks in the RC walls. A number of infills were damaged.	Evacuated	-1/0/4/8/13	
Cozumel 52	Severe cracks in the beam/slab system.	Evacuated	Stories: 0/3/7/roof	
Parque España 47	Damage in the confined infills along the height of the building.	Partially occupied	0/2/4/6/roof	

Table 4.1.2 Instrumented Buildings: Damage Observations (continued)

Building	*Observed Damage*	*Vacancy Status*	*Instrumented Floors*	*Photo*
Amsterdam 130	Minor aesthetic cracks in limited number of infills.	Fully functional	0/1/2/4/Roof	
Campo Eliseos 200	Undamaged	Fully functional (some floors not finished)	0/22	
Martin Mendalde 1755	Undamaged	Fully functional	-1/2/5/9	
Escuela Primaria Erasto Valle	Evacuated due to damage in a staircase, infills, and RC joints. Infills removed prior to visit	Evacuated and under repair	0/1/2/3/R	

4.2 Equipment

The buildings were instrumented with an array of 19 uniaxial accelerometers. The sensors were mounted on perpendicular sides of rectangular brackets, so that the horizontal accelerations on two perpendicular directions could be measured. The accelerometers were connected through cables to a data acquisition module, which was equipped with signal conditioning cards and operated through a laptop. The specifications of the deployed equipment are provided in this section.

The 19 uniaxial accelerometers have a measuring range of ±5g, sensitivity of 1000 mV/g, and resolution of 0.000003g (PCB Piezometrics, 2016). A typical accelerometer is shown in Figure 4.2.1a. The ATC team had 15 PCB 393B04 accelerometers for indoor use and four water-resistant PCB W394B04 accelerometers to use at the roof level. Low-noise cables of lengths up to 10

ft connected the accelerometers to the data acquisition system, with a male 10-32 connection on one end to connect to the accelerometers and a BNC male connection on the other end. The latter was connected to long BNC cables with lengths between 20 and 300 ft, used to span the distance between the accelerometers and the data acquisition chassis (DAQ).



(a) Accelerometer PCB 393B04



(b) Signal Conditioning Module NI 9234



(c) Data Acquisition Chassis cDAQ-9178

Figure 4.2.1 Equipment used for the instrumentation of the selected buildings.

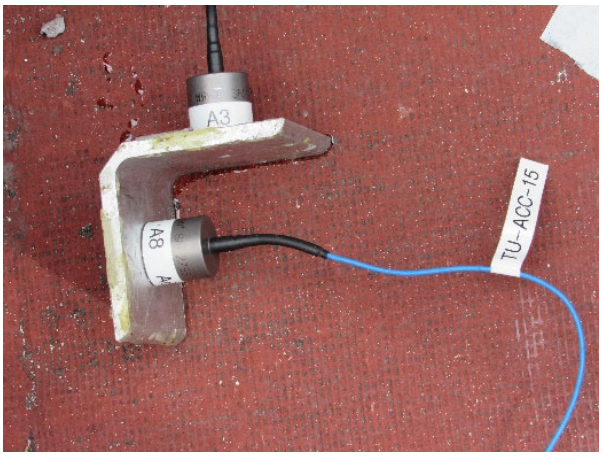
Ambient vibrations were recorded using a Data Acquisition Chassis cDAQ-9178 with eight slots that can record at a frequency of 51,200 samples/sec (National Instruments, 2017). This frequency is significantly higher than the needs of this mission, so a recording frequency of 2 kHz was selected to reduce the size of the data files. The DAQ was operated from a laptop and powered by a portable battery where power outlets were absent. For the signal conditioning, six NI 9234 acquisition modules were used. A signal conditioning card and the DAQ chassis are shown on Figures 4.2.1b and c.

4.3 Field Procedure

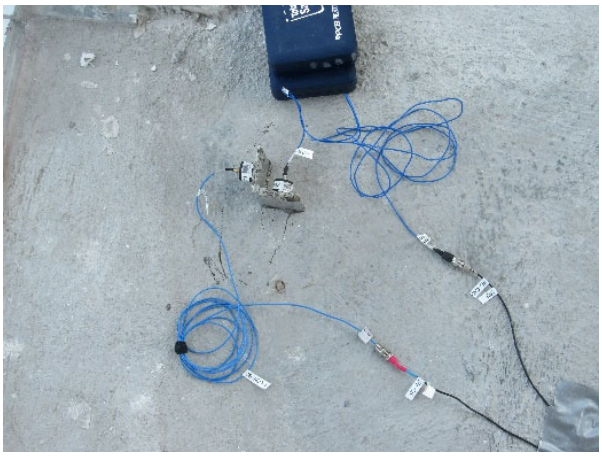
Each instrumented building was first inspected to collect information on the structural system and member layout, damage, and accessibility, as drawings were not generally available prior to the visits. Following inspection, the team selected locations for the DAQ and sensors so the most possible complete modal shapes could be obtained, considering possible disturbance to building occupants and construction crews, when present.

The accelerometers were mounted on the selected locations using aluminum brackets attached on the slabs using epoxy, as shown on Figure 4.3.1. While one member of the team was setting up the brackets and mounting the sensors, the other team members were running the BNC cables between the sensors and the DAQ. When all sensors were connected to the DAQ (Figure 4.3.1c), the DAQ was turned into recording mode and files of 3-min acceleration time histories were retrieved. The recordings lasted on average one hour per building, with a setup of 3-5 hours, depending on size, layout,

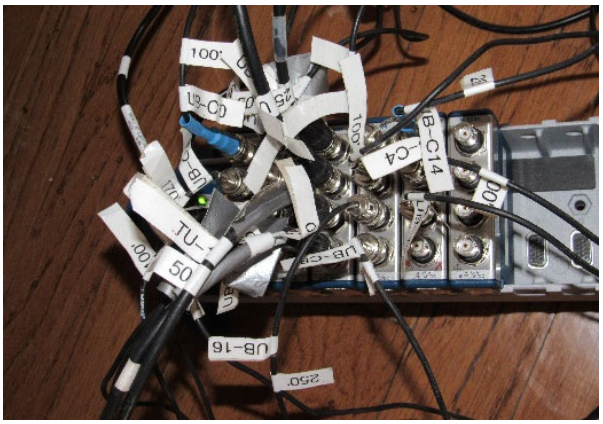
and complexity of the building, number of available team members and their familiarity with the process. The setup was documented in the field on printed metadata sheets that were typed later (Figure 4.3.2).



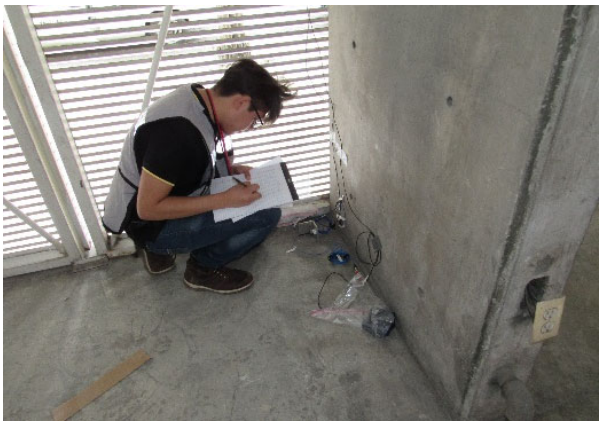
(a) Installed accelerometers



(b) 10-32 cables linking accelerometers to BNC

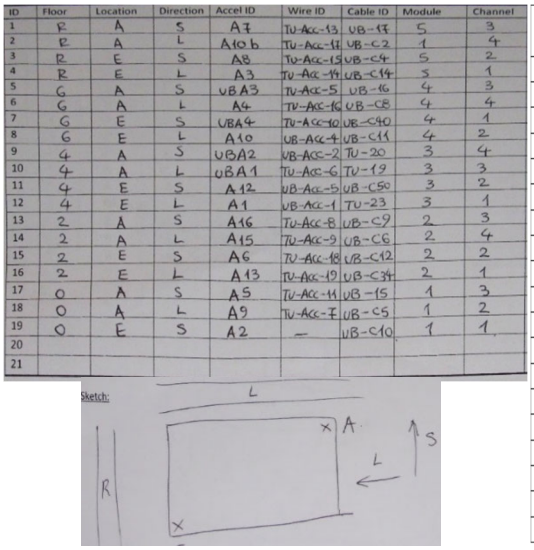


(c) Cables connected to signal conditioning cards



(d) Documentation of instrumentation setup

Figure 4.3.1 Examples of the installed instruments.



(a) In-situ notes

No.	Floor	Location	Direction	ID			Module	Channel	File Col
				Accel	Wire	Cable			
1	R	A	S	A7	TU-ACC-13	UB-17	5	3	19
2	R	A	L	A10b	TU-ACC-17	UB-C2	1	4	4
3	R	E	S	A8	TU-ACC-15	UB-C4	5	2	18
4	R	E	L	A3	TU-ACC-14	UB-C14	5	1	17
5	6	A	S	UBA3	TU-ACC-5	UB-16	4	3	15
6	6	A	L	A4	TU-ACC-16	UB-C8	4	4	16
7	6	E	S	UBA4	TU-ACC-10	UB-C40	4	1	13
8	6	E	L	A10	UB-ACC-4	UB-C11	4	2	14
9	4	A	S	UBA2	UB-ACC-2	TU-20	3	4	12
10	4	A	L	UBA1	TU-ACC-6	TU-19	3	3	11
11	4	E	S	A12	UB-ACC-5	UB-C50	3	2	10
12	4	E	L	A1	UB-ACC-1	TU-23	3	1	9
13	2	A	S	A16	TU-ACC-8	UB-C9	2	3	7
14	2	A	L	A15	TU-ACC-9	UB-C6	2	4	8
15	2	E	S	A6	TU-ACC-18	UB-C12	2	2	6
16	2	E	L	A13	TU-ACC-19	UB-C34	2	1	5
17	0	A	S	A5	TU-ACC-11	UB-15	1	3	3
18	0	A	L	A9	TU-ACC-7	UB-C5	1	2	2
19	0	E	S	A2	NO LABEL	UB-C10	1	1	1

(b) Typed metadata notes

Figure 4.3.2 Example of the in-situ and typed documentation.

4.4 Data Processing

The obtained ambient vibrations records were down-sampled, detrended, and filtered to obtain cleaner signals. The Fast Fourier Transforms (FFT) and the Power Spectral Densities (PSD) of the processed signals were derived and then used to obtain the transfer functions and identify the building natural frequencies, while the Cross-Power Spectra (CPS) were estimated to define the mode shapes. The identified mode shapes are not presented here for conciseness, but they are considered to characterize the identified modes as translational or torsional. Details on the methods employed here from a similar study on a school building in Nepal can be found in Bose et al. (2016).

4.5 Collected Data

4.5.1 Parque España 47

Parque España 47 is an 8-story apartment building constructed in the 2000s, shown in Figure 4.5.1. The building is located at La Condesa area, over the transition soil zone between firm ground and lake clay, with the regional clay layer estimated to be approximately 25-m thick based on geologic data. The ATC team was informed that the building is supported on pile foundation connected to a rigid slab at the top. The structural system combines concrete shear walls, RC slabs, steel beams and columns, and masonry infills. The amount of the shear walls decreases from the ground to the 1st floor, and from the 1st to the 2nd floor. Beyond the 2nd story the shear wall layout is maintained in all stories above. The stairs are on the exterior of the building, supported by steel beams cantilevering out from the slabs.



(a) Corner view (b) Middle block view

Figure 4.5.1 Eight-story residential building at Parque España 47 (Coordinates 19.4151, -99.172).

Moderate damage was observed in a few joints between steel columns and the RC slab at floors 2 to 4, as shown in Figure 4.5.2. The figure also illustrates severe damage in infill panels. The damage can be attributed to the layout of the concrete shear walls and the masonry panels that were placed eccentrically to provide an open layout and unobstructed views. The asymmetric placement of the walls resulted in a flexible structure with significant torsional behavior. Some of the masonry walls were demolished before the ATC visit, and crews were replacing them during the day of the ambient vibration recordings.

Accelerometers were installed on the ground, 2nd, 4th, and 6th floors, and the roof as shown in Figure 4.5.3. A total of 19 accelerometers were installed: 3 on the ground, and 4 at the other stories. In the instrumented floors, 2 accelerometers were placed at 2 opposite corners to record translational and torsional movement. A single accelerometer was placed at one corner of the ground floor. The ambient vibration of this building was recorded for 84 minutes. The recordings were continuous but have been archived in files containing 3-min records to facilitate the post-processing of the data.

Processing of the data allowed the identification of five modes of this building. All mode shapes include a kink between the 1st and 2nd floors due to the discontinuity of few shear walls. The system identification results, summarized in Table 4.5.1, indicate that the 1st and 4th vibration modes are a mix of the 1st and 2nd translational modes along the short (S) direction and a torsional mode, with the largest deformation along the S direction at location

E (Figure 4.5.4). The 2nd and 5th modes are mostly translational along the long (L) direction, and correspond to the 1st and 2nd classic modes along this direction. Finally, the identified 3rd mode is purely torsional.



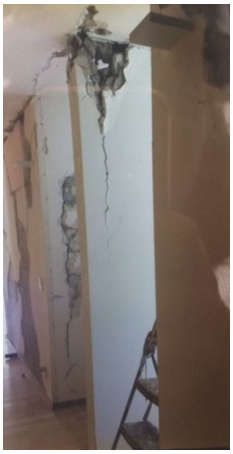
(a) Slab-column joint damage



(b) Typical damage in an infill wall



(c) Demolished infills



(d) Demolished infills

Figure 4.5.2 Damage patterns at Parque España 47.

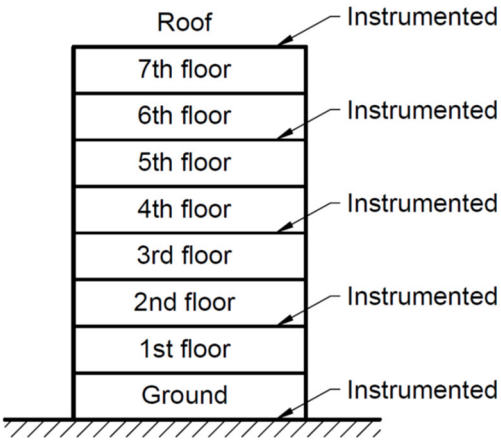


Figure 4.5.3 Instrumented floors at Parque España 47.

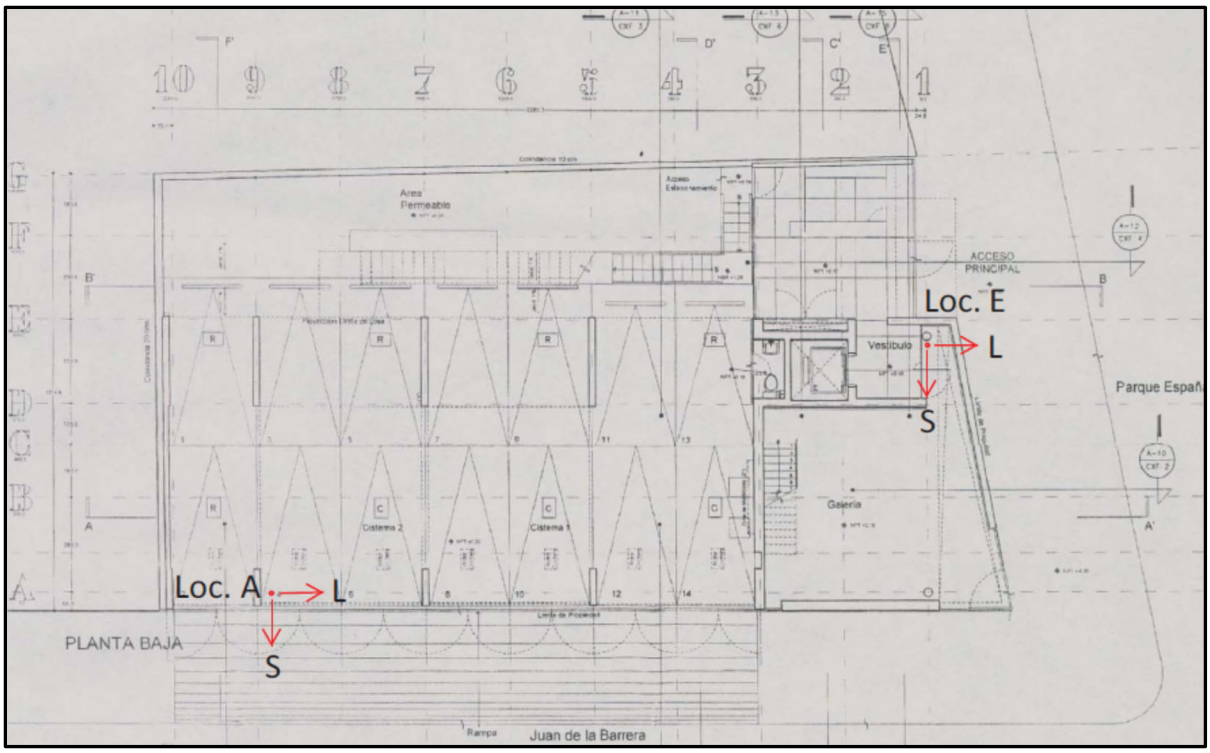


Figure 4.5.4 Locations of accelerometers at Parque España 47.

Table 4.5.1 Identified Modes of Building at Parque España 47

Mode #	*Frequency (Hz)*	*Mode Description*
1	0.8	Torsional / 1st classical translational mode along S
2	1.2	1st classical translational mode along L
3	1.5	Torsional
4	3.1	Torsional / 2nd classical translational mode along S
5	4.4	2nd classical translational mode along L

4.5.2 Amsterdam 130

Amsterdam 130 is a 6-story apartment building shown in Figure 4.5.5, built in the 2000s. The building is within the La Condesa area. Both this building and Parque España 47 are corner buildings designed by the same architect around the same era with similar lateral resisting systems. The structural system of Amsterdam 130 consists of RC shear walls eccentrically placed to create an open living area, and steel frame supporting the slabs, as shown in Figure 4.5.6. The ATC team did not identify visible damage in the structural RC and steel members, but only some minor damage between the infill panels and the slabs above.

Ambient vibration recordings were obtained with accelerometers installed on the ground, 1st, 2nd, 4th floors and roof as illustrated on Figure 4.5.6. The 19 accelerometers were laid out similarly to Parque España 47: three on the ground and four in other instrumented stories. The ambient vibration was recorded continuously for 129 minutes. The system identification results, summarized in Table 4.5.2, indicate that the 1st mode contains translation along both horizontal directions, as per the 1st classic translational mode. The 2nd and 3rd modes appear to be torsional with different centers of rigidity.



Figure 4.5.5 Six-story residential building at Amsterdam 130 (Coordinates: 19.4117, -99.171).

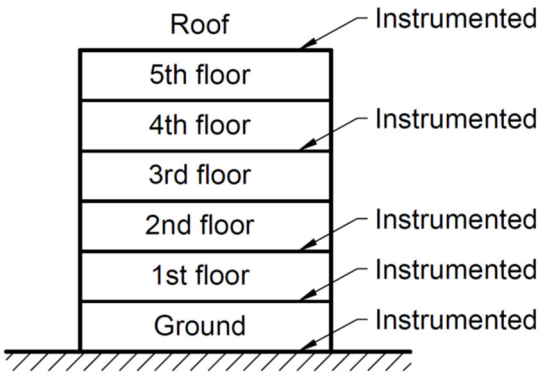


Figure 4.5.6 Instrumented floors in Amsterdam 130.

Table 4.5.2 Identified Modes of Building at Amsterdam 130

Mode #	*Frequency (Hz)*	*Mode Description*
1	1.59	1st classic translational mode along both S and L directions
2	1.85	Torsional
3	3.1	Torsional

4.5.3 Avenida Mexico 19

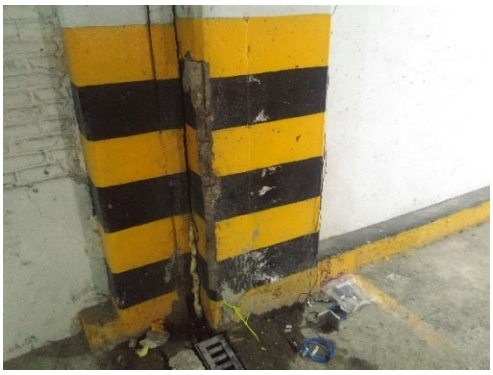
Avenida Mexico 19 is the 14-story apartment building shown in Figure 4.5.7. The building was constructed in the 1970s within the La Condesa soil transition zone area. The two sides perpendicular to the façade are covered by shear walls connected with frame members in the perpendicular direction. The same shear wall layout is maintained in all floors, although the top two floors housing the penthouse have slightly smaller floorplans. An elevator shaft and staircases are in the middle of the building. Per its residents, the structure experienced minor cracks in the 1985 earthquake and was lightly retrofitted with short steel rings along two of the columns in the first two stories. At the time of the visit, most owners had vacated and were skeptical about the building, considering repair and strengthening options.



Figure 4.5.7 14-story Residential building in Avenida Mexico 19 (Coordinates: 19.4142, -99.169).

Information provided by residents indicates that the shaking was felt significantly more in the direction of the shear walls. The ATC team identified many diagonal cracks in the shear walls as shown in Figure 4.5.8c. Several infill walls, as high as at the 6th story, were damaged as illustrated in Figure 4.5.8d. In the basement level, damage was observed in some

columns. At the front entrance, cracks on the ground indicated uplifting and possible rotation of the building that was visually identified but not quantified. At the second, NSF-funded visit of Dr. Stavridis, the tilt was quantified using a Lidar scanner to be 0.4% at the roof. However, it was not clear to the team whether the tilt and the cracks on the shear walls were developed during or prior to the 2017 earthquake.



(a) Corrosion of exposed rebar



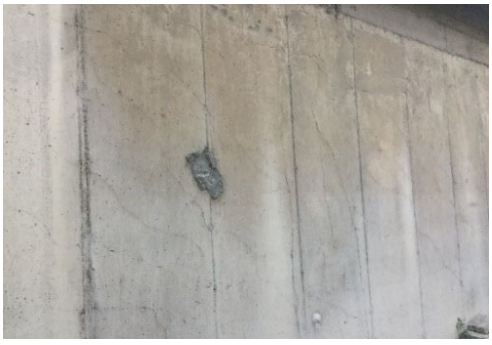
(b) Concrete crushing



(c) Diagonal shear wall cracks



(d) Damaged infill



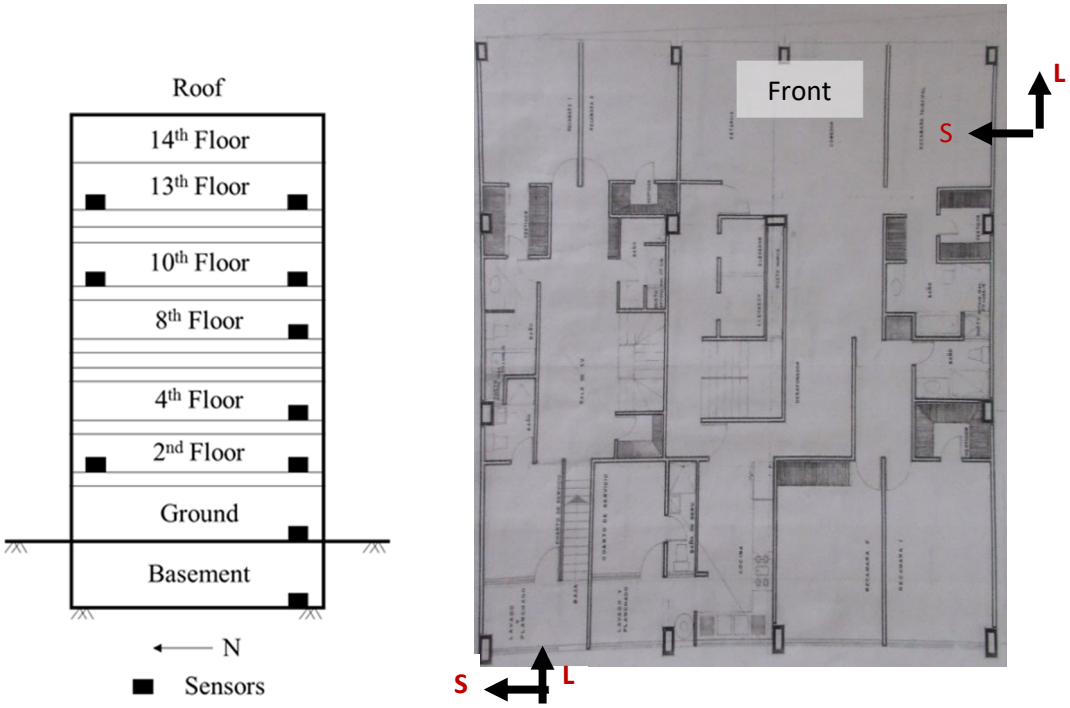
(e) Preexisting and new cracks in walls



(f) Sidewalk damage indicating rotation

Figure 4.5.8 Observed damage in Avenida Mexico 19.

During the ATC team's visit, ambient vibration recordings were obtained at the basement, ground, 4th, 8th, and 13th floors. However, these recordings had high noise-to-signal ratio and did not allow the identification of the vibration modes. Hence, in the second NSF-funded visit of Dr. Stavridis in January 2018, the building was instrumented again. In the second visit sensors were installed in the basement, ground, 2nd, 4th, 8th, 10th and 14th floors. In all stories, two accelerometers were installed at the front corner shown in Figure 4.5.9, while in the 2nd, 10th, and 13th stories, two additional accelerometers were placed at opposite corners.



(a) Instrumented floors (b) Instrumentation locations

Figure 4.5.9 Instrumented floors and floor plan of Avenida Mexico 19.

Ambient vibrations were recorded continuously for 63 minutes. The system identification results of Table 4.5.3 indicate that the first two modes correspond to the 1st translational classic mode along the parallel and perpendicular to the façade directions, respectively. However, both modes include slight torsional components. The 3rd mode appears to be purely torsional, while the 4th mode is the second classic mode parallel to the façade. The shape of the 5th mode cannot be clearly identified, while the 6th mode appears to be torsional.

Table 4.5.3	Identified Modes of Building at Avenida Mexico 19	
Mode #	*Frequency (Hz)*	*Mode Description*
1	0.46	1st classic translational, parallel to the façade, with slight torsion in the other direction
2	0.76	1st classic translational, perpendicular to the façade with slight torsion in the other direction
3	1.04	Torsional
4	1.60	2nd classic translational, parallel to the façade with slight torsion in the other direction
5	3.00	The shape not clear
6	4.10	Torsional

4.5.4 Campo Eliseos 200

The 24-story apartment building at Campos Eliseos 200 is one of the two buildings of Figure 4.5.10, built in the 2010s in the transition zone from firm ground to the lake deposits. This structure was not thoroughly inspected by the ATC team because access was granted only to the 22nd floor that was not finished at the time of inspection (Figure 4.5.10). Other floors were finished and already occupied at that time. The structural system at the 22nd floor consisted of RC frames and it can be assumed that the same system extends throughout the building. Maintenance personnel informed the ATC team that no damage was observed in the building.

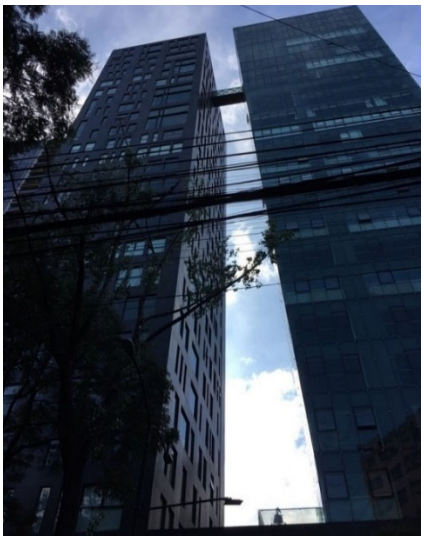


Figure 4.5.10 24-story residential buildings at Campos Eliseos 200 (Coordinates: 19.4279, -99.193).

Ambient vibration recordings were obtained with accelerometers installed in the ground and the 22nd floor. A total of 8 accelerometers were installed, two on the ground and six at the 22nd floor. The ambient vibration was recorded continuously for 54 min with identified modal frequencies shown on Table

4.5.4. However, the mode shape along the height cannot be identified as only one story was instrumented due to the limited access provided.



(a) Floor system and frames (b) Open space

Figure 4.5.11 22nd floor of Campos Eliseos.

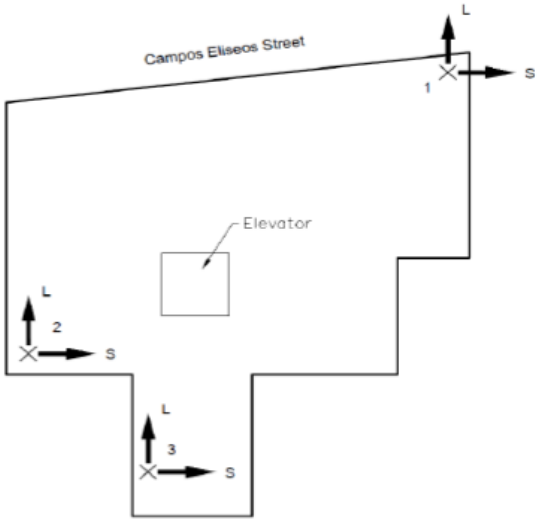


Figure 4.5.12 Floor plan and instrumentation locations at Campos Eliseos 200.

Table 4.5.4 Identified Modes of Building at Campos Eliseos 200

Mode #	*Frequency (Hz)*	*Mode Description**
1	0.38	Translational parallel to the street
2	0.52	Translational perpendicular to the street
3	0.63	Torsional
4	1.28	Translational parallel to the street
5	1.51	Torsional
6	1.78	Translational perpendicular to the street
7	2.00	Torsional
8	2.28	Translational parallel to the street
9	3.70	Torsional

* Due to lack of sensors along the height, it is not possible to obtain reasonable mode shapes.

4.5.5 Cozumel 52

Cozumel 52 is the 10-story apartment building shown in Figure 4.5.13. The building was constructed in the 1970s with an L-shaped plan view and is in the transition soil zone. The initial structural system consisted of RC frames with beams embedded in waffle slabs.



Figure 4.5.13 Cozumel 52: 10-story residential building (Coordinates: 19.4184, -99.171).

Following the 1985 earthquake, the structure was repaired and retrofitted. The retrofit involved the addition of four shear walls along its height and the increase of the cross section of the columns at the façade. Following the 2017 Puebla-Morelos earthquake, the building was evacuated due to extensive damage in the slabs and beams at the first two floors. Several infill walls were severely damaged in the first five stories and large pieces of plaster were detached from the ceilings and walls throughout the building. Typical damage is shown in Figure 4.5.14.

Ambient vibration recordings were obtained with a total of 16 accelerometers installed on the ground, 3rd and 7th floors, and the roof as shown on Figure 4.5.15. Four accelerometers were placed at each instrumented story, two at opposite corners. A typical floor plan with locations and directions of the sensors are shown in Figure 4.5.16. Ambient vibration was recorded continuously for 90 min. The identified modes in Table 4.5.5 include a strong torsional component, likely due to the damage. The 3rd and 5th identified modes appear to be only torsional, while modes 1 and 2 include a classic first mode along the long (L) and short (S) directions, respectively.

Similarly, the 4th identified mode includes a classic second mode along the S direction. A mode around 2.08 Hz appeared in some channels between modes 3 and 4, however, it could not be clearly identified in all channels.



(a) Damaged RC beams and masonry infills



(b) Plaster detached from a masonry infill



(c) Plaster detached from an RC wall



(d) Plaster detached from the ceiling

Figure 4.5.14 Cozumel 52: Typical building damage.

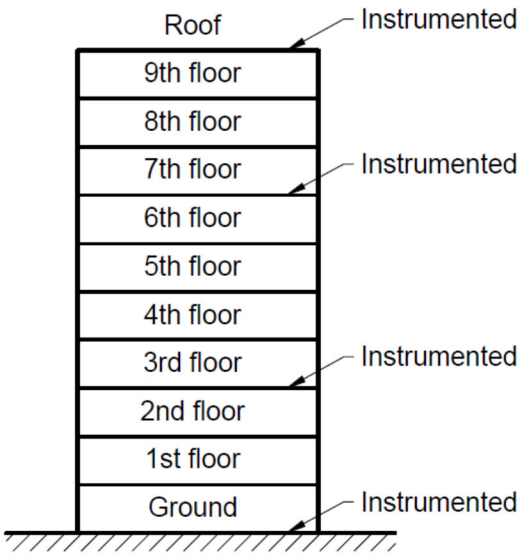


Figure 4.5.15 Instrumented floors in Cozumel 52.

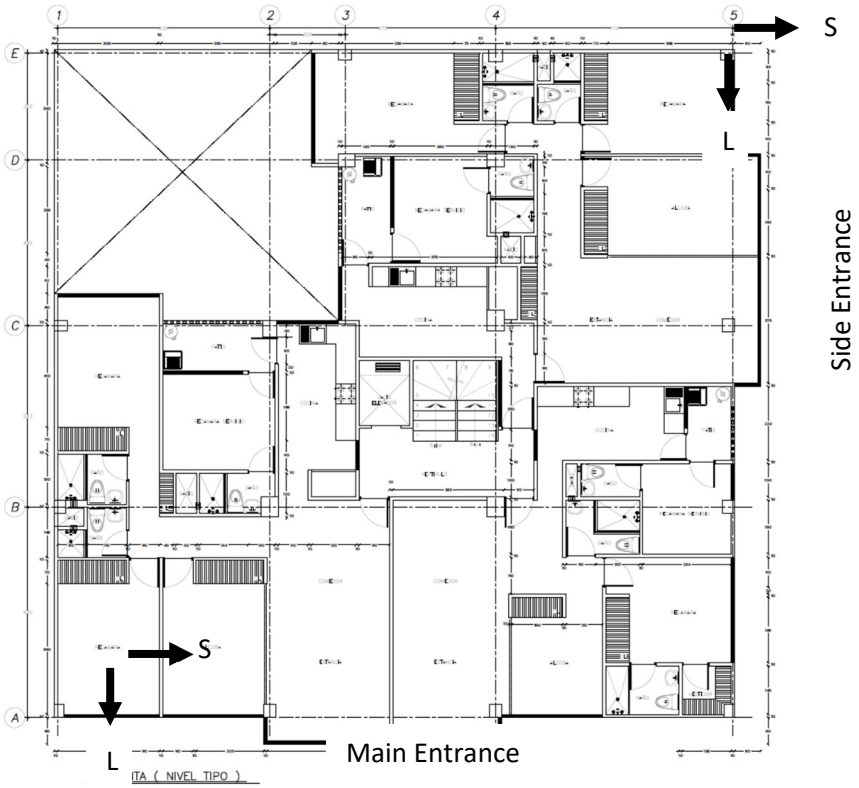


Figure 4.5.16 Floor plan view and locations and direction of installed accelerometers in Cozumel 52.

Table 4.5.5 Identified Modes of Building at Cozumel 52

Mode #	*Frequency (Hz)*	*Mode Description*
1	0.73	Torsional / 1st classic translational mode along L direction
2	0.82	Torsional / 1st classic translational mode along S direction
3	1.13	Torsional
4	2.75	Torsional / 2nd classic translational mode along S direction
5	2.95	Torsional

4.5.6 Escuela Primaria Erasto Valle

The four-story school building shown in Figure 4.5.17 was posted UNSAFE by the local engineers due to excessive damage in a staircase and infill that were demolished by the time of the NSF-funded visit in January 2018. The structure consists of RC frames combined with few concrete shear walls along the long direction of the structure. The remaining metal staircase is not a part of the structure and therefore it is not expected to affect the structure's dynamic characteristics. Due to the ongoing demolition, most of the damage could not be observed except for some spalling noted on concrete members as seen in Figure 4.5.18.

Ambient vibration recordings were obtained with accelerometers installed in all floors: the ground, 1st, 2nd, and 3rd floors, and roof (Fig. 4.5.19). A total of 18 accelerometers were installed with 4 at each story in the opposite corners (NW and SE) except for the roof, where only 2 sensors were placed at the SE corner due to safety concerns. The ambient vibration was recorded continuously for 75 min. The system identification results of Table 4.5.6, show three modes: translational along the short (NS) and long (EW) directions, and a torsional one.



Figure 4.5.17 Four-story school Escuela Primaria Erasto Valle (Coordinates: 19.3806, -99.210).



Figure 4.5.18 Damaged elements in Escuela Primaria Eraso Valle.

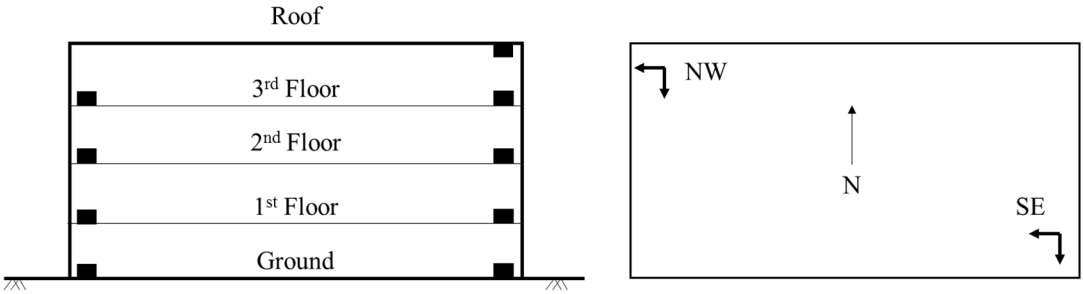


Figure 4.5.19 Layout of instrumentation in Escuela Primaria.

Table 4.5.6 Identified Modes of School Building at Escuela Primaria Erasto Valle

Mode #	*Frequency (Hz)*	*Mode Description*
1	2.92	Translational along the NS direction
2	4.67	Translational along the EW direction
3	5.80	Torsional.

4.5.7 Martin Mendalde 1755

The nine-story residential building shown in Figure 4.5.20 was constructed in 1975. It has a 30 to 35 cm waffle slab and reticular design without beams. The masonry consists of 150-mm thick hollow bricks and cement-sand mortar, and the walls are separated from the RC columns with styrofoam. Following the Puebla-Morelos earthquake, the building did not exhibit any visual structural damage, with only limited cracks on masonry panels observed.

As shown in Figure 4.5.21, ambient vibration recordings were obtained with twelve accelerometers: two at one corner of the basement and the 2nd floor, while four were installed at the 5th floor and the penthouse. The ambient vibration was recorded continuously for 66 min and archived in 3-min acceleration records. Table 4.5.7 presents the information on the first three identified modes which include two translational modes like the classic 1st mode along the short (O) and the long (P) directions of the building, as well as a torsional mode.



Figure 4.5.20 Nine-story building at Martin Mendalde 1755 (Coordinates: 19.3627, -99.172).

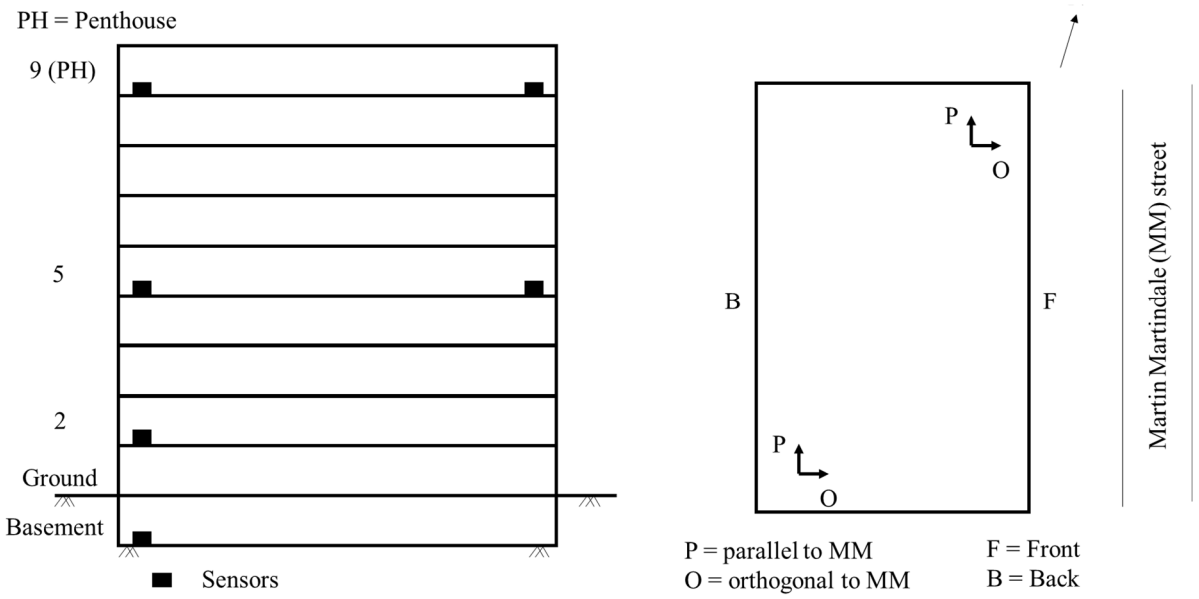


Figure 4.5.21 Instrumentation layout for Martin Mendalde 1755.

Table 4.5.7 Identified Modes of School Building at Martin Mendalde 1755

Mode #	*Frequency (Hz)*	*Mode Description*
1	0.57	1st classical translational along direction O
2	1.26	1st classical translational along direction P
3	1.97	Torsional

Chapter 5
Geotechnical Observations

5.1 Geologic Setting

The valley of Mexico City is a closed basin located in the highest part of the Mexican plateau. The boundaries on the north are the mountains of Tepozotlan and Tezontlalpan, on the east the Apan and Sierra Nevada planes, on the west the Monte Alto and Sierra de las Cruces, and on south the Chichinautzin mountain (Figure 5.1.1).

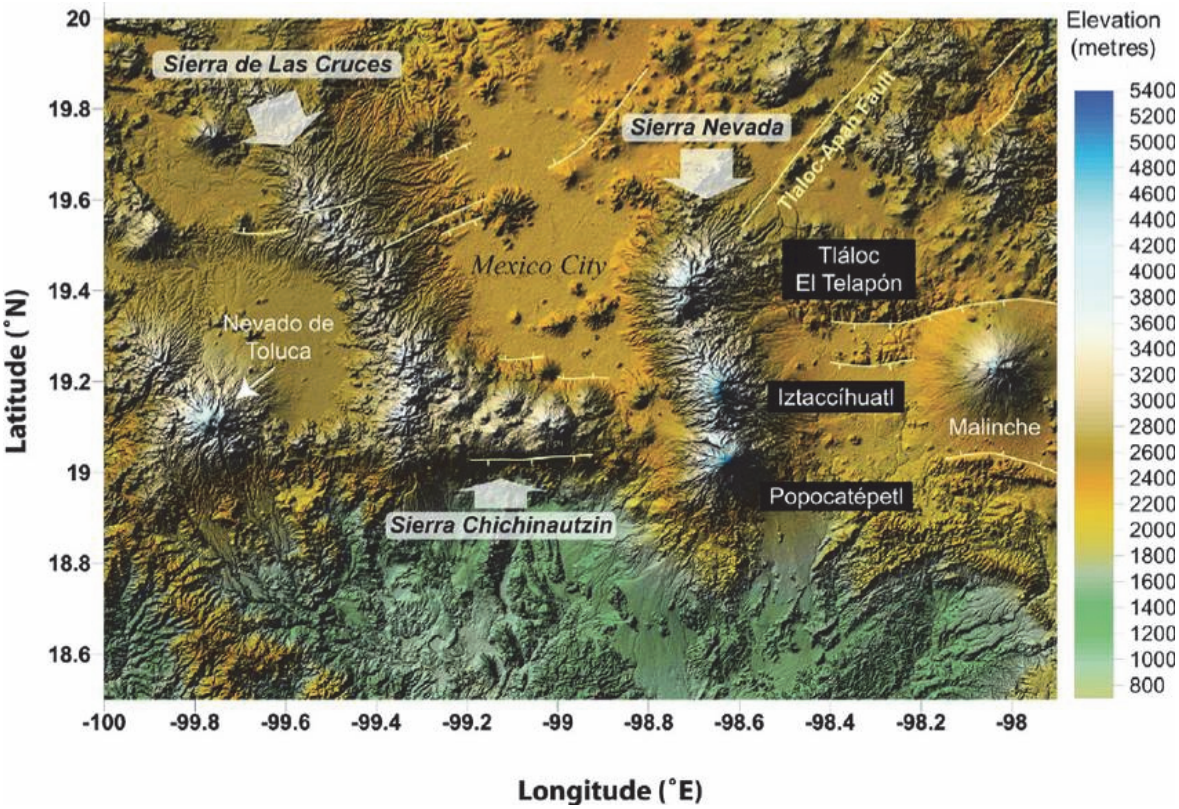


Figure 5.1.1 Digital Elevation Model of the Mexico City basin area (after Cadoux et al., 2011).

The Valley of Mexico is mainly formed by volcanic materials, while the surface layers consist of alluvial deposits, mostly lacustrine clays. Massive eruptions of the past 700,000 years have transformed the valley into a closed basin. The Sierra de Chichinautzin mountains form a natural barrier that confines the valley of Mexico which remained a closed basin with few shallow lakes until the end of the 15th century. The City of Mexico was founded in a small island of the Texcoco Lake. When the Nochistongo cut

was completed in 1789, the valley became an open basin and afterwards all lakes were drained through the Tequisquiac, Deep Drainage, and Emisor Oriente tunnels. Currently, except from small remaining bodies of water, the lakes have practically disappeared as shown in the 3D image of Figure 5.1.2.

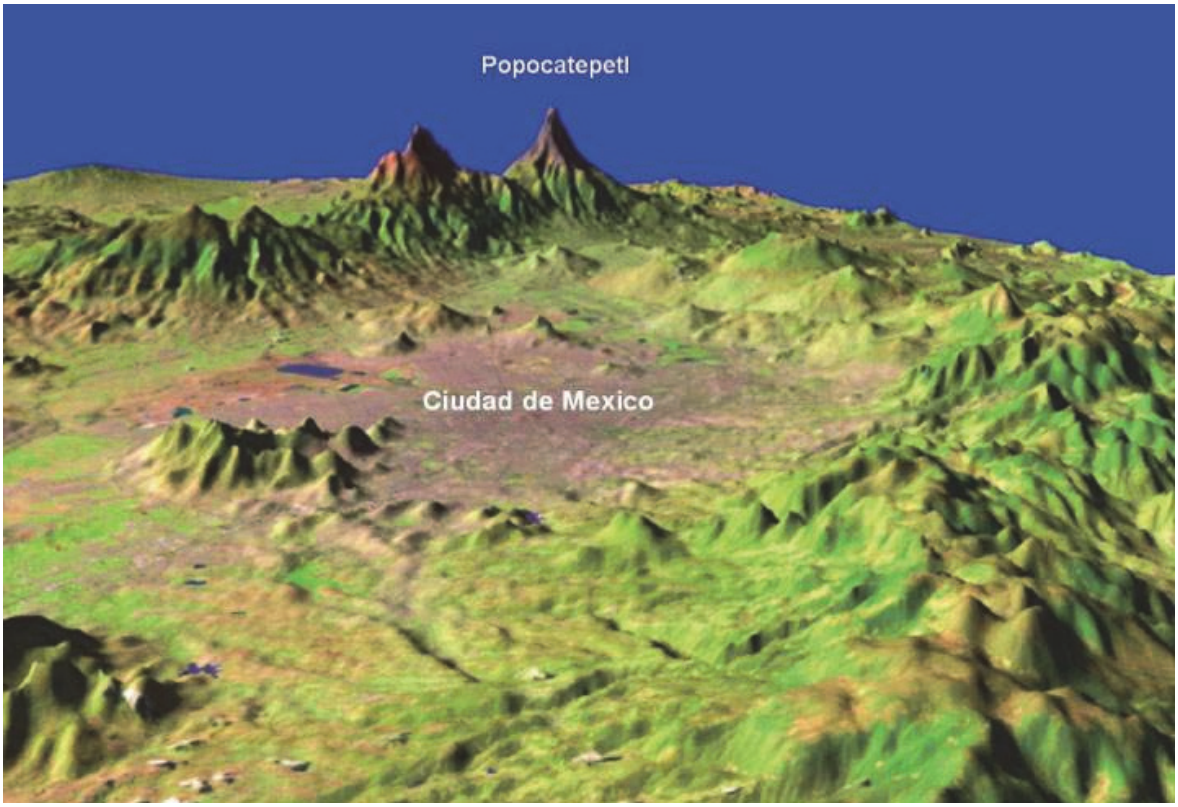


Figure 5.1.2 3D computer image of the landscape surrounding Mexico City (Windows Universe, 2017).

Large part of Mexico City is built on top of highly plastic soft clays sediments interlayered with thin silt and sand layers. The clayey deposits of Mexico City are known to be extremely compressible (Marsal and Mazari, 1959) with shear wave velocities, V_s, that can be as low as 40 m/s to 90 m/s and Plasticity Index, PI, that reach 200 to 300%. The PI is the factor that affects soil non-linear behavior the most; the soil practically remains within the elastic range accompanied by low damping, even for large earthquake strains. This behavior contributes significantly to the large soil amplification effects in the lake zone observed in past earthquakes (Romo and Auvinet, 1992).

The combination of extremely soft soils and regional subsidence throughout the center of the city have historically induced damaging differential settlements in many monuments and structures built in the former lake area.

5.2 Geotechnical Setting

5.2.1 Geotechnical Background

The Mexico City region is characterized by volcanic material, alluvial deposits and lacustrine clays. Typically, the top layer is the Fill/Upper Clay Series, a man-made fill mixed with volcanic ash and low plastic silty clay with water content and liquid limit properties as high as 300% and 400%, respectively. Below this surface lies a layer of compact silty sands that are underlain by the so-called "capa dura" or hard layer: a compact, alluvial sand layer that extends from a depth of 25 to 30 m below grade. Underneath the "capa dura" layer lies a series of pre-consolidated lacustrine clay deposits called "lower clay" series that eventually transition into thick layers of medium compact silty sands called "depósitos profundos" or deep deposits. Below these deep deposits, lies the igneous bedrock. Figure 5.2.1 illustrates this generic soil profile, originally proposed by Ovando-Shelley et al. (2007):

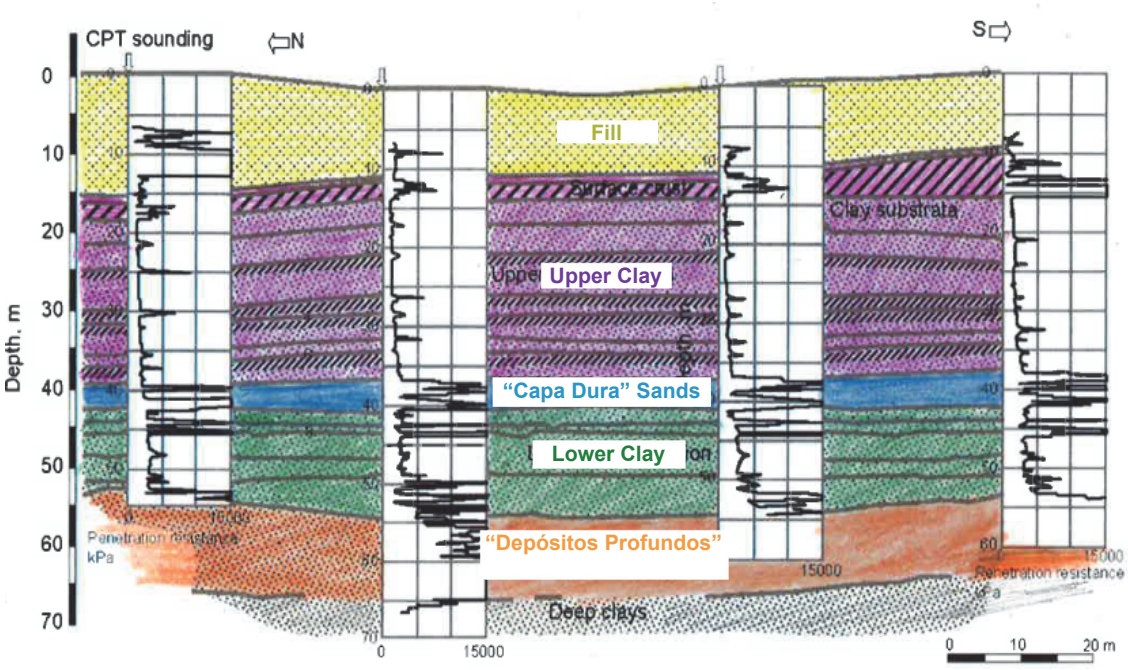


Figure 5.2.1 Generalized soil stratigraphy in central Mexico City (Ovando-Shelley et al., 2007).

The Mexico City clay deposits are notorious for being an extremely plastic material, which displays very low shear strengths and large compressibility. Their nature is heterogeneous as a mixture of volcanic, lacustrine sediments with microfossils and organic matter. Understanding the site response of the Mexico City subsurface relies heavily on the static and dynamic soil characteristics. Typical properties of Mexico City clays are provided in Table 5.2.1 based on Alberto and Hernandez (2017).

Table 5.2.1 Typical Properties of Mexico City Clays (after Alberto and Hernandez, 2017)

Soil Parameter	*Value*	*Soil Parameter*	*Value*
Void Ratio e	5 – 10	Water Content w (%)	220 – 420
Porosity n	0.83 – 0.93	Liquid Limit w_L (%)	110 – 485
Specific Unit Weight γ (kN/m^3)	12	Plastic Limit w_P (%)	37 – 116
Permeability k (cm/s)	10^{-7}	Plastic Index PI (%)	73 – 342
Compressibility Index C_c	3 – 8	Undrained Shear Strength S_u (kPa)	15 – 35
		Shear Wave Velocity V_s (m/s)	< 100

These regional clays behave almost linearly for shear strains, γ, as high as 0.1%, resulting in small shear modulus G degradation and damping, ξ, increment, even under long-duration subduction-type earthquakes, as the 1985 event (Mayoral et al., 2015). Depending on the level of earthquake-induced γ, the G and ξ vary for: (1) *small* strains as shown on Figure 5.2.2, based on resonant column tests performed by Díaz-Rodríguez and Lopez-Flores (1999); (2) *middle* strains, as per Figure 5.2.3 when γ exceeds the elastic threshold (Díaz-Rodríguez, 1989); and (3) *large* strains as shown on Figure 5.2.4 (Díaz-Rodríguez et al., 1992).

The 1985 M_w8.0 Michoacán earthquake resulted in several studies for typical sites with the background shown on Table 5.2.2 and subsurface conditions in general agreement with those presented on n Figure 5.2.1. Details for selected sites from in-situ and laboratory cone penetrometer (CPT) and shear wave velocity (V_s) tests are shown on Figures 5.2.5 through 5.2.14.

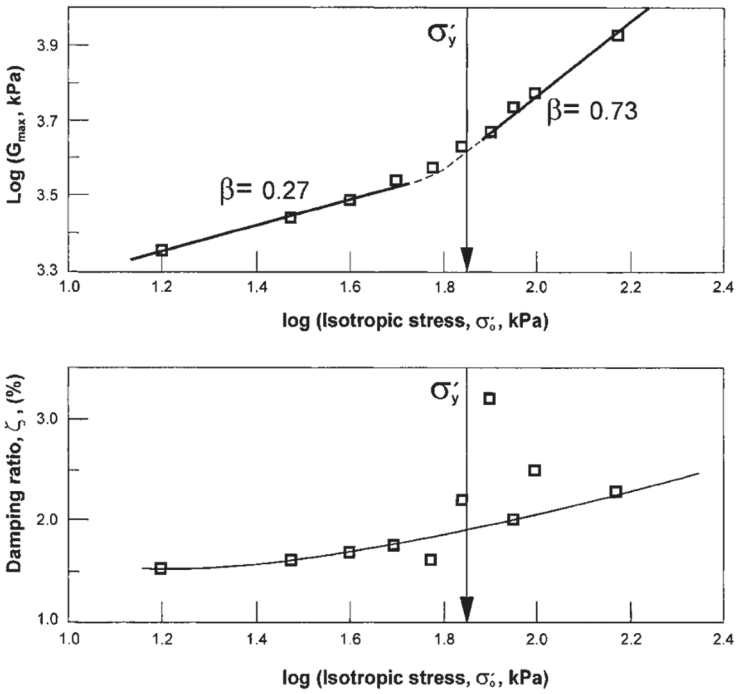


Figure 5.2.2 Low-strain shear modulus and damping (Diaz-Rodriguez and Lopez-Flores, 1999).

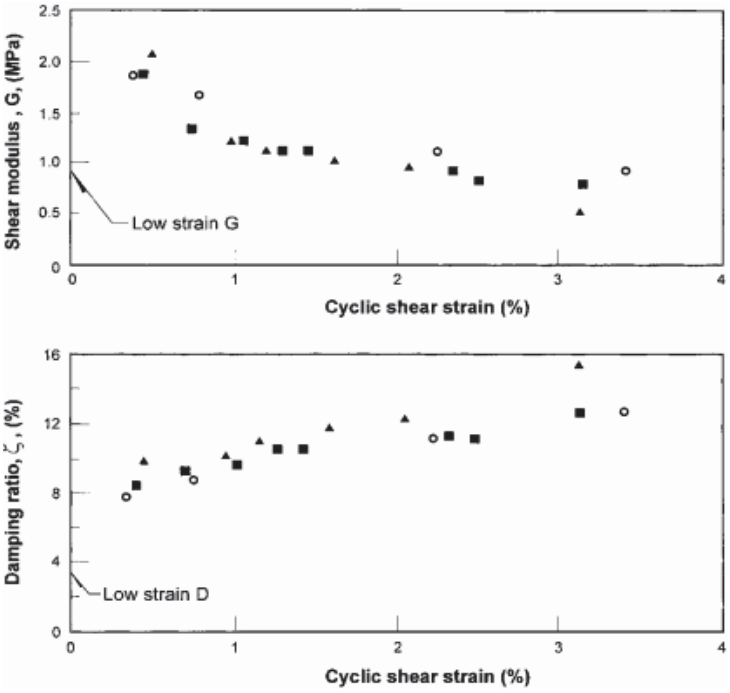


Figure 5.2.3 Middle-strain shear modulus and damping (Diaz-Rodriguez, 1989).

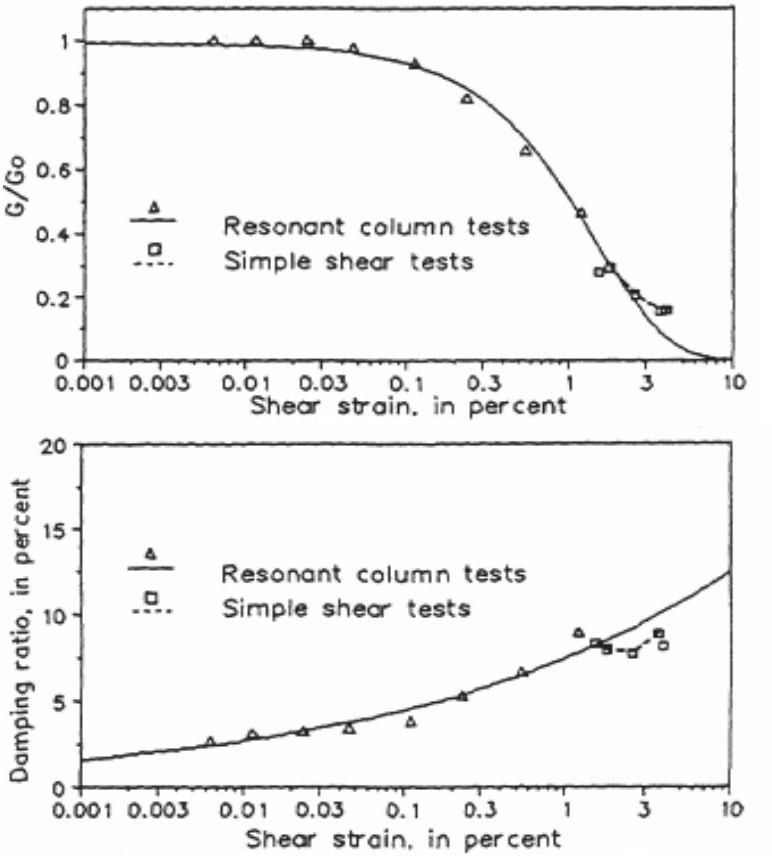


Figure 5.2.4 Large-strain shear modulus and damping (Diaz-Rodriguez et al., 1992).

Table 5.2.2 Site Characteristics for Cases Studied after the 1985 Michoacán Earthquake

Site	*Location*		*Description*		
Name	*LAT*	*LON*	*Type*	*Use*	*Address*
Ministry of Communications and Transportation (SCT)	19.387	-99.12	Strong Motion Station		Manzanas 12, Tlacoquemecatl del Valle, 03200 Ciudad de México, CDMX
Central de Abastos (CDAO)	19.375	-99.09	Strong Motion Station		Delegación Iztapalapa, Canal de Río Churubusco S/N, Col. Central de Abastos, Área Federal Central de Abastos, 09040 Ciudad de México
Río de Janeiro Square	19.421	-99.16	Open Park	Recreational Site	Plaza Río de Janeiro, Roma Norte, 06700 Cuauhtémoc, CDMX
Bernado Quintana	19.371	-99.25	8-story concrete structure supported by a rigid box, embedded 8-m into the soil deposit	Unknown	Bernardo Quintana a Santa Fe, Zedec Sta Fé 01219 Ciudad de México
SECUNDARIA #3	19.425	-99.16	3-story steel structure with concrete walls supported by a superficial mat foundation.	High School	Esq. Nápoles, Av Chapultepec 183, Juárez, 06600 Ciudad de México

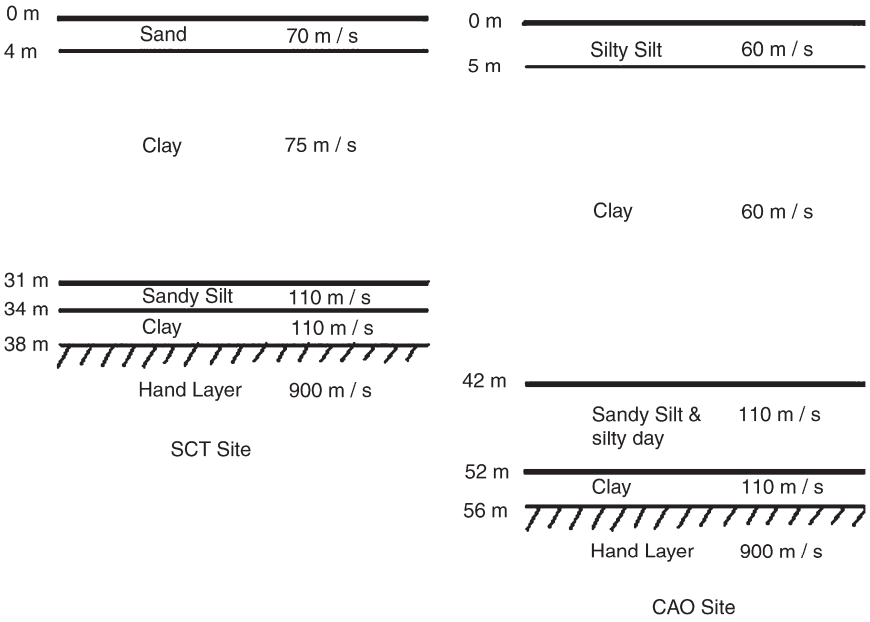


Figure 5.2.5 Simplified soil profiles of the Ministry of Communications and Transportation (SCT) and Central de Abastos (CAO) sites (Ovando-Shelley et al., 2007).

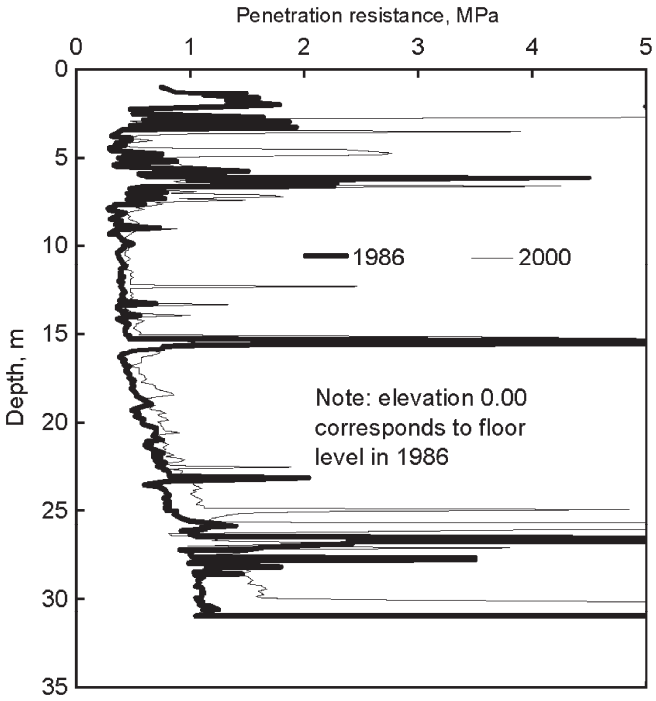


Figure 5.2.6 Cone penetration resistance with depth at the Ministry of Communications and Transportation (SCT) site (Ovando-Shelley et al., 2007).

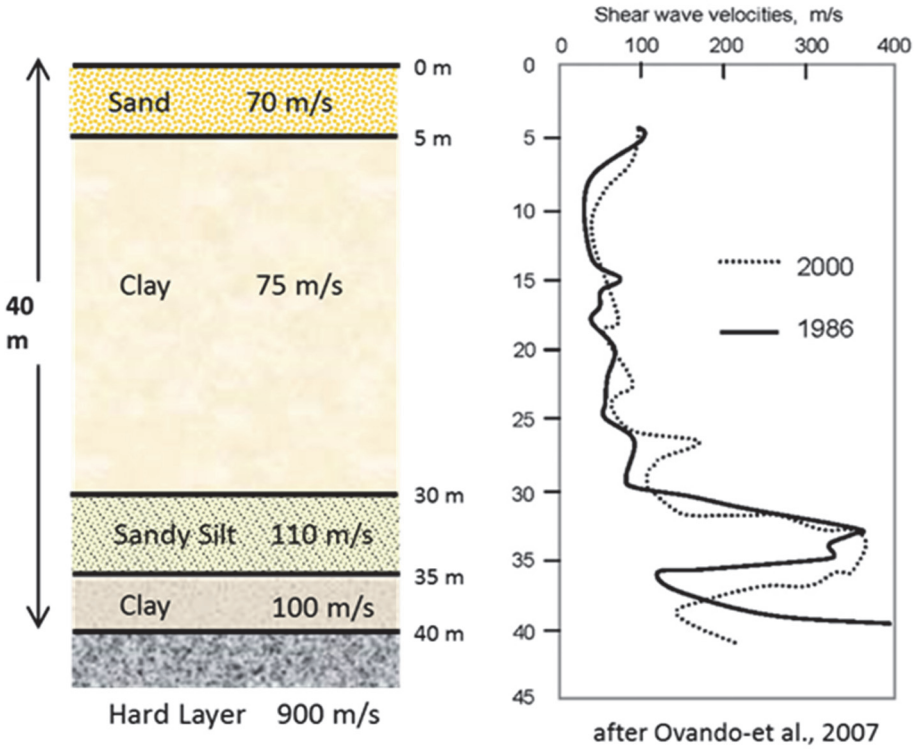


Figure 5.2.7 Shear wave velocity profile at the Ministry of Communications and Transportation (SCT) site (after Ovando-Shelley et al., 2007).

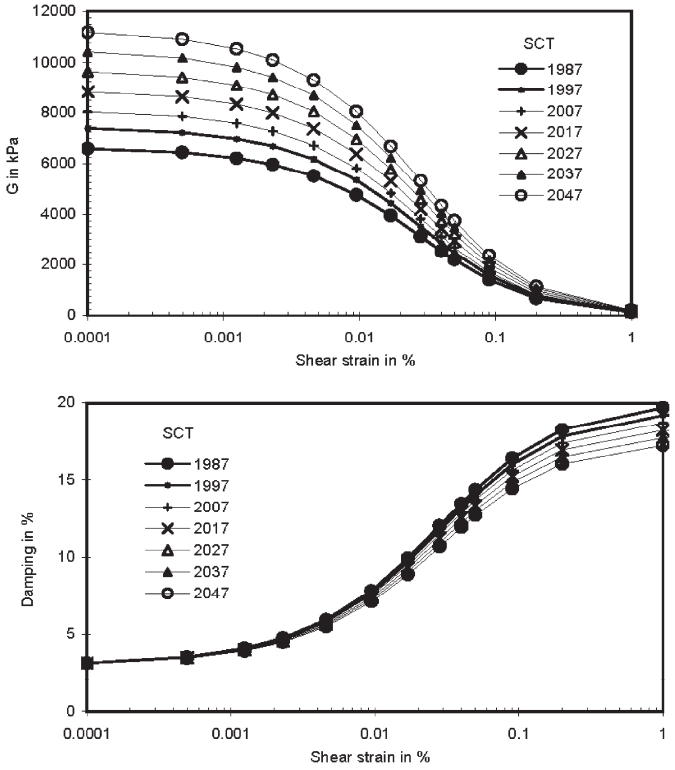


Figure 5.2.8 Shear modulus and damping for a clay sample at the Ministry of Communications and Transportation (SCT) site (Ovando-Shelley et al., 2007).

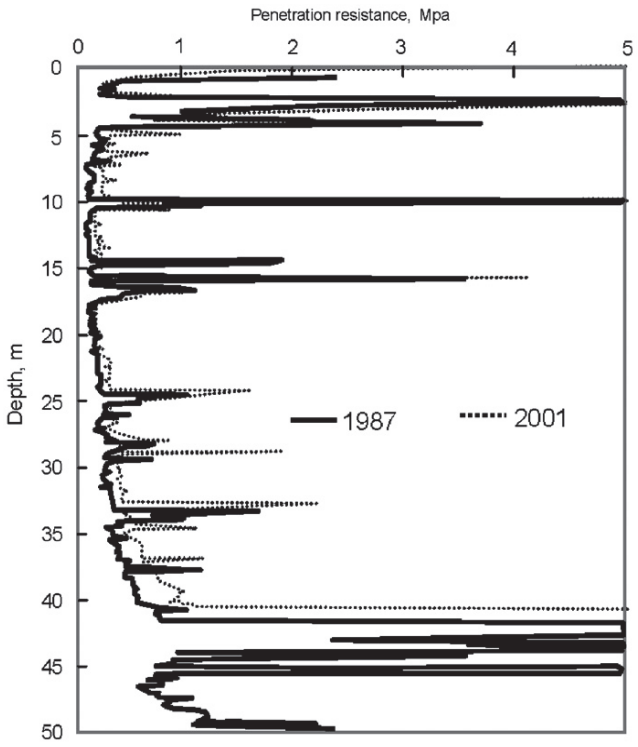


Figure 5.2.9 Penetration resistance with depth for the Central de Abastos (CAO) site (Ovando-Shelley et al., 2007).

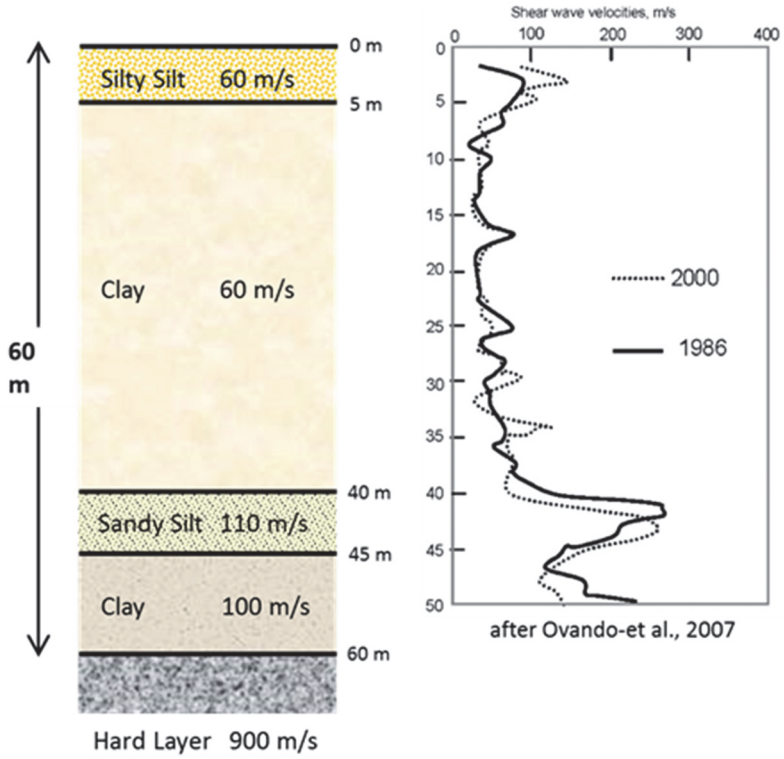


Figure 5.2.10 Shear wave velocity profile at the Central de Abastos (CAO) site (after Ovando-Shelley et al., 2007).

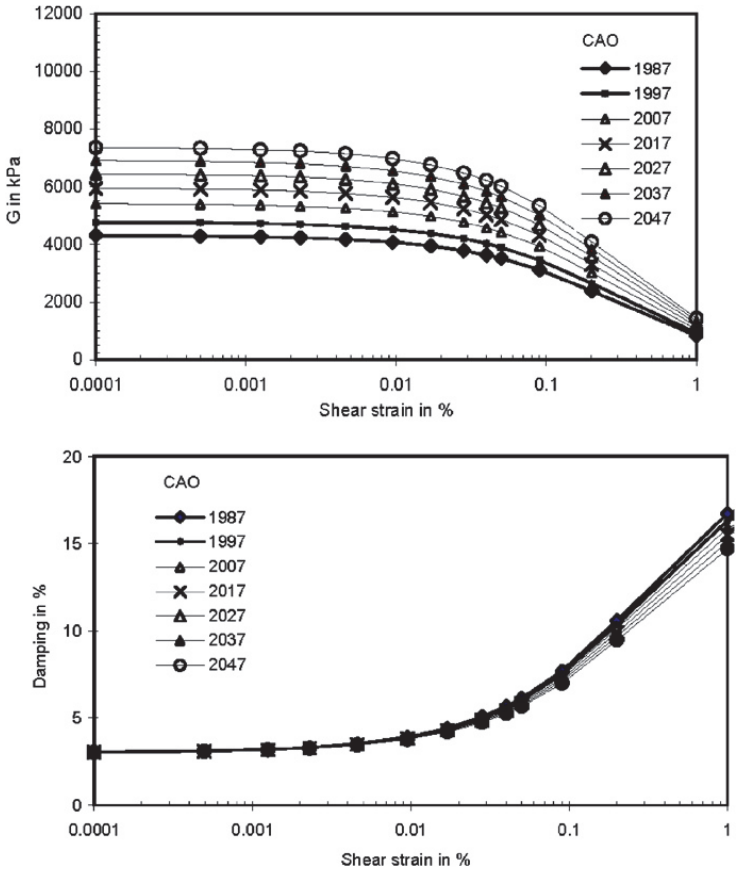


Figure 5.2.11 Dynamic stiffness and damping curves for a clay sample from the Central de Abastos (CAO) site (Ovando-Shelley et al., 2007).

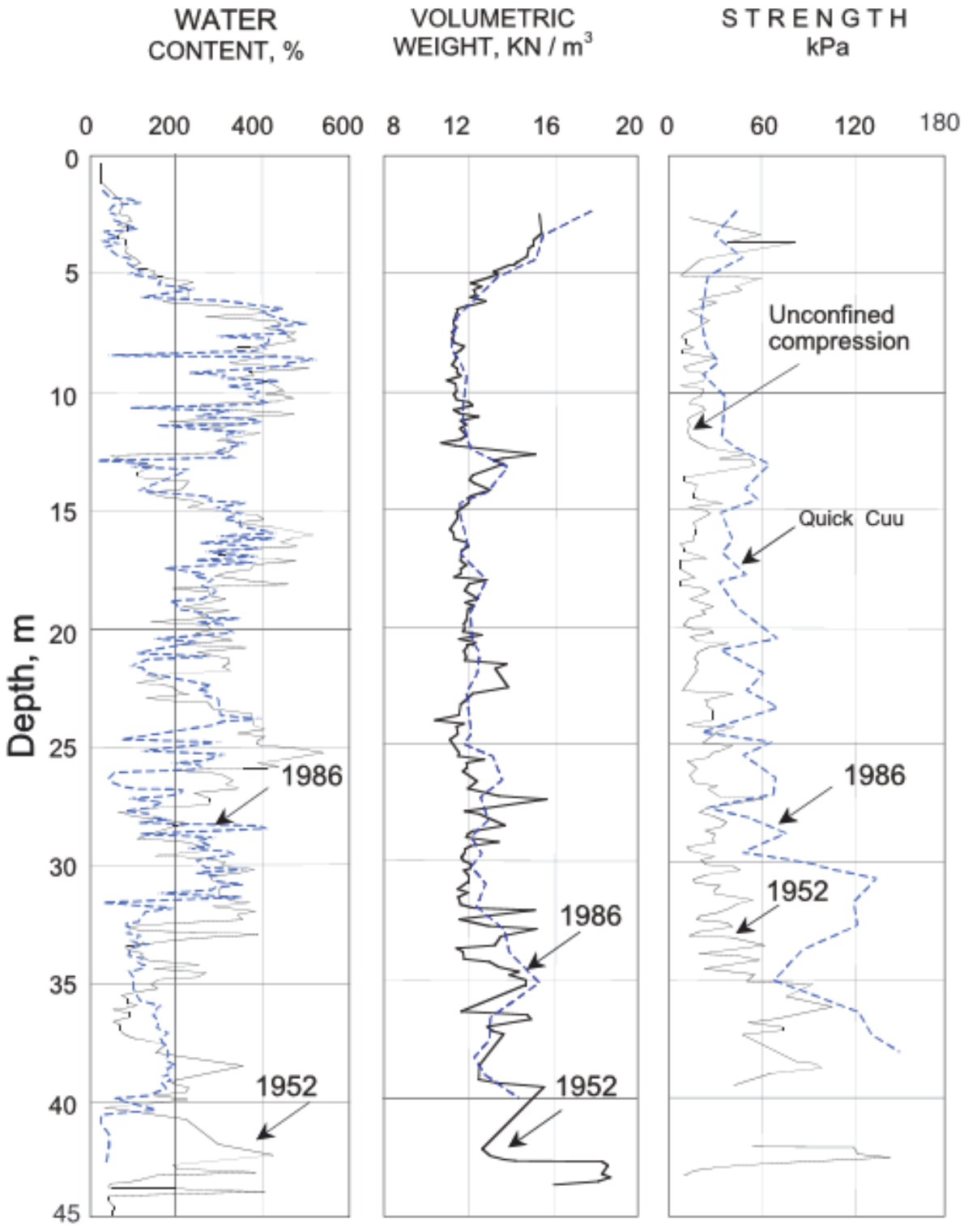


Figure 5.2.12 Changes in water content, volumetric weight and strength at Río de Janeiro Square, Mexico City, during the period 1950-1986 (after Méndez, 1991).

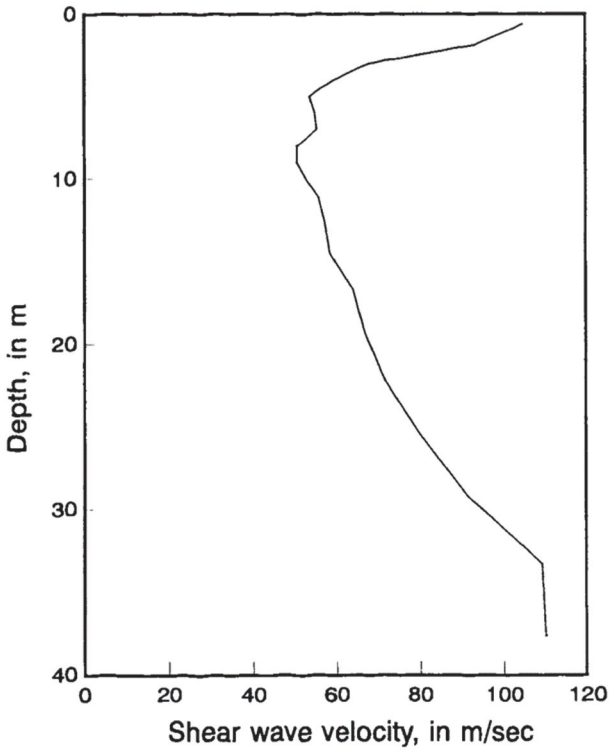


Figure 5.2.13 Shear wave velocity profile at Bernardo Quintana building site (after Romo, 1995).

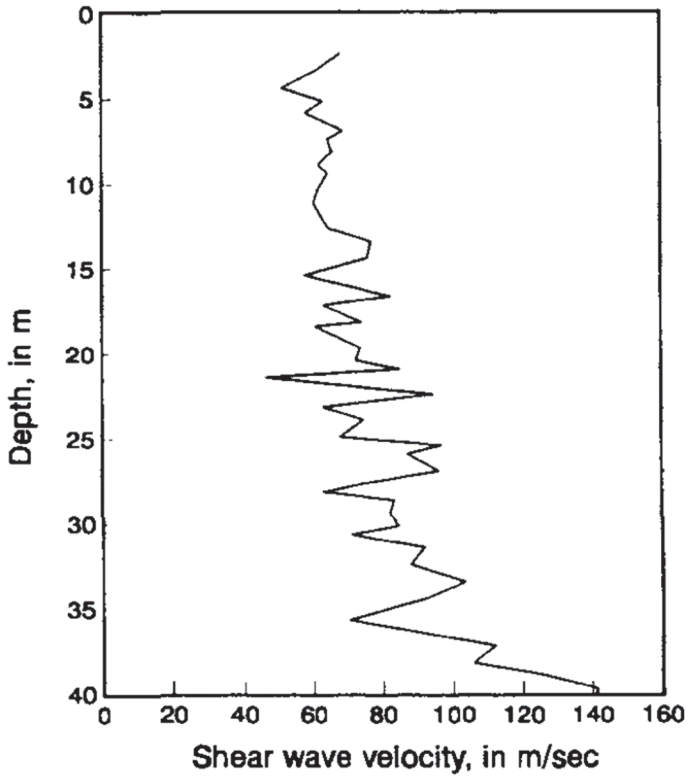


Figure 5.2.14 Shear wave velocity profile at Secundaria 3 site (after Romo, 1995).

5.2.2 Simplified Typical Profiles

The ATC team derived generalized soil profiles consisting of the characteristic regional clay deposit laying over a stiff layer, referred to as "bedrock." The simplified assumptions for the properties of the clay are shear wave velocity, V_s, of 80 m/s and plasticity index PI of 200%. To represent the subsurface conditions of sites of interest to the ATC building investigations, a one-dimensional elastic soil column was assumed with fundamental period, T, equal to $4H/V_s$, where H is the assumed depth to "bedrock" depending on the location within the lake. Hence, the generic profiles of Figure 5.2.15 were derived with corresponding predominant soil periods.

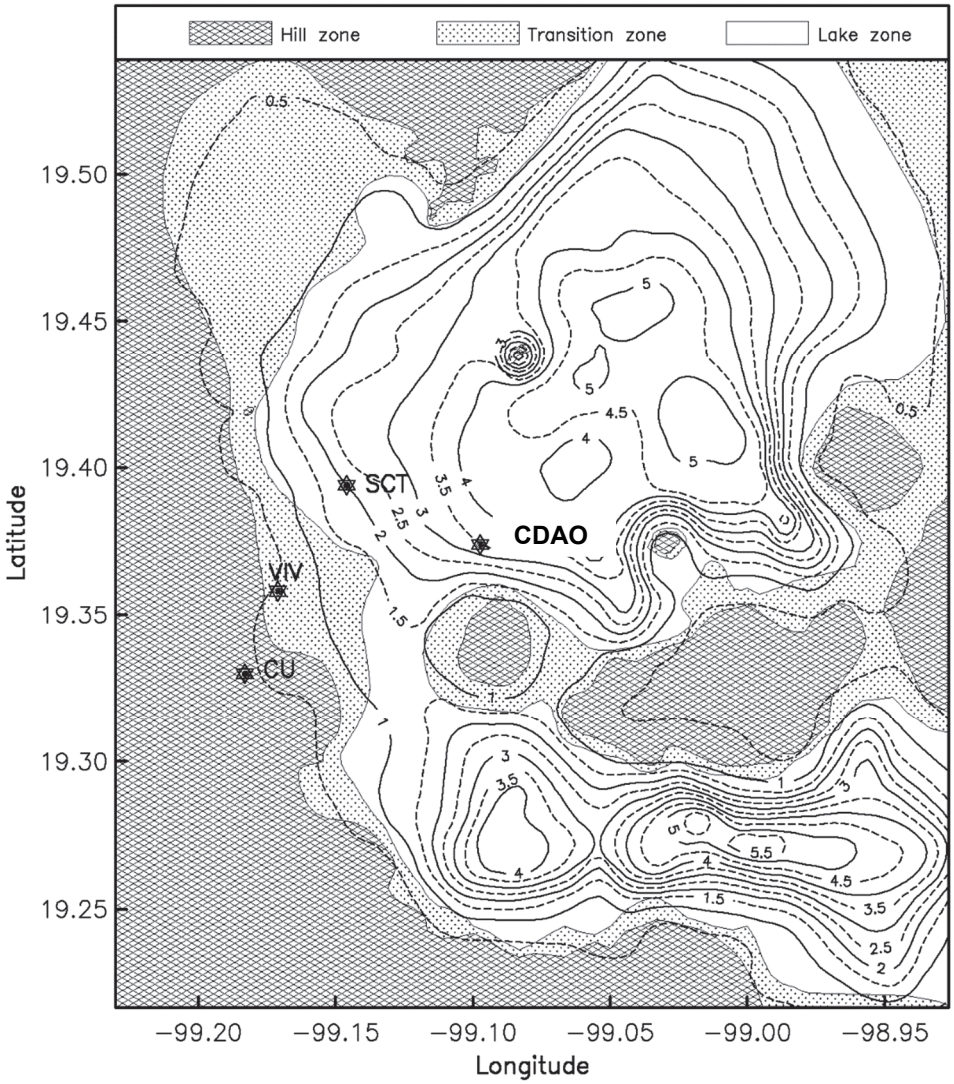


Figure 5.2.15 Predominant soil periods for Mexico City (mod. from Ordaz and Perez-Rocha,1992).

Using the profiles of Figures 5.2.7 and 5.2.10 and assuming constant V_s of 80 m/s through the thickness H for the clay layers, the following observations are made:

1. Figure 5.2.7 indicates that site SCT has a thickness H=40 m that translates into an estimated elastic soil period T= 2.0 s.
2. Figure 5.2.10 indicates that site CAO has a thickness H=60 m that translates into an estimated elastic soil period T= 3.0 s.

Both sites are included in Fig. 5.2.15, and the estimated predominant periods shown in the map contours are consistent with the elastic properties described in this section. Following these assumptions, all sites presented in this report have been assigned a generic soil profile as shown in Fig. 5.2.16:

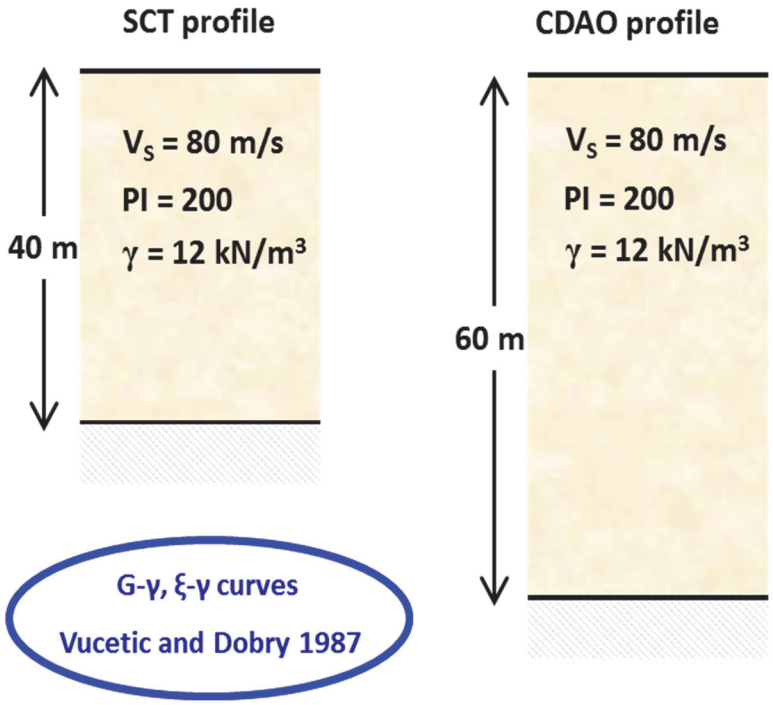


Figure 5.2.16 Assumed generic profiles for SCT and CDAO sites.

Table 5.2.3 and 5.2.4 summarize the generic geotechnical profiles for the buildings inspected and instrumented by the ATC team.

Table 5.2.3 Generic Geotechnical Profiles for Sites with $H<25$ m

Estimated Clay Layer Thickness H		
H < 20 m	*H ≈ 20 m*	*H ≈ 25 m*
Campo Eliseos 200*	586 Prolongación Petén	Av. Mexico 19*
Calzada Del Hueso	285 Avenida General, Emilio Zapata	Cozumel 52*
47-5 Calle Rancho El Arco	915 Prolongación Petén	Parque España 47*
480 Calzada Del Hueso	224 Avenida Emperadores	Amsterdam 130*
Calle Rancho Mante	23 Calle Hacienda San José	609 Calle Azores
Taxqueña and Cerro Torres	4353 Avenida División Del Norte	517 Calle Tokio
18 Avenida 8 (Tlalpan)	64 Bahia de Ballenas	403 Calle Sevilla
Coquimbo 909	32 Avenida Matatlan	157 Avenida Emperadores
Coquimbo 911		521 Eje Central
Coquimbo 911Bis		17-13 Calle Saratoga
126 Yautepec		617 Calle Filipinas
		232 Calle Amsterdam
		275 Campeche
		245 Tehuantepec
		128 Calle Amsterdam
		107 Calle Amsterdam
		149 Sonora
		Avenida Mexico 4
		49 Amsterdam
		52 Cozumel

Table 5.2.4 Generic Geotechnical Profiles for Sites with $H>25$ m

Estimated Clay Layer Thickness H			
H ≈ 30 m	*T ≈ 35 m*	*H ≈ 45m*	*H ≈ 50 m*
10 Calle Paseo Del Río	Emilio Zapata 56	Palacio de Bellas Artes	202–210 Calle Dr Juan Navarro
20 Calle Paseo Del Río		Notary historical heritage	103 Calle Dr Rafael Lucio - Edif. Centauro
53 Paseo Nuevo			103 Calle Dr Rafael Lucio - Osa Mayor
65 Paseo Nuevo			Calle Jose Maria Izazaga 32
86 Avenida Oaxaca			
107 Calle Salamanca			

5.3 Geotechnical Reconnaissance

Several buildings in the meioseismal area, namely the Roma and La Condesa neighborhoods, experienced substantial permanent deformations due to rotation at their foundation. Some of these structures had been experiencing static differential settlements prior to the 2017 earthquake as they are founded in the deep soft clay deposits. The seismic event induced additional dynamic settlements or rotations and associated damage due to soil-structure interaction (SSI) phenomena of soil compaction and softening. Identifying the SSI outcomes is an arduous task because the inertial and kinematic effects in the superstructure and foundations are not separated from the field-observed residual deformations.

The ATC team performed geotechnical reconnaissance in structures that exhibited damage due to partial or complete foundation failure in the form of excessive settlement of the ground floor or rotation of the whole building as a rigid body. Figure 5.3.1 shows the geotechnical observation locations at: (1) two residential buildings with rotation of their foundation (uplift or settlement) at 210 Calle Dr. Lucio and 128 Calle Amsterdam; and (2) two historical monuments, Palacio de Bellas Artes and Notary Historical Heritage. The subsurface conditions in all four buildings include a top soft clay deposit, 80-m thick, based on local information collected by our team. Background on each case are given in Table 5.3.1 with details in the following sections.

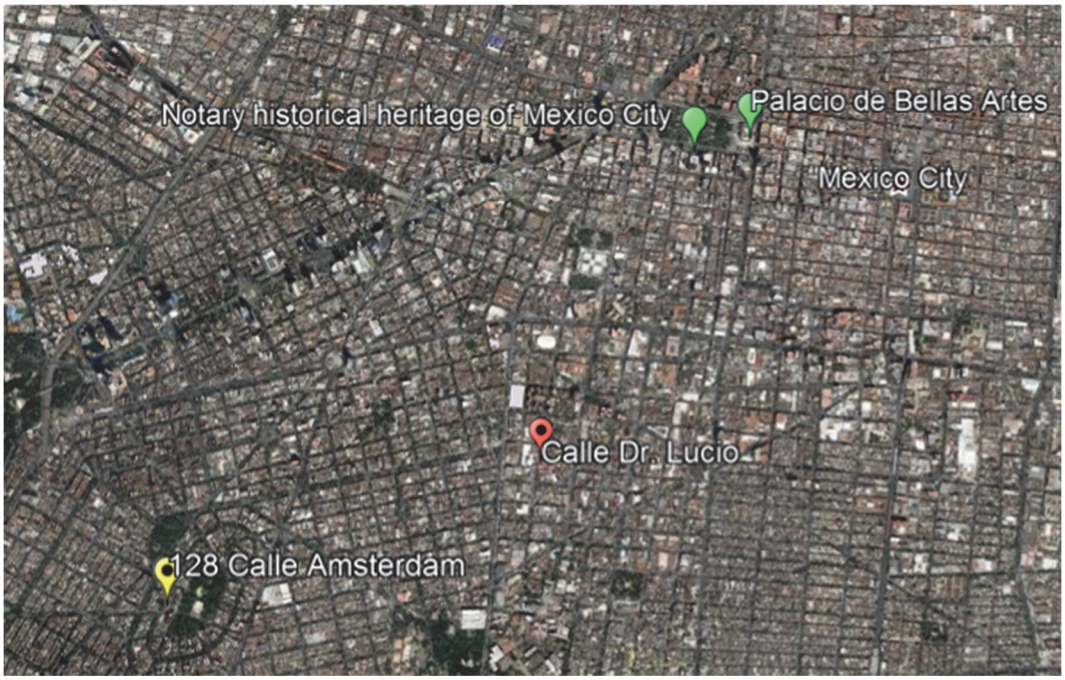


Figure 5.3.1 Geotechnical reconnaissance: Locations of inspected structures (base map by Google Earth).

Table 5.3.1 Information on the Four Structures Inspected by ATC for Geotechnical Effects

Structure		*Location*		*Design Info*				
Name - Address	*Geotech. Building No.*	*LAT*	*LON*	*Stories*	*Era*	*Main Structural System*	*Subsurface*	*Foundation*
210 Calle Doctor Lucio	1	19.420000	-99.151719	15	1970s	Concrete frame with URM infill	Deep Soft Mexico City Clay	RC mat with friction piles
128 Calle Amsterdam	2	19.412000	-99.171000	6		Reinforced concrete frame		Unknown
Notary historical heritage of Mexico City	3	19.435000	-99.144000	2-3	1600s	Unknown		
Palacio de Bellas Artes	4	19.435000	-99.141000	3	1930s	Concrete or masonry; waffle slab and URM infill walls. Unknown lateral load resisting system.		

5.3.1 210 Calle Dr. Lucio

The 210 Calle Doctor Lucio structure is a 15-story residential building constructed in the 1970s located at the corner of J. Navarro and Doctor R. Lucio Drives in the Osa Mayor area (Coordinates: 19.421137, -99.151719). The building is in a complex of almost identical structures (see Fig. 5.3.2), with two L-shaped units connected at their corners by a staircase and elevator shaft. The foundation is a reinforced concrete (RC) mat with friction piles.



Figure 5.3.2 Location map with the inspected 210 Calle Doctor Lucio structure within the 5-buidling complex outlined in green (base map from Google Earth).

Despite their similar construction type, geometry, and foundation-soil conditions, the five buildings responded differently to the 2017 Puebla-Morelos earthquake. Only two of them suffered severe damage (Fig. 5.3.3): Building 1, inspected by ATC (Figs. 5.3.3-12) and Building 2, located on the opposite side of the road.



Figure 5.3.3 Partial view of 3 buildings in the 210 Calle Doctor Lucio complex (left). Damage in the masonry walls of Building 1 (right). (Coordinates: 19.421137, -99.151719).



Figure 5.3.4 210 Calle Doctor Lucio: Uplift at Building 1(Coordinates: 19.421137, -99.151719).



Figure 5.3.5 210 Calle Dr. Lucio, Building 1: Uplift at east side entrance and tension crack at bottom of column (left) with measurement at ground level (right; Coordinates: 19.421137, -99.151719).

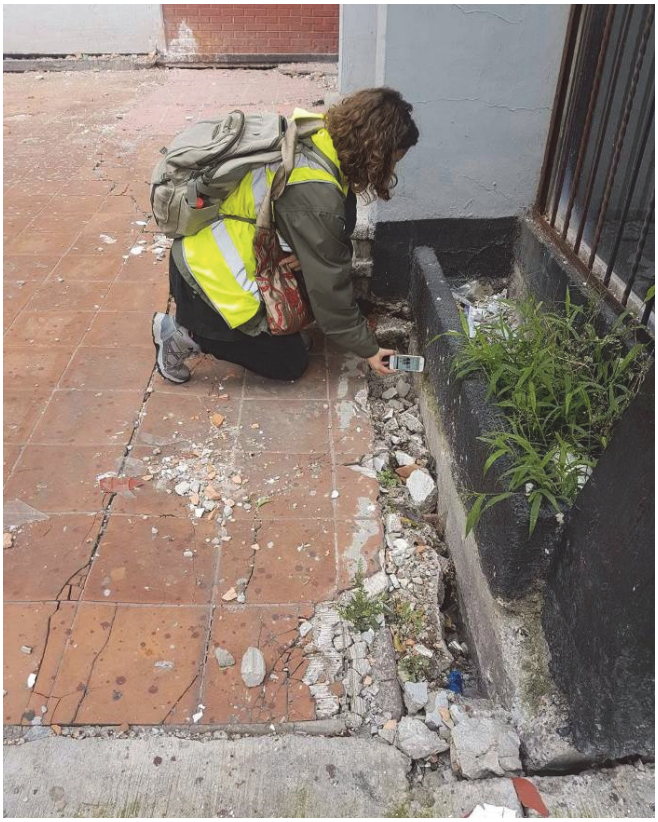


Figure 5.3.6 Building 1, 210 Calle Dr. Lucio: Ground level crack (GPS: 19.421137, -99.151719).



Figure 5.3.7 Building 1, 210 Calle Dr. Lucio: uplifted part of a corner at the location shown on the insert (Coordinates: 19.421137, -99.151719).



Figure 5.3.8 Tilted stone fence column at west side of Building 1, 210 Calle Dr. Lucio (Coordinates: 19.421137, -99.151719).

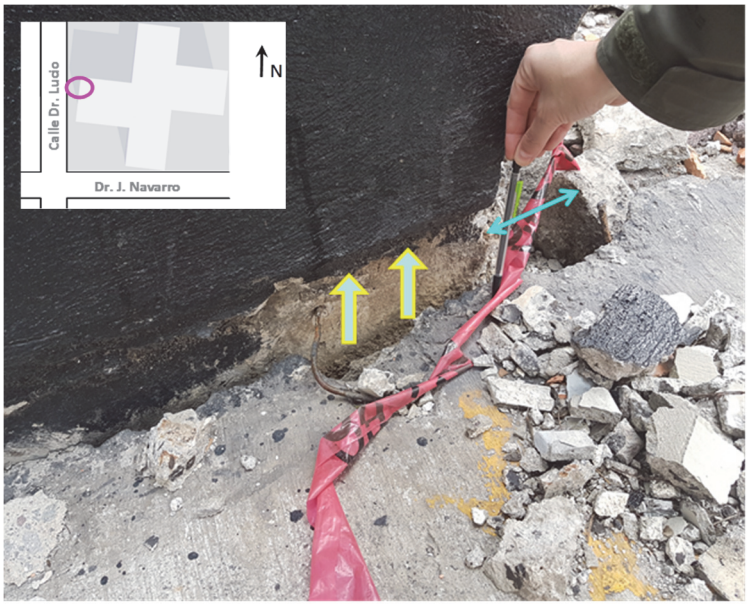


Figure 5.3.9 Building 1, 210 Calle Dr. Lucio uplifted corner (see insert). The blue line measuring the horizontal gap may be evidence of rocking motion (Coordinates: 19.421137, -99.151719).

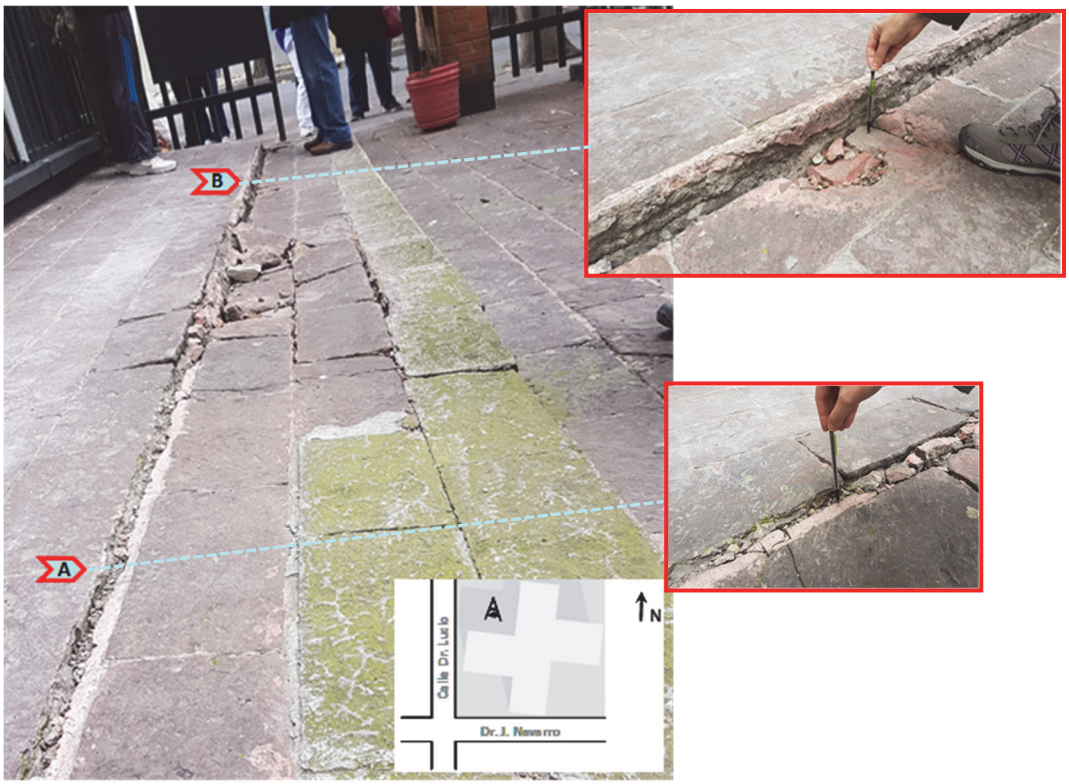


Figure 5.3.10 Side of tilted Building 1, 210 Calle Dr. Lucio: Reference points A, B (left) and (right) corresponding vertical displacements due to uplifting (Coordinates: 19.421137, -99.151719).



Figure 5.3.11 Building 1, 210 Calle Dr. Lucio: Separation along staircase likely caused by rocking motion of the right-hand side of the building (Coordinates: 19.421137, -99.151719).

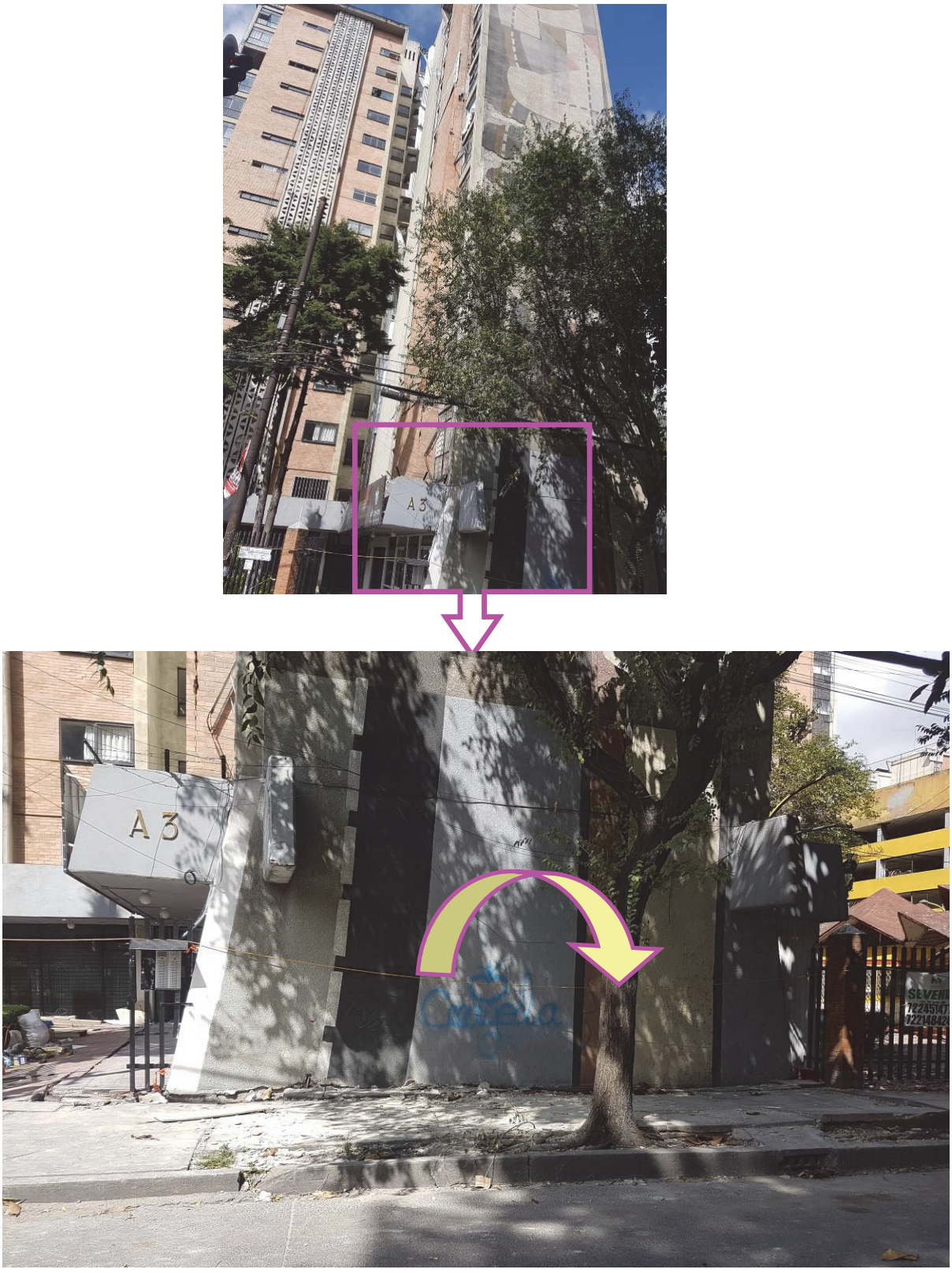


Figure 5.3.12 Tilted building 1, 210 Calle Dr. Lucio: Side view (top) and detail on the ground level (bottom) (Coordinates: 19.421137, -99.151719).



Figure 5.3.13 Building 1, 210 Calle Dr. Lucio: Local Civil Protection inspection engineers (left); team member Dr. Ktenidou on cracked road likely due to settlement (right) (Coordinates: 19.421137, -99.151719).



Figure 5.3.14 Building 1: 1st floor stair detachment (Coordinates: 19.421137, -99.151719).



Figure 5.3.15 Horizontal displacement measured from top and vertical displacement measured from side of 1st floor stair detachment shown in the previous figure (Coordinates: 19.421137, -99.151719).



Figure 5.3.16 Building 1, 210 Calle Dr. Lucio. Views inside of: (a) 1st floor office; and (b) an apartment at ground floor (Coordinates: 19.421137, -99.151719).



Figure 5.3.17 Building 1, 210 Calle Dr. Lucio. Vertical separation gap at 3rd floor (left). Separation gap at 4th floor (right; Coordinates: 19.421137, -99.151719).



Figure 5.3.18 Building 1 separation at 7th (left), 9th (right) floors (Coordinates: 19.421137, -99.151719).



Figure 5.3.19 Building 1 separation view from 15th floor (Coordinates: 19.421137, -99.151719).



Figure 5.3.20 Building 1, 210 Calle Dr. Lucio. Local buckling of lateral steel reinforcement bars at the 2nd floor level (Coordinates: 19.421137, -99.151719).

As shown on the collection of observations for Building 1 at 210 Calle Dr. Lucio in Figs 5.3.2 to 5.3.20, the southern half of this building appears to have rotated on its foundation as a rigid body, while the northern half remained on its place. Subsequently, Building 1 had split at the staircase location along its height. Specific evidence of rotational movement on the foundation level and/or uplifting is presented on Figures 5.3.3 to 5.3.12 and local buckling effects on Figure 5.3.20.

The separation between the two halves of Building 1 is shown on Figures 5.3.11 and 5.3.19. The ATC team observed the structure from inside, moving from the ground to the 15th floor, recording the increase of roof-to-roof separation distance shown on Figures 5.3.16 to 5.3.19 that demonstrate

that the rotation of the northern half induced larger vertical and horizontal displacements along the height of Building 1.

Figure 5.3.21 shows a sketch of Building 1 made on site. It includes all key observations made. The blue lines indicate the approximate movement observed at the interface between building base and ground surface. The red arrows indicate the direction in which the photographs shown in this section were taken (Figures 5.3.4-11 and 5.3.20). The notes along the building walls indicate the condition of the walls (damage to plaster, masonry, column, etc.). The pavement cracking is also shown.

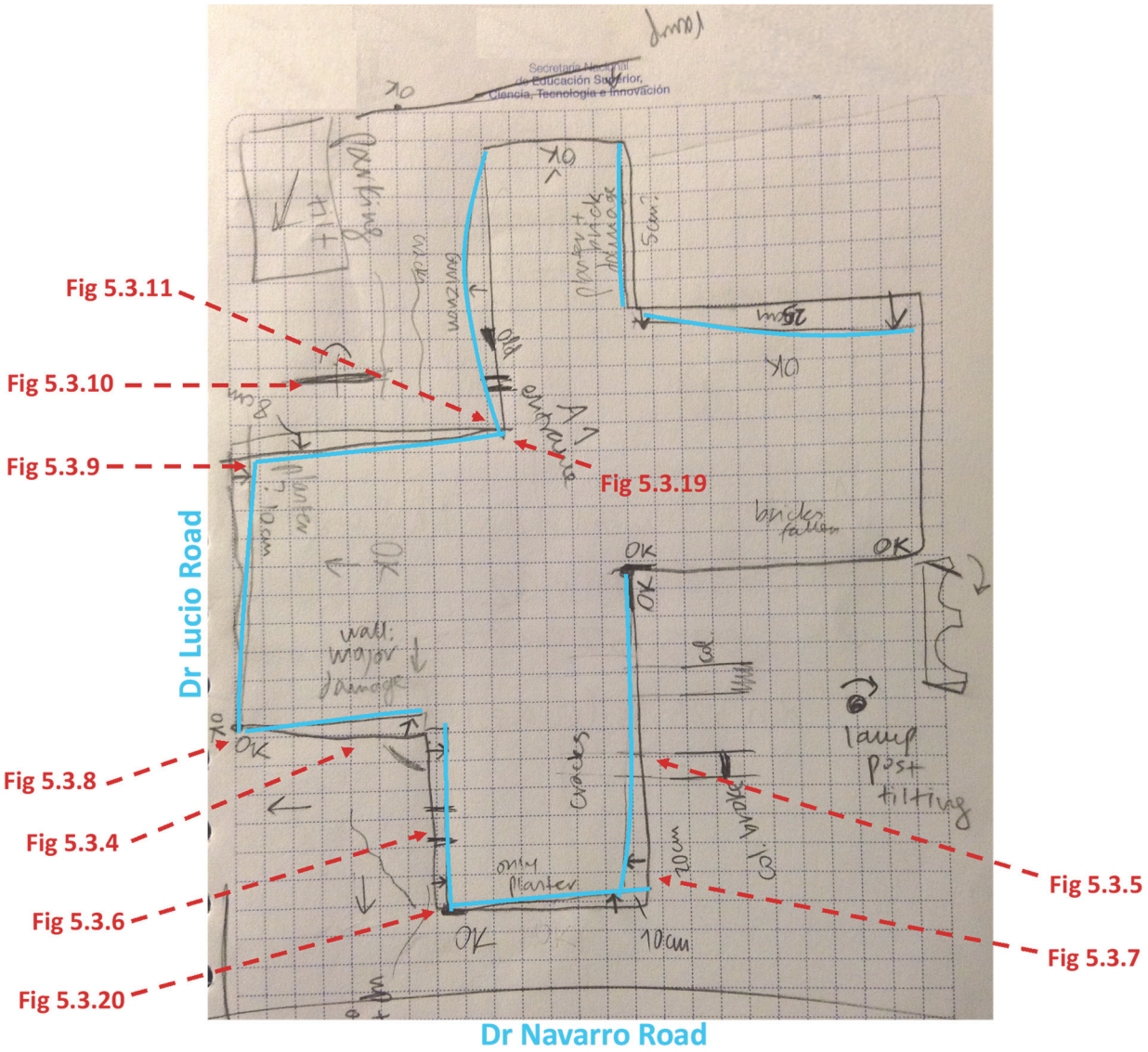


Figure 5.3.21 Sketch of Building 1 with key observations. Blue lines indicate the approximate movement observed at the interface between building base and ground surface. Red arrows indicate the direction in which the photographs shown in this section were taken. Notes along the building walls indicate the condition of the walls (damage to plaster, masonry, column, etc.). Pavement cracking is also shown.

5.3.2 128 Calle Amsterdam

The 128 Calle Amsterdam (Building 2) is a 6-story residential structure that was visited by the ATC team to record evident geotechnical and soil-structure interaction effects (Coordinates: 19.411925, -99.171203). At the time of arrival of the ATC team, some of the residents had remained in their apartments, since the building had not been evacuated. The location of Building 2 is indicated in the map of Figure 5.3.22.



Figure 5.3.22 Location of Building 2, 128 Calle Amsterdam identified in the magenta outline of the Goggle Earth map (GPS Coordinates: 19.411925, -99.171203).

At the first glance, no apparent damage was observed as shown on the left view of Fig. 5.3.23. However, a more detailed inspection revealed that the entire structure had rotated by approximately 5.4 degrees as a rigid block until it reached and touched the neighbor building (Figures 5.3.23 to 5.3.25). Based on information provided by the residents, the building had exhibited substantial settlement and had already rotated prior to the 2017 earthquake, but not as much as in its current state. Figure 5.3.26 shows the pavement shape adjustment to comprehend the settlement at the ground level. Interior observations shown on Figures 5.3.27 to 5.3.29 indicate damage limited to wall cracking and no visible cracks at the structural beams and columns.

Based on the reconnaissance and historical information, it is likely that the settlement and rotation under static conditions, and the seismically-induced rotation of Building 2 was caused primarily to the subsidence and softening of the layer of soft clay below the building.



Figure 5.3.23 Building 2, 128 Calle Amsterdam: Front view (left) and opening of joint Building 2 and the adjacent 130 Amsterdam structure (right, coordinates: 19.411925, -99.171203).



Figure 5.3.24 Building 2, 128 Calle Amsterdam: A more detailed view of the opening joint at the right side between the 128 and 130 Amsterdam buildings (Coordinates: 19.411925, -99.171203).



Figure 5.3.25 Structural joint at the left side of the 128 Calle Amsterdam Building 2 (Coordinates: 19.411925, -99.171203).



Figure 5.3.26 Building 2, 128 Calle Amsterdam: Parking lot exterior front (left) and side (right) views with evidence of soil subsidence prior to the 2017 earthquake (Coordinates: 19.411925, -99.171203).



Figure 5.3.27 Building 2, 128 Calle Amsterdam: 1st floor apartment (top) and dance school with wall cracks (middle); 4th floor undamaged structural column (bottom; coordinates19.411925, -99.171203).



Figure 5.3.28 Building 2, 128 Calle Amsterdam staircase wall cracks at 1st (left) and 3rd floor (right), with direction of cracks towards the direction of tilting (Coordinates: 19.411925, -99.171203).



Figure 5.3.29 Parking lot of Building 2, 128 Calle Amsterdam appears undamaged (Coordinates: 19.411925, -99.171203).

5.3.3 Notary Historical Heritage at Avenida Juárez

The Notary historical heritage building [Acervo Histórico De Notarías De La Ciudad De México] is the only remaining part of the baroque structure of the Monastery of Corpus Christi which was founded in 1724. This monumental structure is within the historic center (shown on map of Fig. 5.3.30; coordinates: 19.434550, -99.144167) that suffered negligible damage compared to the hardly hit areas of Roma and La Condesa.

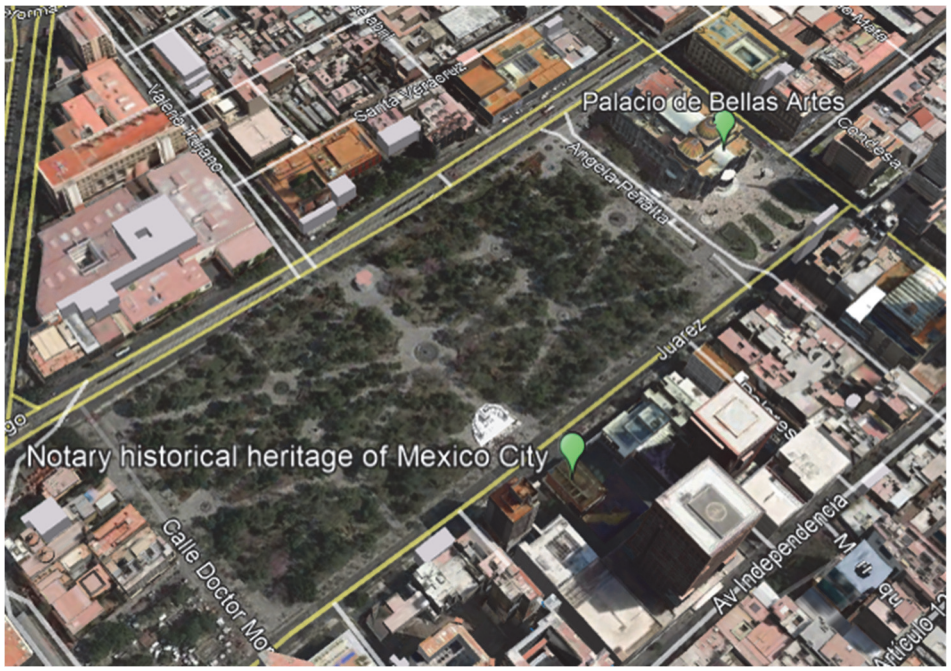


Figure 5.3.30 Historic center of Mexico City with locations of the Notary historical heritage (Building 3) and Palacio de Bellas Artes (Building 3). Base map from Google Earth.

The architect was Pedro de Arrieta who also designed the Palace of the Inquisition and the Temple of San Felipe Neri "La Profesa." The monastery was partially destroyed during the 1985 earthquake and since then, the façade has been integrated into the existing building (Fig. 5.3.31). Notaries stamps and other notarial documents are in this building, with the General Archive of Notaries (under the General Legal Directorate and Legislative Studies) being responsible for their conservation, custody and reproduction.

This historical structure showed no significant failure signs based on visual inspections of the exterior made by the ATC team (Figures 5.3.32 and 5.3.33). There was no visual evidence of settlements along the perimeter of the building at the ground level. Minor cracks were identified at the back side, present before the 2017 earthquake shown on Figures 5.3.34 and 5.3.35.



Figure 5.3.31 Façade of Notary historical heritage (Building 3, Coordinates: 19.434550, -99.144167).



Figure 5.3.32 Notary historical heritage Building 3: no damage signs (Coordinates: 19.434550, -99.144167).



Figure 5.3.33 Back side of Notary historical heritage Building 3 (Coordinates: 19.434550, -99.144167).



Figure 5.3.34 Side view of Notary historical heritage Building 3 indicating soil settlement: ground level crack (left); crack opening (right; Coordinates: 19.434550, -99.144167).



Figure 5.3.35 Side view of Notary historical heritage Building 3 with pre-existing cracks (Coordinates: 19.434550, -99.144167).

5.3.4 Pallacio de Bellas Artes

The Palace of Fine Arts (Pallacio de Bellas Artes) is a prominent cultural center in the capital of Mexico (Fig. 5.3.36), located on the western side of the historic center of Mexico City next to the Alameda Central Park. It was designed by the Italian architect Adamo Boari with a neoclassical exterior and Art Nouveau architectural rhythms and Art Deco interior.



Figure 5.3.36 Panoramic view of Pallacio de Bellas Artes Building 4 (GPS: 19.435278, -99.14111).

Construction started in 1904 but was stopped by year 1913 due to complications from the soft subsurface conditions stopped construction. The operations resumed about 20 years later, in 1932, under Mexican architect Federico Mariscal, until its completion in 1934. Since then, the Pallacio has settled more than 4.6 m. Currently, the entrance is from what was once the 1st floor, and the original entrance hall is a basement.

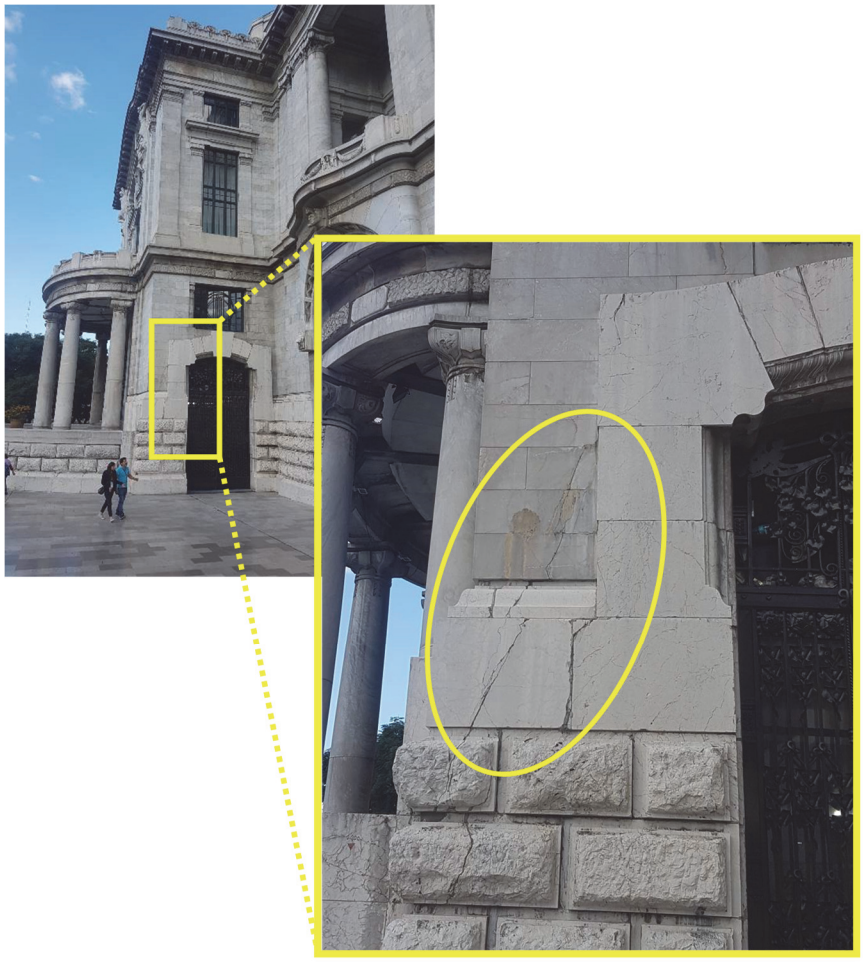


Figure 5.3.37 Cracks on the marble façade of the Pallacio Building 4 (GPS: 19.435278, -99.14111).

Historically, the building has been settling uniformly, likely because of the uniform pressure on its foundation. The 1985 Michoacan earthquake caused no damage to the Pallacio, while minor damage was observed from the 2017 Puebla-Morelos earthquake. As shown on Figures 5.3.37 through 5.3.39, small cracks appeared on the marble façade at the left side as shown on Figure 5.3.37. No additional seismic subsidence was observed as indicated on Figure 5.3.38. A construction joint in the marble pavement appeared on Figure 5.3.39 to have opened at the back of the monument after the event, based on reports of the Pallacio's security staff.



Figure 5.3.38 Pallacio de Bellas Artes Building 4: left and right of front side with no additional soil subsidence observed after the 2017 earthquake (Coordinates: 19.435278, -99.14111).

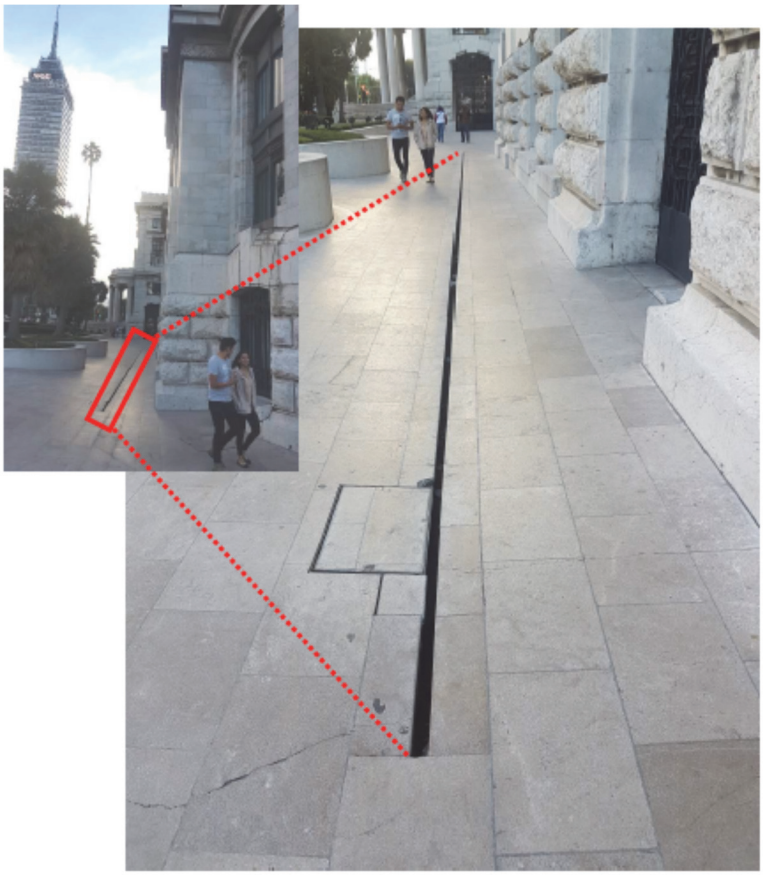


Figure 5.3.39 Open joint at back side of Pallacio Building 4 (Coordinates: 19.435278, -99.14111).

5.4 Site Response

5.4.1 General

As discussed in Chapter 3, Mexico City is essentially the bed of now-extinct lakes, which forms a closed basin surrounded by mountains. The old lakebed is now covered by urban development and consists of clay sediments with high water content and varying thickness from 20 m (close to the hilly zone) to 120 m (at the Tlahauc region at the southern part of the lake). The 3D geomorphology of the Mexico City basin (Figure 5.4.1) is essential in evaluating the soil response at the surface (Arroyo et al., 2013; Flores-Estella et al., 2006; Aviles & Perez-Rocha, 1998; Chavez-Garcia & Bard, 1994; Sanchez-Sesma et al., 1993).

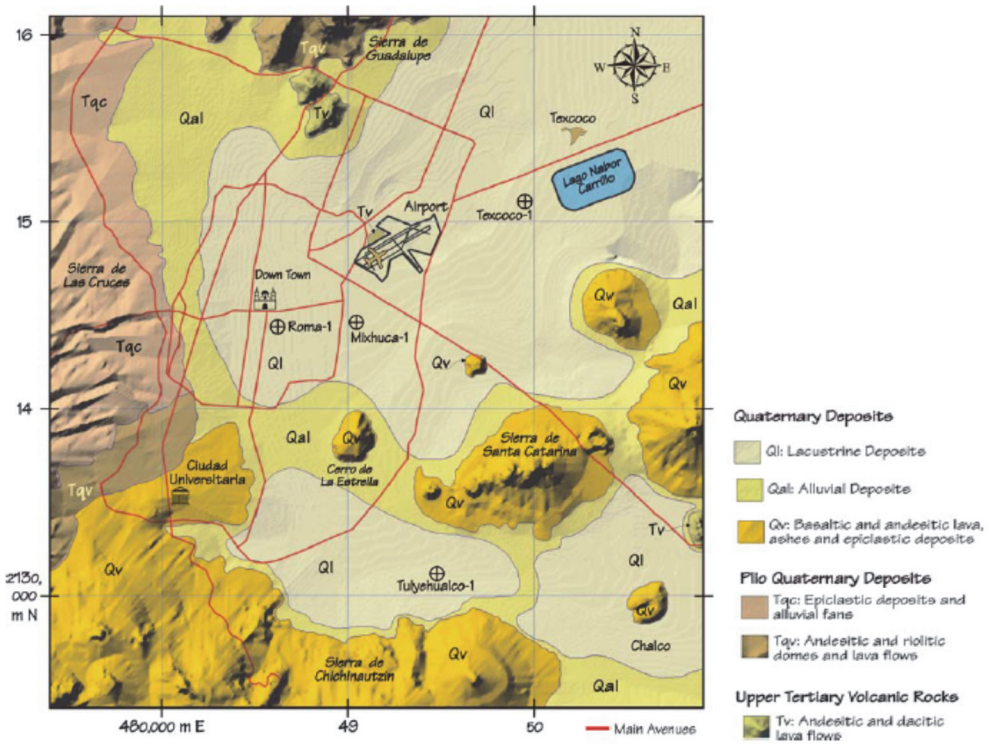


Figure 5.4.1 Digital elevation model and Mexico geology (Flores-Estrella, 2004; Flores-Estrella et al., 2006).

For a preliminary estimation of the soil response the one-dimensional (1D) equivalent-linear amplification theory is applicable for the regional soils and ground motions. This section presents results from 1D site response analyses using the program SHAKE2000 (Schnabel et al., 1972) and the soil profile modeled by horizontal layers ending at a halfspace as discussed earlier in the chapter. Each layer is homogeneous and isotropic and its dynamic behavior is described with G-γ, ξ-γ curves available from the literature for the regional soils.

Three simplified, generic profiles were analyzed based on the thickness, H, of the Mexico Clay within the extent of the city, as shown on the geologic section of Figure 5.4.2. The H = 25 m profile corresponds to the upper depth limit for the Transition Zone (see Section 5.2), whereas the H of 30 and 40 m are within the Lake Zone. Each soil profile is characterized by a homogeneous clay layer with properties of: Plasticity Index, PI = 200÷300; specific unit weight, γ = 12 kN/m^3; and mean shear wave velocity, V_S = 80 m/s.

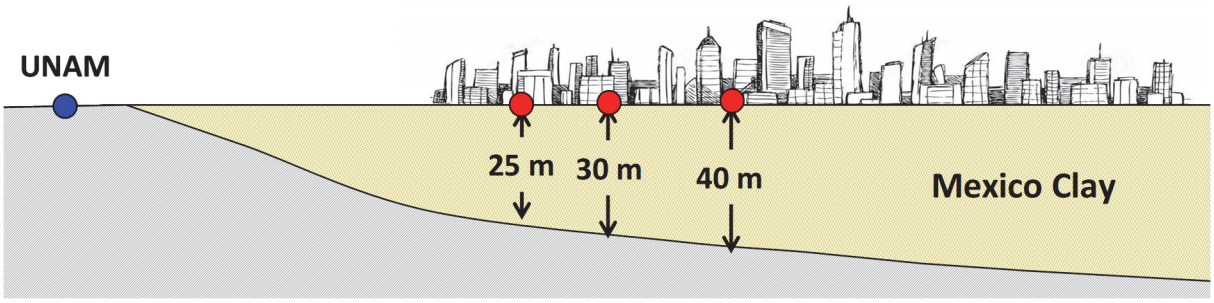


Figure 5.4.2 Three generic soil profiles analyzed with soft clay thickness H of 25; 30; and 40 m.

The nonlinear dynamic behavior of clay is approximated by the G-γ, ξ-γ curves of Vucetic and Dobry (1991) for PI of 200 as shown in red on Fig. 5.4.3.

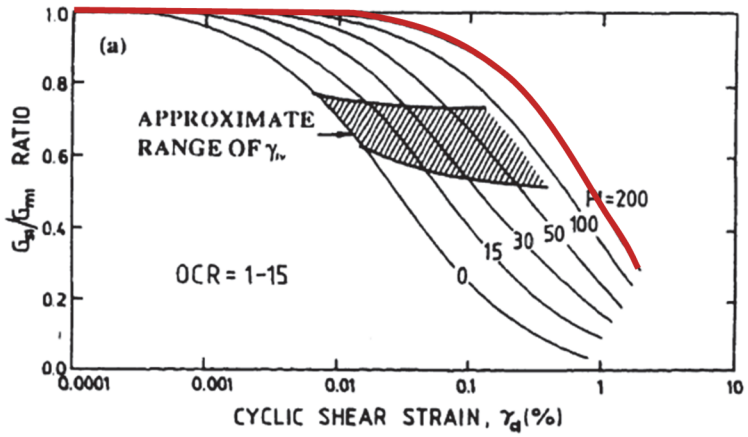


Figure 5.4.3 Vucetic & Dobry (1991) shear strain G-γ and damping ξ-γ curves, for different plasticity indices PI. The Mexico City clay is simulated using the PI = 200 curves shown in red.

The earthquake input was taken as the bedrock outcrop, which could be taken by several recording stations on the Hilly Zone. The UNAM record was chosen for the 1D analyses, with the assumption that the outcrop motion is not much different with the bedrock motion.

5.4.2 *Response of Typical Soil Profiles*

The earthquake response at the ground surface of the three typical soil profiles with soft clay thickness, H, of 25, 30, and 40 m to the 2017 UNAM record used as excitation at the rock outcrop was calculated. Figure 5.4.4 shows the acceleration (A) time history and response spectrum (SA) at the ground surface for H = 25 m (in red), excited by the UNAM motion (in blue). The Peak Ground Acceleration (PGA) at the base is 0.05g and is amplified 3 times at the ground surface with PGA of 0.15g. This soil profile had an elastic period of 1.25 seconds that was elongated to 1.4 seconds by the end of the shaking; evidence of soil nonlinearities.

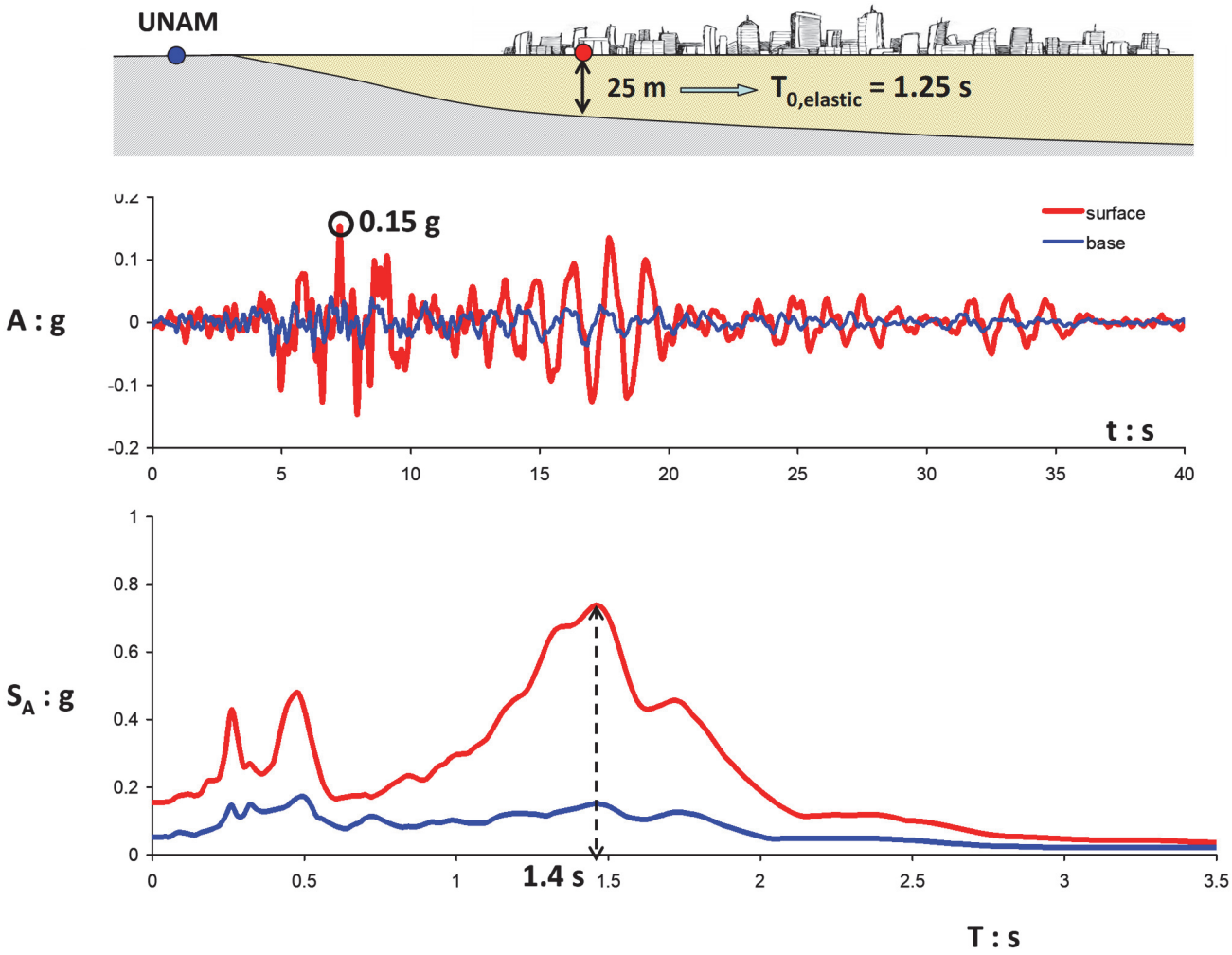


Figure 5.4.4 Soil response of the H = 25 m soil profile: acceleration and response spectra at the rock outcrop (blue lines) and the ground surface (red lines).

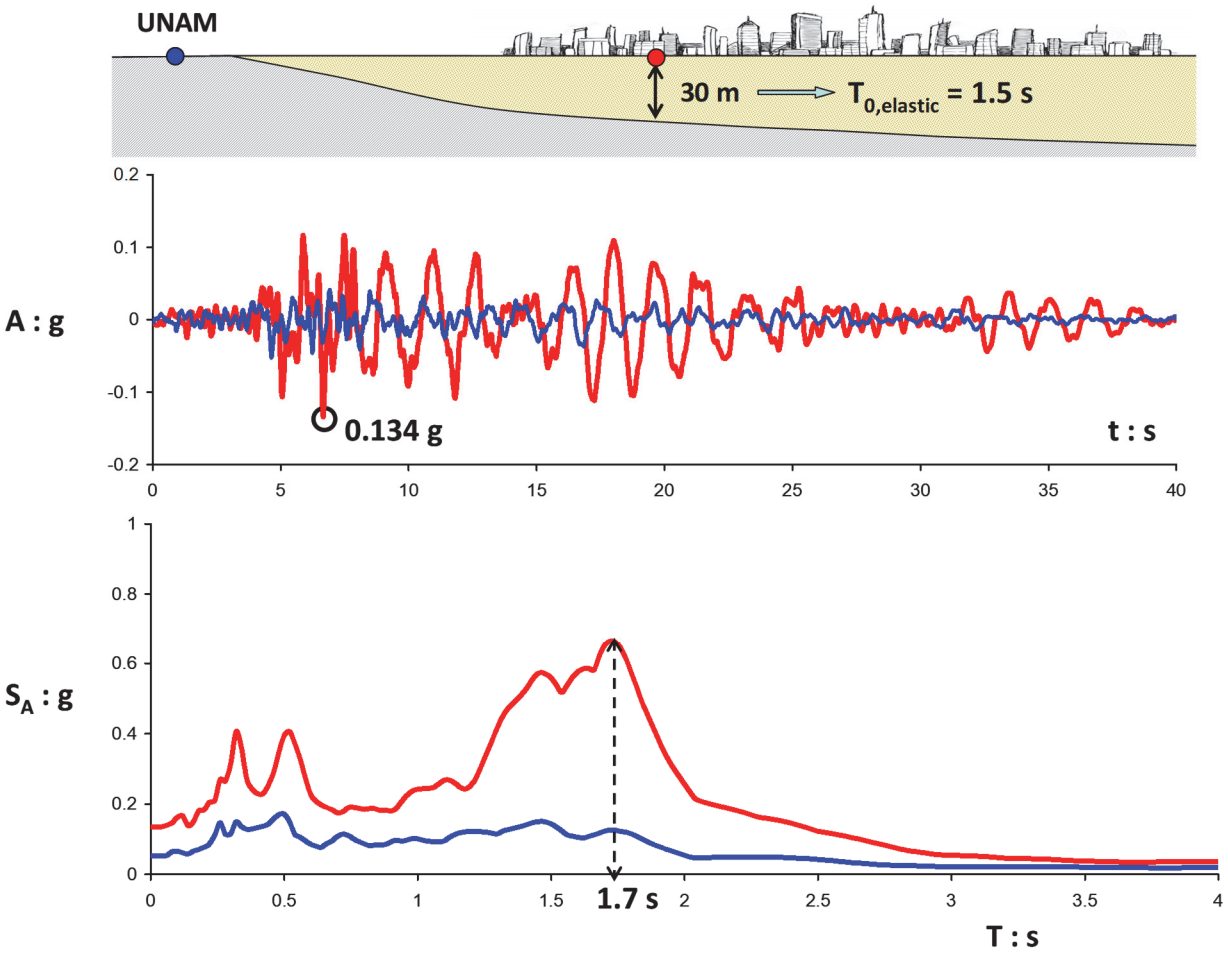


Figure 5.4.5 Soil response of the H = 30 m soil profile: acceleration and response spectra at the rock outcrop (blue lines) and the ground surface (red lines).

Figure 5.4.5 presents the surface response for the profile with H = 30 m that amplified the PGA from 0.05g at the base to 0.134g. The predominant soil period increased from the initial elastic value of 1.5 seconds to 1.7 seconds. For the deeper soil profile with H = 40 m – representative of the SCT site - the PGA on the surface is 0.09g and the predominant site period became 2.2 sec from the elastic value of 2.0 sec (Fig. 5.4.6).

A trend appears to be that as the clay depth increases, the corresponding response on the ground surface decreases. Therefore, for the 2017 earthquake, it is not the deeper sites of the Mexico City lake that exhibit the higher PGAs, but rather the ones located in the transition zone (with H = 10 to 25 m). A summary plot with all acceleration response spectra is given in Figure 5.4.7.

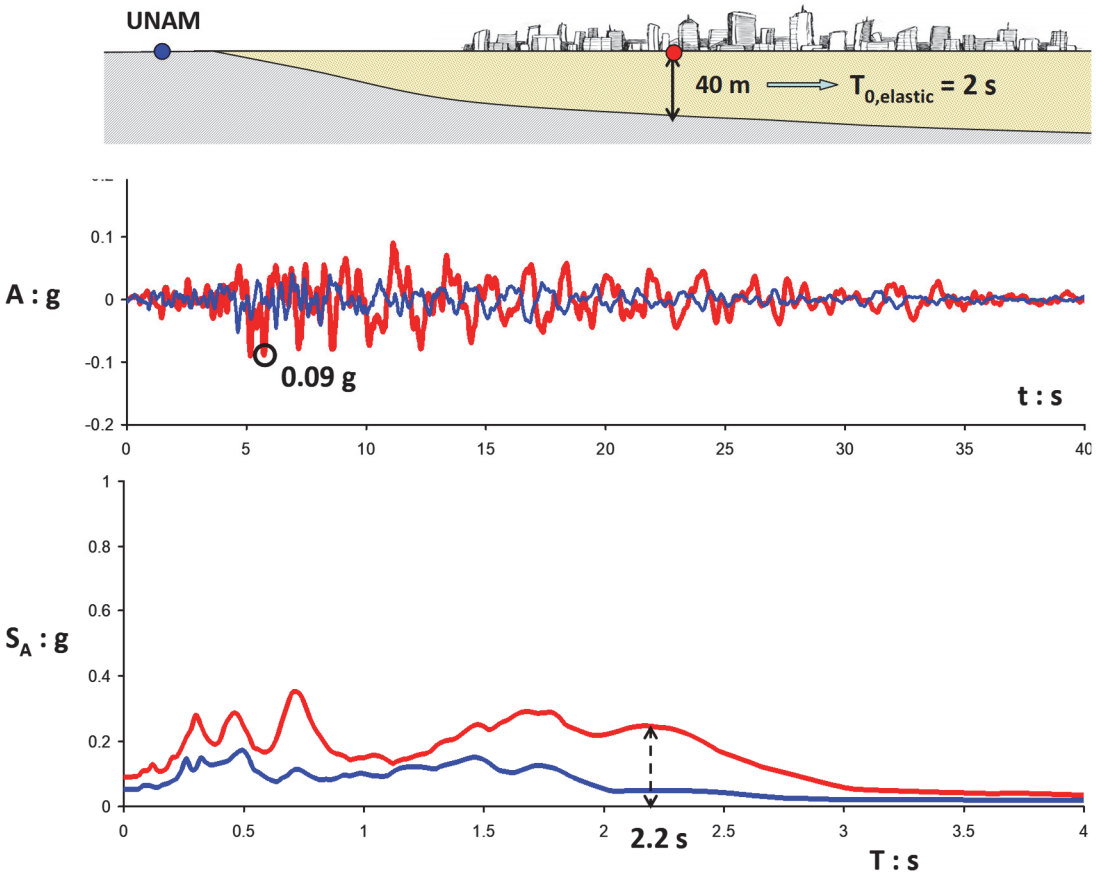


Figure 5.4.6 Soil response of the H = 40 m soil profile: acceleration and response spectra at the rock outcrop (blue lines) and the ground surface (red lines).

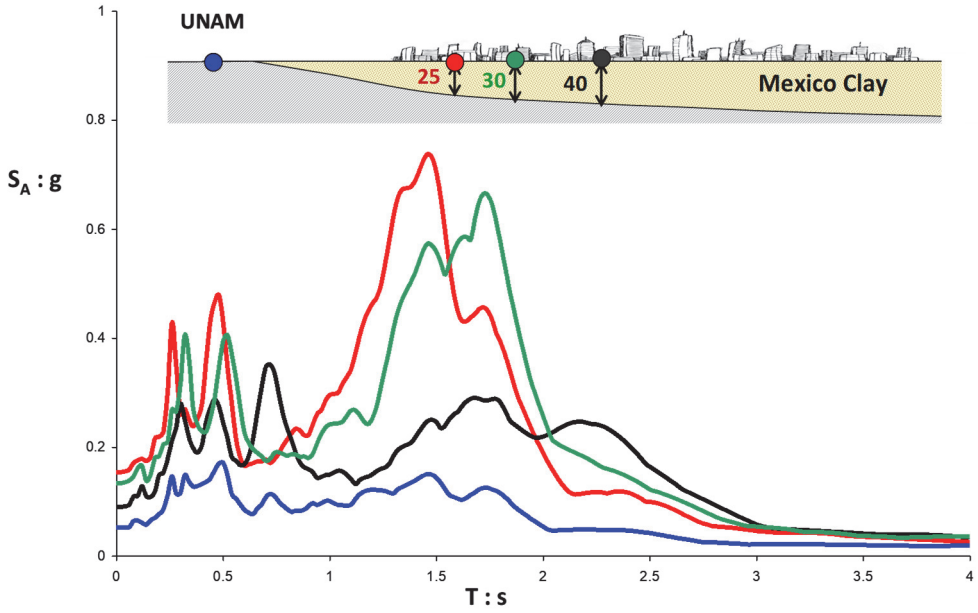


Figure 5.4.7 Acceleration response spectra of the: 2017 recorded UNAM motion (in blue), and surface response of a soft clay profile with thickness H of 25 m (red), 30 m (green), and 40 m (black).

5.4.3 Comparisons with the 1985 Michoacán Earthquake

A comparison of the recorded and calculated ground motions between the 2017 Puebla-Morelos and 1985 Michoacan earthquakes was prepared. Figure 5.4.8 presents the acceleration time histories recorded at the ground surface at the SCT site during the two events on top of a 40-m thick clay profile. The PGA recorded in the 1985 event is 0.2g, two times the PGA calculated for the 2017 event that overall exhibits lower acceleration levels throughout the 40 seconds of motion. Similarly, the corresponding response spectra of Fig. 5.4.9 show higher spectral response in the 1985 event.

For the profile with H = 25 m, the 1985 SCT recorded accelerogram is similar to the computed one using the 2017 UNAM recorded rock motion (Figs 5.4.10 and 5.4.11), with PGAs of 0.2 and 0.15 g for 1985 and 2017, respectively, and overall shape of acceleration pulses. This can be attributed to the shorter predominant soil period for this shallower profile.

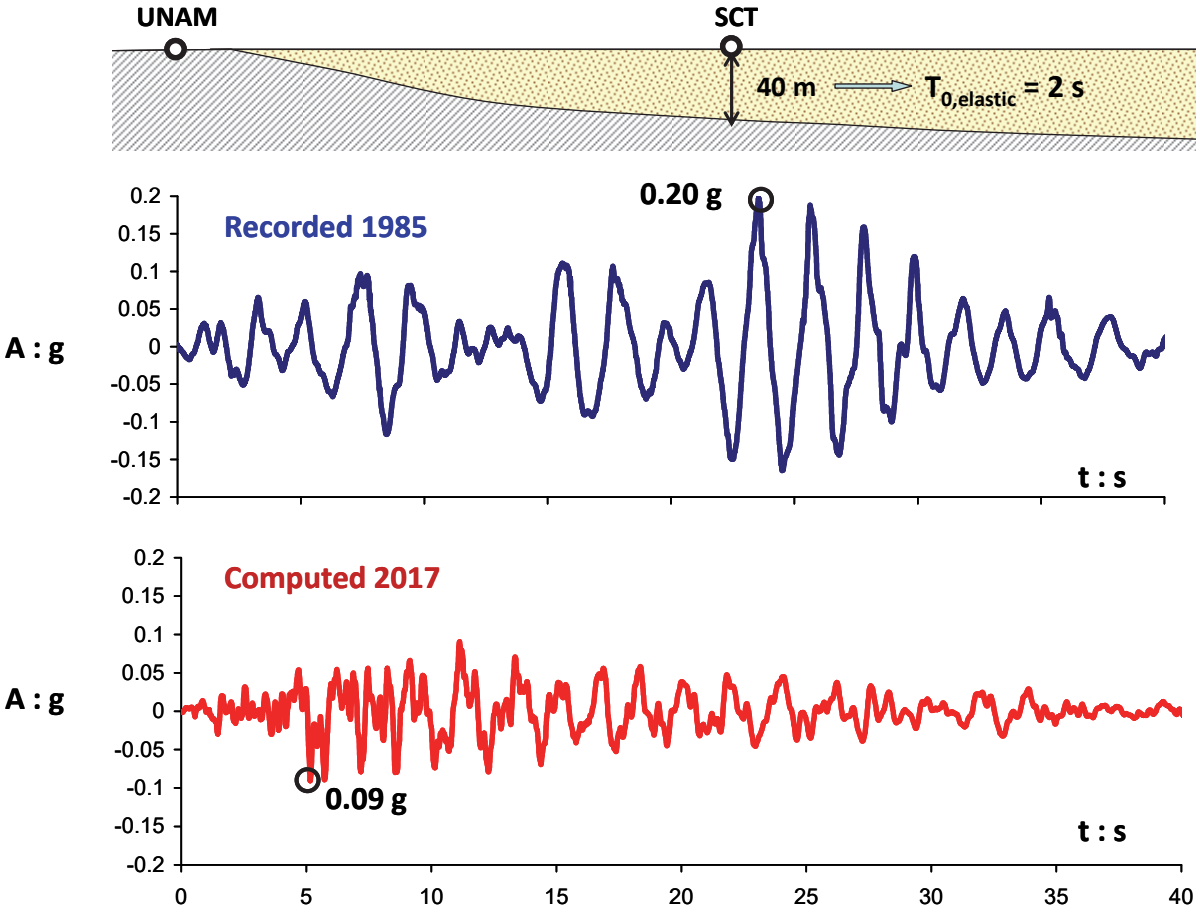


Figure 5.4.8 Comparison of surface acceleration time histories at the SCT station: recorded in the 1985 Michoacan earthquake (top) and computed for H = 40 m subjected to the 2017 UNAM record.

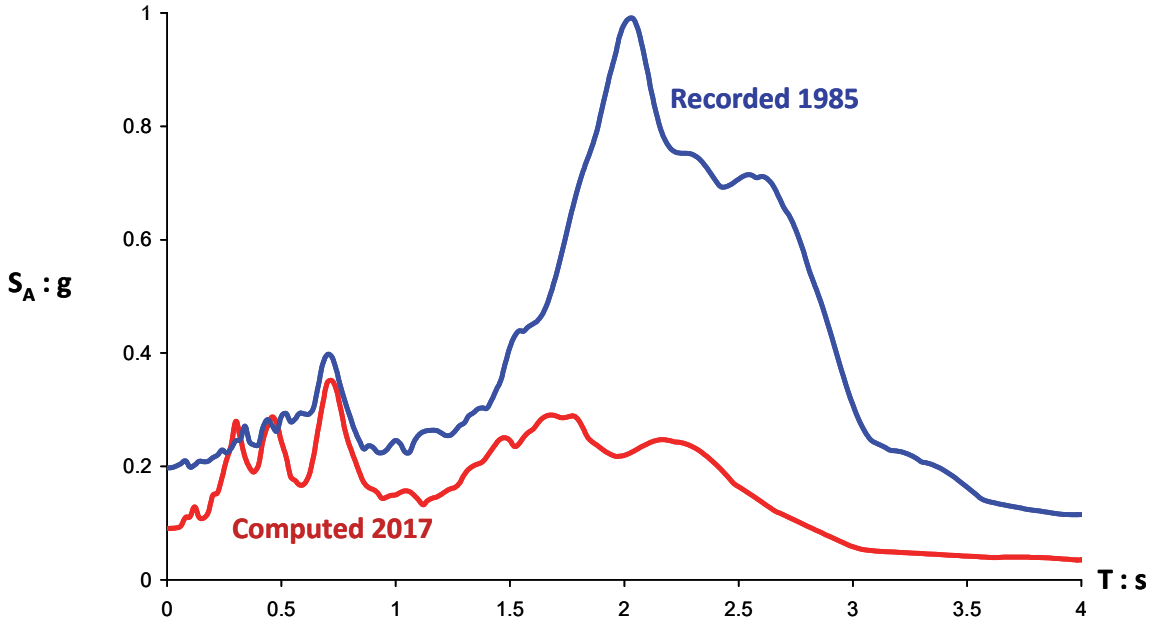


Figure 5.4.9 Acceleration response spectra of: (a) recorded SCT motion in the 1985 earthquake and (b) computed response on top of a 40-m clay soil profile to the 2017 UNAM recorded motion.

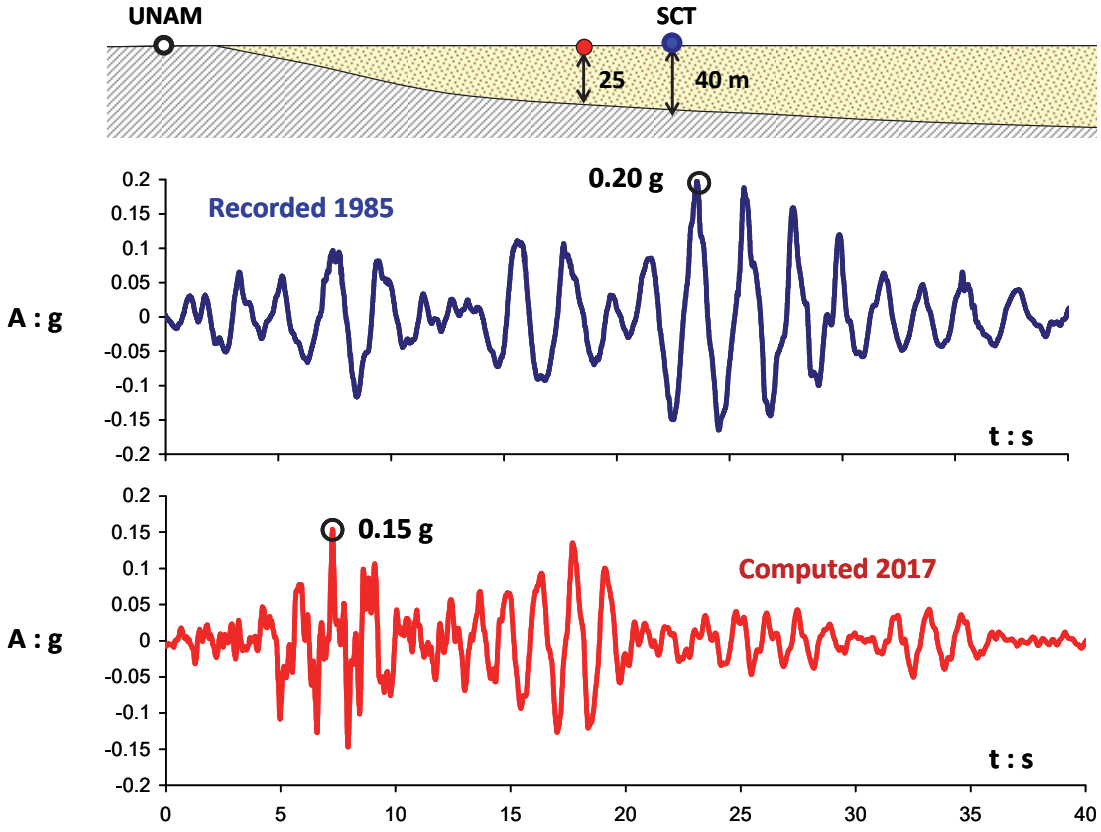


Figure 5.4.10 Comparison of surface acceleration time histories at the SCT station: recorded in the 1985 Michoacan earthquake (top) and computed for H = 25 m subjected to the 2017 UNAM record.

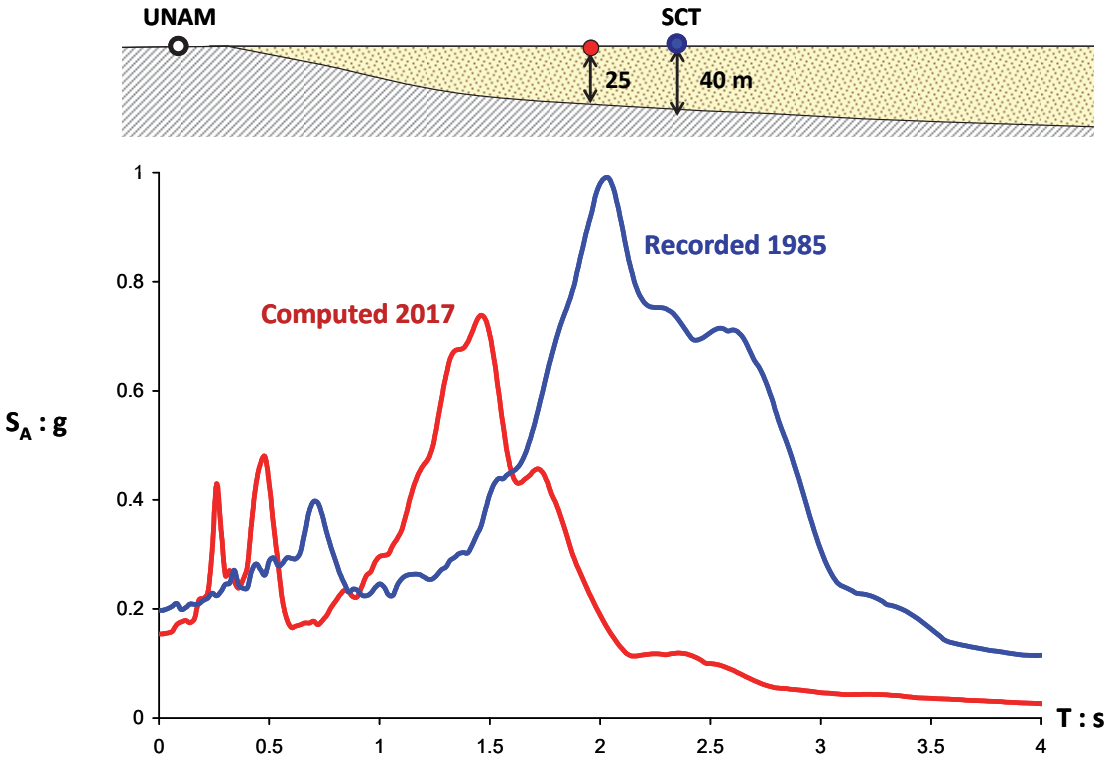


Figure 5.4.11 Acceleration response spectra of: (a) recorded SCT motion in the 1985 earthquake and (b) computed response on top of a 25-m clay soil profile to the 2017 UNAM recorded motion.

The ground motion comparison supports the 2017 observation of minor damage in sites with clay thickness around 40 m - a vast contrast with the 1985 response at those locations, as shown on the collapsed buildings map of Fig. 5.4.12 (Mayoral et al., 2017). Most of the collapsed buildings were within Zone IIIb at the northwestern part of the city center (H = 20 to 35 m) in 1985, and within Zone IIIa west of the city center (H = 10 to 35 m) in 2017, as per the zoning of the 2004 Mexico City Building Code (NTCS, 2004).

The simplified 1D amplification study clearly points to the transition zone with clay thickness of 10-35 m as the likely most affected area during the 2017 earthquake is the transition zone with clay thickness of 10-35 m, and not the region of the deeper lake deposits.

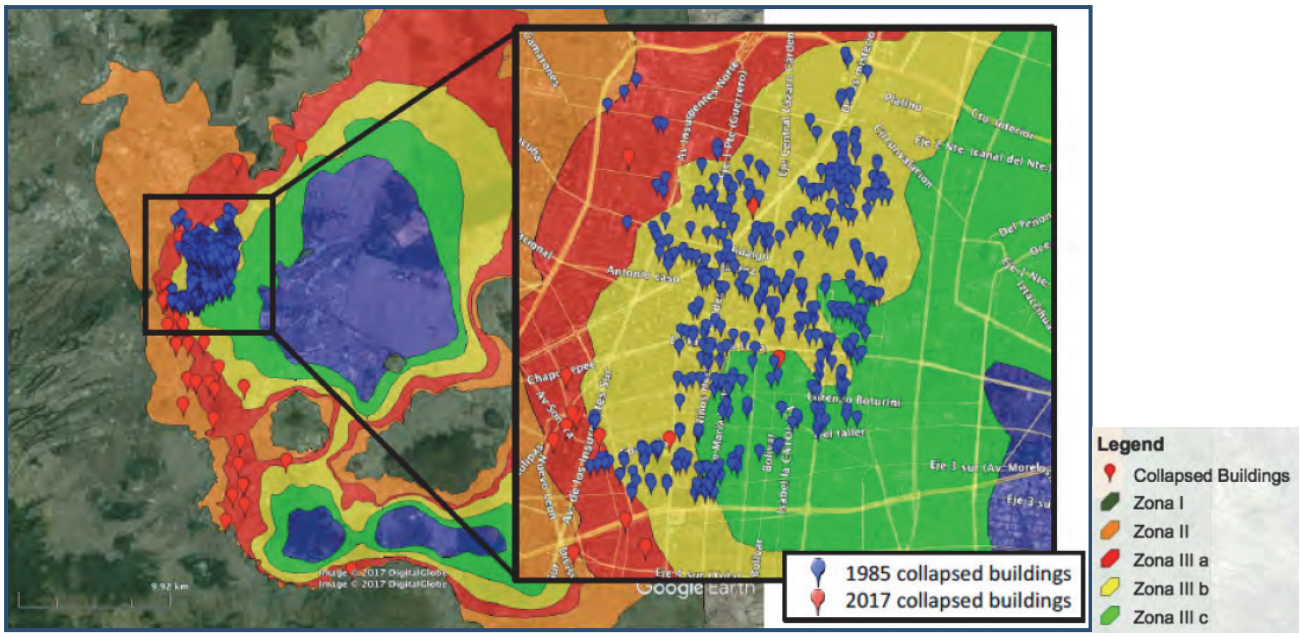


Figure 5.4.12 Collapsed buildings in Mexico City in the 1985 M_w8.1 Michoacán (blue) and 2017 M_w7.1 Puebla-Morelos (red) earthquakes overlaid on the NTCS (2004) zoning (Mayoral et al., 2017).

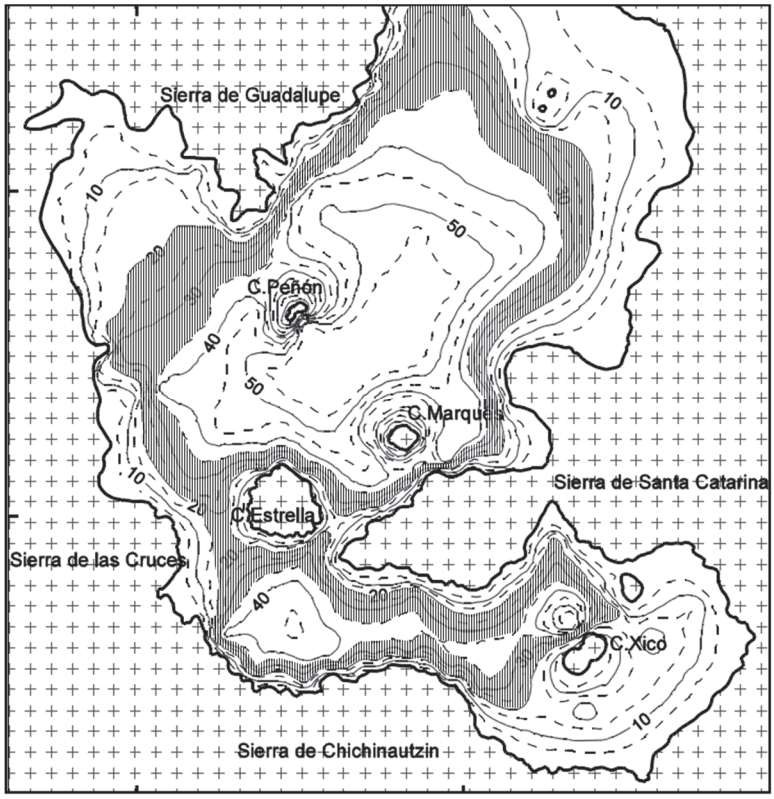


Figure 5.4.13 Contours of equal thickness of the compressible strata in the Mexico City lake zone (Martínez González, 2015) with hatching of the area of expected high soil response in ATC studies.



Figure 5.4.14 Building collapse and severe damage observed by the Mexican CICM (2017).

The hatched area on Fig. 5.4.13 is the zone where peak soil response is predicted agrees with the pattern of buildings with severe damage (called "high-risk") or collapse (Fig. 5.4.14) reported by the Federación de Colegios de Ingenieros Civiles de Mexico (CICM) overlaid on Figs. 5.4.15 and 5.4.16 (Mayoral et al., 2017).

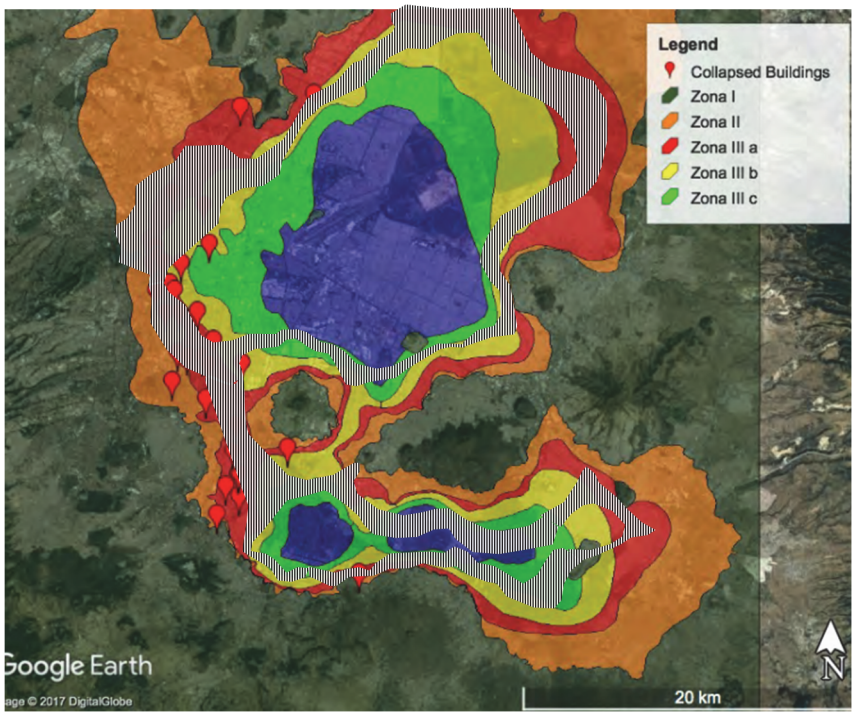


Figure 5.4.15 Collapsed buildings in Mexico City (Mayoral et al., 2017) overlaid by the ATC-predicted hatched area of maximum soil spectral response.

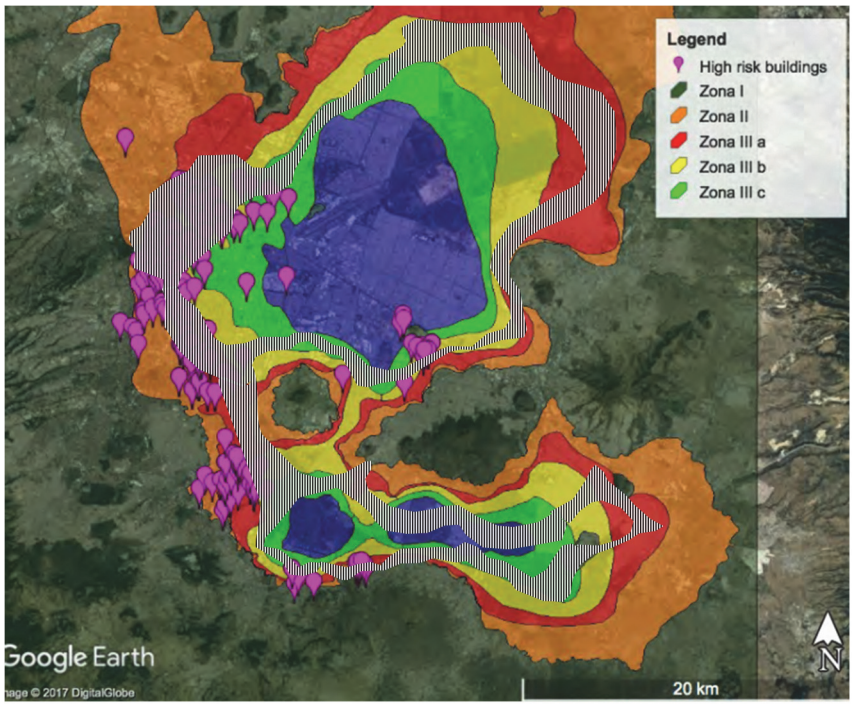


Figure 5.4.16 High-risk buildings in Mexico City (Mayoral et al., 2017) overlaid by the ATC-predicted hatched area of maximum soil spectral response.

Chapter 6
Structural Observations

6.1 Reconnaissance Activities

6.1.1 Reconnaissance Observations

The mission of the ATC reconnaissance team was to collect data in areas of Mexico City that were affected by the Puebla earthquake on September 19, 2017. The buildings of interest included damaged and collapsed buildings, as well as undamaged buildings. Figure 6.1.1 shows the location of each of the 70 buildings presented in this chapter.

Most of the buildings in Mexico City have a similar construction type: reinforced concrete frames with unreinforced masonry (URM) infill walls. Due to the lack of a robust lateral load resisting system, the URM walls contributed to the lateral resistance against earthquake loads and sustained significant damage in the process. This structural system represents the majority of buildings inspected by the team. Variations include reinforced concrete flat slabs supported on concrete columns or waffle slabs supported on concrete columns, with URM infill. Many of the buildings observed also have a strong direction with many infill walls (typically perpendicular to the street where there are few windows) and a weaker transverse direction with few infill walls (typically parallel to the street where there are windows).

Other structural systems observed included steel structures, concrete structures with shear walls, and URM structures. Some structures had innovative seismic resistant systems that were of interest to note.

The majority of buildings in Mexico City are between three to twelve stories tall, but the height range of buildings observed varied from two story to over twenty story. Table 6.1.1 summarizes basic information for each of the 70 buildings.

In Section 6.2, buildings are categorized into groups for ease of identification based on level of damage as well as structural characteristics. Additionally, buildings are grouped based on areas of potential future work.

Section 6.3 presents a description of the structural system, existing damage or retrofit conditions after the 1985 earthquake if applicable, damage and

observations after the 2017 earthquake, discussion, and recommendations for all of the 70 buildings observed by the ATC team. The level of observations for each building varied since access to buildings varied (exterior only vs. exterior and interior).

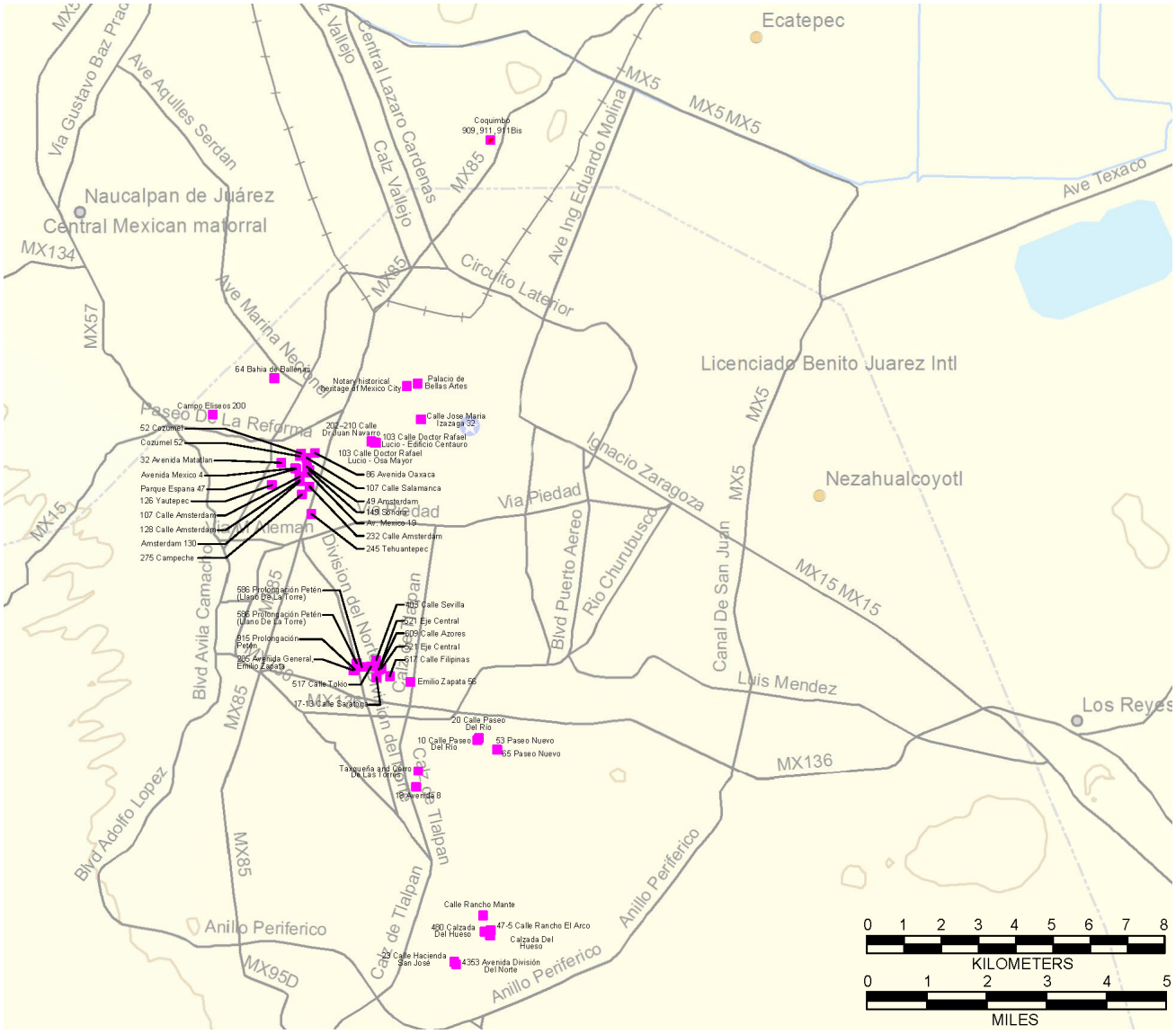


Figure 6.1.1 Map showing location of buildings observed by the ATC team.

Table 6.1.1 Summary of Building Observations

ID	Name	Structural System	Level of Damage	# of Stories	Year Built	Evacuated	Tag
1	4 Ave Mexico	Irregular shape, reinforced concrete frame with URM walls	No significant structural/nonstructural damage from exterior. Evacuated.	10	Unknown	Yes	4
2	*4 Minatitlan	Reinforced concrete frame with URM walls	Severe nonstructural and moderate structural damage.	6	1976-1978	Yes	3
3	8 San Antonio Abad	Reinforced concrete frame with waffle slab with URM walls	Moderate nonstructural and structural damage	13	Unknown	Yes	3
4	10 Calle Paseo Del Rio	Irregular shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	9	Early 1980's	Yes	3
5	*11 Ave Mexico	Irregular shape, reinforced concrete frame with URM walls	Moderate to severe structural and nonstructural damage	8	Unknown	Yes	3
6	15 Calle Hacienda San Jose	H-shape, reinforced concrete frame with URM walls	Severe structural damage	5	Early 1980's	Yes	3
7	*18 Avenida 8 (Tlalpan Comunidad)	Reinforced concrete frame with URM walls	Severe structural and nonstructural damage and building collapse	5-6	1957	Yes	3
8	*19 Ave Mexico	Reinforced concrete frame and concrete shear walls	Moderate structural and nonstructural damage	15	Unknown	Yes	3
9	*20 Calle Ozuluama	Irregular shape, reinforced concrete frame with URM walls	Moderate to severe structural and nonstructural damage	6	Unknown	Yes	3
10	20 Calle Paseo del Rio	Reinforced concrete frame with URM walls	Moderate nonstructural damage	6	Unknown	Yes	3
11	32 Calle Rancho El Arco	Reinforced concrete frame with URM walls	Collapse	6	Unknown	Yes	3
12	32 Mazatlan	C-shape, reinforced concrete frame with URM walls	Minor nonstructural damage	6	Unknown	Unknown	4
13	38 Jose Maria Izazaga	Reinforced concrete frame with waffle slab with URM walls	Moderate nonstructural damage	12	Unknown	Yes	4
14	*47 Parque España	Reinforced concrete slab and bearing walls, with steel columns	Moderate structural and nonstructural damage	7	2006	Yes	2
15	49 Amsterdam	Unknown	Minor damage	11	Unknown	No	4
16	*52 Cozumel	Reinforced concrete frame with URM walls, with existing retrofits after 1985	Moderate to severe structural and nonstructural damage	10	Pre-1985	Yes	3

*Buildings were entered

Table 6.1.1 Summary of Building Observations (continued)

ID	Name	Structural System	Level of Damage	# of Stories	Year Built	Evacuated	Tag
17	*53 Iztaccihuatl	H-shape, reinforced concrete frame with URM walls	Moderate to severe nonstructural damage	9	Unknown	Yes	2
18	53 Paseo Nuevo	Irregular shape, reinforced concrete frame with URM walls	Moderate to severe nonstructural damage	6	Unknown	Yes	4
19	56 Ave Mexico	L-shape, reinforced concrete frame with URM walls	Moderate nonstructural damage	9	Unknown	Unknown	4
20	56 Eje Central Lazaro Cardenas	Building under construction with steel X_braces	No damage	15+	Current construction	Not applicable	1
21	56 Emilio Zapata	Reinforced concrete frame with URM walls	Collapse	7	2017	Yes	3
22	*64 Bahia De Ballenas	L-shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	6	1982	Yes	3
23	65 Paseo Nuevo	Irregular shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	8	1972	Yes	3
24	66 Calz. San Antonio Abad	Reinforced concrete frame with URM walls and possible concrete shear walls	Minor nonstructural damage observed from exterior only	12	2016	No	1
25	86 Oaxaca	Reinforced concrete frame with URM walls with possible past retrofit	Minor to severe damage	7	1986	Unknown	2
26	99 Av Mexico	Irregular (rounded) shape, reinforced concrete frame with URM walls	Minor nonstructural damage	6	Unknown	Unknown	2
27	104 Calle Salamanca	Building of unknown structural system with post tensioned diagonal braces	Minor damage	12	Unknown	No	1
28	105 Ave Mexico	Irregular shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	6	Unknown	Yes	3
29	107 Calle Amsterdam	Corner, L-shape, reinforced concrete frame with URM walls	Collapse	9	Unknown	Yes	3
30	117 Av Mexico - Edificio Sagor	Irregular shape, reinforced concrete frame with URM walls	Severe nonstructural damage	7	Unknown	Yes	3
31	122 San Antonio Abad	Reinforced concrete frame with URM walls, and concrete shear walls + column retroffits	Partial collapse and severe nonstructural and structural collapse	9	Pre-1985	Yes	3
32	124 Calle Amsterdam	Reinforced concrete frame with URM walls	Severe structural and nonstructural damage	7	Unknown	No	2
33	*126 Yautepec	Reinforced concrete frame with URM walls	No damage	4	Unknown	No	1
34	*128 Amsterdam Avenue	Reinforced concrete frame with URM walls	Moderate to severe structural and nonstructural damage	6	Unknown	Yes	2
35	*130 Amsterdam	Reinforced concrete frame with URM walls, and concrete shear walls	Minor nonstructural damage	6	2002	No	1

*Buildings were entered

Table 6.1.1 Summary of Building Observations (continued)

ID	Name	Structural System	Level of Damage	# of Stories	Year Built	Evacuated	Tag
36	*132 Calle Atlixco	Reinforced concrete frame with URM walls	Minor nonstructural damage	5	Unknown	No	1
37	141 Avenida Sonora	Reinforced concrete frame with URM walls	Moderate nonstructural damage	14	Unknown	Unknown	4
38	143 Medellin	Reinforced concrete frame with URM walls	Moderate to severe structural and nonstructural damage	20	Unknown	No	2
39	149 Avenida Sonora	Irregular shape, reinforced concrete frame with URM walls	Partial collapse	8	Unknown	Yes	3
40	158 Avenida Emperadores	Reinforced concrete frame with URM walls	Minor damage	8	Unknown	Unknown	4
41	162 Avenida Sonora	Reinforced concrete frame with URM walls	Severe structural damage	10	Unknown	Yes	3
42	*187 Camino Santa Teresa	Reinforced concrete frame with URM walls and possible concrete shear walls	No damage	2	Unknown	No	1
43	*200 Campos Eliseos	Reinforced concrete frame with URM walls and possible concrete shear walls	Minor nonstructural damage	25	2014	No	1
44	*224 Avenida Emperadores	Irregular shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	6	1975	Yes	3
45	*232 Calle Amsterdam	C-shape, reinforced concrete frame with URM walls	Severe structural and nonstructural damage	9	Unknown	Yes	3
46	245 Tehuantepec	C-shape, reinforced concrete frame with URM walls	Minor nonstructural damage	5	Unknown	Yes	4
47	275 Campeche	Reinforced concrete frame with URM walls	Moderate to severe structural and nonstructural damage	5	Unknown	Yes	3
48	285 Avenida General	Reinforced concrete frame with URM walls	Moderate structural damage	4	Unknown	Yes	4
49	405 Calle Seville	Irregular shape, reinforced concrete frame with URM walls	Severe nonstructural damage	5	Unknown	Yes	3
50	480 Calzada Del Hueso	Corner, reinforced waffle concrete slab supported on concrete columns	Collapse	8	Late 1980's	Yes	3
51	517 Calle Tokio	Reinforced concrete frame with URM walls, (x3) similar buildings	Collapse	5	1982	Yes	3
52	519 Calzada Del Hueso	Concrete and steel structural system combination	Minor nonstructural damage at exterior	2	Late 1980's	Yes	4

*Buildings were entered

Table 6.1.1 Summary of Building Observations (continued)

ID	Name	Structural System	Level of Damage	# of Stories	Year Built	Evacuated	Tag
53	521 Eje Central	Reinforced concrete frame with URM walls, and concrete shear walls	Minor nonstructural damage observed from exterior	8	Current construction	Not applicable	4
54	586 Prolongacion Peten	Triangular, reinforced concrete frame with URM walls	Severe nonstrutural damage/collapse	4	Unknown	Yes	3
55	*609 Calle Azores	Reinforced concrete frame with URM walls	Severe damage	5	Unknown	Yes	3
56	617 Calle Filipinas	Reinforced concrete frame with URM walls	Moderate to severe nonstrutural damage	6	2009	Yes	3
57	714 Calle Saratoga	Irregular shape, reinforced concrete frame with URM walls	Collapse	5	Unknown	Yes	3
58	911 Coquimbo	Reinforced concrete frame with URM walls	Collapse	7-8	1983	Yes	3
59	915 Prolongacion Peten	Reinforced concrete frame with URM walls	Collapse	7	Unknown	Yes	3
60	1171 Calzada de Tlalpan	H-shape, reinforced concrete frame with URM walls	Minor to moderate structural and nonstructural damage	11	1970	No	2
61	2050 Calz. de Tlalpan	Steel structure with tall story height	Partial collapse	1	Unknown	Yes	3
62	2065 Canal de Miramontes	Reinforced concrete frame with URM walls with flat plate roof canopy	Partial collapse	2	Unknown	Yes	3
63	4353 Avenida Division Del Norte	Reinforced concrete frame with URM walls	Severe nonstructural damage	5	Early 1980's	Yes	3
64	Centauro	Connected L-shapes, reinforced concrete frame with URM walls	Severe structural and nonstructuraldamage	16	1969	Yes	3
65	*Osa Mayor	Connected L-shapes, reinforced concrete frame with URM walls	Severe structural and nonstructuraldamage	16	1969	Yes	3
66	Colegio Bilingue Heroes	Reinforced concrete frame with URM walls	Minor observations	Varies	Unknown	No	4
67	Jardin Guadalupe Servin De La Mora	Irregular shape, reinforced concrete frame with URM walls	Minor observations	Varies	Unknown	Unknown	4
68	Iglesia Fatima	Reinforced concrete frame with URM walls	Moderate to severe damage	-	1972	Unknown	4
69	Notary historical heritage of Mexico	Unknown	Moderate to severe damage	2-3	Unknown	No	4
70	Palacio De Bellas Artes	Unknown	Minor observations	-	1934	No	4

*Buildings were entered

6.2 Further Case Studies

6.2.1 Summary of Building Observations

The ATC team collected information on 70 buildings during the mission. The degree of detail in the observations described in Section 6.3 depends on the access to each building. The team had interior access to 21 buildings, which were observed in detail. Others were observed from the exterior due to limited access, and some buildings were only observed in passing but were identified because they expand the body of knowledge available on the overall performance of buildings in Mexico City.

The level of structural damage observed ranged from no damage, cosmetic nonstructural damage, severe nonstructural damage (including cracking and collapse of unreinforced masonry infill walls), cracking and spalling in the concrete structural elements, plastic hinging of concrete columns, pounding and leaning, local failures of vertical load carrying elements, column and story partial collapse, and complete structural collapse. Additionally, sidewalk detachment, translation, and settlement were also observed.

In addition, the team instrumented and monitored 5 buildings to collect structural dynamic properties. Ground motion records near all building sites are discussed in Chapter 3 and presented in Appendix A, and not specifically mentioned for each building.

6.2.2 Potential Case Studies

Case studies of specific buildings will aid in the development of new methodologies or benchmark existing methods. The following sections categorize buildings into the following descriptive groups for ease of identification.

1. Instrumented buildings
2. Buildings with minor damage
3. Buildings with moderate to severe damage
4. Buildings located at the street corner
5. Buildings with innovative lateral load resisting systems
6. Buildings with partial or complete collapse
7. Buildings with plan irregularities

Furthermore, the buildings are categorized based on areas of potential future work. (Note: a building can be listed in more than one category if they fit the description of multiple categories.)

8. Buildings that can be monitored long term
9. Buildings suitable for additional soil studies
10. Buildings suitable for additional ground motion studies
11. Buildings suitable for retrofit studies
12. Buildings suitable for FEMA P-2018 studies
13. Buildings suitable for ATC-134 studies
14. Buildings that are not of any interest for future studies

For each category, a summary of potential future work is presented below. The individual building reports in Section 6.3 contain additional discussions and recommendations specific to each building.

6.2.2.1 Instrumented Buildings

The following five buildings were instrumented; refer to Chapter 4 for more information:

- Site #8, 19 Ave Mexico
- Site #14, 47 Parque España: Structural drawings are available for this building..
- Site #16, 52 Cozumel
- Site #35, 130 Amsterdam
- Site #43, 200 Campos Eliseos: This building was only instrumented at one floor.

6.2.2.2 Buildings with Minor Damage

There are some buildings that experienced cosmetic or minor damage. The characteristics of these buildings are presented below. Even though the information for some of these buildings is limited, they are recommended for further research and studies.

- **Site #1, 4 Ave Mexico:** This building has typical characteristics such as a courtyard in the middle, and URM infill masonry in most of the exterior faces. Also, it has an irregular plan shape, it is positioned in the corner and is located in the transition zone.
- **Site #5, 11 Ave Mexico:** This building has plan irregularity and it is positioned in the street corner. This structure is of interest since it did not experience major damage to the exterior masonry walls, unlike other buildings of similar construction.

- **Site #66, 15 Calle Hacienda:** This building has limited data but if more data can be obtained, it would be of interest to investigate the lateral load resisting system and the exterior wall construction since there was minor damaged observed from the exterior.
- **Site #24, 66 Calz. San Antonio Abad:** This would be an interesting building to study because it has typical building construction, is located in the street corner, but only sustained minor damage.
- **Site #33, 126 Yautepec:** This building is a good candidate for further studies because it sustained less damage than expected, compared to other structures of similar characteristics.
- **Site #36, 132 Calle Atlixco:** This building might be a potential candidate for future studies because it suffered minor damage despite the vulnerabilities (corner position and URM exterior walls).
- **Site #37, 141 Avenida Sonora:** This building might be a potential candidate for future studies because it suffered minor damage despite the vulnerabilities (corner position and URM exterior walls).
- **Site #52, 519 Calzada Del Hueso:** Since there is limited information about the interior of the mall, the structure is not a good candidate for further individual structural studies. However, a social study can be completed with a focus on community resilience and the effect on closing a large facility on the local economy (at the neighborhood level).

6.2.2.3 Buildings with Moderate to Severe Damage

There are some buildings that sustained moderate to severe damage for which future studies are of interest. The characteristics of these buildings are presented below. Information for some of these buildings is limited.

- **Site #22, 64 Bahia de Ballenas:** Building plan drawings are provided in Section 6.3.22. This is a corner building with plan irregularities that represents some of the typical characteristics of buildings that were damaged during the earthquake. The building is a candidate for further studies focused on torsion and the impact of drift.
- **Site #25, 86 Oaxaca:** A subset of structural drawings are provided in Section 6.3.25.
- **Site #26, 99 Ave. Mexico:** Even though this building is not a good candidate for further ATC studies, it would be of interest to research and study the performance of a building with this quarter-circle plan shape.
- **Site #30, 117 Ave Mexico:** This building is a potential candidate for further studies because it represents the typical plan shape of a building:

long rectangular structure with side and middle courtyards. It would be of interest to complete a study focused on the social/architectural implementation of courtyards and the structural impact on buildings.

- **Site #31, 122 San Antonio Abad:** This building might be a good candidate for future studies.
- **Site #39, 149 Sonora:** This building is a candidate for further studies including a focus on the performance of the cage retrofit solution that had been implemented in this building. It would be of interest to research if any other buildings in Mexico City have had a similar retrofit solution in the past.
- **Site #44, 224 Avenida Emperadores:** The first story of this building was severely damaged. This building can potentially be a candidate for a study focused on the impact of courtyards (building plan openings) on the structural performance of a building.
- **Site #45, 232 Calle Amsterdam:** This building was severely damaged. Access to the interior was granted so the team observed the interior damage in detail. This building can be a potential candidate for further ATC studies, to be focused on structural performance.
- **Site #49, 405 Calle Seville:** Since there is limited information about the building, the structure is not a good candidate for further individual structural studies, unless more information is obtained. However, since the building has a typical plan area, which is composed of a long rectangle with exterior courtyard openings, it would be of interest to gather qualitative information about the performance of these structures in Mexico City.
- **Site #51, 517 Calle Tokio:** These buildings are good candidates for a structural study focused on the collapse probability of each building. If building drawings can be obtained, a full study is recommended to be completed.
- **Site #55, 609 Calle Azores:** A subset of structural drawings are provided in Section 6.3.55. This building is a good candidate for future studies.
- **Site #58, 911 Coquimbo:** These buildings are good candidates for a structural study focused on the collapse probability of each building. If building drawings can be obtained, a full study is recommended to be completed.
- **Site #64, Centauro:** This building is located in the same complex as the building Osa Major (#65). These two buildings had significant damage so it would be of interest to study performance of the remaining

structures that have the same characteristics (plan area, height, and construction type).

6.2.2.4 Buildings Located at a Street Corner

Various buildings that were observed were located in the street corners and the level of damage observed varied. It would be of interest to do a study comparing the behavior of corner buildings throughout the city. The following are potential sites visited that can add to the data collection for such specific potential study.

- **Site #5, 11 Ave Mexico:** This is a corner building with plan irregularity with moderate to severe damage in nonstructural and structural elements.
- **Site #16, 52 Cozumel:** This is a corner building with plan irregularity (L-shape) with moderate to severe damage in nonstructural and structural elements. It had been reinforced before the 2017 earthquake. This building was instrumented.
- **Site #19, 56 Ave Mexico:** This is a corner building with plan irregularity (L-shape). Visible exterior damage is minor and includes spalling of plaster finishes and minor cracking of infill.
- **Site #22, 64 Bahia de Ballenas:** This is a corner building with plan irregularity (L-shape). Visible exterior damage is minor and includes spalling of plaster finishes and minor cracking of infill. A subset of structural drawings are provided in Section 6.3.22.
- **Site #24, 66 Calz. San Antonio:** This is a new corner building. The plan shape is unknown. The structure had minor, cosmetic damage.
- **Site #26, 99 Ave Mexico:** This is a corner building with a plan area that has a quarter-circle shape. Limited information was obtained. No damage was visible in the exterior of the building.
- **Site #28, 105 Ave Mexico:** This is a corner building, with plan irregularity, that was leaning and had severe cracks.
- **Site #29, 107 Amsterdam:** This is a corner building with plan irregularity (L-shape). The building collapsed and had been demolished before the site visit.
- **Site #35, 130 Amsterdam:** This is a corner building with plan irregularity. The building seems to have behaved well during the earthquake since most of the damage observed was cosmetic. This is a newer building constructed in 2002.
- **Site #36, 132 Calle Atlixco:** This is a corner building with a rectangular plan area. There was no visible damage to the structure.

- **Site #37, 141 Avenida Sonora:** This is a corner building with a rectangular plan area. There is very limited information about this building. Significant diagonal cracking was noted from the exterior of this building in the apparent infill walls that are placed within reinforced concrete frames.
- **Site #38, 143 Medellin:** This is a corner building with plan irregularity. There was severe damage observed in the structure, although the building was occupied at the time of the visit. Due to the size of this building, the number of occupants is expected to be rather large and therefore the risk exposure emanating from compromising structural damage during earthquakes is probably more significant than for other structures that the team observed in the city.
- **Site #40, 158 Avenida Emperadores:** This is a corner building with plan irregularity (H-shape). There is very limited information about the damage of the building in the interior. In the exterior, no significant structural damage was observed.
- **Site #50, 480 Calz. Del Hueso:** This is a corner building that collapsed during the earthquake.
- **Site #54, 586 Prolongacion Peten:** This is a corner building that had severe damage of the infill panels at the exterior. The interior was not observed.
- **Site #56, 617 Calle Filipinas:** This is a corner building that had significant damage of the exterior URM infill walls.
- **Site #59, 915 Prolongacion Peten:** This is a corner building of C-shape plan area that completed collapsed during the earthquake.
- **Site #62, 2065 Canal de Miramontes:** This is a rectangular corner building and had a roof deck collapse.
- **Site #63, 4353 Avenida Division Del Norte:** This is a corner building with plan irregularity that sustained extensive damage with significant out-of-plane failure of the masonry infill walls and cracking in the structural elements.
- **Site #64/65, Centauro and Osa Major:** These two buildings are part of a large complex. The buildings are both corner buildings with an X-shape plan area. The buildings have severe structural damage.

6.2.2.5 Buildings with Innovative Lateral Load Resisting Systems

There are some buildings observed that had innovative systems implemented in the lateral load resisting system. It may be of interest of investigate how

many buildings in Mexico City have implemented this system and the seismic performance and level of damage to these structures.

- **Site #13, 38 Jose Maria Izazaga**: This is a building that had metallic dampers attached to chevron braces. A general research recommendation would be to determine the percentage of dampers that yielded in this building and had to be replaced.
- **Site #20, 56 Eje Central Lazaro Cardenas**: This building under construction is composed of concrete encased steel column frames supporting composite metal deck floors. At the east exterior face of the building, there are steel braces that form an X-pattern within four to six stories.
- **Site #27, 104 Calle Salamanca**: This building has post tensioned diagonal cables exterior of the west façade. These are connected to steel columns throughout the height of the building.

6.2.2.6 Buildings with Partial or Complete Collapse

Approximately 25% of the buildings that collapsed in Mexico City were observed by the ATC team. It might be of interest to further investigate some of these structures to determine potential causes of failure. Below are the buildings that suffered partial or complete collapse. All collapses were included, even those with very limited observations.

- **Site #11, 32 Calle Rancho El Arco**: This building collapsed and had being demolished and removed before the ATC team visited the site.
- **Site #21, 56 Emiliano Zapata**: This is a specific case scenario where a new building collapsed during the earthquake. As observed, it seems that the construction was not adequate. It would be of interest to do a study of the construction quality and inspection policies in Mexico City. Additionally, further analytical studies to predict this collapse can be completed.
- **Site #29, 107 Amsterdam**: All of the stories in this building, except the first story, completely collapsed. The building had mostly been demolished and removed before the ATC team visited the site.
- **Site #31, 122 San Antonio Abad**: This building suffered a partial collapse of the fifth floor and severe damage to several other columns along the north face of the building.
- **Site #39, 149 Sonora**: This building had three levels added to the original structure. The first level that was added, which corresponds to the sixth story in the building, completely collapsed.

- **Site #50, 480 Calz. Del Hueso**: This building is a corner building that completely collapsed. Possible failure includes punching shear of the slab.
- **Site #51, 517 Calle Tokio**: This site has a total of 3 buildings of similar characteristics in a row. Two out of the three buildings had a first story collapse.
- **Site #57, 714 Calle Saratoga**: This building had a long plan area. The first two stories of the structure completely collapse.
- **Site #58, 911**: This site has a total of 3 buildings of similar characteristics in a row. The middle building completely collapsed.
- **Site #59, 915 Prolongacion Peten**: This building collapsed and had being demolished and removed before the ATC team visited the site.
- **Site #61, 2050 Calz. de Tlalpan**: This one-story building, unlike the rest of the construction observed, was composed of steel joists supported by steel trusses, supported by concrete columns. The side of this building collapsed exposed the deficiency in the lack of diaphragm ties in the roof perimeter.
- **Site #62, 2065 Canal de Miramontes**: This building has a roof deck supported on thin concrete columns that collapsed. Similar to Site #61, it is likely there was lack of diaphragm ties in the roof perimeter.

6.2.2.7 Buildings with Plan Irregularities

Most of the buildings observed had plan irregularities. This induces torsional effects that may not have been considered in the original design of the structures. Some buildings are not rectangular, with the sides forming polygons or very irregular shapes, shifting the center of mass of the structure. Other buildings are rectangular but have various plan openings for courtyards, which is common in a typical building in Mexico City. These openings could potentially interrupt the load path of the lateral load. Further studies, either focused on one building or a set of buildings with similar irregularities, can be completed to determine the impact of the geometry on the building performance. For a satellite view of the plan area refer to each individual building section.

- **Site #1, 4 Avenida Mexico**: This building has approximately a 5-sided polygon plan area with an interior courtyard opening on all floors.
- **Site #4, 10 Calle Paseo Del Rio**: This building has approximately a 10-sided polygon plan area. Additionally, the bulkheads vary in height.

- **Site #5, 11 Avenida Mexico**: This building has approximately a 6-sided polygon plan area.
- **Site #6, 15 Calle Hacienda San Jose**: This building has an H-shape plan area.
- **Site #9, 20 Calle Ozuluama**: This building is rectangular with numerous courtyard openings along the exterior.
- **Site #10, 20 Calle Paseo Del Rio**: This building has an H-shape plan area.
- **Site #11, 32 Calle Rancho El Arco**: This building has an H-shape plan area.
- **Site #12, 32 Avenida Mazatlan**: This building has a C-shape plan area.
- **Site #13, 38 Jose Maria Izazaga**: This building has a 10-sided polygon plan area.
- **Site #15, 49 Calle Amsterdam**: This building has a C-shape plan area.
- **Site #16, 52 Cozumel**: This building has an L-shape plan area (or reentrant corner).
- **Site #17, 53 Iztaccihuatl**: This building has an H-shape plan area.
- **Site #18, 53 Paseo Nuevo:** This building has an H-shape plan area with an interior courtyard opening on all floors.
- **Site #19, 56 Avenida Mexico**: This building has an L-shape plan area (or reentrant corner). Additionally, at the last floor, part of the plan area is set back, leaving the west portion of the building at a lower elevation.
- **Site #22, 64 Bahia de Ballenas**: This building has an L-shape plan area (or reentrant corner).
- **Site #23, 65 Paseo Nuevo:** This building has an H-shape plan area with an exterior courtyard opening on all floors along one of its sides.
- **Site #26, 99 Ave Mexico:** This building has quarter-circle plan area.
- **Site #28, 105 Ave Mexico**: This building has a 5-sided polygon plan area with an interior and exterior courtyard opening on all floors.
- **Site #29, 107 Amsterdam**: This building has an L-shape plan area (or reentrant corner).
- **Site #30, 117 Ave Mexico**: This building is rectangular with one interior and two exterior courtyard openings on all floors.

- **Site #31, 122 San Antonio Abad**: This building is rectangular with more than 75% of the elevator core located outside of the rectangular plan area.
- **Site #32, 124 Amsterdam**: This building is rectangular and has a reentrant corner.
- **Site #33, 126 Yautepec**: This building is rectangular with an interior courtyard opening on all floors.
- **Site #34, 128 Amsterdam**: This building has mostly an H-shape plan area with one side having significan irregularity.
- **Site #35, 130 Amsterdam**: This building has a trapezoid-shape plan area.
- **Site #38, 143 Medellin**: This building has a V-shape plan area with a tower at the middle.
- **Site #39, 117 Ave Mexico**: This building is rectangular with a reentrant corner and one exterior courtyard opening on all floors.
- **Site #40, 158 Avenida Emperadores**: This building has an H-shape plan area.
- **Site #41, 162 Avenida Sonora**: This building is rectangular with one interior courtyard opening on all floors. Additionally, approximately half of the building is one story higher than the other half.
- **Site #42, 200 Campos Eliseos**: One of the towers at this site has an 8-side polygon plan area.
- **Site #44, 224 Avenida Emperadores**: This building is rectangular with three interior courtyard openings on all floors.
- **Site #45, 232 Calle Amsterdam**: This building has a C-shape plan area. Additionally, there seems to be an interior courtyard opening on all floors.
- **Site #46, 245 Tehuantepec**: This building has a C-shape plan area.
- **Site #49, 405 Calle Seville**: This building is rectangular with five exterior courtyard opening on all floors.
- **Site #54, 586 Prolongacion Peter**: This building has a trapezoid-shape plan area.
- **Site #55, 609 Calle Azores**: These buildings have an H-shape plan area.
- **Site #57, 714 Calle Saratoga**: This building is rectangular with one interior and five exterior courtyard opening on all floors.

- **Site #59, 915 Prolongacion Peten**: This building has a C-shape plan area.
- **Site #60, 1171 Calzada de Tlalpan**: These buildings have an H-shape plan area.
- **Site #61, 2050 de Tlalpan**: This building has an oval plan area.
- **Site #63, 4353 Avenida Division Del Norte**: This building has an L-shape plan area (or reentrant corner).
- **Site #64, Centauro**: This building has an X-shape plan area.
- **Site #65, Osa Mayor**: This building has an X-shape plan area.

6.2.2.8 Buildings that can be Monitored Long Term

There are some buildings observed for which long-term instrumentation and monitoring would be adequate. The data collected for a few selected buildings would be significantly valuable for further ATC studies. Additionally, if another earthquake, of relatively moderate magnitude occurs, the information prior to seismic event would be available for comparison and for further research.

- **Site #1, 4 Ave Mexico:** This building may be a possible candidate for monitoring because it is representative of typical residential construction in the area. Even though it is of irregular plan area, it has typical characteristics including: courtyard in the middle and unreinforced infill masonry in most of the exterior faces. This building would also be of interest to study because of its irregular shape, corner position, and location in the transition zone. There was no visible masonry damage from the exterior which is distinctive from various irregular, corner buildings of similar height in the city which did suffer significant exterior wall infill damage during this earthquake.
- **Site #3, 8 Calzada San Antonio Abad:** If more details regarding the structural damage of the structure are obtained, this building is a good candidate for monitoring because of its relatively regular plan shape and minor damage at the exterior.
- **Site #24, 66 Calz. San Antonio Abad:** This is a new building, completed in 2016. Even though the building interior was not observed, the building had mostly cosmetic damage on the exterior. Because of its corner position and typical building construction, the building is a good candidate for long-term instrumentation and monitoring.
- **Site #25, 86 Oaxaca:** This is a building completed in 1986. The interior of the building was not observed, although if access is provided, this

would be a good candidate for long-term monitoring because of its typical construction and regular shape.

- **Site #35, 130 Amsterdam:** This is a relatively new building completed in 2002. This is one out of the five buildings that were monitored during the reconnaissance. However, it would be a good candidate for long-term monitoring because it is a corner building, has a shear wall lateral load resisting system and suffered minor damage during the earthquake.
- **Site #36, 132 Calle Atlixco**: This building might be a potential candidate for long-term monitoring because it suffered minor damage despite the vulnerabilities which include its corner location, unreinforced masonry walls and weak first story condition.
- **Site #37, 141 Avenida Sonora**: If the contact information for the building manager/owner can be obtained, this building can be a candidate for further studies and instrumentation because of its characteristics (height, corner position, and building construction).
- **Site #40, 158 Avenida Emperadores**: If the contact information for the building manager/owner can be obtained, this building can be a candidate for further studies and instrumentation because of its characteristics (height, corner position, H-shape and building construction). However, at this point, information about the structure is very limited.
- **Site #43, 200 Campos Eliseos**: This is the tallest building observed in detail (25 stories). It was constructed in 2014. Minor damage was observed during the site visit. It would be of interest to monitor this building since it possesses common characteristics of the recent construction in Mexico City.
- **Site #53, 521 Eje Central**: If the drawings and contact information of the building manager/owner can be obtained, this can be a "new" building that can be studied and potentially instrumented and monitored long term.

6.2.2.9 Buildings Suitable for Additional Soil Studies

Among the buildings observed, there were some for which the damage could have been due to the failure of the soil. It would be of interest to study the soil conditions in some of these buildings to better understand the cause of failure.

- **Site #3, 8 Calzada San Antonio Abad**: In front of this building, sidewalk damage and separation were observed.

- **Site #4, 10 Calle Paseo Del Rio**: This building has a significant lean that occurred over years. Additionally, a building in the vicinity (see 20 Calle Paseo Del Rio) also had sidewalk cracks therefore a block of buildings can be studied for potential soil failure in the future.
- **Site #10, 20 Calle Paseo Del Rio**: Due to the settlement and cracks in the sidewalk, as well as the proximity to a leaning building (see Site #4 10 Calle Paseo Del Rio), this building and the neighboring structures are good candidates for soil conditions and potential soil failure studies.
- **Site #15, 49 Calle Amsterdam**: This building was reported leaning before the earthquake.
- **Site #23, 65 Paseo Nuevo**: This building is leaning towards its front. Buildings in the surrounding area, such as 10 and 20 Calle Paseo Del Rio, also seem to have damage most likely related to soil failure.
- **Site #32, 124 Calle Amsterdam**: This building exhibits ground deformation as well as northward leaning.
- **Site #34, 128 Calle Amsterdam**: This building had a significant ground floor tilt. It may be interesting to study this complete block since various buildings were observed and are documented in this report.
- **Site #41, 162 Avenida Sonora**: The sidewalk in front of this building was observed to be depressed.
- **Site #46, 245 Tehuantepec**: This building seems to be leaning west.
- **Site #47, 275 Campeche**: This building exhibits horizontal ground deformation and appears to be leaning east towards the neighboring building.
- **Site #60, 1171 Calzada de Tlalpan**: This building exhibits pre-existing and post-earthquake damage due to the sidewalk.
- **Site #69, Notary Historical Heritage of Mexico City**: There was ground settlement observed at the interface of the structure with the sidewalk on the west of the building. A gap was present between the façade and ground level. Additional sidewalk cracks were present.

6.2.2.10 Buildings Suitable for Additional Ground Motion Studies

Although ground motion directionality studies can be performed for any of the buildings observed, especially for those with detailed information, the following site is recommended:

- **Site #7, 18 Avenida 8**: This complex is composed of numerous buildings, many of which had been evacuated and were empty at the time

of the ATC visit. Most of the buildings had a very similar plan area and construction type. One of the buildings, specifically the one that was perpendicular to the others, collapsed. It would be of interest to investigate if the ground motion in the direction longitudinal to the collapse building was stronger than the orthogonal component of the ground motion. See site report for more information.

6.2.2.11 Buildings Suitable for Retrofit Studies

From the buildings that were observed, there were buildings for which a retrofit solution would not be feasible. However, for some of the buildings, common retrofit strategies can be proposed depending on the level of damage. For the following buildings, the damage is described and a possible retrofit solution for each structure is recommended. Note that these are preliminary recommendations and each building should be studied and inspected in detail before finalizing each retrofit plan.

- **Site #2, 4 Minatitlan**: This building has a reinforced concrete slab supported by a concrete frame. Lateral loads are resisted by the concrete frame with URM infill, and 8-inch thick concrete shear walls at the elevator. The building, similar to numerous structures around the city, had unreinforced masonry infill walls that were severely damaged because they acted as part of the lateral force resisting system. One retrofit solution that is advised is to remove the damaged walls and replace them with reinforced masonry walls. A retrofit solution for the concrete walls that had minor cracks is not presented but should be completed in addition to the solution mentioned previously.
- **Site #9, 20 Calle Ozuluama**: This building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. The unreinforced infill walls were severely damaged because they resisted part of the lateral load. It is recommended that they are removed and replaced by reinforced masonry walls.
- **Site #45, 232 Calle Amsterdam**: The building is composed of reinforced concrete frames with unreinforced masonry infill walls. Although the central elevator appears to be of concrete construction (a concrete core walls), the lateral force resisting system of the building is primarily concrete frame with infill masonry (model building type C3A). The building had unreinforced masonry infill walls that were severely damaged because they acted as part of the lateral force resisting system. One retrofit solution that is advised is to remove the damaged walls and replace them with reinforced masonry walls.

6.2.2.12 Buildings Suitable for FEMA P-2018 Studies

FEMA P-2018, *Seismic Evaluation of Older Concrete Buildings for Collapse Potential*, (FEMA, 2018) presents a simplified methodology that can be applied to evaluate building performance of non-ductile concrete buildings. The following buildings are potential candidates that can be utilized to calibrate this methodology:

- **Site #8, 19 Avenida Mexico**: This is a reinforced concrete building with a regular plan area. The structural system consists of reinforced concrete slabs, beams, columns, and shear walls. Two of the columns in the second floor of the building were retrofitted after the 1985 earthquake with reinforced concrete jackets. This building was instrumented during the field visit.
- **Site #35, 130 Amsterdam**: This is a reinforced concrete building with a rectangular plan area, with one of the corners protruding outwards. It has a reinforced concrete slab supported on reinforced concrete shear walls. The building was instrumented during the field visit.
- **Site #43, 200 Campos Eliseos**: This is a reinforced concrete building with an irregular plan area. It has a reinforced concrete slab supported on reinforced concrete beams and columns. Lateral loads are resisted by the reinforced concrete moment-resisting frame in both building directions. One floor was instrumented during the field visit.

6.2.2.13 Buildings Suitable for ATC-134 Studies

ATC-134 is a NIST-funded project focused on reinforced concrete buildings, with the purpose of developing a benchmark across multinational building codes, standards, and guidelines. At the time of publication of this report, this project was still ongoing. The following buildings are potential candidates that can be incorporated into ATC-134 studies.

- **Site #8, 19 Avenida Mexico**: This is a reinforced concrete building with a regular plan area. The structural system consists of reinforced concrete slabs, beams, columns and shear walls. Two of the columns in the second floor of the building were retrofitted after the 1985 earthquake with reinforced concrete jackets. This building was instrumented during the reconnaissance trip.
- **Site #14, 47 Parque España**: This is a reinforced concrete building with a regular plan area. The building has a reinforced concrete slab supported on reinforced concrete columns, reinforced concrete walls, and steel columns. Lateral loads are resisted by the reinforced concrete walls and moment frames in both building directions. Structural drawings are

available for this building and presented in Section 6.3.14. The structural system consists of reinforced concrete slabs, beams, columns and shear walls. Two of the columns in the second floor of the building were retrofitted after the 1985 earthquake with reinforced concrete jackets. This building was instrumented during the reconnaissance trip.

- **Site #31, 122 San Antonio Abad**: This is a reinforced concrete building with a regular plan area and an elevator core that extends outwards. The structural system consists of reinforced concrete slabs supported on concrete frames. Lateral loads are resisted by the reinforced concrete moment-resisting frames and the reinforced concrete shear walls at the offset core. Several columns along the north face of the building had been either repaired or retrofitted after the 1985 earthquake. The retrofit strategy consisted of a steel cage composed of angles at the corners with flat steel horizontal bars.
- **Site #43, 200 Campos Eliseos**: This is a reinforced concrete building with an irregular plan area. It has a reinforced concrete slab supported on reinforced concrete beams and columns. Lateral loads are resisted by the concrete moment-resisting frame in both building directions. One floor was instrumented during the reconnaissance trip.

6.2.2.14 Buildings that are not of any Interest for Future Studies

In contrast to the previous categories, this category will present the list of buildings that are most likely not candidates for any further studies.

- **Site #9, 20 Calle Ozuluama**: This building had typical damage in the interior and exterior which is expected as observed in other buildings with similar construction and characteristics.
- **Site #11, 32 Calle Rancho El Arco**: This building was demolished at the time of the visit therefore information is very limited.
- **Site #32, 32 Avenida Mazatlan**: This building has very little observations. There was no structural damage observed from the exterior.
- **Site #17, 53 Iztaccihuatl**: This building had typical damage in the interior and exterior which is expected as observed in other buildings with similar construction and characteristics.
- **Site #18, 53 Paseo Nuevo**: This building was observed in the dark therefore very limited information is available.
- **Site #29, 107 Amsterdam**: This building was demolished at the time of the visit therefore information is very limited.

- **Site #38, 143 Medellin**: This building appeared to have suffered significant damage although it was not evacuated at the time of the visit. Even though it is not a candidate for further ATC studies, it is one of the buildings that should undergo full inspection by an official due to the large number of occupants.
- **Site #40, 158 Avenida Emperadores:** This building was not observed in detail therefore it is not a candidate for further studies. However, if more information can be obtained, it would be a good candidate due to its characteristics (height, corner position, H-shape and building construction).
- **Site #42, 187 Camino:** This is the building for the "Colegio de Ingenieros Civiles De Mexico AC", equivalent to the American Society of Civil Engineers (ASCE) in the United States. This building was not observed in detail therefore it is not a candidate for further ATC studies.
- **Site #48, Gra. Emiliano Zapata:** This building was not observed in detail because of restricted access.
- **Site #59, 915 Prolongacion Peten:** This building was demolished at the time of the visit therefore information is very limited.
- **Site #68, Iglesia Fatima:** This is a church that was not observed in detail.
- **Site #70, Palacio de Bellas Artes:** This is a historic cultural center in Mexico City that was not observed in detail.

6.3 Information Collected for Sites Visited

6.3.1 Site #1: 4 Avenida Mexico

6.3.1.1 Building Description

This building is located on 4 Avenida Mexico, between Avenida Sonora and Plaza Popocatépetl. The general location and specific coordinates are shown on Figure 6.3.1.1. As observed from the satellite maps in Figure 6.3.1.2, the plan area of this building is irregular. The building has ten stories. Its construction date is unknown.

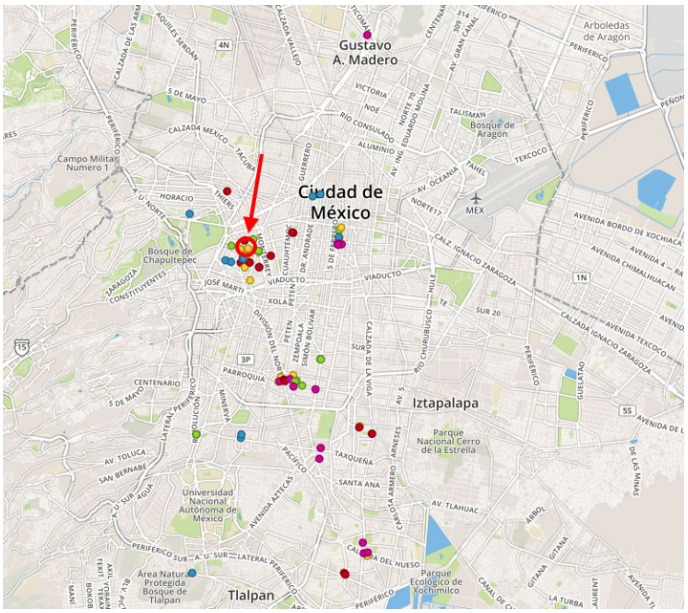


Figure 6.3.1.1 Location of site (Fulcrum Database). Coordinates: 19.4145872168513, -99.1682782396674



Figure 6.3.1.2 Plan satellite view of site (Google Maps, 2017)

TheATC team did not enter this building. Based on the typical construction in the surrounding area, the building most likely has a reinforced concrete slab supported on concrete frames. Lateral loads are most likely resisted by the concrete frame with URM infill in both directions. Fig 6.3.1.3 below shows a front view of the building.



Figure 6.3.1.3 Front view of the building.

6.3.1.2 Damage and Observations—2017

The building was only observed from the street. No significant damage was observed on the building exterior; however, the building does not appear to have been occupied at the time of reconnaissance.

There is a small building behind the observed building that appears to have suffered severe cracking, as shown in Figure 6.3.1.4. The smaller building may be leaning on this building for support.

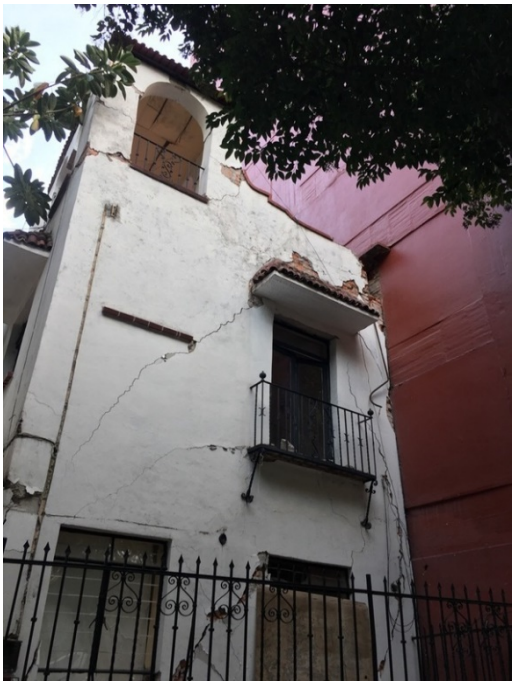


Figure 6.3.1.4 Severe cracks on the rear wall of the smaller building located behind the observed building

6.3.1.3 Recommendations

The building may be a possible candidate for monitoring because it is representative of typical residential construction in the area.

6.3.2 Site #2: 4 Minatitlan

6.3.2.1 Building Description

This building is located in 4 Minatitlan, between Calle Aguascalientes and Tlaxcala. The general location and specific coordinates are shown on Figure 6.3.2.1. The plan area is rectangular, approximately 10m x 14m, as shown in the plan satellite view in Figure 6.3.2.2. The building has 6 stories with no basement. Its construction date was around 1976 to 1978.

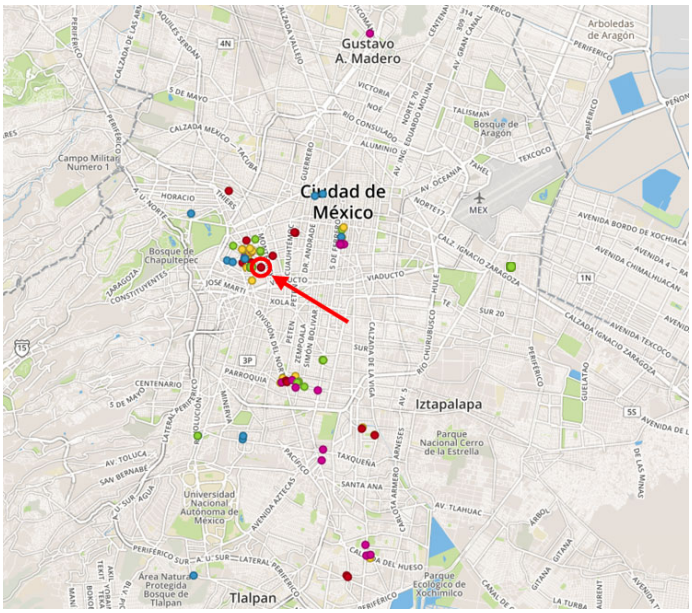


Figure 6.3.2.1 Location of site (Fulcrum Database). Coordinates: 19.408535, -99.164761



Figure 6.3.2.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported by a concrete frame. Lateral loads are resisted by the concrete frame with URM infill, and 8 inch thick concrete shear walls at the elevator. Figure 6.3.2.3 below shows the front view of the building.

The beams and columns in the frames were measured to be 21 inches and 23 inches deep, respectively, as shown on Figure 6.3.2.4.



Figure 6.3.2.3 Front (west) view of the building.



(a) Measurement of beam depth (21″) (b) Measurement of column width (23″)

Figure 6.3.2.4 Concrete frame measurements near front of building.

6.3.2.2 Damage and Observations—2017

The building has severe nonstructural and moderate structural damage. Residents had been evacuated and the structure can no longer be used for intended purpose. No evidence of seismic retrofit was observed.

The main damage was to the URM partitions and infill. The infill had no positive connection to the columns or beams, and the hollow clay tiles generally had no grout.

The owner and engineer were available on site. Access to interior was allowed, and we were able to discuss the building performance, history, etc. Three transverse concrete shear walls were observed.

The masonry walls surrounding elevator were significantly cracked, as shown in Figure 6.3.2.6.



(a) Joint separation between adjacent building (b) Close up of (a)

Figure 6.3.2.5 Front (west) view of the building



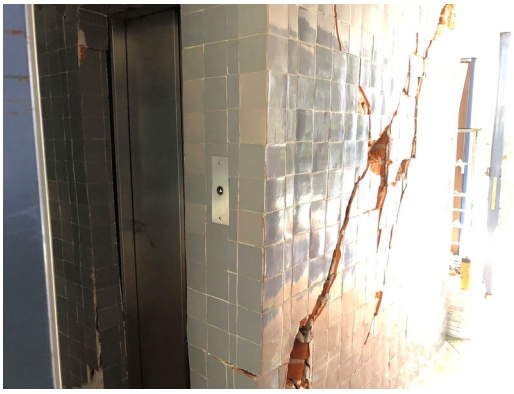
(a) Cracks on infill walls near elevator



(b) Close up of (a)



(c) Cracks on infill walls



(d) Cracks on infill walls surrounding elevator





(e) Cracks on infill walls surrounding elevator

Figure 6.3.2.6 Interior elevator walls plaster

Additionally, there was minor cracking to the reinforced concrete shear walls at the elevator core, as shown in Figure 6.3.2.7. Compared to brick infill, concrete columns had minor cracks.

When viewed from the parking, the rear side of the building had severe cracks that resulted in spalling of bricks and windows. The severe in-plane cracks and out-of-plane damage in the walls is shown in Figure 6.3.2.8.

Finally, there were significant cracks inside an apartment unit at walls and columns, as shown in Figure 6.3.2.9. The building has shown to have severe cracks throughout the building.



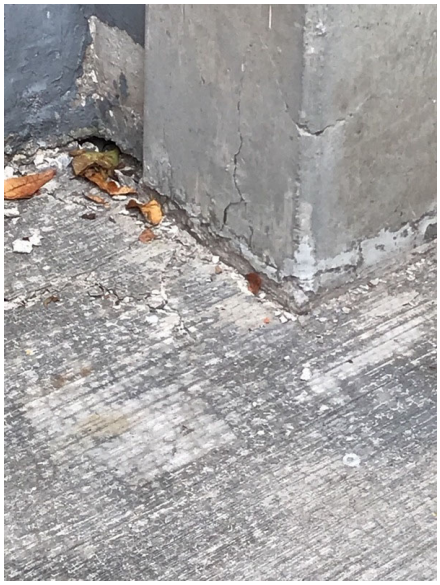
(a) Minor cracks on concrete wall



(b) Minor cracks on concrete wall



(c) Cracks on concrete column

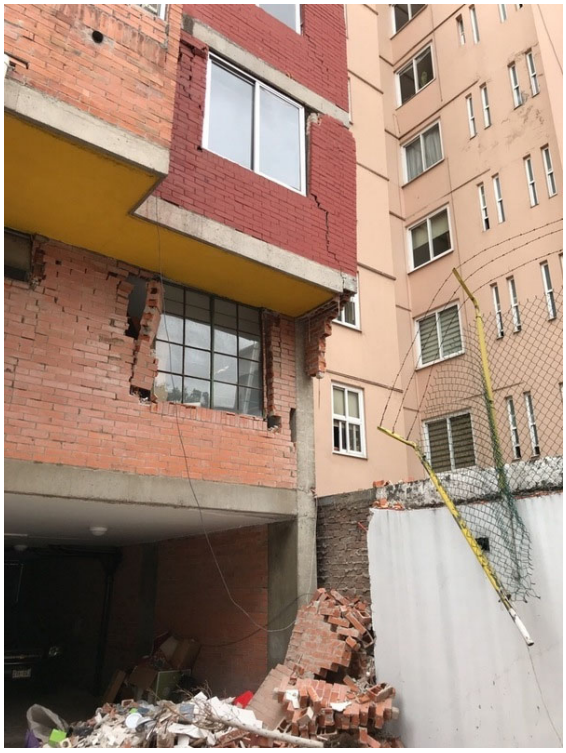


(d) Close up of (c)

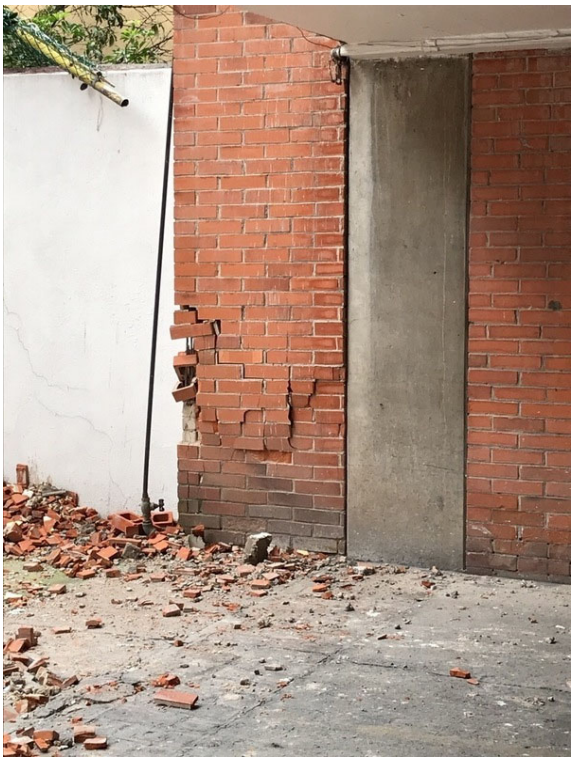
Figure 6.3.2.7 Cracks on wall and column near the elevator



(a) Fallen bricks and window in the back



(b) Cracked and fallen brick facade



(c) Cracked and fallen brick facade



(d) Broken window.



(e) Cracked and fallen brick facade



(f) Cracked and fallen brick facade



(g) Fallen bricks and window viewed from back



(h) Close up of (g)

Figure 6.3.2.8 Infill wall in-plane and out-of-plane failure



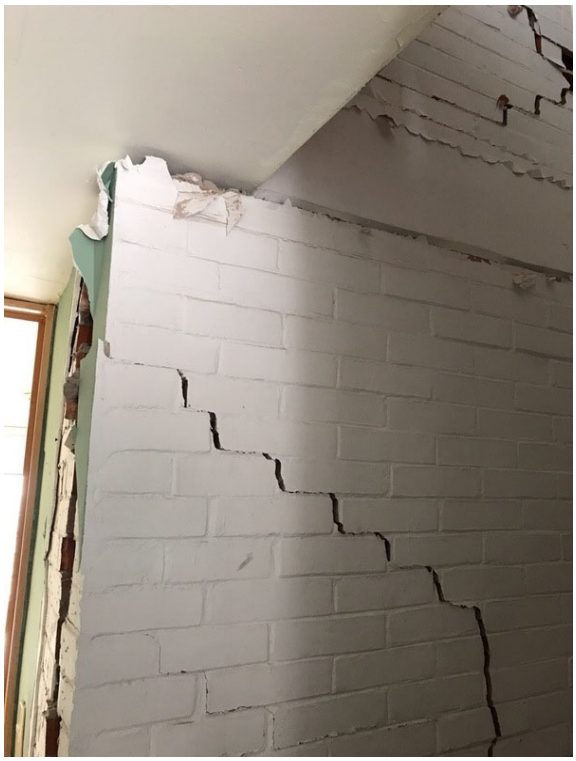
(a) Cracked infill walls inside an apartment



(b) Cracked plaster inside an apartment



(c) Cracked open infill wall inside an apartment



(d) Cracked open infill wall inside an apartment



(e) Spalled infill wall inside an apartment



(f) Partially collapsed infill wall inside apartment



(g) Cracks on ceiling near column cap



(h) Cracks on ceiling near column cap



(i) Failed infill wall (j) Horizontal cracks on infill wall

Figure 6.3.2.9 Damage to interior walls and columns

6.3.2.3 Discussion

Damage to the concrete beams, columns and transverse shear walls was minor. The building had extensive damage to the infill and partition walls. The infill and partitions were constructed with a combination of brick and hollow clay tile. The hollow clay tile walls were not placed tight against the frame and were generally ungrouted. This led to large portions of the infill and partitions falling away from the framing.

6.3.3 Site #3: 8 Calzada San Antonio Abad

6.3.3.1 Building Description

This building is located in 8 Calzada San Antonio Abad, between Fray Servando Teresa de Mier and Chimalpopoca. The general location and specific coordinates are shown on Figure 6.3.3.1. The building has 13 stories and a partial two story portion on its north side. The construction date is unknown.

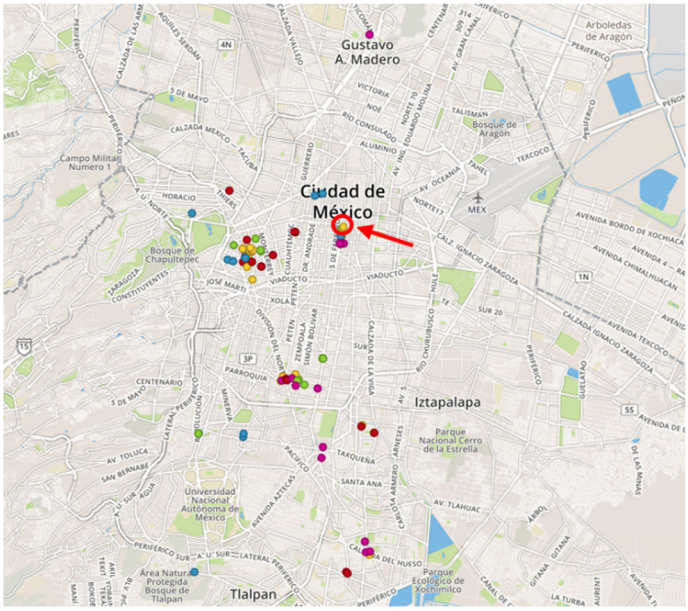


Figure 6.3.3.1 Location of site (Fulcrum Database). Coordinates: 19.423050, -99.133156.

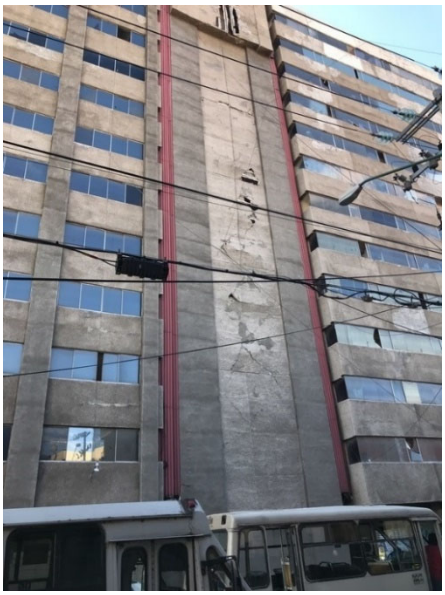


Figure 6.3.3.2 Plan satellite view of site (Google Maps, 2017).

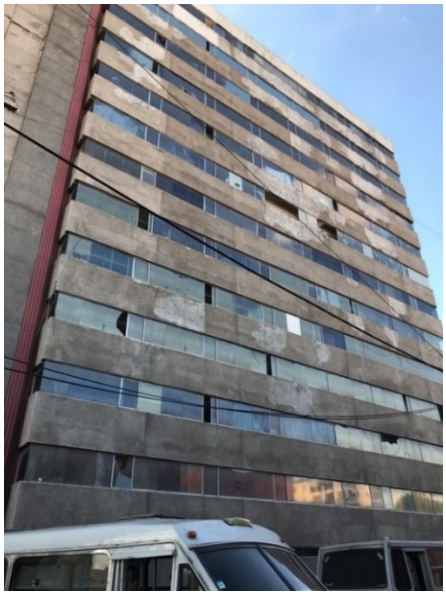
The building has reinforced concrete frames, possibly with interior/stair/elevator shaft concrete walls, with a waffle slab (evident in one partial photo taken from the exterior since there was no access to the interior of the building), with unreinforced masonry infill walls. The lateral loads are resisted by the concrete frame with URM infill in both building directions and, possible concrete shear walls enclosing stair/elevator shafts. The building elevations are shown in Figure 6.3.3.3.



(a) Building southwest elevation



(b) Building (rear) east elevation



(c) Building (rear) east elevation

Figure 6.3.3.3 Building elevations.

6.3.3.2 Damage and Observations—2017

From the exterior at the rear of the building, one story columns supporting an enclosure at the ground floor were observed to be severely damaged at the top connection. This spalling and hinging could be a result of the captive column condition of these one-story light columns because there are infill walls on both sides of the column. There was no other visible damage to the rest of the structure.

The thin cracks observed in the rear façade were mostly existing, but did expand when comparing these to the 3D view from Google Maps 2015.

There was damage to the façade around the column in the southeast corner as shown on Figure 5a. However, after comparing to the 3D view in Google Maps 2015 it is clear that this condition was existing. There were also cracks showing settlement and sidewalk separation, as shown in Figure 6.3.3.6, but it is unclear is if this condition was existing or new.



Figure 6.3.3.4 Column hinging due to captive column condition.



(a) Cracks before earthquake, Google Maps 2015 (b) Cracks observed after the earthquake

Figure 6.3.3.5 Existing rear façade condition before and after the earthquake, Google Maps 2015.



(a) Existing ground damage at the sidewalk (b) Sidewalk separation. It is unclear if this was existing

Figure 6.3.3.6 Existing ground damage at the sidewalk.



Figure 6.3.3.7 Rear elevation of the building. Box indicates location of close up photo showing possible separation joint between the two wings of the structure (not confirmed).



Figure 6.3.3.8 See Figure 6.3.3.7 above. Possible separation joint (not confirmed).

6.3.3.3 Discussion

It appeared that this building had been evacuated and was not in use following the earthquake. There was some interior demolition and clean-up work ongoing in some of the upper floors at the time of the team's visit to the structure. Most of the signs of damage appeared to be old and there was no clear indication of major damage to the primary structural system during the subject earthquake. Access to the interior was not available and therefore only a cursory examination of the building's exterior was possible.

6.3.3.4 Recommendations

A complete post-earthquake structural investigation and evaluation of the building is called for and should be performed prior to determining whether the structure is safe for continued occupancy in its current condition or not.

6.3.4 Site #4: 10 Calle Paseo Del Rio

6.3.4.1 Building Description

This building is located in 10 Calle Paseo Del Rio, between Cuarta Calle Paseo Chico and Avenida Paseo de los Jardines. The general location and specific coordinates are shown on Figure 6.3.4.1. The building has 9 stories and 1 basement. As observed from the satellite maps in Figure 6.3.4.2, the plan area of this building is irregular. Its construction date is unknown, but is estimated to be early 1980s.

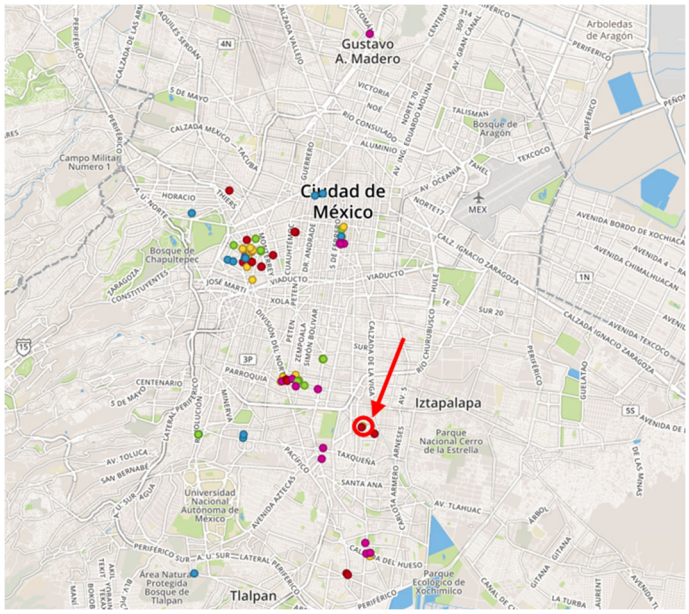


Figure 6.3.4.1 Location of site (Fulcrum Database). Coordinates: 19.3500431953178, -99.1261080467134.



Figure 6.3.4.2 Plan satellite view of site (Google Maps, 2017).

The building is composed of reinforced concrete frames with unreinforced infill masonry walls. In the transverse direction the infill has numerous openings. The building elevation is shown in Fig 6.3.4.2.



Figure 6.3.4.3 Building elevation. No significant noticeable damage to ground floor which appears to be a soft story.

6.3.4.2 Damage, Repairs, and/or Rehabilitation—1985

On the back and side walls, concrete X-braces were observed, which might have been added after the 1985 earthquake. This retrofitting system is typically used in Mexico City. After the 1985 earthquake, there was permanent lateral deformation according to the neighbors.



Figure 6.3.4.4 Concrete x-brace in infill wall might indicate previous retrofit in the west face of building

6.3.4.3 Damage and Observations—2017

All observations were made from outside as well as from the roof of the neighboring building. The building has relatively minor damage from outside, but it is leaning east and in full contact with the neighbor building. Glass breakage is evident at the front of the building.

The leaning can be due to plan irregularity and soft story. There is visible pounding damage but it is not severe. According to a neighbor, the building was built prior to 1985, and after 1985 EQ the building had permanent deformation/drift toward east. Around 2014, it displaced more due to another seismic event, and after the 2017 EQ the building moved further east. According to the neighbors, the building seemed to be moving with cracking noise. The measured separation joint at the roof of the western neighbor is 30 inches wide and at ground floor is 13 inches. Although this indicates the building has moved 17 inches at roof level, the width of the separation gap between the east neighboring building does not agree with this conclusion. Overall, the building might have moved accumulatively 6 inches to 8 inches since the 1985 earthquake. The adjacent building to the east does not appear to have moved significantly.

The first story of this building is taller and more open. There is no visible damage at this level. At the upper floors, few exterior columns have diagonally oriented cracks, approximately one at each level. No significant damage was observed to the back of the building.

The interior courtyard was observed from the neighbor building. Some cracks of beams and joints were visible, although these could have been existing cracks prior to the earthquake. Also observed were the longitudinal walls in the exterior west, which had relatively minor damage.



(a) The building leans to the right (east). Gap is 30″ at roof and 13″ at the ground floor.



(b) 6″-8″ gap between neighboring building closed. No major visible damage to the adjacent building.

Figure 6.3.4.5 Observed building leaning against east neighboring building.



(a) Minor noticeable damage at ground floor



(b) Minor noticeable damage at ground floor



(c) Moderate cracks in the columns at front façade



(d) No significant damage observed to the back of the building

Figure 6.3.4.6 Observed building damage.



(a) Interior courtyard from neighbor building. Some cracks of beams and joints visible might be from before the 09/19/17 earthquake



(b) Relatively minor damage in the long direction (perpendicular to street)



(c) Minor damage to longitudinal walls (west face of building)

Figure 6.3.4.7 Observed building damage in the courtyard and longitudinal walls.

6.3.4.4 Recommendations

Since this building is currently leaning and it is to be demolished, it is not a candidate for monitoring or further structural studies. However, it would be of significant interest to study the soil conditions in this block because of the significant lean that occurred over years. Additionally, a building in the vicinity (see 20 Calle Paseo Del Rio) also had sidewalk cracks therefore a block of buildings can be studied for potential soil failure in the future.

6.3.5 Site #5: 11 Avenida Mexico

6.3.5.1 Building Description

This building is located in 11 Ave Mexico, at the intersection of Avenida Mexico and Avenida Sonora. The general location and specific coordinates are shown on Figure 6.3.5.1. The building has 8 stories and a bulkhead. This is a corner building and the plan area is irregular, as shown in the plan satellite view in Figure 6.3.5.2. Its construction date is not known.

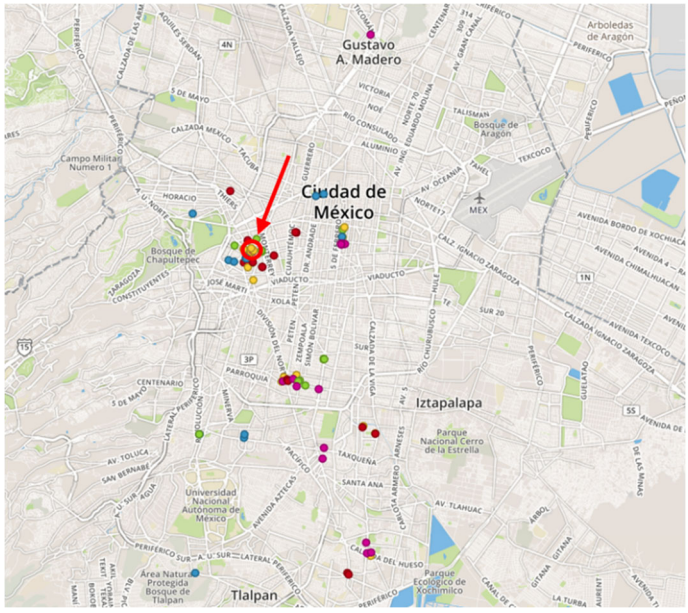


Figure 6.3.5.1 Location of site (Fulcrum Database). Coordinates: 19.4143360166237, -99.168932064917.



Figure 6.3.5.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with unreinforced masonry infill in both building directions. The building elevation is shown in Figure 6.3.5.3.



Figure 6.3.5.3 Front (southeast) building elevation.

6.3.5.2 Damage and Observations—2017

Overall there was no significant damage visible from the exterior. However, there was moderate-to-severe structural damage observed in the interior of the building.

At the ground floor there was minor cosmetic damage in the infill masonry wall. In some of the upper floors, the connection between the stair and landing was damaged. There was one minor column with large cracks and spalled concrete. Some cracks in the bottom of the slabs were visible. Several of the URM infill panels were cracked, showing evidence of both in-plane and out-of-place damage.



(a) Minor cosmetic damage in the ground infill masonry wall



(b) Damaged stair connection



(c) Horizontal crack in the concrete column



(d) Horizontal crack in the concrete column



(e) Damaged concrete column with severe spalling



(f) Cracks in the bottom of the slab



(g) Cracks in unreinforced masonry walls



(h) Out of plane failure of reinforced masonry infill walls

Figure 6.3.5.4 Nonstructural and structural damage.

6.3.6 *Site #6: 15 Calle Hacienda San Jose de Vista Hermosa*

6.3.6.1 Building Description

This building is located on 15 Calle Hacienda San Jose Vista Hermosa, between Hacienda de la Escalera and Hacienda de Xalpa. The general location and specific coordinates are shown on Figure 6.3.6.1. The building has 5 stories and it was built in early 1980s. The structure has an H-shape plan area, shown on the plan satellite view of the site on Figure 6.3.6.2.

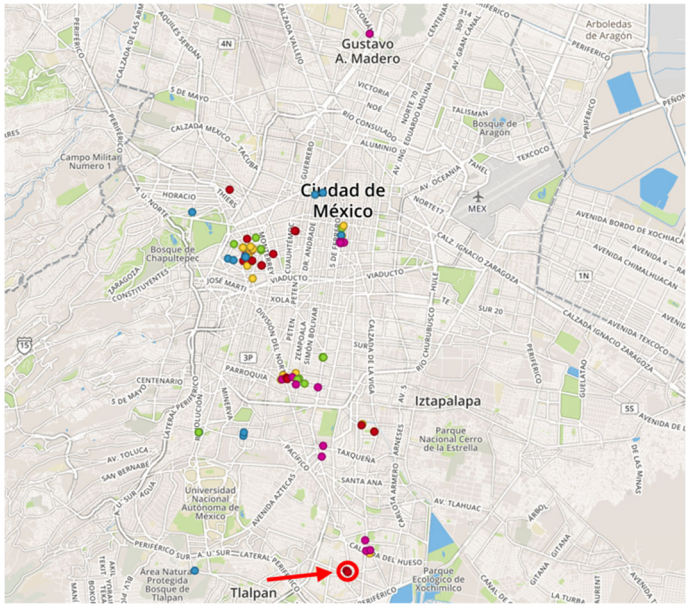


Figure 6.3.6.1 Location of site (Fulcrum Database). Coordinates: 19.2967874743224, -99.1319605429649.



Figure 6.3.6.2 Plan satellite view of site (Google Maps, 2017).

The building structural system was not apparent although it is most likely composed of reinforced concrete slab supported on concrete beams/columns. The lateral resisting system is not evident from outside. The building elevation is shown in Fig 6.3.6.3.



Figure 6.3.6.3 Front (west) elevation.

6.3.6.2 Damage and Observations—2017

The building showed no apparent structural damage from the exterior although it was evacuated. However, as observed from the ground floor, there was severe damage to the concrete columns (spalling). Soft story is also suspected.



Figure 6.3.6.4 Significant spalling in interior column.

6.3.6.3 Recommendations

A complete post-earthquake structural investigation and evaluation of the building is called for and should be performed prior to determining whether the structure is safe for continued occupancy in its current condition, possible retrofit solutions and/or need for demolishment.

Even though there was visible damage at the first floor in the interior of the building, there was minor nonstructural damage to the exterior observed, as opposite to other buildings with falling infill exterior walls. Therefore it would be of interest to investigate (1) the lateral load resisting system and (2) the exterior wall construction of the structure.

6.3.7 Site #7: 18 Avenida 8

6.3.7.1 Building Description

This is the "Unidad Habitacional Tlalpan Complex" that is composed of 10 residential buildings and a community center, located at 18 Avenida 8. The buildings are located between Cerro San Antonio and Alvaro Galvez y Fuentes, and between Avenida 8 and Calz. De Tlapan. The general location and specific coordinates are shown on Figure 6.3.7.1.

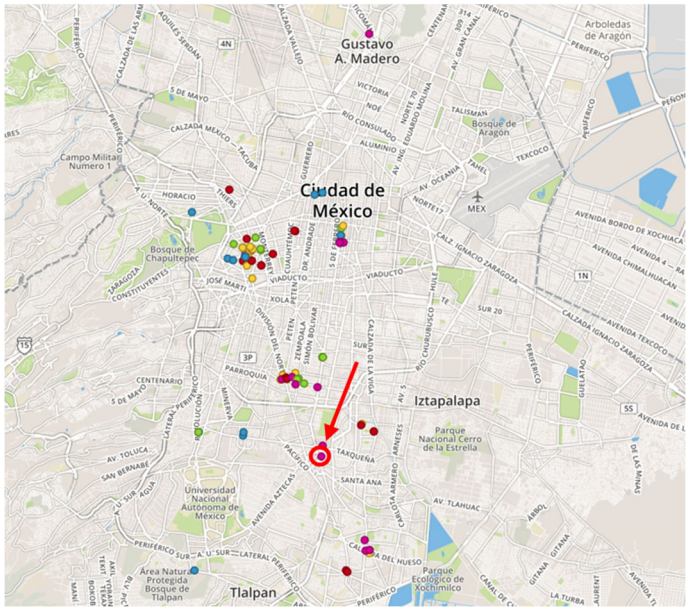


Figure 6.3.7.1 Location of site (Fulcrum Database). Coordinates: 19.3385610357107, -99.1415610072195.

The building construction is concrete slab supported by concrete frame with thin columns and unreinforced masonry infill walls. It was built approximately in 1957.

One of the buildings collapsed and the remaining stayed standing, although evacuated. Overall, all the buildings had similar construction types. There were three buildings that had a larger footprint area, as seen in Figure 6.3.7.2, each being five stories tall. The rest of the buildings had approximately the same width and were also five stories tall. However, the building that collapsed was six stories tall with what appears to be a first story with a more substantial concrete frame structural system than the rest. Construction above the first story was similar to the other buildings, according to the tenants. The collapse occurred above the first story.

As seen in Google Maps sketch, in Figure 6.3.7.2, most of the buildings that collapsed are oriented in the N-S direction. Some are oriented diagonally. The only building that was oriented in the E-w direction was the building that collapsed.

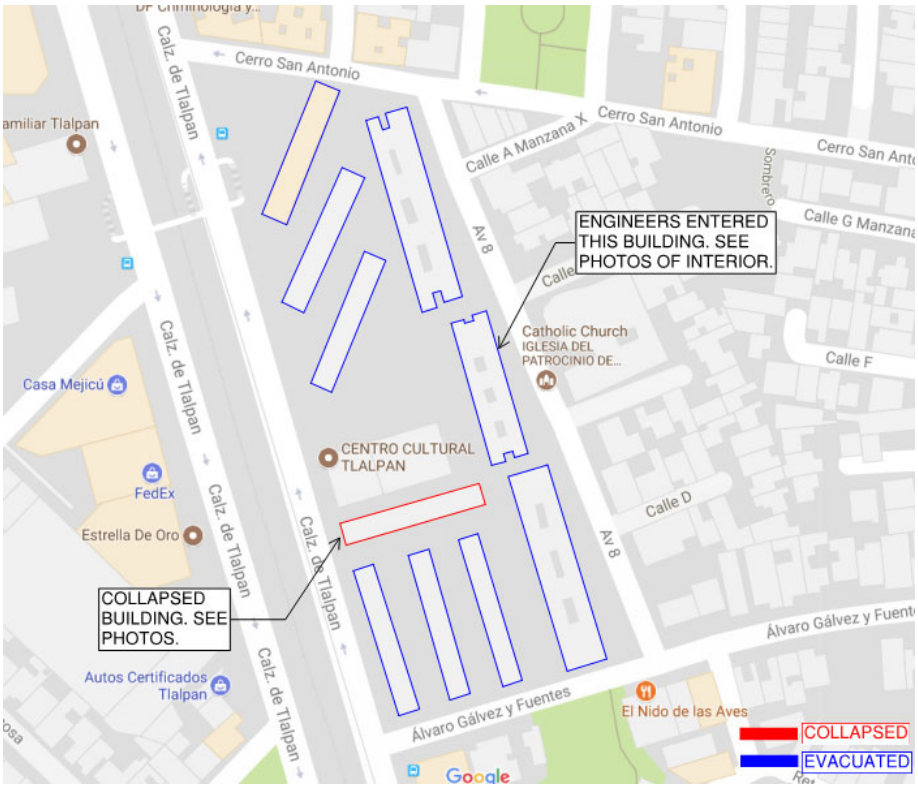


Figure 6.3.7.2 Community plan captured from Google 2017. The outlines buildings were residential.

6.3.7.2 Damage, Repairs, and/or Rehabilitation - 1985

The buildings were approximately 60 years old. It is unknown if there was any damage due to the 1985 earthquake, however, no repairs were completed in the complex after, according to some tenants.

6.3.7.3 Damage and Observations – 2017

All of the buildings were evacuated and were cordon off until inspected. However, access was provided to one of the standing buildings which was observed in detail. The collapsed building was observed from distance.

Collapsed Building



Figure 6.3.7.3 Panoramic view of north side of collapsed building.

This building was six stories tall with its long side in the E-W direction. The first story is taller and seems to have closely spaced columns (more substantial in size than other buildings) with infill walls in between. However, there are continuous window openings in the longitudinal direction between the columns which would weaken the load path to the infill walls. The five stories above that collapsed were mostly unreinforced masonry infill walls with thin columns. The detached, now hanging columns, are visible in Figure 6.3.7.3. As observed from Google maps, captured in Figure 6.3.7.5, the building had an exterior open window layout similar to the other buildings in the complex.



(a) First story view from Google Maps 2017, pre-earthquake



(b) First story remaining after the earthquake

Figure 6.3.7.4 First story in the collapsed building.



Figure 6.3.7.5 Opened window layout in the collapsed building as observed.

Damaged, Standing Building



(a) Interior courtyard. (b) Exterior view. No lateral system in long direction.

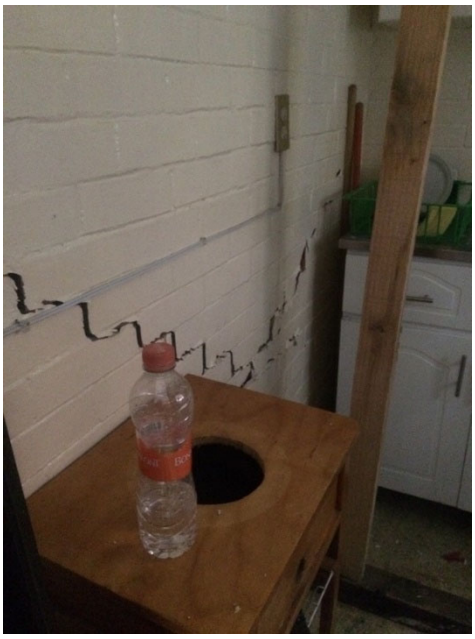
Figure 6.3.7.6 Views of interior and exterior windows and infill walls.

The buildings that remained standing have an open layout in the longitudinal direction, as observed from Figure 6.3.7.6. The building observed in detail is five stories tall with a basement level. The long side of the building in the N-S direction. The building lacks a definable lateral resisting system in the longitudinal direction. As observed from the hallway in the center, majority

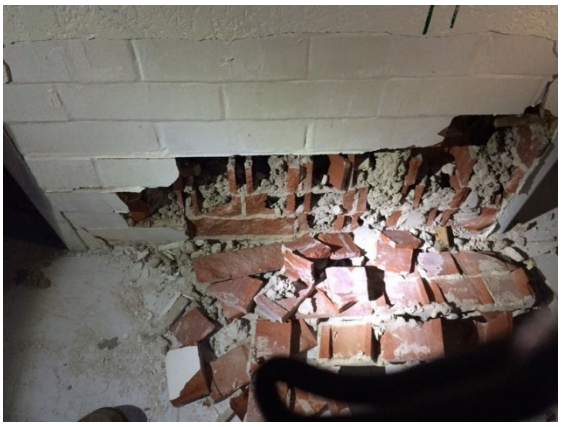
of the walls have window openings and there is no appreciable structural lateral support in that direction. This is similarly observed in the exterior walls. Inside the apartments, most of the partition walls are oriented in the transverse direction. The exterior and interior walls in the transverse direction are hollow masonry (approximately 6 cm) that are perpendicular to each exterior window mullion with a 20 cm (+/-) zone with vertical reinforcement at each end of the wall. Most of the interior walls in the longitudinal direction are of drywall construction. There is severe damage in the longitudinal walls both in and out-of-plane. There were also some cracks and spalling observed in the concrete columns.



(a) Out of plane failure of longitudinal infill wall



(b) In-plane cracks of longitudinal infill wall



(c) Typical masonry wall is of hollow masonry (similar to HCT) that is about 10 cm thick.



(d) Short infill wall that provides support in the long direction. Crack width is measured at 12 to 22 mm.

Figure 6.3.7.7 In-plane and out-of-plane failure of infill URM walls.

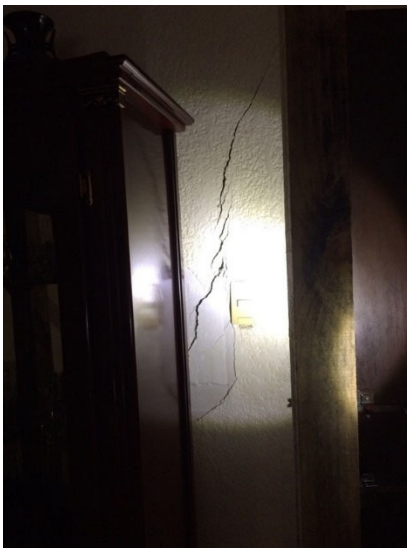


Figure 6.3.7.8 Crack in infill concrete column.

6.3.7.4 Discussion

As observed in the standing building, there is no defined lateral resisting system in the longitudinal direction. This could have been similar in the building that collapsed. It is possible that the stairs in the remaining buildings acted to resist the lateral loads in the longitudinal direction. Overall, the infill nonstructural masonry partitions provided resistance to the lateral forces as observed in the in-plane cracks.

6.3.7.5 Additional Information

At the moment of the visit, the buildings had not been officially inspected. The tenants had a repair detail in hand and mentioned that the building might be retrofitted instead of demolished.

6.3.7.6 Recommendations

A complete post-earthquake structural investigation and evaluation of each remaining building is called for and should be performed prior to determining whether the structure is safe for continued occupancy in its current condition, possible retrofit solutions and/or need for demolishment.

This complex serves as a good potential ground motion directionality study. The ground motion seems to be in the longitudinal/weaker direction of the collapse building.

6.3.8 Site #8: 19 Avenida Mexico

6.3.8.1 Building Description

This building is located in 19 Ave. Mexico, between Av. Parras and Av. Sonora, next to Parque Mexico. The general location and specific coordinates are shown on Figure 6.3.8.1. The building has 15 stories and a basement that is used as garage. The plan satellite view of the site is shown on Figure 6.3.8.2. Its construction date is unknown.

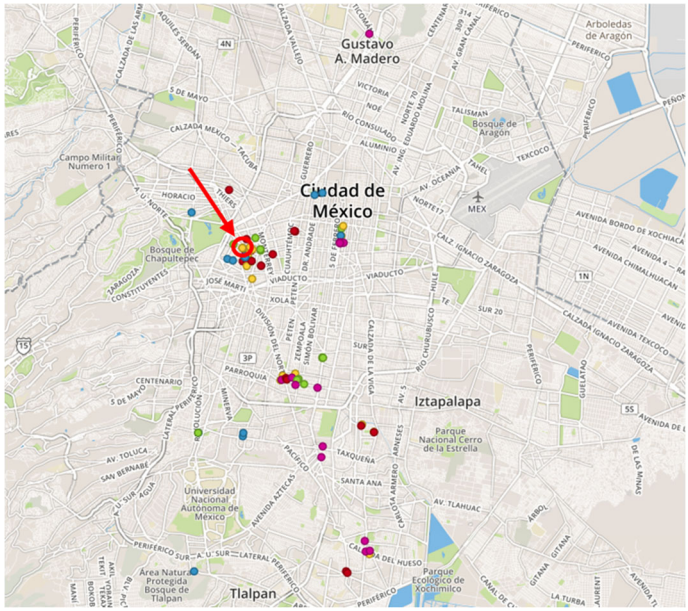


Figure 6.3.8.1 Location of site (Fulcrum Database). Coordinates: 19.4141518045398, -99.1692414880722.



Figure 6.3.8.2 Plan satellite view of site (Google Maps, 2017)

The structural system consists of reinforced concrete slabs, beams, columns and shear walls in the direction perpendicular to its façade. The front (southeast) elevation is shown on Figure 6.3.8.3.



Figure 6.3.8.3 Front (southeast) building elevation.

6.3.8.2 Damage, Repairs, and/or Rehabilitation—1985

Two of the columns in the second floor of the building were retrofitted after the 1985 earthquake with reinforced concrete jackets.

6.3.8.3 Damage and Observations—2017

According to the residents, shaking during the earthquake was stronger in the direction of the shear walls. Moderate structural damage was observed in the building as illustrated in Figure 6.3.8.4. Overall, the building appeared to be leaning and had cracks in the infill partitions and the RC shear walls on the first story. Moreover, there was damage in a limited number of columns in the basement. Nonstructural damage was also observed in the ceiling, interior walls, and partitions. Due to the damage, 16 units out of 21 were vacated during the reconnaissance visit as the building was deemed unsafe.



(a) Column spalling (basement)



(b) Crack in the slab (ground floor)



(c) Diagonal cracks on shear wall (ground floor)



(d) Displaced sidewalk



(e) Damage in concrete elements (ground floor)



(f) Exposed rebar due to spalling (basement)



(g) Crack in the sidewalk



(h) Damage in infill wall (4th story)

Figure 6.3.8.4 Observed damage.

6.3.8.4 Additional Comments

The building was instrumented. See Chapter 4 for more information.

6.3.9 Site #9: 20 Calle Ozuluama

6.3.9.1 Building Description

This building is located in 20 Calle Ozuluama, between Avenida Nuevo León and Amsterdam. The general location and specific coordinates are shown on Figure 6.3.9.1. The building has 6 stories and is of irregular plan shape as shown in Figure 6.3.9.2. Its construction date is unknown.

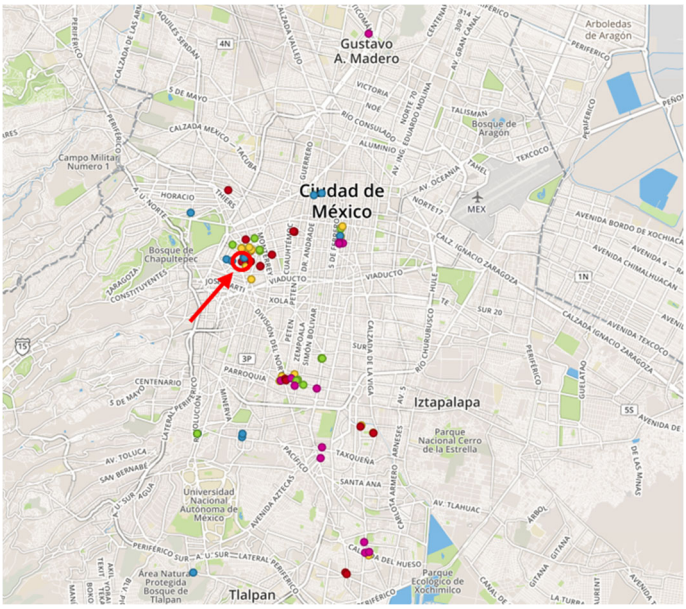


Figure 6.3.9.1 Location of site (Fulcrum Database). Coordinates: 19.410217, -99.172315.

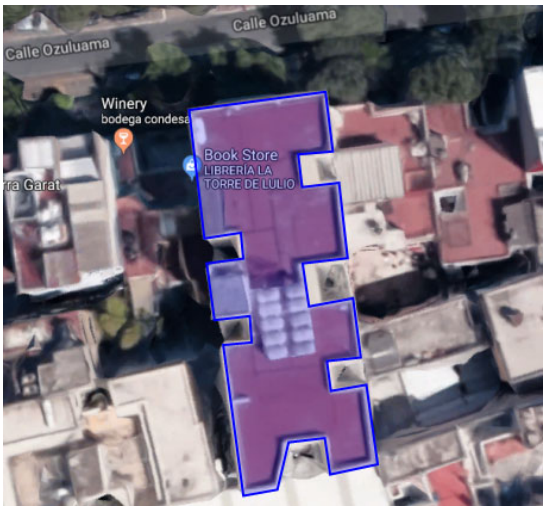


Figure 6.3.9.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. The building elevations are shown in Fig 6.3.9.3.



Figure 6.3.9.3 Front (north) building elevation.

6.3.9.2 Damage, Repairs, and/or Rehabilitation—1985

There are possible indications of pre-existing structural retrofit. These include the braced on the east exterior middle bay, as shown in Figure 6.3.9.4.

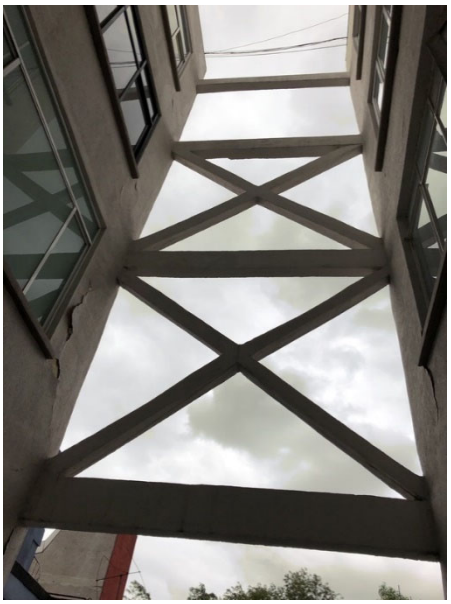
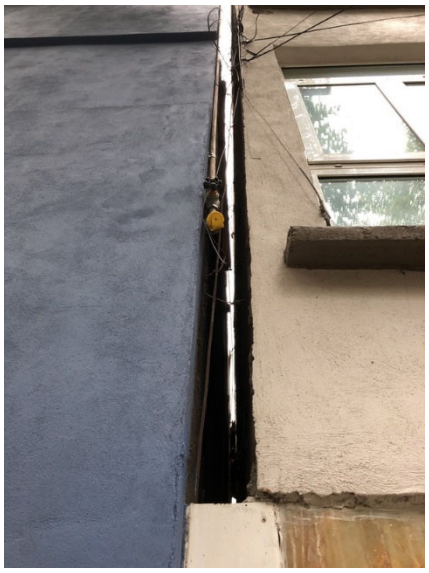


Figure 6.3.9.4 Front (north) building elevation.

6.3.9.3 Damage and Observations—2017

No pounding was observed in the east side of the building. The separation joint with the building to the east was consistent throughout the height. However, on the west side, there was sign of pounding and separation joint distress with the adjacent building, which was of a shorter height.



(a) Separation joint with east adjacent building



(b) West joint (shorter adjacent structure)



(c) West side joint pounding and joint distress

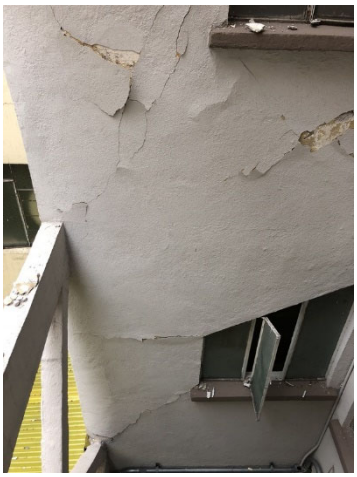
Figure 6.3.9.5 Separation joints on both sides of building/

The west side of the building had minor cracks in the infill masonry walls.



Figure 6.3.9.6 West face of building showing minor cracks.

In the exterior courtyard, there were plaster cracks at the back (south) of the building. Additionally, severe spalling was observed at the column/beam joint which also had bent vertical bars.



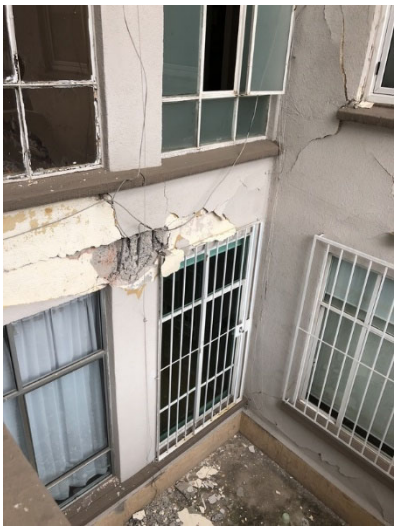


(a) and (b) Prominent plaster cracks at the back (south) the building.





(c) and (d) Prominent plaster cracks in a different courtyard





(e) and (f) Column/beam joint concrete spalling and bent bars

Figure 6.3.9.7 Damage in the exterior courtyards.

There were also large vertical cracks in the plaster on the upper floors.



(a) North face wall from the inside roof



(b) North face vertical infill plaster cracking from the balcony looking up the roof.

Figure 6.3.9.8 Photos of damages in courtyard side.

In the interior of the building, there was damage in all of the stories. There were minor cracks at the garage level. Going up to the lobby at the stairs, typical diagonal plaster cracks were observed as well as cracking in the brick infill walls.



(a) Minor cracks in garage level



(b) Diagonal plaster and infill cracking staircase brick wall roof.

Figure 6.3.9.9 Photos of ground floor damages.

In the lobby there was a ground floor column with significantly spalled concrete and a vertical rebar buckled outwards.



Figure 6.3.9.10 Damage in the lobby. Close up reveals ground floor column with spalled concrete and buckled rebar.

At the second floor, there were severe cracks in the infill brick masonry walls. Also, there were door headers that had concrete spalling. This was observed on the upper floors as well although it was more severe at the 2nd floor. This could be due to potential pounding by the two-story adjacent building. Additionally, there was a column that had severe spalling and had a vertical buckled rebar.

In the third floor there was severe cracking of the infill masonry. There was a massive infill rupture showing the stair step sliding. At these locations there were several inches of sliding and separation.



(a) Cracks in the infill brick wall vertical rebar



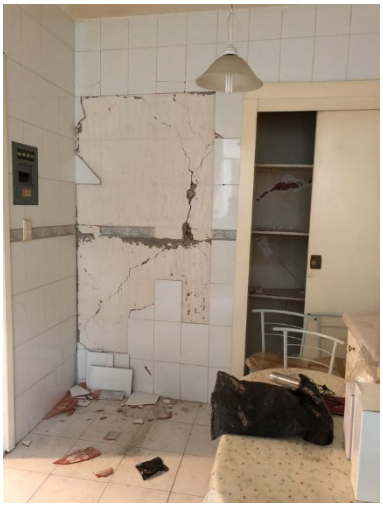
(b) Severe spalling of concrete column and bent vertical rebar



(c) Door header cracks and concrete spalling



(d) Exposed infill wall by door

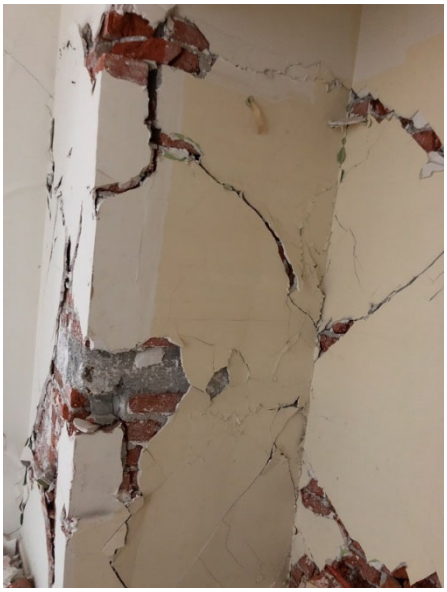


(e) Cracks in interior wall

Figure 6.3.9.11 Damage in the 2nd story.



(a) Infill wall cracks.



(b) Infill damage adjacent to column



(c) Massive infill rupture showing stair step sliding



(d) Several inches of sliding and separation

Figure 6.3.9.12 Damage in the 3rd story.

6.3.9.4 Discussion

The severity of the damage in this building is clearly apparent by examining the interior apartment areas. The extent and type of structural damage renders this structure unsafe for occupancy in its current condition. The damage caused by rupture and sliding failure of the brick infills within RC frames is quite serious. Several bounding columns appeared to be compromised due to this displacement of the infill walls thus rendering the building unsafe and perhaps even an area hazard in the event of a large aftershock or large future earthquake.

6.3.9.5 Additional Information

This building was pointed out and shown to the team by area resident Ms. Lorena Gonzales. It appeared to not be on the lists of buildings identified by EERI etc. in their earlier drive-by surveys. According to Ms. Gonzales there is a primary school adjacent to this building in the rear of the structure. If that is the case, it would be prudent to take extra precautions so as not to expose the school children to the heightened risk emanating from this compromised building structure.

6.3.9.6 Recommendations

A complete and detailed structural evaluation of this building must be performed by a qualified structural engineer as soon as possible. As an extra precaution the adjacent primary school building should not be used until and unless this structural evaluation is completed and the SE determined the best course of action going forward.

6.3.10 Site #10: 20 Calle Paseo Del Rio

6.3.10.1 Building Description

This building is located on 20 Calle Paseo Del Rio, in the intersection of Paseo del Rio and Cuarta Calle Paseo Chico. The general location and specific coordinates are shown on Figure 6.3.10.1. The building has 6 stories, with no basement. There is a garage at the ground floor. The structure has an H-shape plan area, shown on the plan satellite view of the site on Figure 6.3.10.2. Its construction date is unknown.

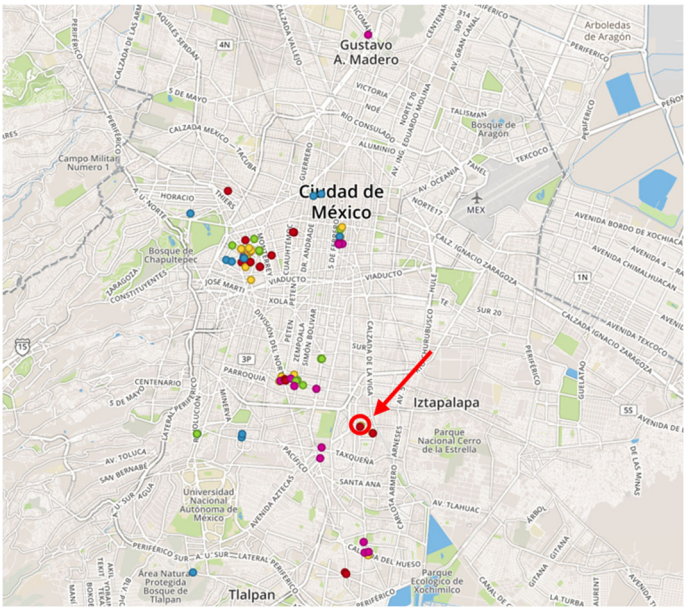


Figure 6.3.10.1 Location of site (Fulcrum Database). Coordinates: 19.350370, -99.125690.

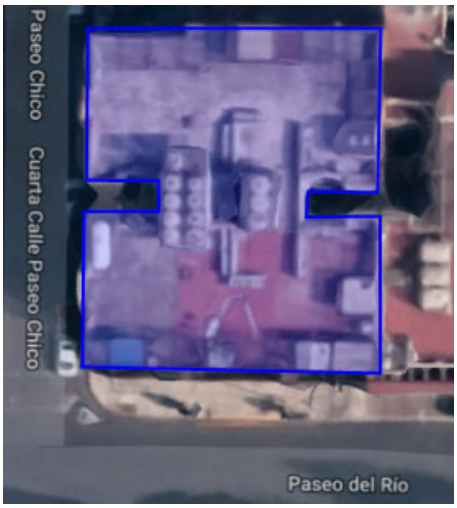


Figure 6.3.10.2 Plan satellite view of site (Google Maps, 2017).

The building appears to have a reinforced concrete slab system supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. The building elevation is shown in Fig 6.3.10.3.



Figure 6.3.10.3 Side (west) and back (north) elevation view of the building.

6.3.10.2 Damage and Observations—2017

No observations were made inside the building. There are more masonry infill walls in the N-S direction than in the E-W direction. Most of the building damage (nonstructural) is visible in the E-W direction. There was no visible evidence of retrofit.

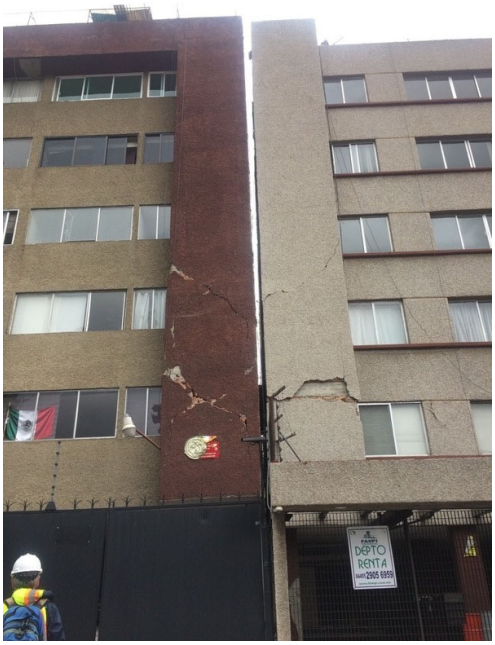
There are cracks in the exterior wall that show lateral resistance by the infill walls in the E-W direction. There might have been pounding damage at the first floor above the ground which indicates potential soft story concentrated movement.



Figure 6.3.10.4 Cracks in the exterior front (south) infill wall.



(a) Cracks in the walls at the courtyard



(b) Damage from possible pounding

Figure 6.3.10.5 Photos of damage in building.

The ground seems to have displaced. The sidewalk settled and the ramp separated from the garage.



(a) Cracks in ramp to the ground floor parking (b) Settlement of side walk next to building.

Figure 6.3.10.6 Photos of cracks in sidewalk.

6.3.10.3 Recommendations

A complete post-earthquake structural investigation and evaluation of the building is called for and should be performed prior to determining whether the structure is safe for continued occupancy in its current condition, possible retrofit solutions and/or need for demolishment.

Since the building was not inspected in the interior, it is unclear whether it is a good candidate for future ATC structural building studies.

Due to the settlement and cracks in the sidewalk, as well as the proximity to a leaning building (see 10 Calle Paseo Del Rio), this building and the neighboring structures are good candidates for soil conditions and potential soil failure studies.

6.3.11 Site #11: 32 Calle Rancho El Arco

6.3.11.1 Building Description

This building was located in 32 Calle Rancho El Arco, between Rancho Vista Hermosa and Calz. del Hueso. The general location and specific coordinates are shown on Figure 6.3.11.1. The structure had an H-shape plan area as shown on the plan satellite view on Figure 6.3.11.2. The building collapsed and had been demolished and removed.

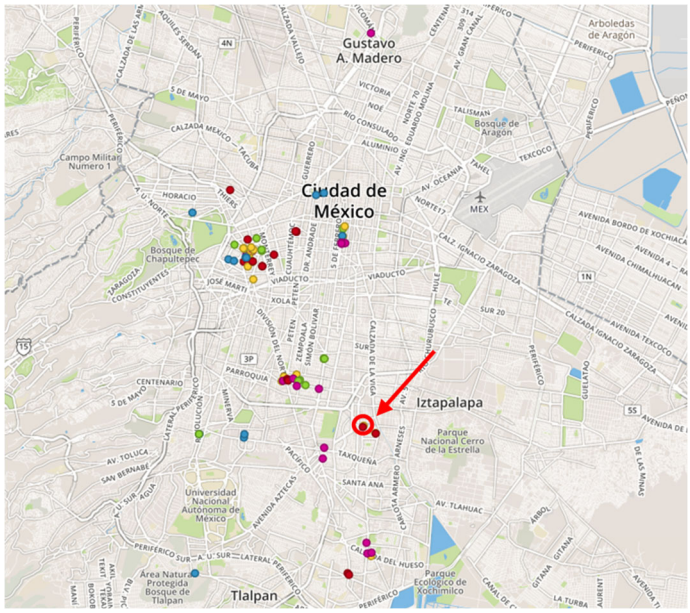


Figure 6.3.11.1 Location of site (Fulcrum Database). Coordinates: 19.304505, -99.123063.

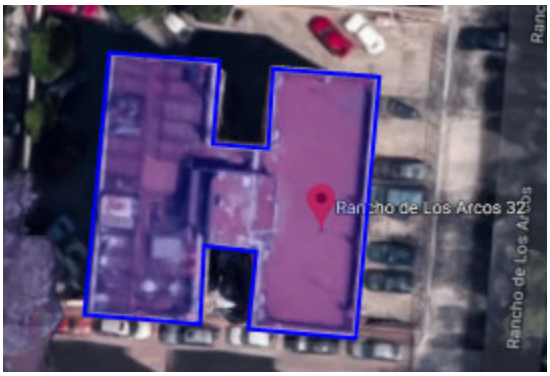


Figure 6.3.11.2 Plan satellite view of site (Google Maps, 2017).

6.3.11.2 Damage and Observations—2017

No observations were completed because the building had been demolished and removed at the time of reconnaissance. As per the view on Google Maps in Figure 6.3.11.4, the building was composed of concrete frame structures with infill walls. The building collapsed towards the front (east) as per photos seen from news sources (ejecentral.com.mx, 2017).



Figure 6.3.11.3 Collapsed structure towards front (ejecentral.com.mx, 2017).



Figure 6.3.11.4 Empty lot after removal of collapsed structure.



Figure 6.3.11.5 Original building, from Google View 2017 before the earthquake.

6.3.11.3 Discussion

Based on the photos, the building collapsed towards the transverse direction which could have been due to a weak lateral load resisting system in that direction. The reinforced concrete frame was most likely the lateral load resisting system in the east-west (transverse) direction, along with the masonry infill walls.

6.3.12 Site #12: 32 Avenida Mazatlan

6.3.12.1 Building Description

This building is located in 32 Avenida Mazatlan, between Juan de la Barrera and Antonio Sola. The general location and specific coordinates are shown on Figure 6.3.12.1. As observed from the satellite maps in Figure 6.3.12.2, the plan area is C-shape. The building has 6 stories and a bulkhead. Its construction date is unknown.

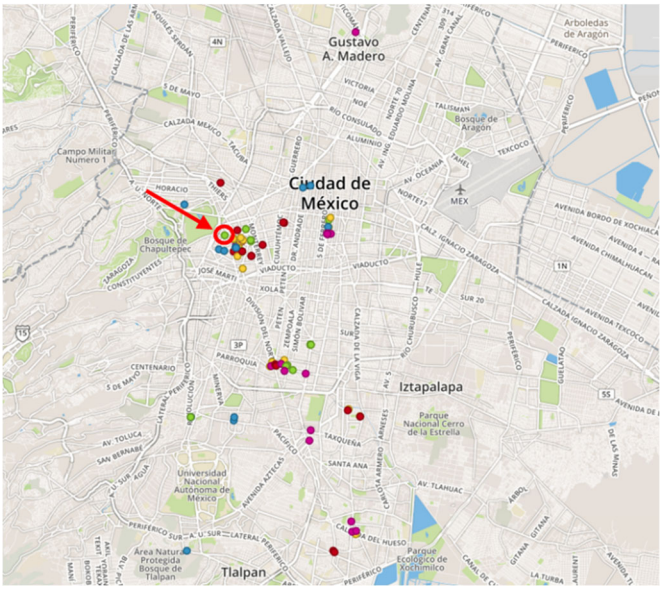


Figure 6.3.12.1 Location of site (Fulcrum Database). Coordinates: 19.416428, -99.175711.



Figure 6.3.12.2 Plan satellite view of site (Google Maps, 2017).

The building interior was not observed due to restricted access. Based on observation from the sidewalk, the building appears to have reinforced concrete slabs supported on concrete frames. Lateral loads are most likely resisted by the concrete frame with URM infill in both building directions. Figure 6.3.12.3 below shows an elevation view (west) of the building.



(a) Front (west) façade (b) Front entrance way

Figure 6.3.12.3 Front view of the building.

6.3.12.2 Damage and Observations—2017

No structural damage was observed. However, there appears to be some damage to the masonry infill walls. From the sidewalk, the observed damage appeared to be mostly cosmetic.

6.3.13 Site #13: 38 Jose Maria Izazaga

6.3.13.1 Building Description

This building is located in 38 Jose Maria Izazaga, between Calle Bolivar and Eje Central Lazaro Cardenas. The general location and specific coordinates are shown on Figure 6.3.13.1. As observed from the satellite maps in Figure 6.3.13.2, the plan area is irregular. The building has 12 stories. Its construction date is unknown.

The structure is composed of a waffle slab system supported on reinforced concrete beams and columns. The building has a system of metallic yield dampers attached in the junction between chevron braces and beams. In the front, there are four bays of dampers. In the back, there are four bays of dampers which transition to larger dampers at the last four floors, as seen in Figure 6.3.13.3.

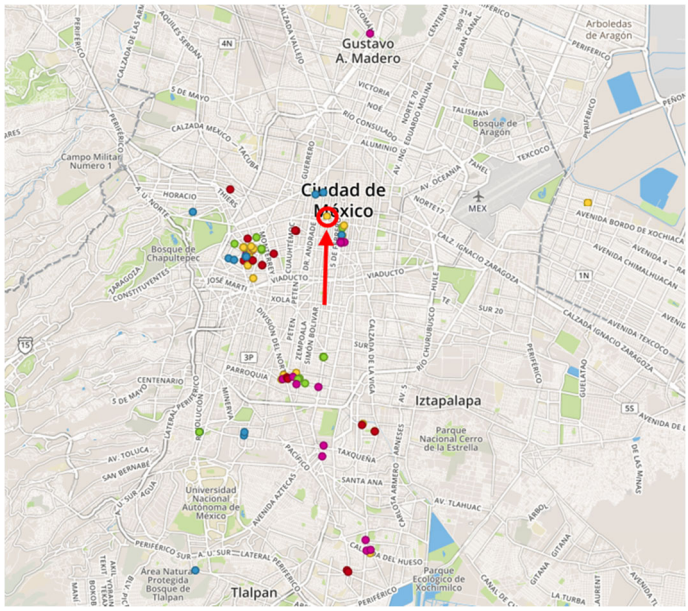
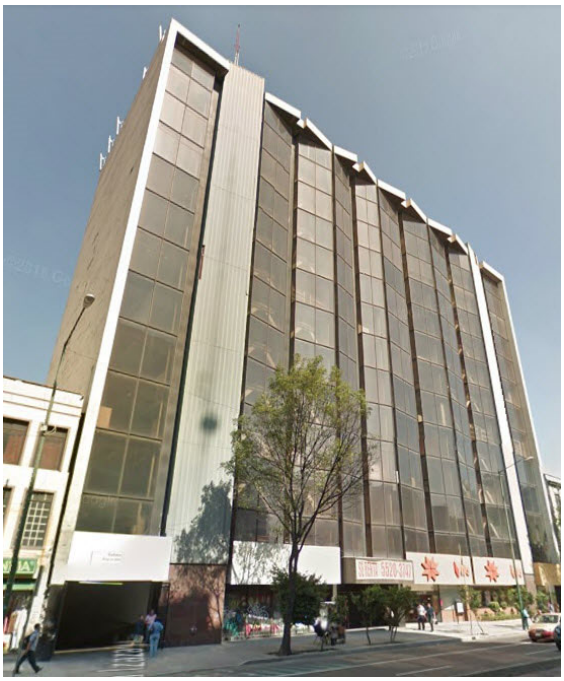


Figure 6.3.13.1 Location of site (Fulcrum Database). Coordinates: 19.426809, -99.139950.



Figure 6.3.13.2 Plan satellite view of site (Google Maps, 2017).



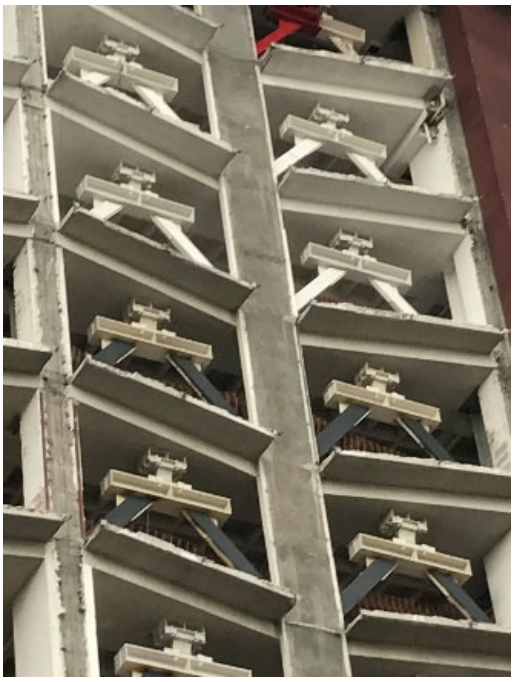
(a) Google Maps, April 2017



(b) Front view during reconnaissance



(c) Metallic dampers



(d) Metallic dampers

Figure 6.3.13.3 Building elevation (south).



Figure 6.3.13.4 Back (north) building elevation view from Google Maps, November 2016.

6.3.13.2 Damage and Observations—2017

The structure was not observed in detail. However, comparing the photos taken on site with the photos from Google maps months before the earthquake, the front (south) façade had been removed, which may potentially suggest nonstructural damage during the earthquake. Additionally, it can be observed from the screen capture prior to the earthquake in Figure 6.3.13.4, from November 2016, that the structure already had some cracks in the infill walls at the back facing east.

6.3.14 Site #14: 47 Parque España

6.3.14.1 Building Description

This building is located in 47 Parque España, at the intersection of Parque España and Juan de la Barrera. The general location and specific coordinates are shown on Figure 6.3.14.1. The building plan view is shown on the satellite maps in Figure 6.3.14.2. The building has 7 stories. The building was designed and constructed in 2006.

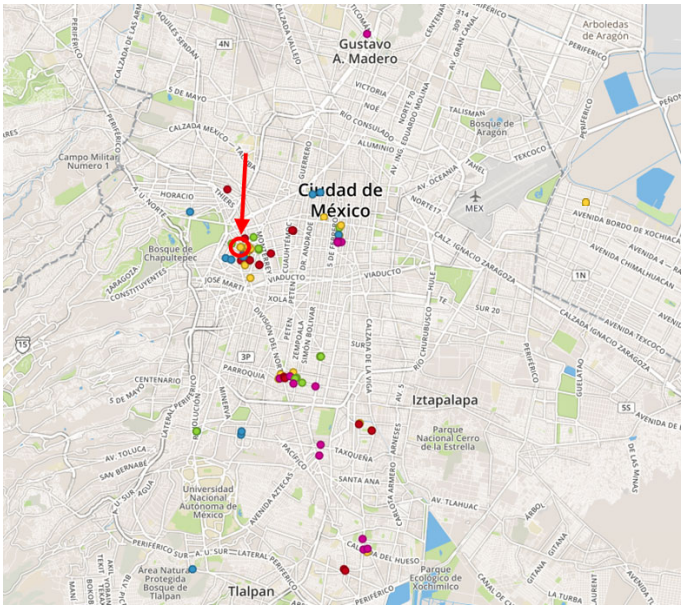


Figure 6.3.14.1 Location of site (Fulcrum Database). Coordinates: 19.4151282541288, -99.1722465679049.



Figure 6.3.14.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on reinforced concrete columns, reinforced concrete walls, and steel columns. Lateral loads are resisted by the reinforced concrete walls and moment frames in both building directions. The building elevations are shown in Fig 6.3.14.3. The building

has plan and vertical irregularities, including severe torsional irregularity. A plan of the building is shown in Fig 6.3.14.4.



(a) Front (east) elevation (b) Side (south) façade is nonstructural block wall

Figure 6.3.14.3 Building elevations.

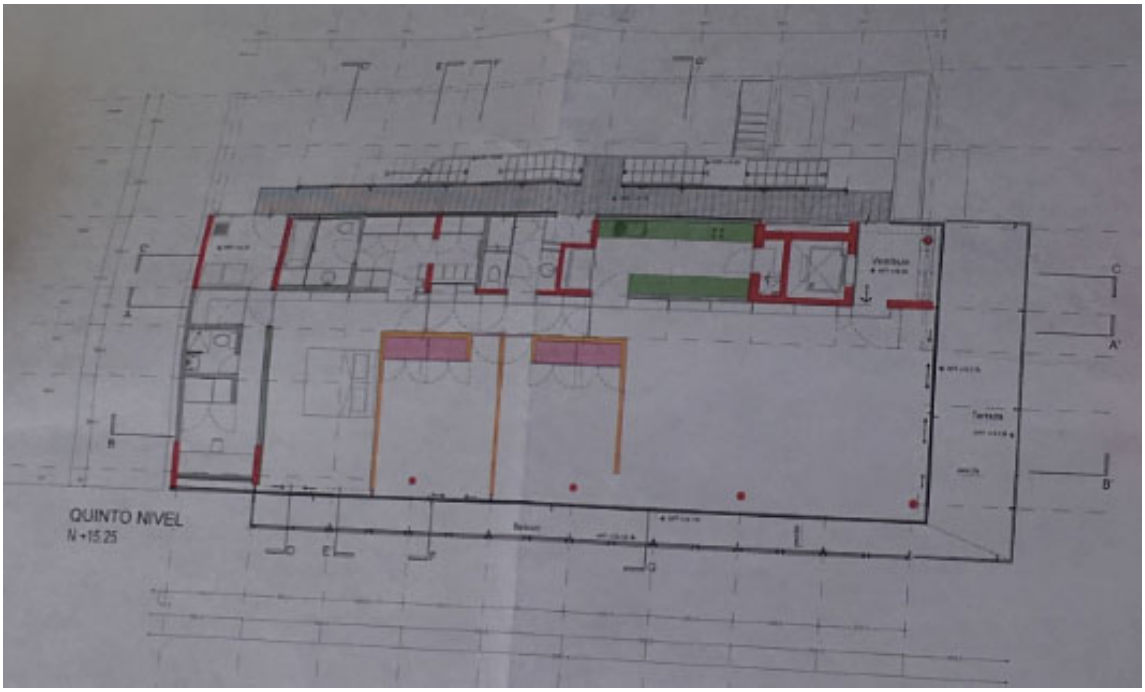


Figure 6.3.14.4 Building plan (5th Floor).

6.3.14.2 Damage and Observations—2017

Overall, this building suffered moderate structural damage. One small concrete column appears to have been crushed during the earthquake. Punching shear failure was observed around columns on the 2nd to 4th floor, and may be present in other locations that are not readily visible.



Figure 6.3.14.5 Punching shear failure of column at 4th floor.

Severe cracks were observed in the non-structural masonry walls, cracking was observed on the plaster on the underside of structural slabs, and damage was observed in ceiling, interior walls, ornamentation, and partitions. There was also severe spalling of a concrete column and wall, as shown in Figure 6.3.14.6.

There is a transfer diaphragm at the second floor level. It transfers the seismic force from the frames to the concrete wall on the east side of the building. Minor diagonal cracks are observed in the diaphragm.

The building appears to have settled over time, and according to residents the settlement was present prior to the earthquake. On the sidewalk outside the building, the cracks were observed.



(a) Cracked and plastered wall



(b) Significant spalling of concrete in column

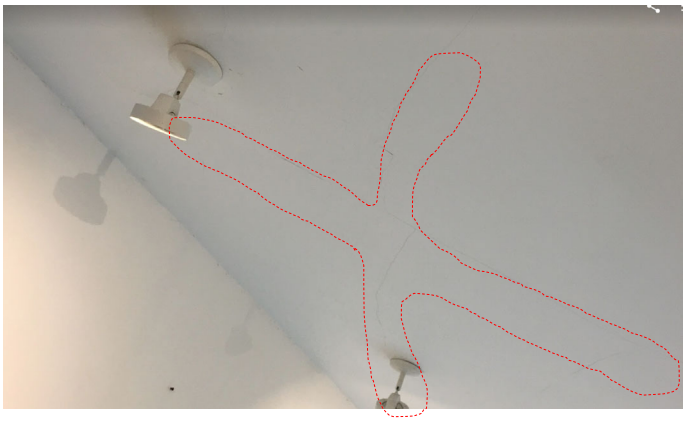


(c) Significant concrete spalling

Figure 6.3.14.6 Damage in walls and columns.



(a) 2nd floor X cracks in block wall



(b) Diaphragm shear cracks

Figure 6.3.14.7 Damage in wall and diaphragm



Figure 6.3.14.8 New crack parallel to building along Juan de la Barrera

Additional minor damages include a buckled cable hanging on the south façade as well as suspected vertical movement around the cable connection to the slab, as shown on Figure 6.3.14.9.



(a) Buckled cable

(b) Suspected vertical movement at connection

Figure 6.3.14.9 Buckled cable and connection to slab.

6.3.14.3 Discussion

Due to the architectural layout, the building is torsionally irregular. There are many walls on one side of the building, where the kitchens, bathrooms, and closets are located, while the other side of the building is supported on steel columns and has an open layout. During the site visit, it was observed that the tenants on each floor would install their own partition in the area with open layout, so the location and construction of the partition varied from floor to floor. These nonstructural partitions appeared to have absorbed energy during the earthquake and the majority were demolished and rebuilt afterwards. They may have prevented more severe damage to the steel columns and concrete slab.

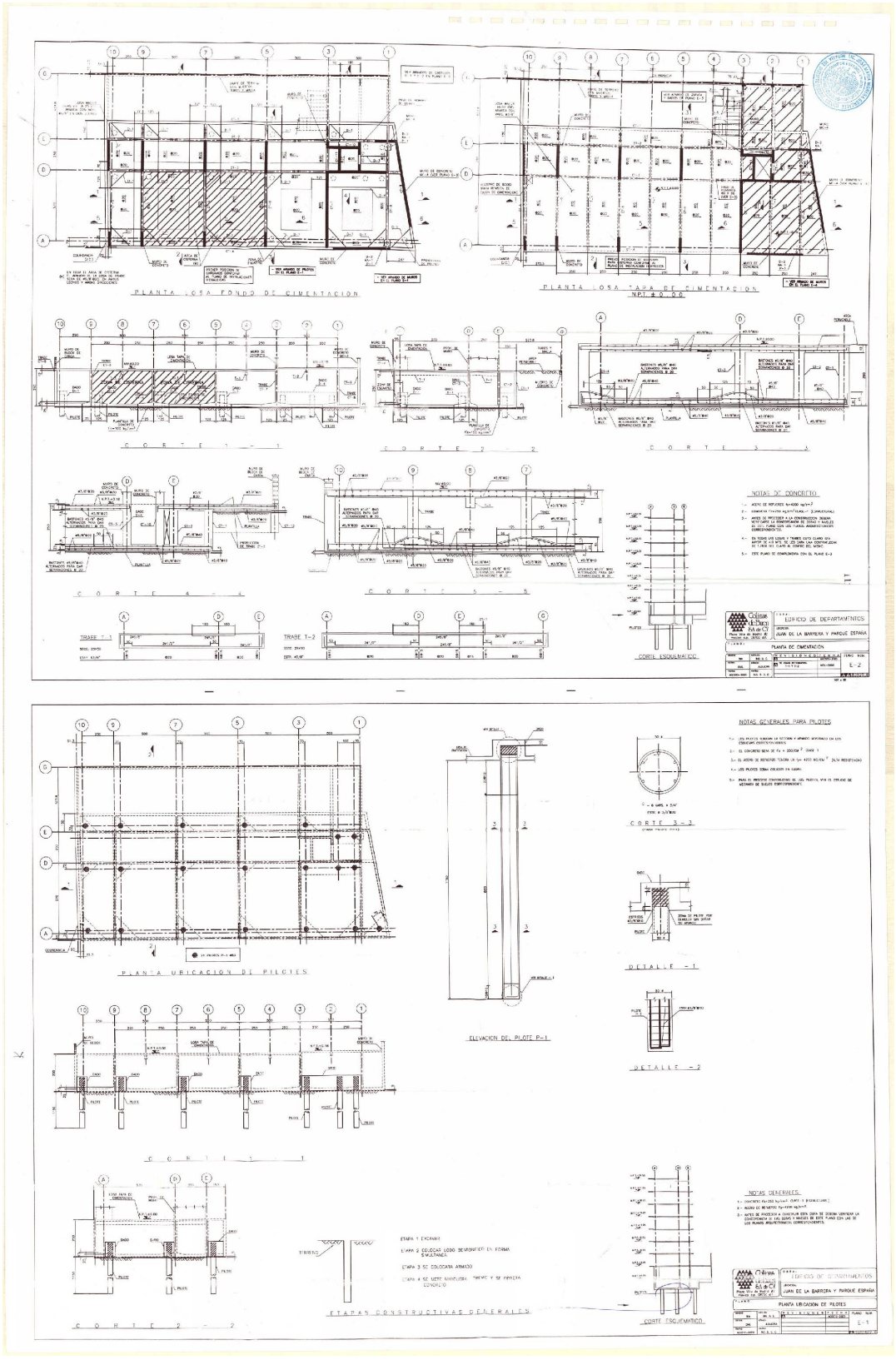
6.3.14.4 Available Information

Structural drawings are available for this building, as presented in Section 6.3.14.5. The building was monitored during the 2017 reconnaissance trip, and the monitoring data is available. Refer to Chapter 4 for more information.

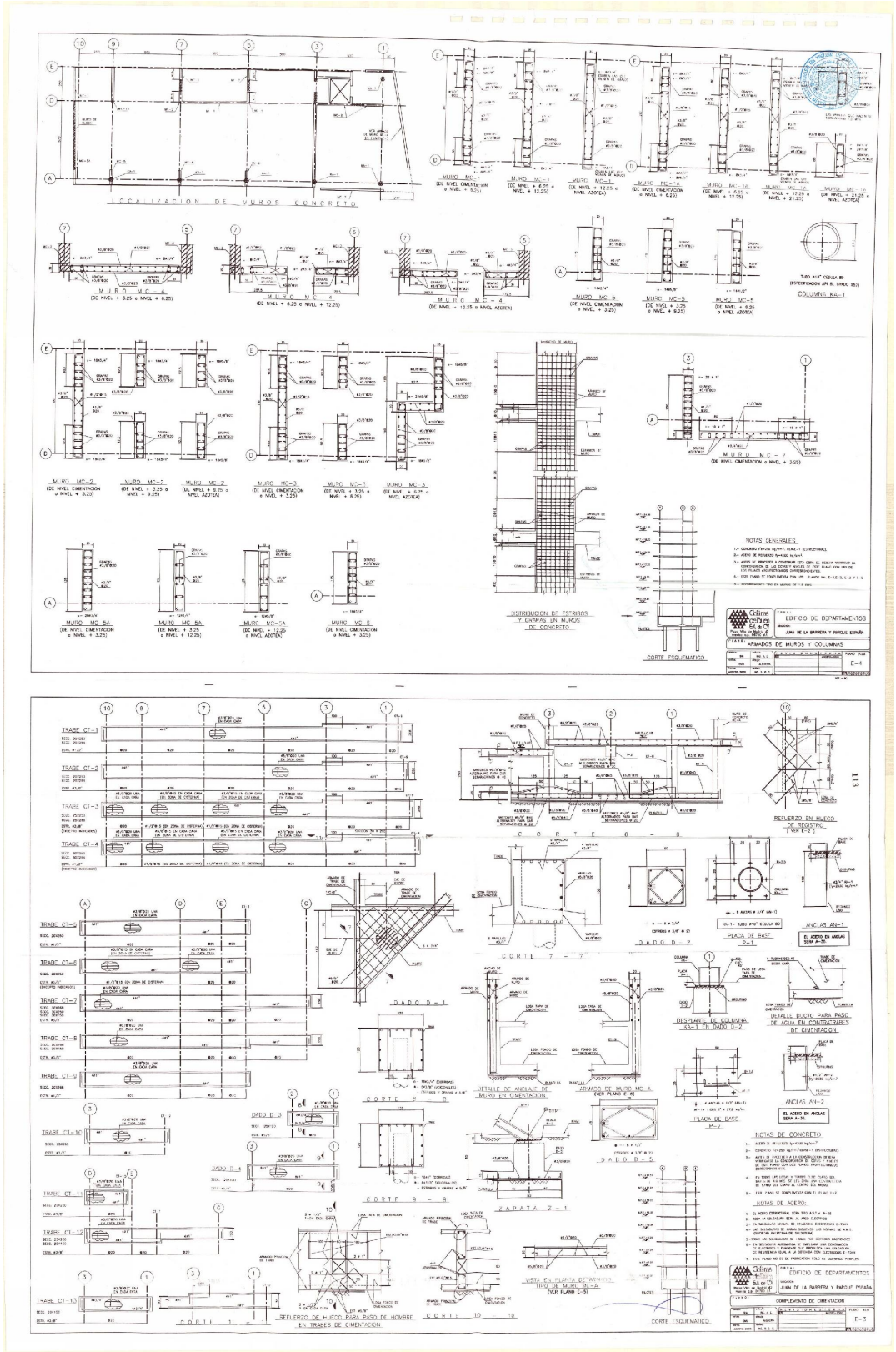
6.3.14.5 Recommendations for Further Study

Further study is being conducted to confirm the punching shear capacity of the concrete slab since punching shear failure was observed. Structural plans available for this building, additional analyses may be performed to assess ways to compensate for the torsional irregularity present in the building.

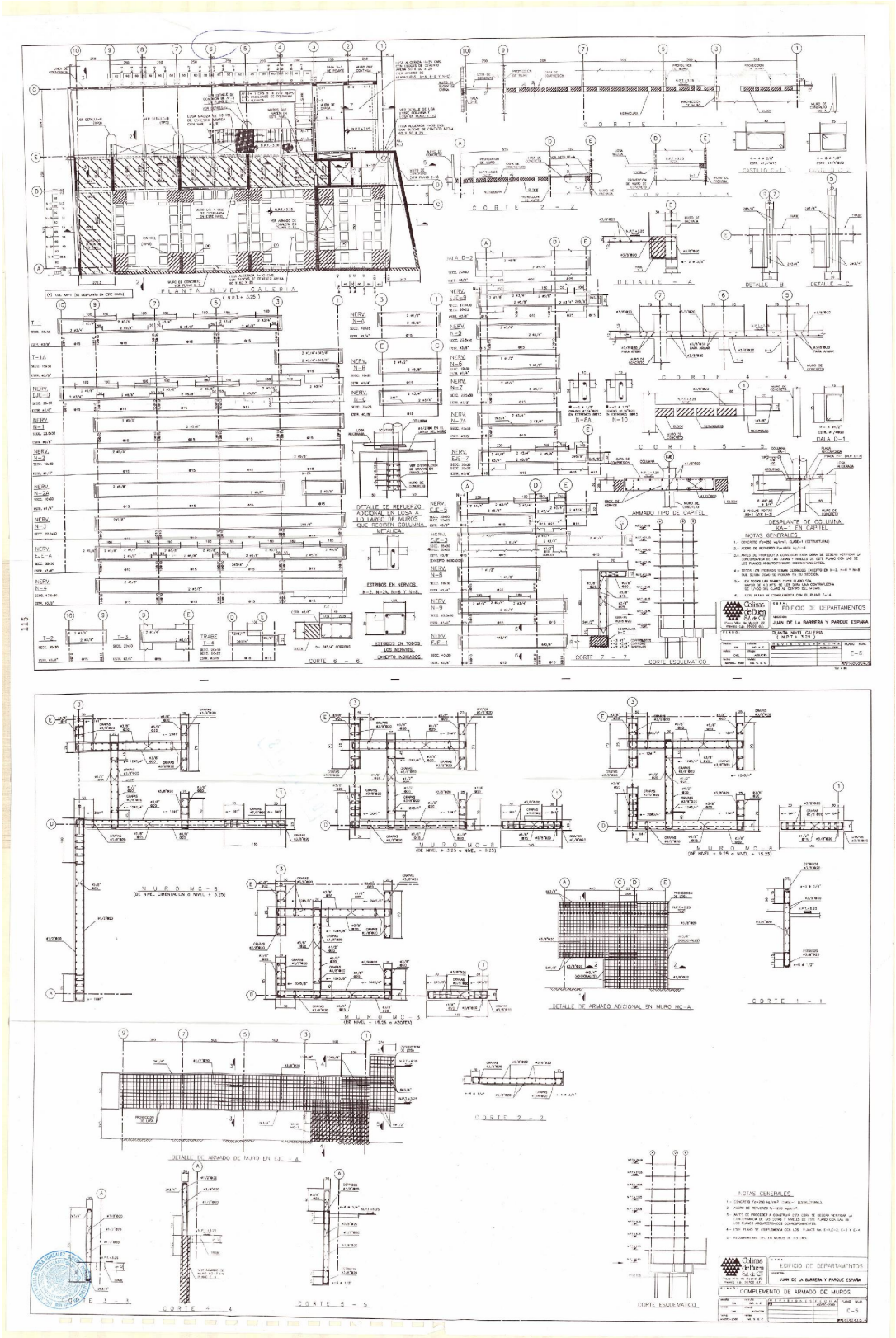
6.3.14.6 Structural Drawings



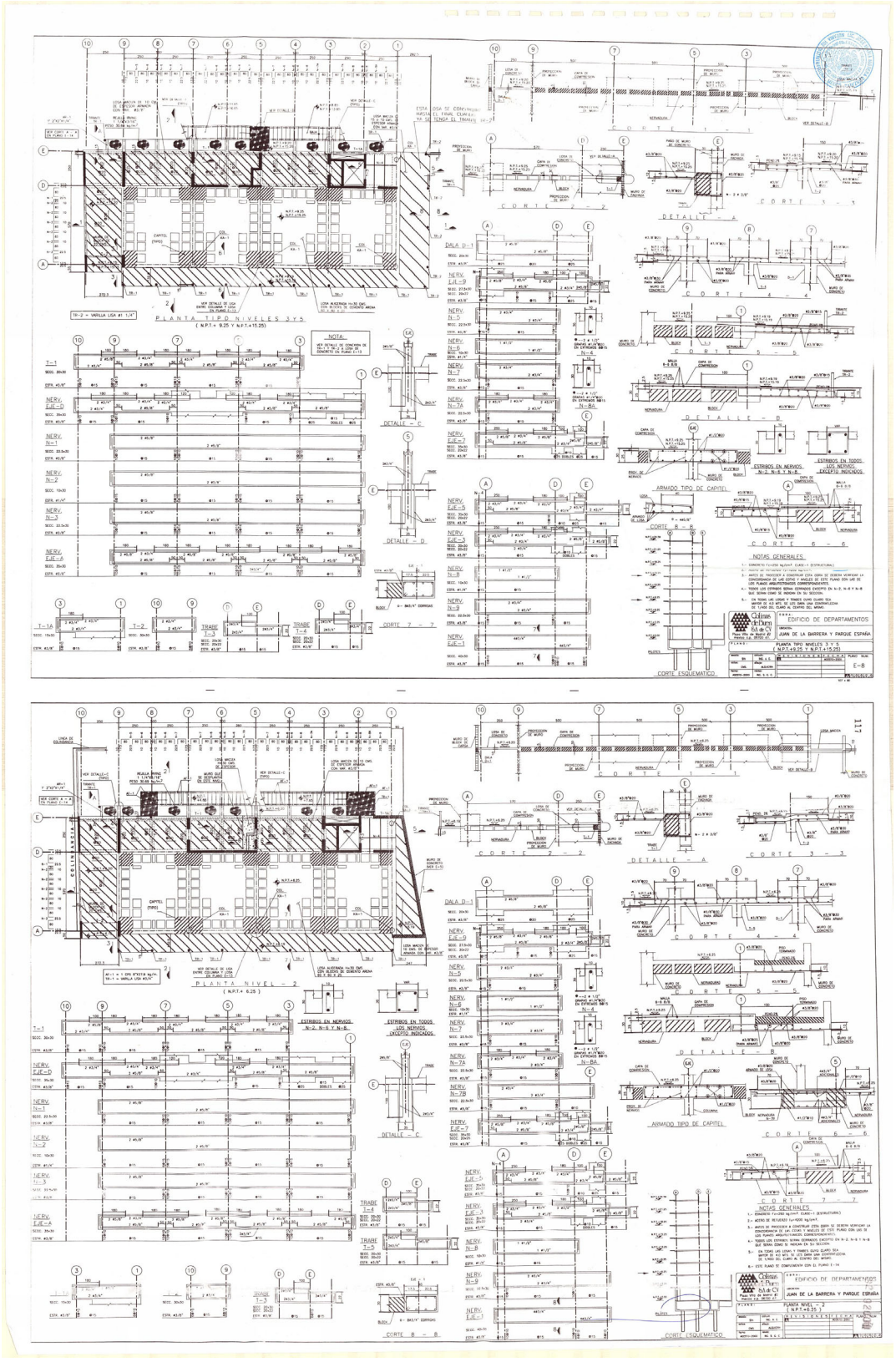
(a) Foundation Plans



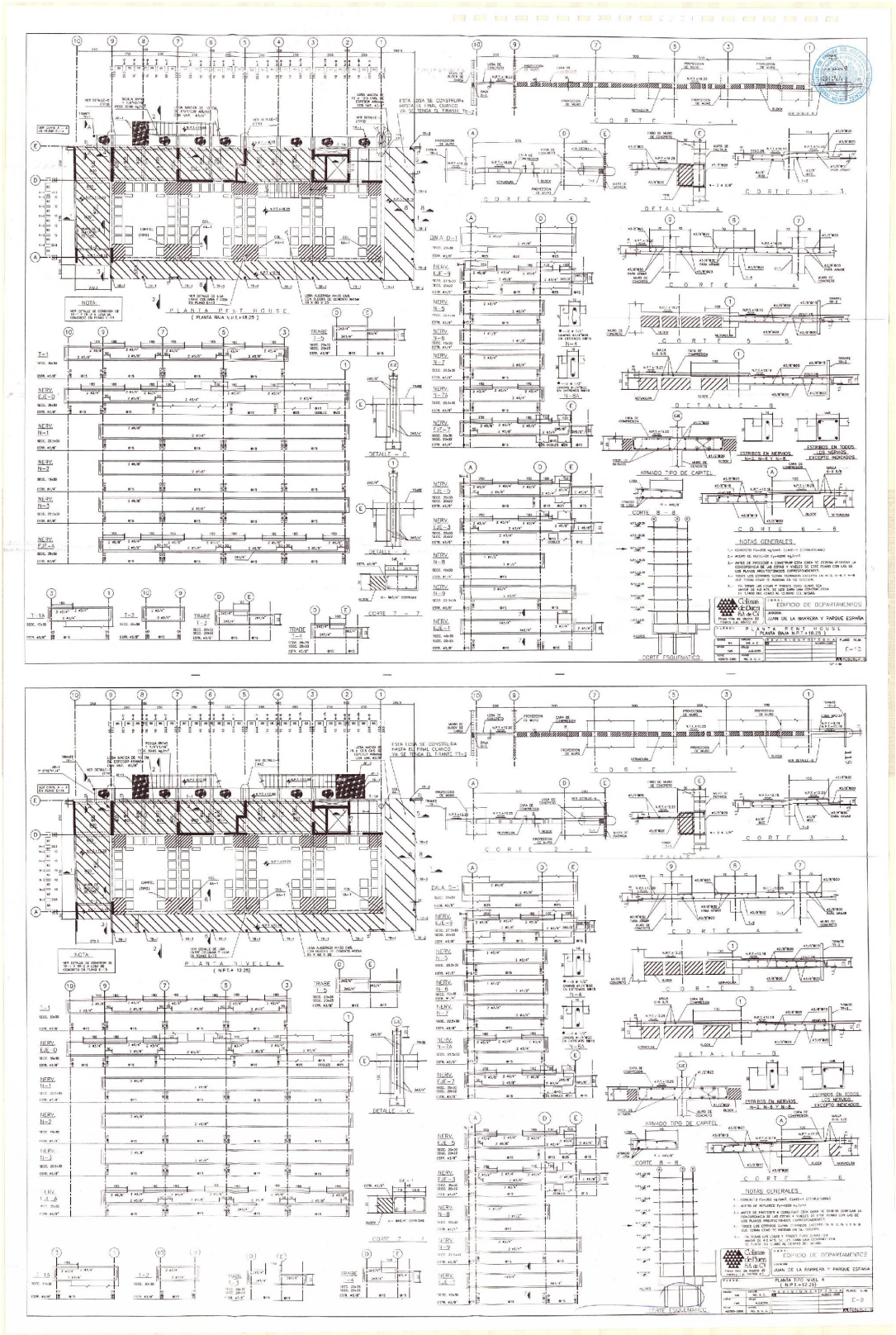
(b) Column and beam reinforcement and details



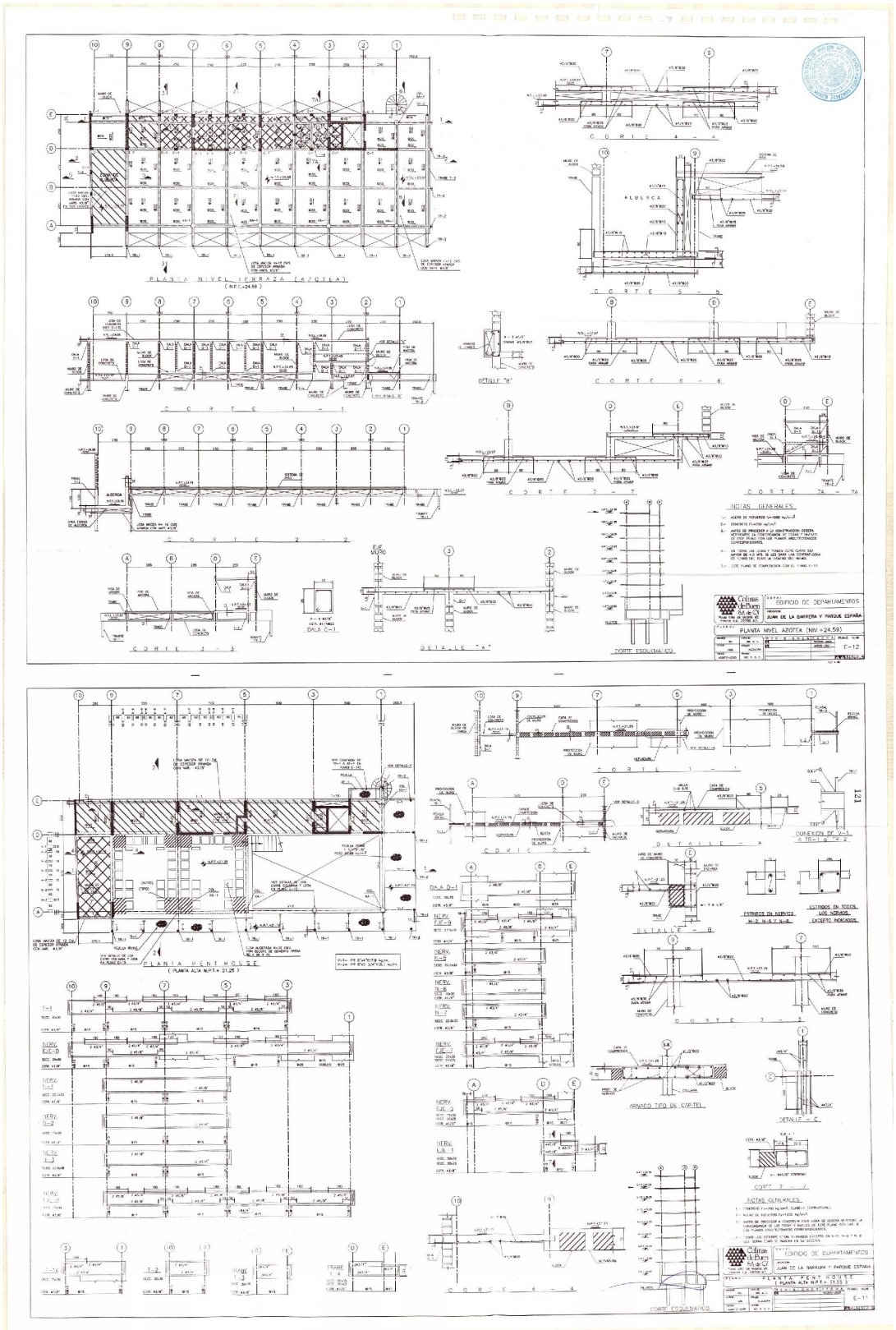
(c) Slab and wall reinforcement



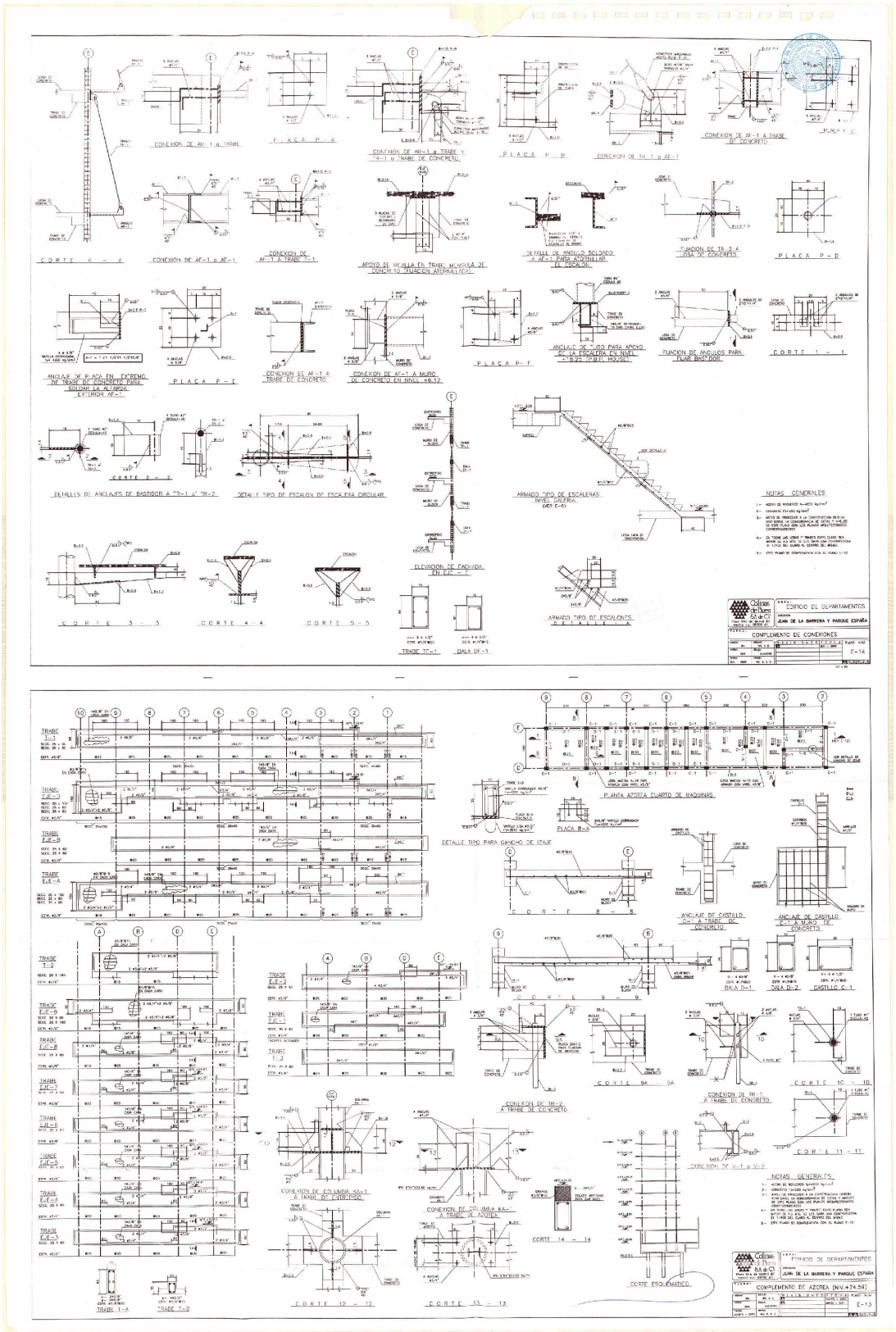
(d) Plan and slab/beam reinforcement for levels 3 and 5, and level 2



(d) Plan and slab/beam reinforcement for the penthouse and 4th level



(e) Plan and slab/beam reinforcement for the penthouse and roof level



(f) Additional roof slab/beam reinforcement, and typical connection details

Figure 6.2.14.10 Building drawings.

6.3.15 Site #15: 49 Amsterdam

6.3.15.1 Building Description

This building is located on 49 Amsterdam, between Calle Huichapan and Av. Sonora. The general location and specific coordinates are shown on Figure 6.3.15.1. The plan area is C-shape, as shown in the plan satellite view in Figure 6.3.15.2. The building has 11 stories. Its construction date is unknown.

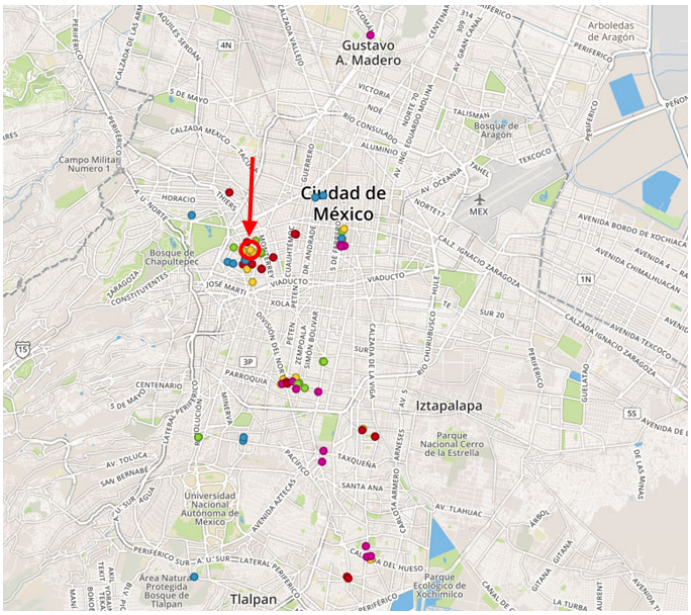


Figure 6.3.15.1 Location of site (Fulcrum Database). Coordinates: 19.415493, -99.169257.

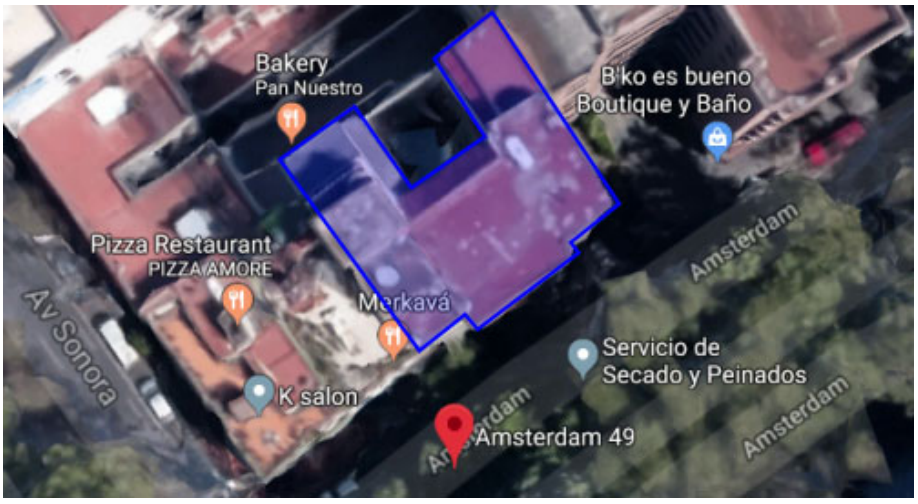


Figure 6.3.15.2 Plan satellite view of the site (captured from Google 2017).

This building was observed only from the street. Based on exterior observation and local construction practice, the building appears to have reinforced concrete slab supported on concrete frames. Lateral loads are most likely resisted by the reinforced concrete moment-resisting frame in both building directions. Fig 6.3.15.3 below shows an elevation view (southeast) of the building.



Figure 6.3.15.3 Front (southeast) building elevation.

6.3.15.2 Damage and Observations—2017

The east wall was observed to be leaning and the lean was measured to be approximately 14 degrees, as shown on Figure 6.3.15.4. However, according to the neighbors, the lean was present before the 2017 earthquake. The building appears to have been occupied at the time of the visit. Very little damage was observed from the exterior of the building.



(a) Building appears to be leaning. (b) Building is measured to be leaning 14 degrees.

Figure 6.3.15.4 Building leaning.

6.3.16 Site #16: 52 Cozumel

6.3.16.1 Building Description

This building is located in 52 Cozumel, between Cda. Salamanca and Calle de Durango. The general location and specific coordinates are shown on Figure 6.3.16.1. The plan area is irregular, as shown in the plan satellite view in Figure 6.3.16.2. The building has 10 stories plus a basement parking garage. Its construction date is unknown.

The building has a reinforced concrete waffle slab supported on the concrete columns. Lateral loads are resisted by the reinforced concrete structural walls and masonry infilled frames in both building directions. The moment frame action from the columns and slabs also contributes to the lateral capacity. The building elevations are shown in Fig 6.3.16.3.

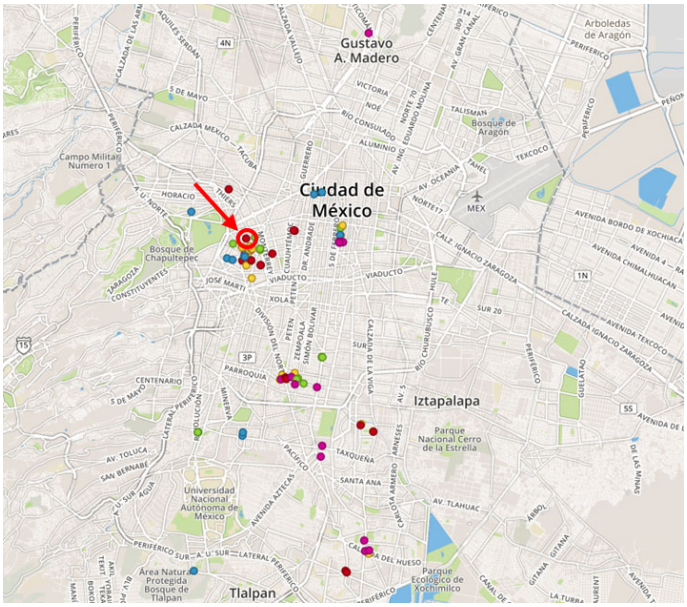


Figure 6.3.16.1 Location of site (Fulcrum Database). Coordinates: 19.418362369779, -99.1706023738712.



Figure 6.3.16.2 Plan satellite view of the site (captured from Google 2017).



(a)West elevation (b) North elevation

Figure 6.3.16.3 Building elevations.

6.3.16.2 Damage, Repairs, and/or Rehabilitation—1985

The building was damaged in 1985 and retrofitted with reinforced concrete structural walls and concrete column jackets as shown in Figure 6.3.16.4. In 1985, the South-west corner columns failed and lost the gravity support. The damage might have been caused due to torsional irregularity of the original layout of the lateral force resisting system, masonry infilled frames and nonductile concrete columns. The concrete column jackets and reinforced concrete structural walls were implemented to mitigate the deficiencies.

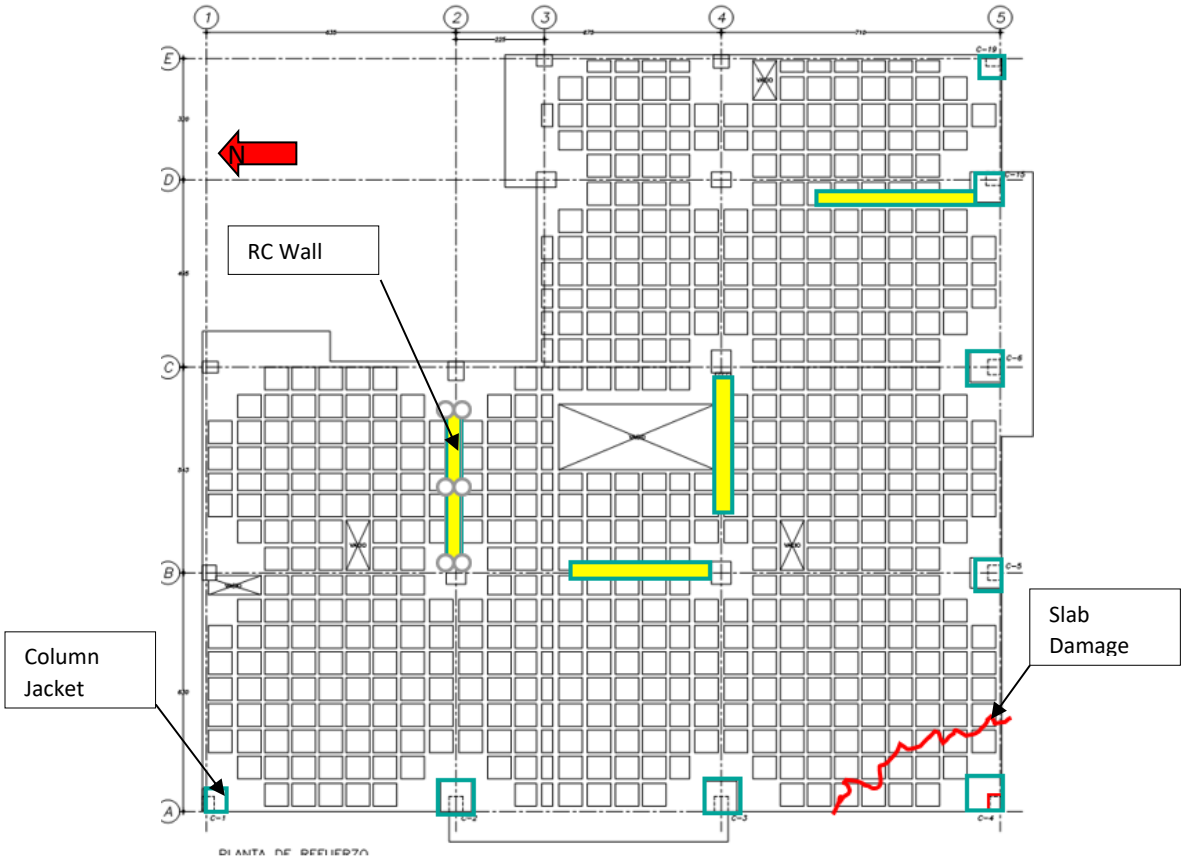


Figure 6.3.16.4 Building elevations with damage and retrofits.

6.3.16.3 Damage and Observations - 2017

The structural damage was caused by the failure of waffle slab near the south-west corner columns which had failed in 1985. However, the waffle slab failure might be caused from the 1985 earthquake and was not identified until 2017 earthquake. The damages in the nonstructural components including masonry partition walls and exterior spandrels, were relatively severe but structural damage was only concentrated where the waffle slab failure occurred. The lateral force resisting system including the reinforced concrete structural walls and column jackets remained functional. The west side of building diaphragm cantilevers from the reinforced concrete structural wall close to the center of building, which likely caused relatively large deformation demand in the columns on the west perimeter of the building.

The deficiency that resulted in the structural failure may be classified as deflection compatibility since the gravity frame did not have enough deformation capacity to accommodate drift demand while the lateral system had adequate capacity.

The elevator was not functional after the earthquake. Severe spalling of architectural finishes was observed around the ends of the link beams at the lower floors. Cracks were observed around the shear wall and link beam joint, although it was unclear if the cracks were caused by the earthquake. Several infills were significantly damaged in the first 5 stories of the building. Plaster was observed to be detached throughout the building, both in the ceilings and walls.



Figure 6.3.16.5 Slab failure. Building engineer said there were pre-existing cracks from the previous earthquake, which led to further damage during the 2017 earthquake.



(a) New link beam and shear walls added

(b) Cracks observed in shear walls at the bottom levels.

(c) Ground floor exposed rebar

Figure 6.3.16.6 Structural damage observations.

6.3.16.4 Recommendations

The building seems repairable. New structural walls are recommended in the south and west perimeter of the building.

6.3.16.5 Additional Information

The building was instrumented. See Chapter 4 for more information.

6.3.17 Site #17: 53 Iztaccihuatl

6.3.17.1 Building Description

This building is located in 53 Iztaccihuatl, between Av. Mexico and Amsterdam. The general location and specific coordinates are shown on Figure 6.3.17.1. The plan area is H-shape, as shown in the plan satellite view in Figure 6.3.17.2. The building has nine stories with no basement. Its construction date is unknown.

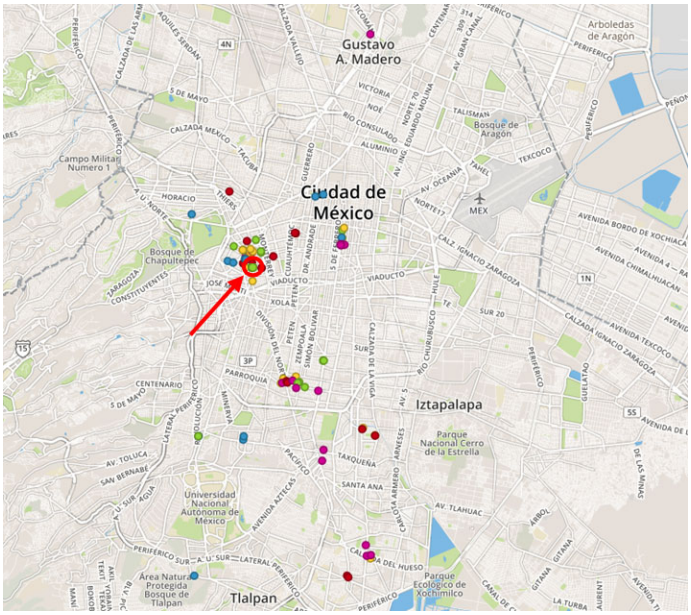


Figure 6.3.17.1 Location of site (Fulcrum Database). Coordinates: 19.410437, -99.169149.



Figure 6.3.17.2 Plan satellite view of the site (captured from Google 2017).

The building has reinforced concrete slabs supported on concrete frames and concrete shear walls. Lateral loads are resisted by a combination of concrete shear walls, URM infill, and concrete moment frame action. The building elevations are shown in Figure 6.3.17.3.



Figure 6.3.17.3 Front view of the building (southwest).

6.3.17.2 Damage and Observations—2017

Overall, the building has moderate damage to several URM infill panels. The concrete shear walls show little-to-no signs of cracking. No evidence of retrofit was observed.



(a) Cracked URM Infill Panels



b) Cracked URM Infill Panels



(c) Close up of (a).



(d) Close up of (a) and (b).

Figure 6.3.17.4 Cracked URM Infill Panel close-up views.

Per Figure 6.3.17.5 below, cracks in the URM infill panels similar to the conditions shown in Figure 6.3.17.4 continue throughout the building.

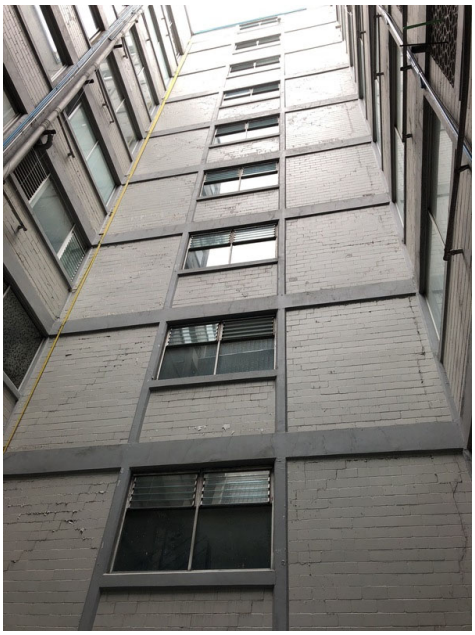


Figure 6.3.17.5 Infilled frames from ground to top viewed from the courtyard.

There were also cracked URM infill panels in the interior of the building, as shown in 6.3.17.6. Generally, the extent of cracking of the URM infill panels was larger at the interior partition walls between units compared to the exterior walls.



(a) Cracked URM infill inside an apartment unit



(b) Spalled plaster at concrete shear wall



(c) Cracked plaster over URM infill



d) Cracked and spalled plaster over URM infill



(e) Infill plaster cracks



(f) Infill plaster cracks/spalls in the interior of the unit

Figure 6.3.17.6 Interior walls infill-plaster cracking.



Figure 6.3.17.7 View from upper floor of the building.

6.3.18 Site #18: 53 Paseo Nuevo

6.3.18.1 Building Description

This building is located on 53 Paseo Nuevo, between Paseo de los Naranjos and Paseo de los Nogales. The general location and specific coordinates are shown on Figure 6.3.18.1. As shown in the plan satellite view in Figure 6.3.18.2, there seems to be three interior courtyards in the building. The building has 6 stories with no basement. Its construction date is unknown.

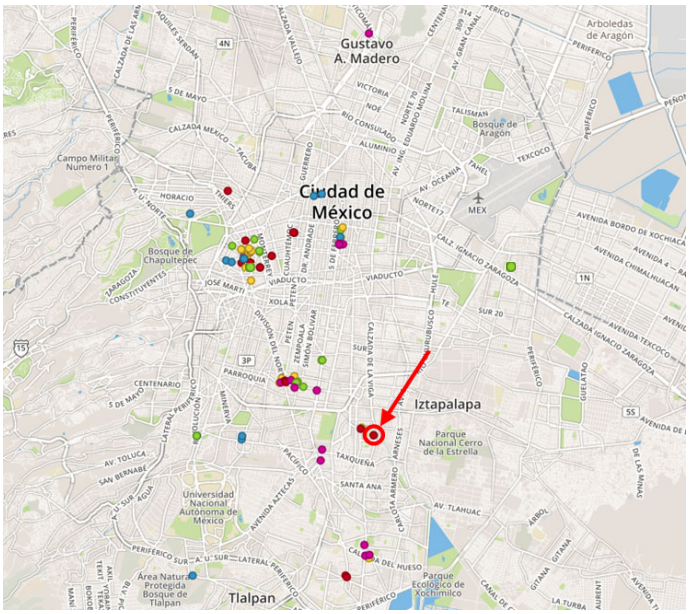


Figure 6.3.18.1 Location of site (Fulcrum Database). Coordinates: 19.347803467, -99.1211919767.



Figure 6.3.18.2 Plan satellite view of the site (captured from Google 2017).

The building structural system was not apparent from outside, however, it is assumed to be composed of concrete slab supported by concrete beams/ columns, with URM infill. The ground story is an open layout parking garage. The building elevation and ground story are shown in Fig 6.318.3.



(a) Front (east) elevation at night (b) Ground floor with holes in the infill wall

Figure 6.3.18.3 Building elevation and ground story.

6.3.18.2 Damage and Observations—2017

No apparent structural damage was visible from outside since it was dark. However, the building had been evacuated. There was nonstructural damage visible of the infill wall at the ground story by the stairs as shown on Figure 6.3.18.3 (b).

6.3.18.3 Recommendations

A complete post-earthquake structural investigation and evaluation of each remaining building is called for and should be performed prior to determining whether the structure is safe for continued occupancy in its current condition, possible retrofit solutions and/or need for demolishment.

6.3.19 Site #19: 56 Av Mexico

6.3.19.1 Building Description

This building is located on 56 Av Mexico, between Av Michoacan and Calle Laredo. The general location and specific coordinates are shown on Figure 6.3.19.1. As observed from the satellite maps in Figure 6.3.19.2, the plan area of this building is irregular (L-shaped). The building has nine stories plus penthouse and no basement. Its construction date is unknown.

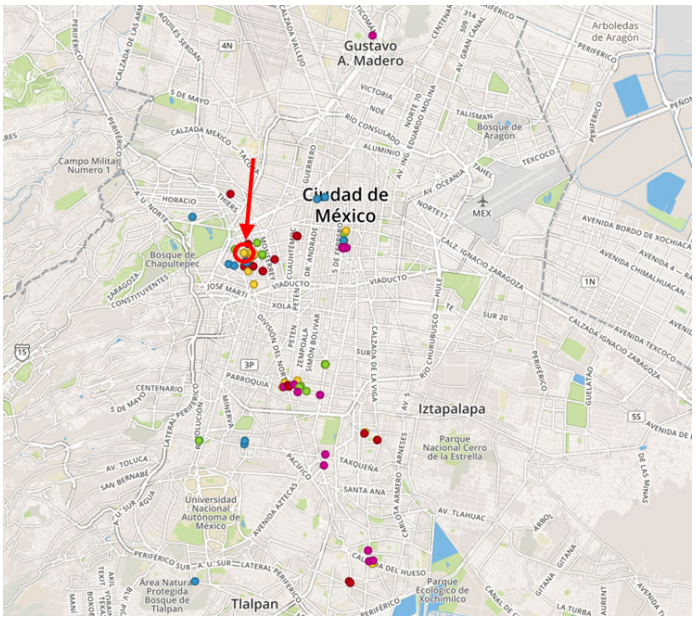


Figure 6.3.19.1 Location of site (Fulcrum Database). Coordinates: 19.412522, -99.170249.



Figure 6.3.19.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill. The building elevation is shown in Fig 6.3.19.3.



Figure 6.3.19.3 Side (north) elevation of the building.

6.3.19.2 Damage and Observations—2017

Minimal observations were made exterior and access to the building interior was not possible. There seemed to be no visible damage observed from the exterior other than spalling of plaster finishes and minor cracking of infill

6.3.20 Site #20: 56 Eje Central Lazaro Cardenas

6.3.20.1 Building Description

This is a corner building located on 56 Eje Lázaro Cárdenas, at the intersection of Av. Arcos de Belén and Eje Lázaro Cárdenas. The general location and specific coordinates are shown on Figure 6.3.20.1. This building was under construction when the earthquake occurred. At the time of the site visit, the 15th floor was being built. The satellite image of the building is not yet available.

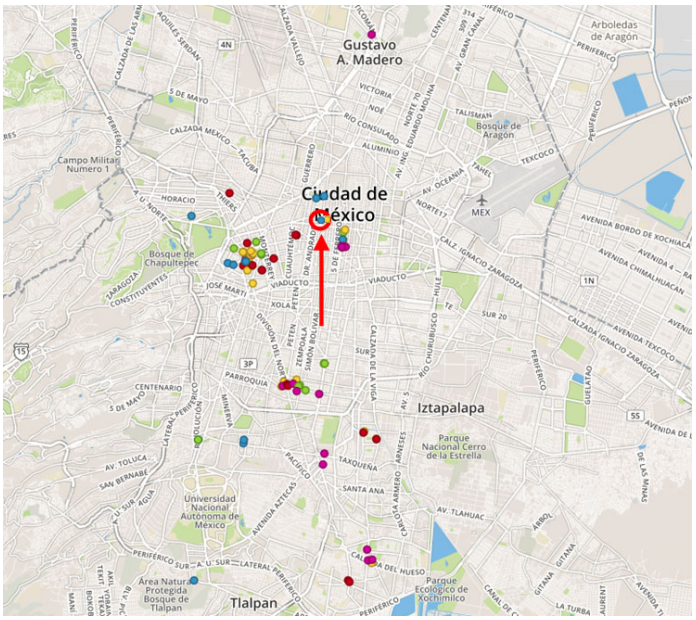


Figure 6.3.20.1 Location of site (Fulcrum Database). Coordinates: 19.426449, -99.142424.

The building is composed of concrete encased steel column frames supporting metal deck floors. At the balconies, the steel is exposed. At the east exterior face of the building, there are steel braces that form an X pattern within four to six stories. At the time of the visit, the concrete encased steel columns at the 2nd to 4th stories were additionally encased with steel cages with grates for additional confinement. The building elevation is shown in Fig 6.3.20.2.



Figure 6.3.20.2 Building elevation (photo taken looking west).



(a) X-braces along the east face



(b) Column cages around columns



(c) 15th floor under construction



(d) Typical balcony framing

Figure 6.3.20.3 Specific areas of the building construction.

6.3.20.2 Damage and Observations—2017

Detailed inspection was not completed to this building. The ATC team passed by and noticed the unique construction system in this new building. No visible damage was observed from a distance.

6.3.21 Site #21: 56 Emiliano Zapata

6.3.21.1 Building Description

This building is located on 56 Emiliano Zapata between Calle Antillas and Calz. de Tlapan, in Portales Sur. The general location and specific coordinates are shown on Figure 6.3.21.1. The building has 7 stories and its construction was completed in 2017. A satellite plan view of the structure is unavailable because of its relatively recent construction.

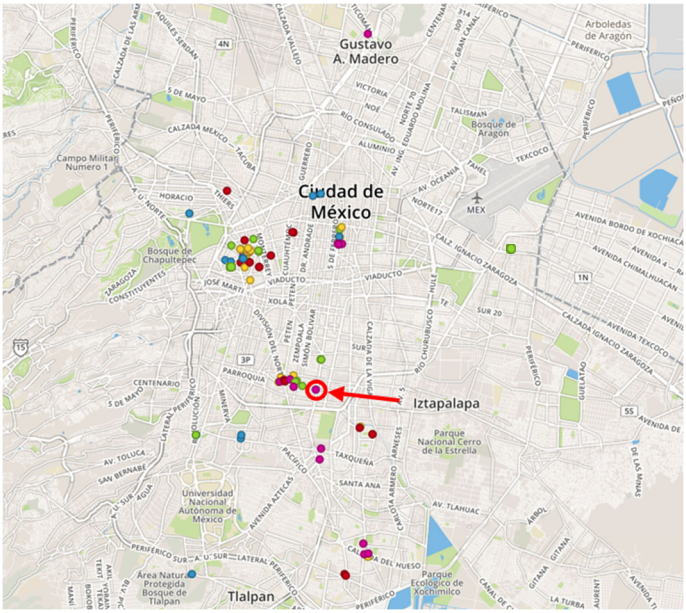
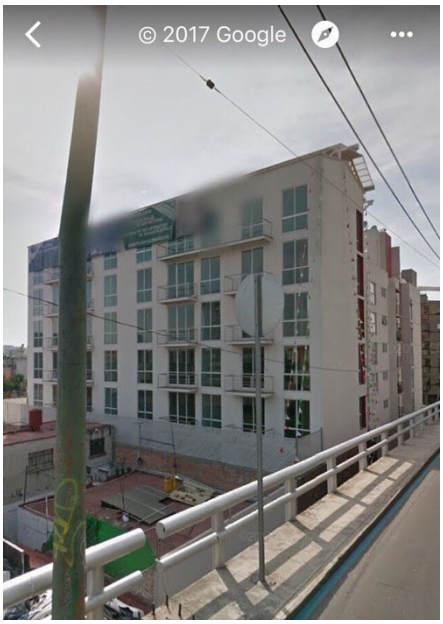
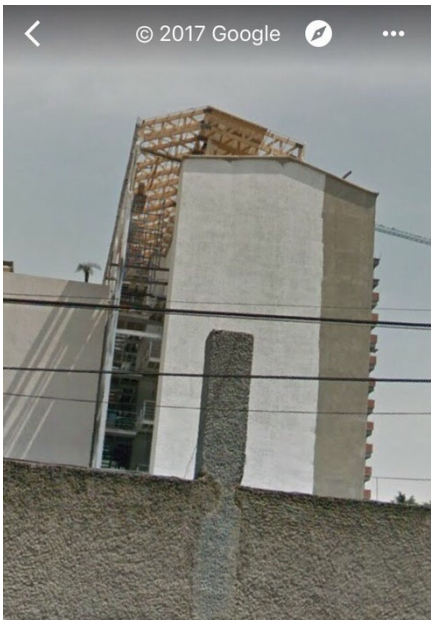


Figure 6.3.21.1 Location of site (Fulcrum Database). Coordinates: 19.364088, -99.143365.

The building has a concrete slab and joist system supported on concrete beams/columns, with masonry infill walls. The existing roof has a garden. Above the roof garden, there is a canopy composed of wood trusses that span from the roof of the building to steel framing with bracing next to the building. The building elevation is shown in Fig 6.3.21.2.





(a) Side (north) view per Google Map 2017 (b) Back (east) view per Google Map 2017

Figure 6.3.21.2 Original building elevations before collapse.

6.3.21.2 Damage and Observations—2017

The most southern part of the building (approximately two units) completely collapsed. According to parking attendants at the neighboring parking lot, the collapse progression occurred as follows: the exterior south concrete wall started to lean outwards and then floor slab at the interior bays collapse. More than half of the exterior wall remained upright but was later demolished.





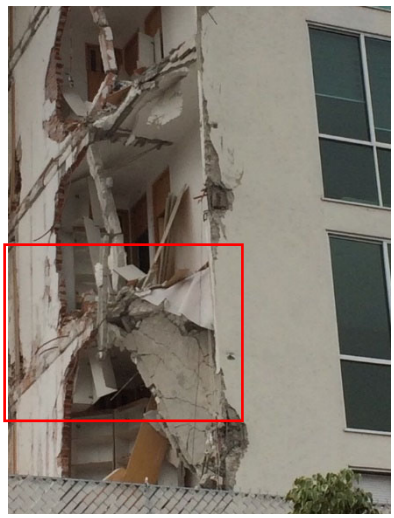
(a) South portion that collapsed (b) Portion (north) did not collapse

Figure 6.3.21.3 Collapsed building after the earthquake.

From the portion of the building that remained standing, no apparent sign of reinforcement tying the diaphragm at the point of separation was observed. The remaining concrete floor slab seems to have been reinforced with welded wire mesh of very light gage. It is possible that the mesh may have snapped. There are very thin edge beams and concrete walls. At the edge beams, which are part of the exterior wall/pier-spandrel system, there is no appreciable rebar crossing the joint (interface of collapse). There are steel beams supporting the balconies which may have interrupted the wall vertical rebar as well as some of edge beam reinforcement.



(a) Elevation view. No appreciable rebar in the floor slab



(b) Interface between collapsed and standing portions



(c) Zoom of (b). No appreciable rebar crossing the joint (interface of collapse) at the edge beam

Figure 6.3.21 Interface between collapse/standing portions of structure.

6.3.22 Site #22: 64 Bahia de Ballenas

6.3.22.1 Building Description

This is a corner building located at 64 Bahia de Ballenas, at the intersection of Bahía de Ballenas and Bahía Magdalena. The general location and specific coordinates are shown on Figure 6.3.22.1. As observed from the satellite maps in Figure 6.3.22.2, the plan area of this building is irregular (L-shaped) with a courtyard in one of the corners. The corner building has 6 stories with no basement. There is a canopy covering the roof, creating a roof penthouse, which was most likely added after the original building construction. The structure was built in 1982.

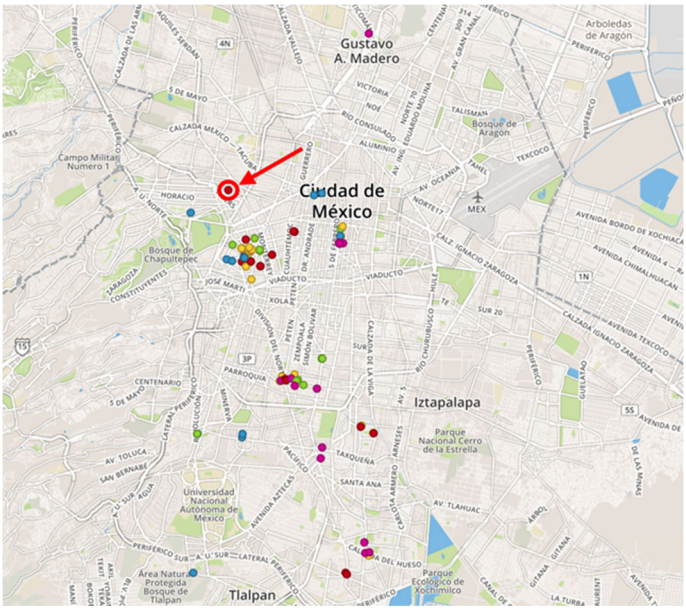


Figure 6.3.22.1 Location of site (Fulcrum Database). Coordinates: 19.436501, -99.177531.



Figure 6.3.22.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions and a central concrete elevator core shear walls. Fig 6.3.22.3 below shows elevation view of the building as well as the roof penthouse addition.



(a) Front (south) building elevation



(b) Side (west) elevation



(c) Inner side of façade facing east



(d) Inner side of façade facing north



(e) Roof penthouse addition



(f) Roof penthouse addition

Figure 6.3.22.3 Elevation views of the building and penthouse addition.

6.3.22.2 Damage and Observations—2017

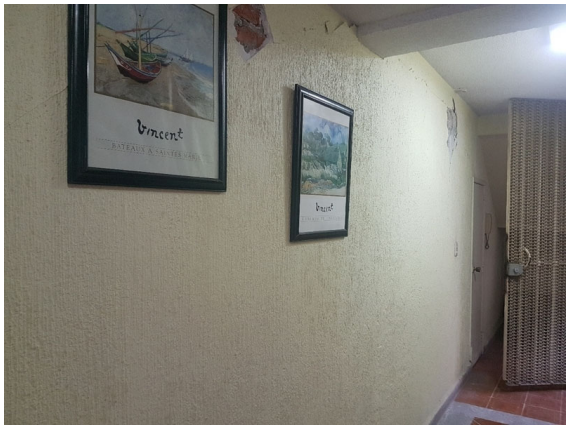
There was severe structural and nonstructural damage observed throughout the building. The building had short columns and plan irregularities. Evidence of retrofit was found in the available structural drawings. Damage was concentrated in the stairs and the four perimeter corner columns throughout the 1st to 4th floors. No damage to the reinforced concrete elevator core was observed.



(a) Ground floor infill walls



(b) In plane cracks in the infill wall



(c) Minor damage in the ground floor interior



(d) No visible damage at ground floor garage

Figure 6.3.22.4 Ground floor damage.

There was no significant structural damage at the ground floor. There is an exterior infill wall at the ground floor, shown on Figure 6.3.22.4, which had in plane cracks.

There was no structural damage visible at the 1st floor. There were light cracks on one of the masonry walls.



(a) Light cracks on the 1st floor masonry wall.



(b) No damage at 1st floor stairs

Figure 6.3.22.5 First floor damage.

At the 2nd floor, there was a severely cracked corner column, as shown on Figure 6.3.22.6. Additionally, there were in plane cracks in the infill masonry walls. This was similarly observed at the 3rd floor.



(a) Details of the 2nd floor cracked corner column



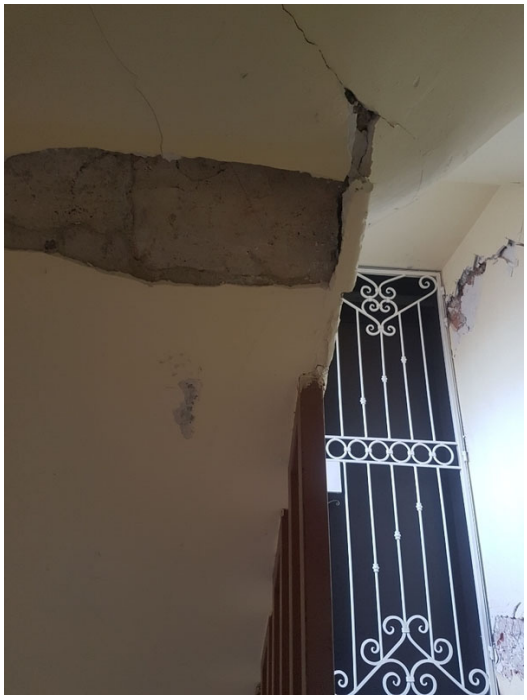
(b) Cracks on the 2nd floor infill wall



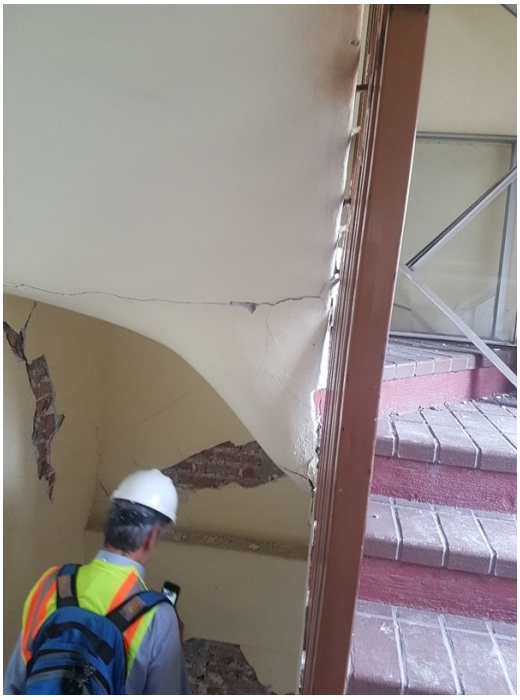
(c) Cracks on the 3rd floor infill wall

Figure 6.3.22.6 Second and third floor damage.

At the 4th floor, there were cracks at the bottom of staircase slab. Additionally, there was significant plaster that had fallen out from the infill masonry wall. At the 5th floor there were cracks at the staircase as well as significant cracks in the infill masonry walls at this level.



(a) Cracks at the bottom of the staircase



(b) Cracks on the staircase at 5th floor.



(c) Infill wall cracks at the stairs between the 4th and 5th floors



(d) Cracks on the 5th floor wall

Figure 6.3.22.7 Fourth and fifth floor damage.

The 6th floor was observed in detail. Even though only minor damage was visible, the owner informed the engineers that all of the columns of this floor had been cracked during the earthquake. Two weeks after the earthquake the damage had been covered prior to the site visit.



(a) Damaged wall finish at stairs



(b) Column that was patched after earthquake





(c) & (d) Columns that were patched two weeks after earthquake

Figure 6.3.22.8 Six floor columns that were cracked during the earthquake were covered up two weeks after the earthquake.

The building was in partial contact with its neighboring building along the west side. Overall there was severe damage to the upper floor columns at the exterior façade visible from outside.



Figure 6.3.22.9 Photos of partial building contact with neighbor building.



(a) (b) (c)

Figure 6.3.22.10 Upper columns at front two sides appear to sustain severe damage in torsion.

6.3.22.3 Discussion

There was very little damage at the ground floor which could have been due to the numerous infill walls at that level. In the structural plans, the infill walls at the ground floor are not shown which could mean that these were added after the original construction.

The severe damage to the columns along the perimeter could be caused by the torsional effects from the plan irregularities in the building.

6.3.22.4 Recommendations

This is a corner building with plan irregularities that represents some of the typical characteristics of buildings that were damaged during the earthquake.

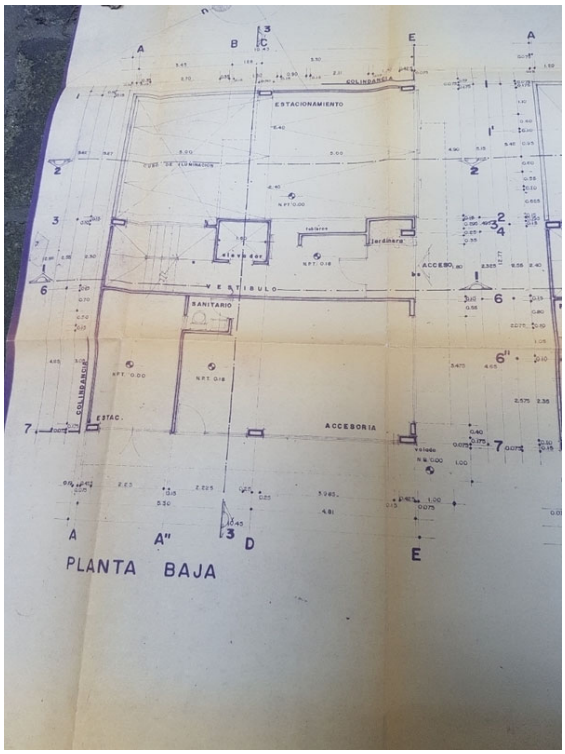
The building is a candidate for further studies focused on torsion and the impact of drift.

6.3.22.5 Additional Information

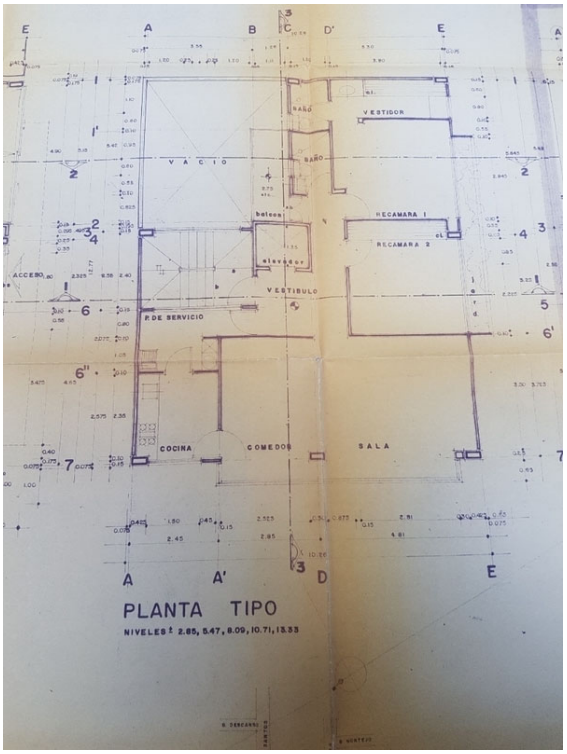
The following subset of drawings are available.



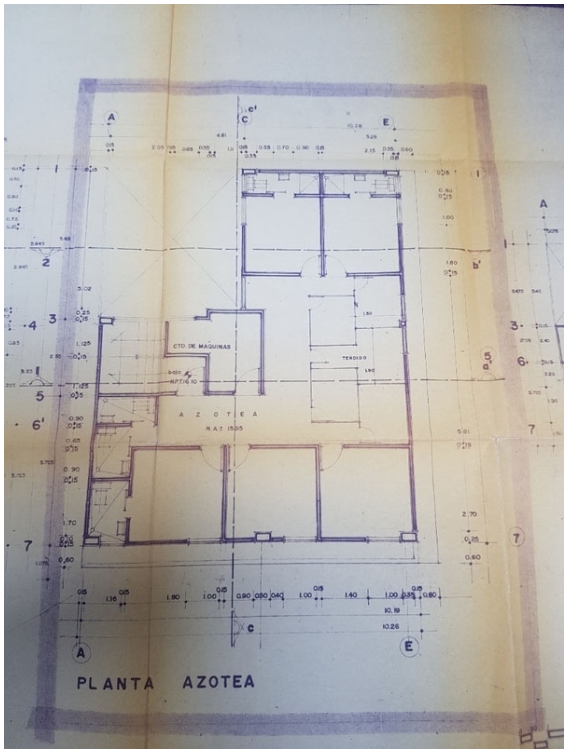
(a) Building caption



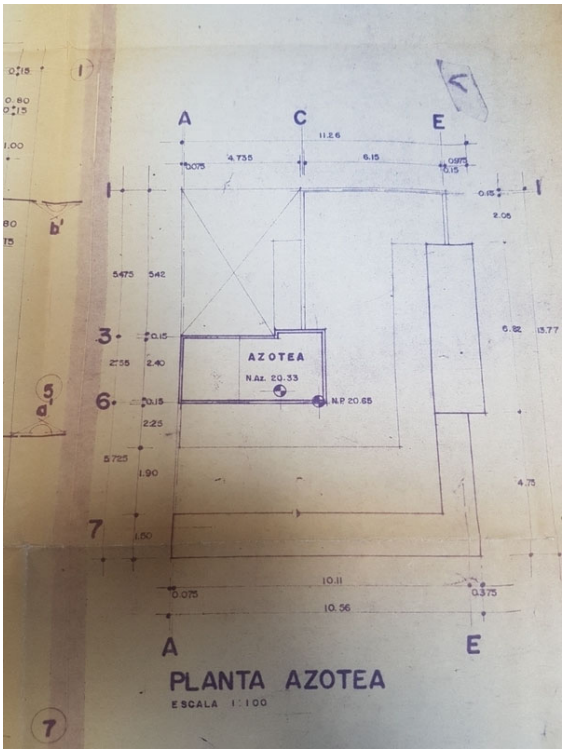
(b) Ground floor plan. Wall is added on line E.



(c) Typical floor plan



(d) Roof plan



(e) Bulkhead roof plan

Figure 6.3.22.11 Structural building plans.

6.3.23 Site #23: 65 Paseo Nuevo

6.3.23.1 Building Description

This building is located in 65 Paseo Nuevo between Paseo de los Nogales and Paseo de los Naranjos. The general location and specific coordinates are shown on Figure 6.3.23.1. As observed from the satellite maps in Figure 6.3.23.2, the plan area of this building is irregular with three courtyards along the perimeter. The building has 8 stories and 1 basement. It was built in 1972.

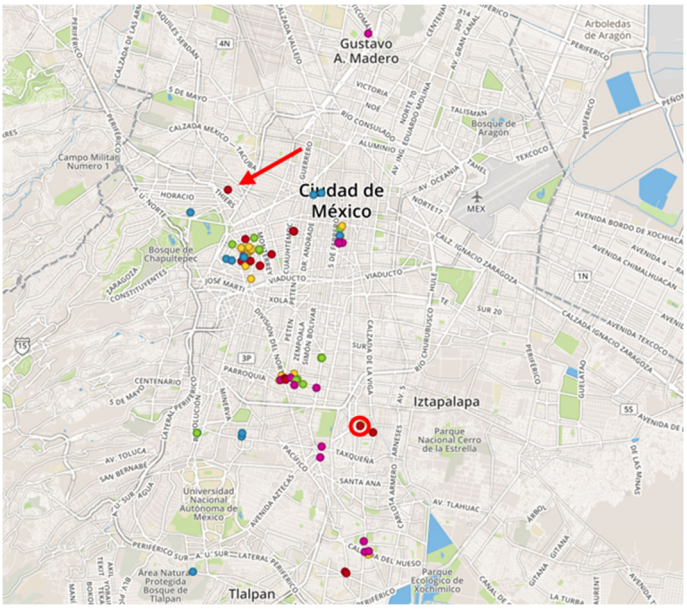


Figure 6.3.23.1 Location of site (Fulcrum Database). Coordinates: 19.347629, -99.121275.

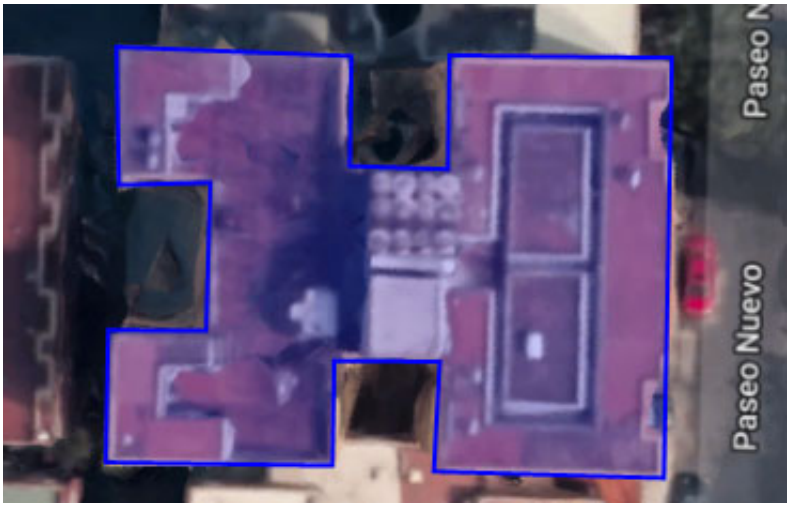


Figure 6.3.23.2 – Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. The ground story has an open layout for the parking garage. The building elevation is shown in Fig 6.3.23.3. The building has plan irregularity and soft story vertical irregularity.



(a) Southeast building elevation.



(b) East elevation

Figure 6.3.23.3 Building elevations.

6.3.23.2 Damage and Observations—2017

In the front of the building, at the enclosed portion of the upper floors balconies, significant out-of-plane failures of the infill walls were observed in both directions. There are no corner columns at the balconies. Generally, no damage was observed in the columns and beams as evident from the street.

According to the neighbors, the building is leaning in both directions (north-south and east-west). Torsional irregularity is not apparent but torsional movement may be present. No evidence of retrofit was found.

Based on the photos taken by the neighbors, there is substantial damage to the building interior.



Figure 6.3.23.4 Out-of-plane failure of URM infill at upper floors enclosed exterior rooms.

6.3.23.3 Recommendations

This building is a candidate for further studies even though there is limited information about the interior damage. Additionally, a soil study is recommended to determine if the soil had an impact on the leaning of the building. Buildings in the surrounding area, such as 10 and 20 Calle Paseo Del Rio, also seem to have damage most likely related to soil failure.

6.3.24 Site #24: 66 Calz. San Antonio Abad

6.3.24.1 Building Description

This building is located on 66 Calzada San Antonio Abad, between Calzada San Antonio Abad and Fernando de Alva Ixtlilxochitl. The general location and specific coordinates are shown on Figure 6.3.24.1. The building has 12 stories above grade. It is not known if a basement exists. Its construction was completed on 2016. A satellite plan view of the structure is unavailable because of its relatively recent construction.

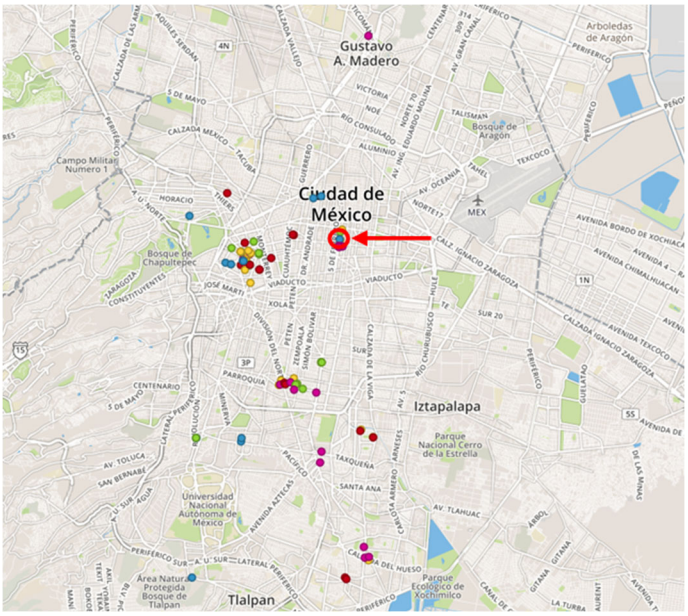


Figure 6.3.24.1 Location of site (Fulcrum Database). Coordinates: 19.4195375267571, -99.1337875784953.

The building has a reinforced concrete slab supported on concrete columns and concrete walls, however, it is unknown if beams are present. Lateral loads are resisted by the reinforced concrete shear walls, URM infill, and through moment-frame action of the columns and floor system. Figure 6.3.24.2 below shows the elevation views of the building.



Figure 6.3.24.2 South building elevation.

6.3.24.2 Damage and Observations—2017

The building has minor (mostly cosmetic) damage. No significant structural damage was observed. Although there was partial evacuation, the building seems to be capable of sheltering its residents. For a corner building, this building seems to be safe from pounding by neighboring buildings. Interior access was not possible hence no observations on interior damages could be conducted.



(a) Spalled veneer



(b) Spalled veneer



(c) Cracks near window

Figure 6.3.24.3 Minor, cosmetic building damage observed from exterior.

6.3.25 Site #25: 86 Oaxaca

6.3.25.1 Building Description

The building is located on 86 Avenida Oaxaca, between Valladolid and Medellín. The general location and specific coordinates are shown on Figure 6.3.25.1. The plan area is rectangular, as shown in the plan satellite view in Figure 6.3.25.2. The building has 7 stories with a bulkhead on the west side. There is an open parking space in the back of the building. Its construction date is 1986 according to the structural drawings.

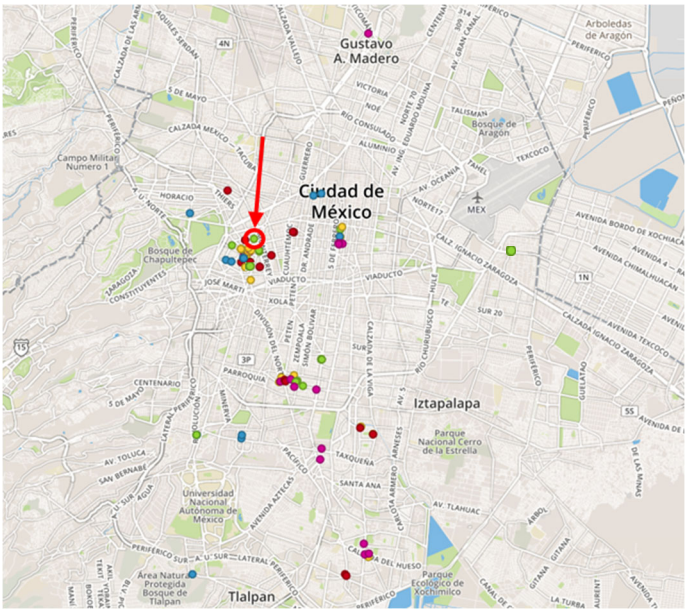


Figure 6.3.25.1 Location of site (Fulcrum Database). Coordinates: 19.418882, -99.167081.



Figure 6.3.25.2 – Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the reinforced concrete moment-resisting frame

in both building directions. Figures 6.3.25.3 and 6.3.25.4 below show the elevation views of the building.



Figure 6.3.25.3 Front (west) view of the building.



(a) Southeast elevation view (b) Northeast elevation view

Figure 6.3.25.4 Rear (east) elevations of building.

6.3.25.2 Damage and Observations—2017

There was no significant damage observed in the front (west) side of the building. The neighboring south building seemed to be leaning against the building. It could have been amplified by the earthquake but it is not clear. However, the street view in Google Maps prior to the earthquake suggests that this condition was existent before the earthquake. It is not clear whether the structures are touching or if the façade is only overlapping.



(a) Photo taken during post-earthquake reconnaissance

(b) Photo from Google Maps, May 2016

Figure 6.3.25.5 The neighboring building on the right (south) seems to have a larger gap at the lower level than at the top.

There is parking on the first floor of the building and a parking ramp run through the building, creating a weak story condition. The beam on top of the parking ramp shows severe spalling at the ends.

Although the team did not enter the building, debris found outside the building suggests that there are masonry infill walls in the building that are jacked with concrete with small diameter (#2) rebar. The jacket appears to have spalled off during the earthquake.



Figure 6.3.25.6 Spalling observed at beam ends on top of parking underpass at the first floor.



(a) Debris found in the rear parking lot of building. It is unclear where this came from.



(b) & (c) Rebar (#2) in concrete element. Pieces appear to be encasement for masonry.

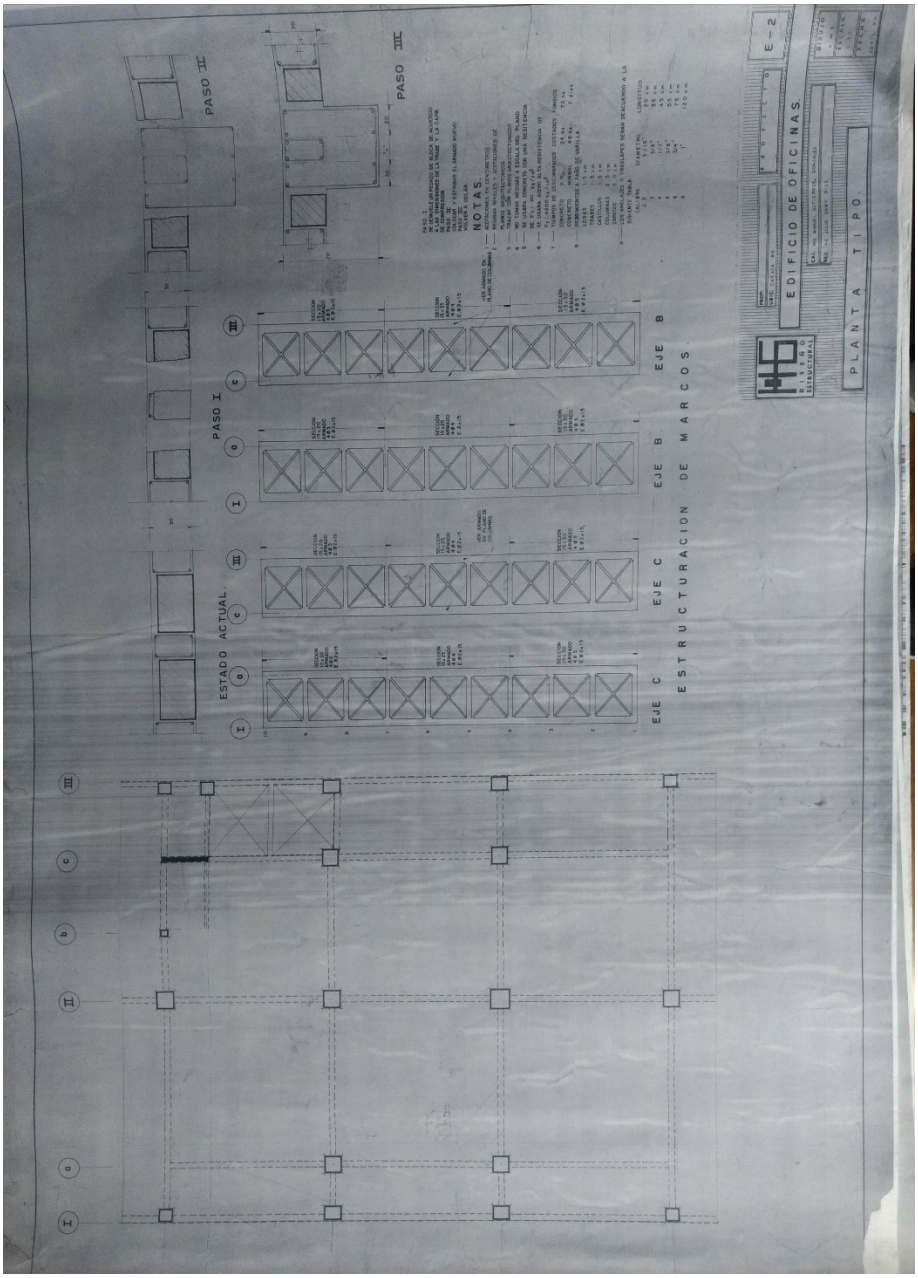
Figure 6.3.25.7 Photos of damage debris found outside of building

Cracking is also observed in the rear façade as shown in the elevation in Figure 6.3.25.4. It is unclear to what extent the structural system has been damaged.

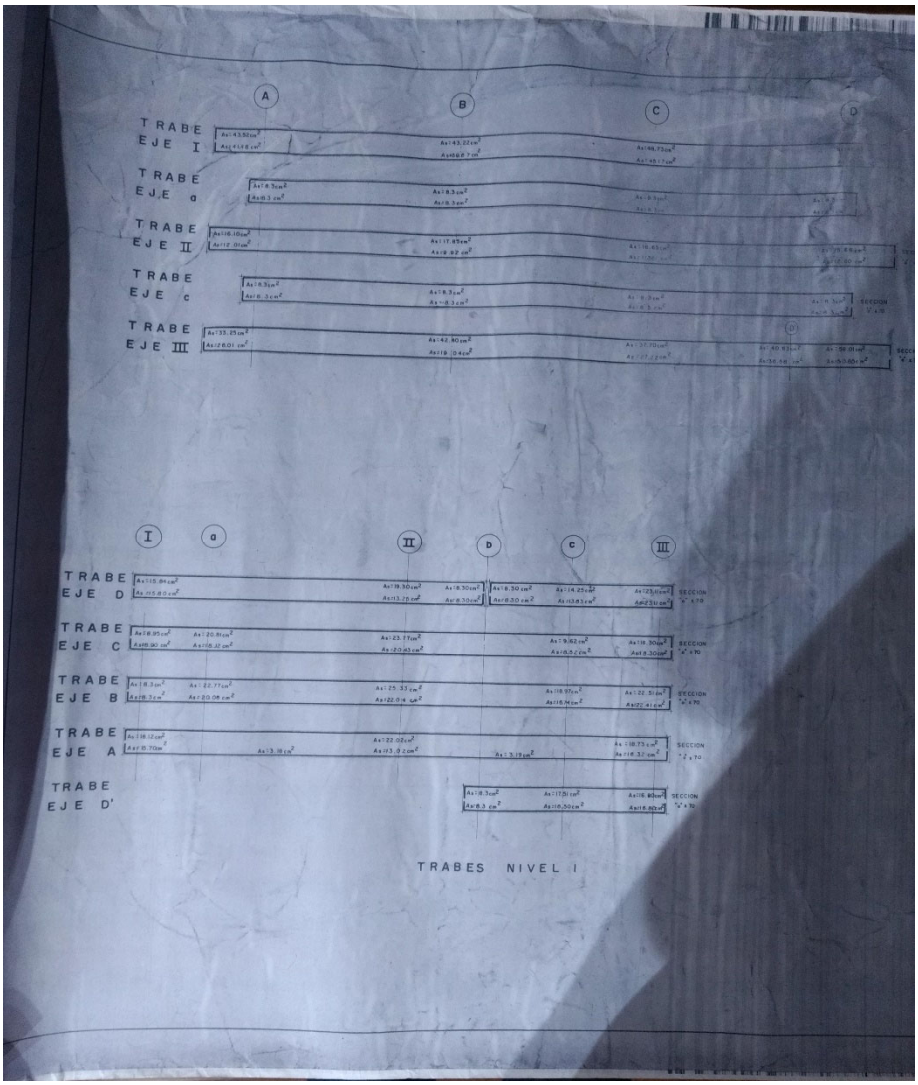
6.3.25.3 Discussion

Reinforcement and jacketing of masonry was observed in many structures, in recognition that masonry elements sustain heavy damage during seismic events.

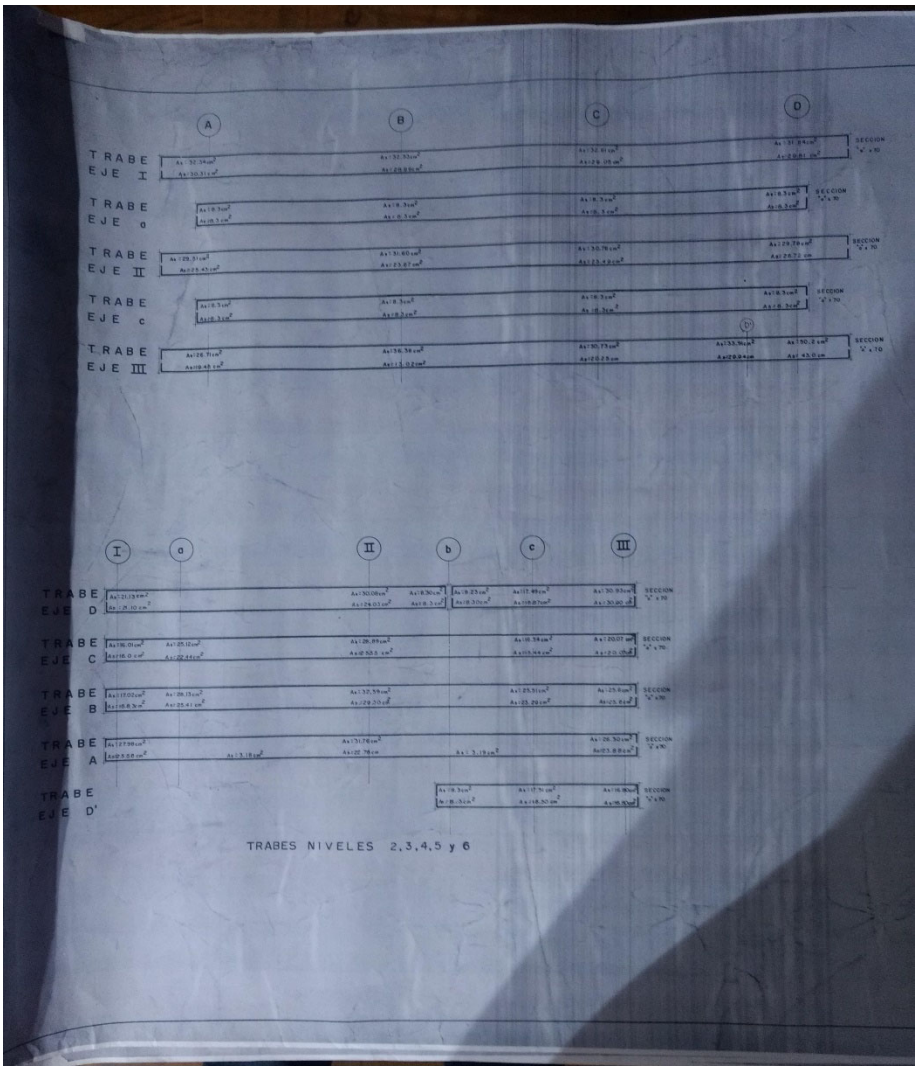
6.3.25.4 Drawings



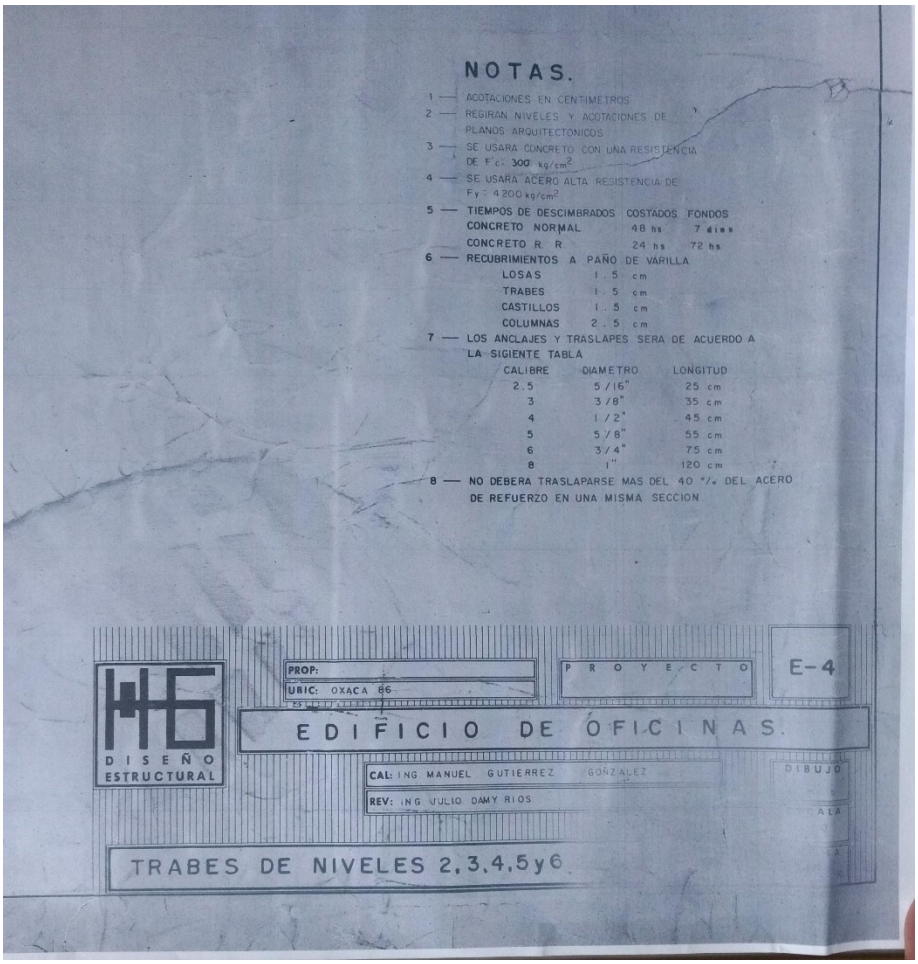
(a) Typical structural plan



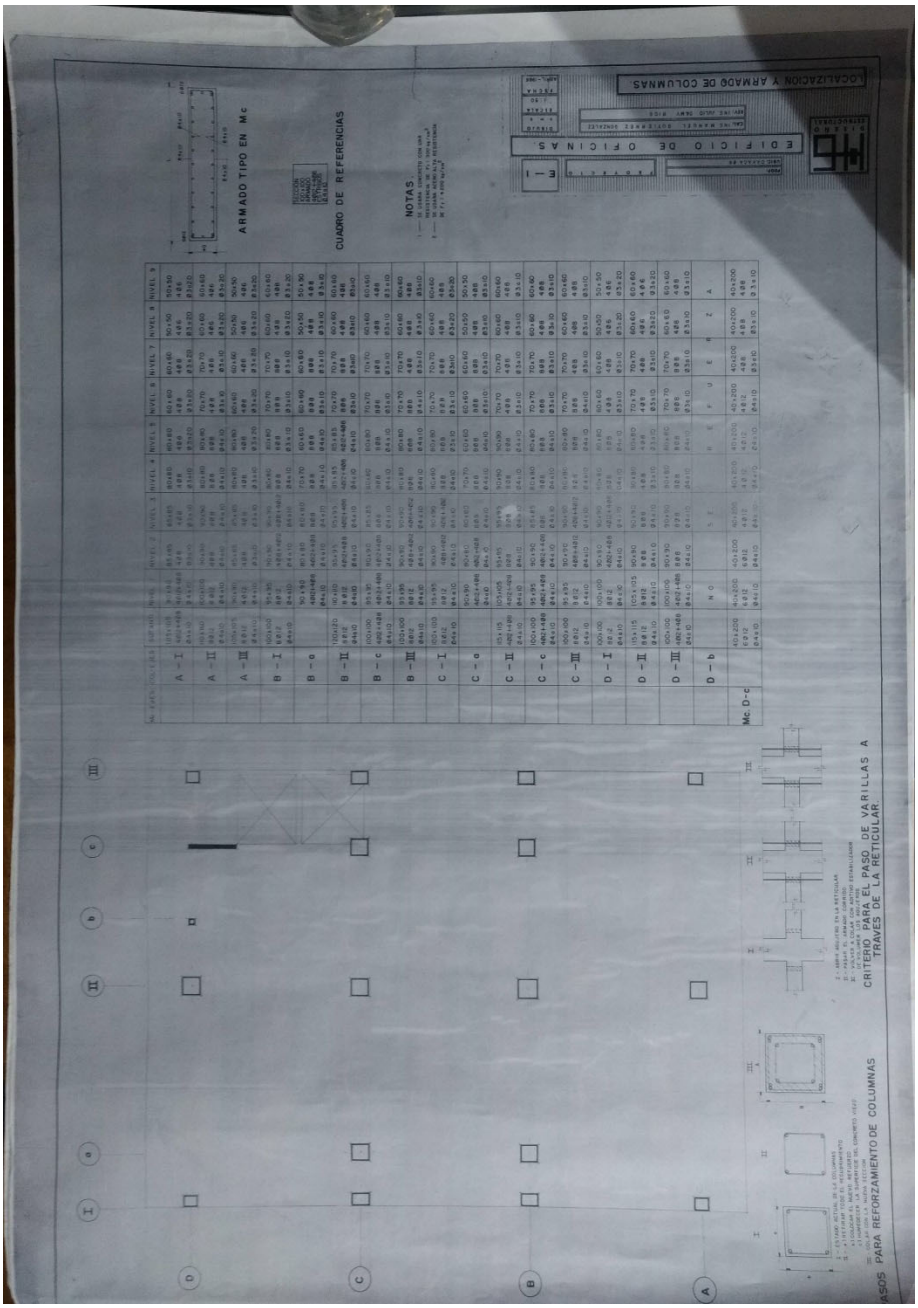
(b) Level 1 beam reinforcement



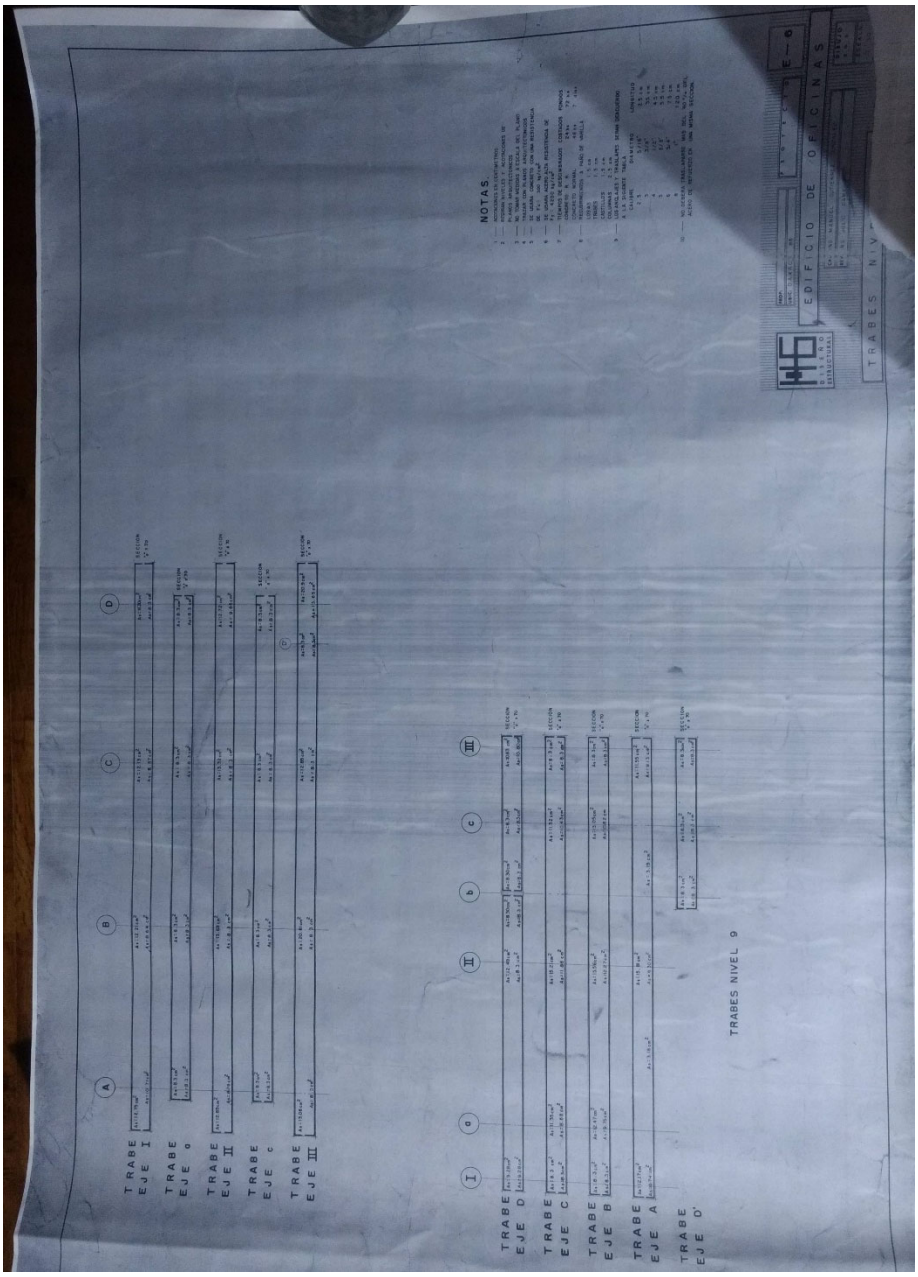
(c) Level 2 to 6 beam reinforcement



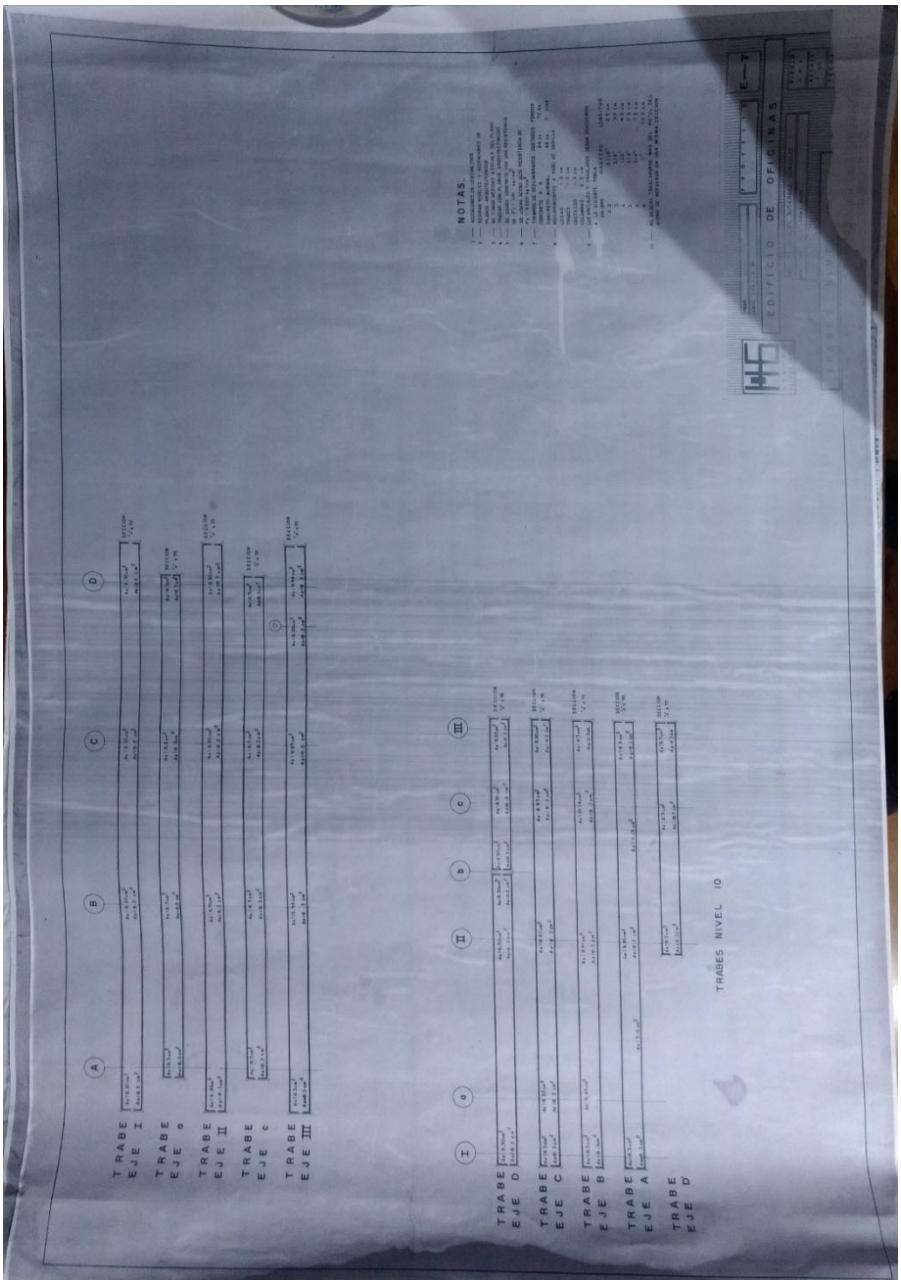
(d) Level 2 to 6 beam reinforcement notes



(e) Column sizes and reinforcement



(f) Level 9 beam reinforcement



(g) Level 10 beam reinforcement

Figure 6.3.25.8 Building structural drawings.

6.3.26 Site #26: 99 Av Mexico

6.3.26.1 Building Description

The building is located in 99 Av Mexico, between Chilpaancingo and Citaltepetl. The general location and specific coordinates are shown on Figure 6.3.26.1. The plan area is fan shape, as shown in the plan satellite view in Figure 6.3.26.2. The building has 6 stories and no basement. Its construction date is unknown.

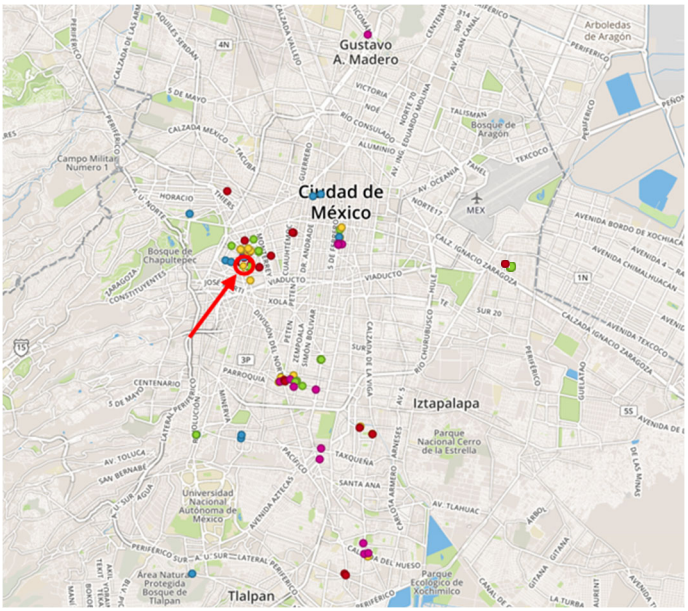


Figure 6.3.26.1 Location of site (Fulcrum Database). Coordinates: 19.410442, -99.170643.

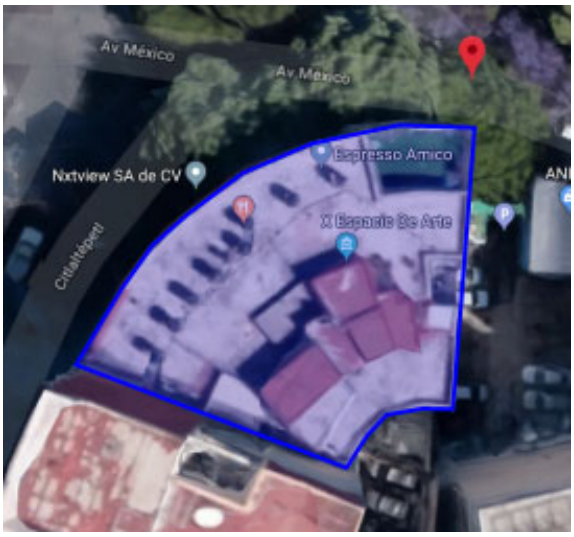


Figure 6.3.26.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill. Figure 6.3.26.3 below shows an elevation view of the building.



Figure 6.3.26.3 East side of the building. This is a corner building across from Parque Mexico.

6.3.26.2 Damage and Observations—2017

Minimal observations were made from exterior, with no visible damage from the streets. Interior access was not possible. Therefore, no observations could be made of the interior damages.



(a) Interior lobby at entrance taken from outside



(b) Separation joint with adjacent building to the south

Figure 6.3.26.4 Front (west) view of the building.

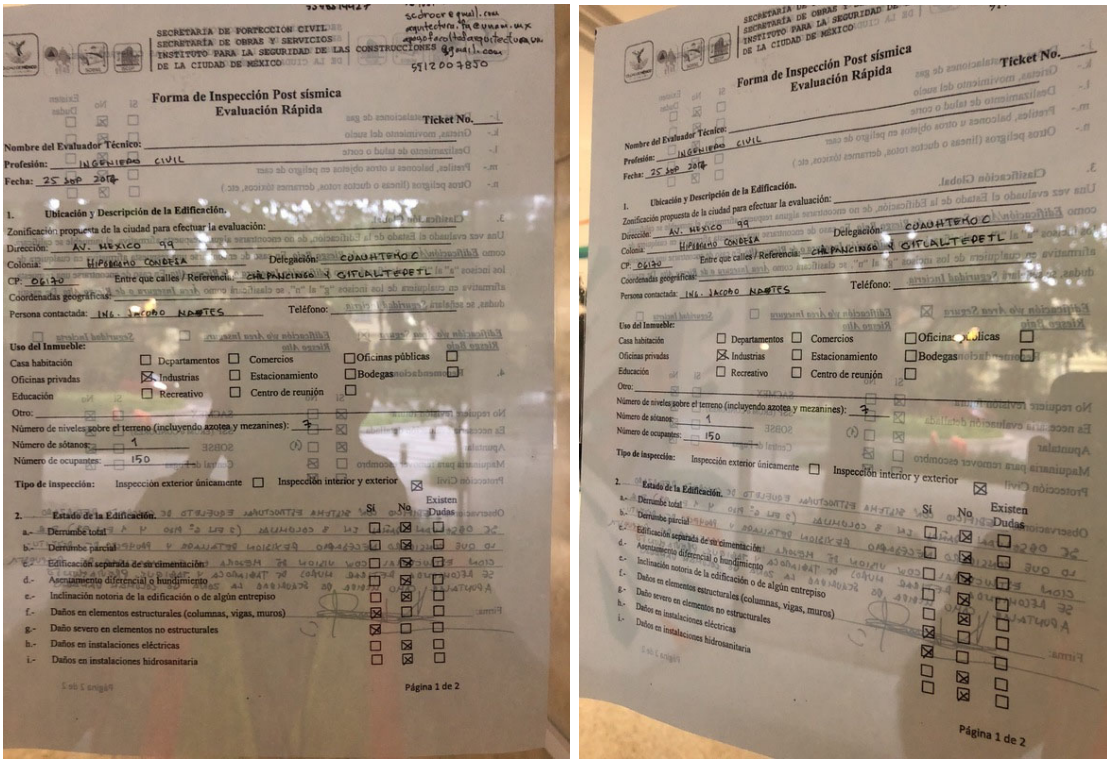


Figure 6.3.26.5 Government notice indicated "yellow" tag.

6.3.27 Site #27: 104 Calle Salamanca

6.3.27.1 Building Description

The building is located in 104 Calle Salamanca, between Colima and Av Oaxaca. The general location and specific coordinates are shown on Figure 6.3.27.1. The plan area is rectangular, as shown in the plan satellite view in Figure 6.3.27.2. The building has 12 stories. Its construction date is unknown.

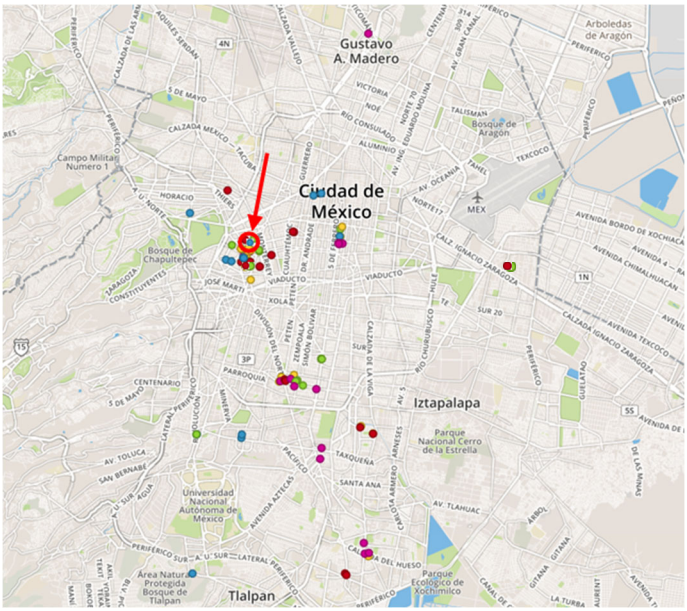


Figure 6.3.27.1 Location of site (Fulcrum Database). Coordinates: 19.417560, -99.168996.



Figure 6.3.27.2 Plan satellite view of the site (captured from Google 2017).

The main structural system of this building is unknown. Along the longitudinal direction on both the front and back sides (west and east respectively), there are post tensioned diagonal cables throughout the height of the building. These are attached to steel columns, exterior of the façade. Figure 6.3.27.3 below shows the elevation views of the building.



(a) Front (west) elevation (b) Side (north) elevation

Figure 6.3.27.3 Building elevations.

6.3.27.2 Damage and Observations—2017

The structure was not observed in detail. The following are the post tensioned cable connections at the base of the building.



Figure 6.3.27.4 Post tensioned cable connection.

6.3.28 Site #28: 105 Avenida Mexico

6.3.28.1 Building Description

The building is located in 105 Avenida Mexico, between Citlatepetl and Chilpancingo. The general location and specific coordinates are shown on Figure 6.3.28.1. The plan area is irregular with an interior courtyard, as

shown in the plan satellite view in Figure 6.3.28.2. The building has 6 stories and no basement. There is an interior and exterior courtyard. Its construction date is unknown.

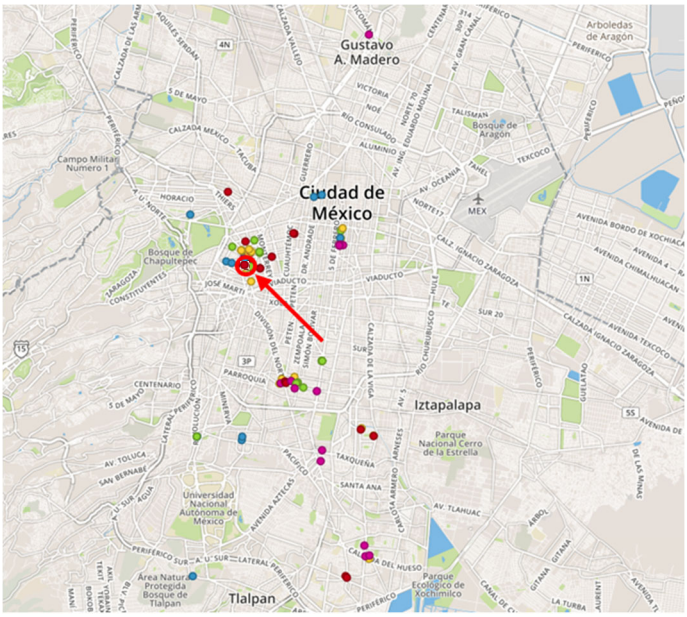


Figure 6.3.28.1 Location of site (Fulcrum Database). Coordinates: 19.410369, -99.170540.

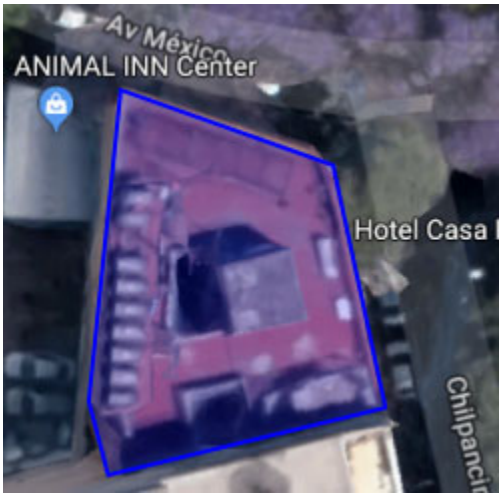


Figure 6.3.28.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the reinforced concrete moment-resisting frame and concrete frame with URM infill. Figure 6.3.28.3 below shows the elevation views of the building.



(a) North side of the building



(b) East side of the building with significant cracking in infill walls and concrete frames

Figure 6.3.28.3 Building elevations.

6.3.28.2 Damage and Observations—2017

The building has severe damage. Severe cracks and leaning of the building were observed. Infill damage was observed from the outside as infill plaster spalling. Interior access was not possible hence no observation of interior damage was conducted. Electricity wires were also down in the area posing a serious hazard in case the power lines are turned on. This and some other buildings pose a significant falling hazard (debris from the precarious infill bricks on the exterior) for the occupants/pedestrians on this street and in this neighborhood.

As observed from 6.3.28.4, the separation joint between this building and the adjacent building closed. Due to closing of the gap between two adjacent buildings, there may be potential pounding.



(a) Separation joint closed



(b) Close up of (a)



(c) Leaning building

re 6.3.28.4 Photos of separation joint.

Most buildings on this street as damaged and displaced. The majority of buildings have URM infill damage.



(a) Most buildings are damaged and displaced



(b) Infill damage



(c) Infill plaster spalling and infill damage



(d) Cracks in canopy

Figure 6.3.28.5 Building damage as observed from sidewalk.



Figure 6.3.28.6 A newer building adjacent to the 105 Ave Mexico with a slightly better condition.

6.3.28.3 Discussion

Significant area hazard as well as “red-tag” status for this heavily damaged building.

6.3.28.4 Additional Information

The site as shown around by the area resident Ms. Lorena Gonzalez.

6.3.28.5 Recommendations

The area should be cordoned off due to falling-debris hazard. This heavily damaged structure needs to be evaluated in detail by a qualified structural engineer to determine future course of action.

6.3.29 Site #29: 107 Amsterdam

6.3.29.1 Building Description

This is a corner building is located in 107 Amsterdam, at the intersection of Amsterdam and Calle Laredo. The general location and specific coordinates are shown on Figure 6.3.29.1. The plan area is L-shaped, as shown in the plan satellite view in Figure 6.3.29.2. The building has 9 stories and no basement. Its construction date is unknown.

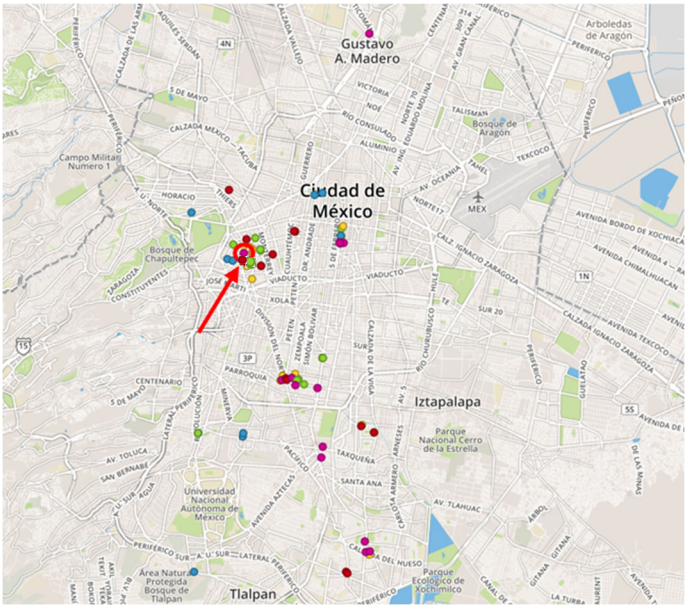


Figure 6.3.29.1 Location of site (Fulcrum Database). Coordinates: 19.412778, -99.171111.



Figure 6.3.29.2 Plan satellite view of the site (captured from Google 2017).

The building collapsed and had been removed before the time of the visit. The building had a reinforced concrete slab supported on concrete frames. Figure 6.3.29.3 below shows the front view of the building obtained from Google Maps.



Figure 6.3.29.3 3D view of the building before earthquake that caused collapse (captured from Google 2017).

6.3.29.2 Damage and Observations—2017

The building collapsed completely. The first floor remained. This resulted in 17 casualties and 1 injured resident. Since no observations were completed at the time of the visit, the cause of failure cannot be determined.





(a) Floors 2-10 collapsed on top of ground floor. (b) Piece of slab and failed column observed

Figure 6.3.29.4 Site after the majority of the collapsed building had been removed.

6.3.30 Site #30: 117 Avenida Mexico

6.3.30.1 Building Description

This is the "Edificio Sagor" building located in 117 Avenida Mexico, between Chilpancingo and Iztaccihuatl, across from Parque Mexico. The general location and specific coordinates are shown on Figure 6.3.30.1. The plan area is rectangular with one interior courtyard and two along the perimeter, as shown in the plan satellite view in Figure 6.3.30.2. The building has 7 stories and no basement. Its construction date is not known.

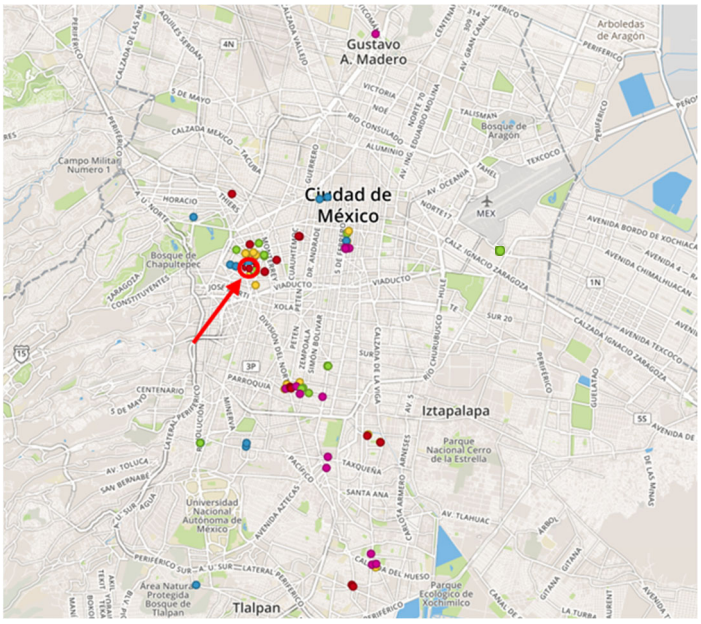


Figure 6.3.30.1 Location of site (Fulcrum Database). Coordinates: 19.410429, -99.169859.

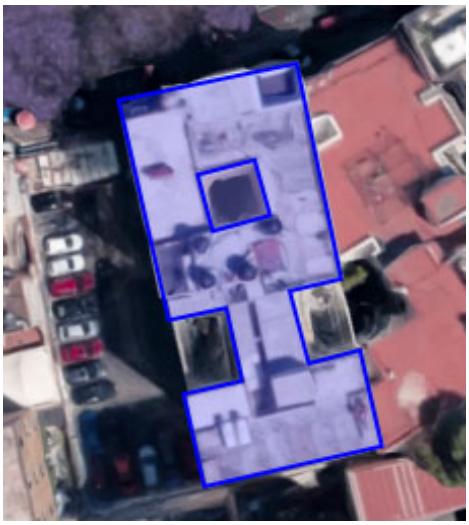


Figure 6.3.30.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on reinforced concrete frames. Lateral loads are resisted by the concrete frame with URM infill and possibly reinforced concrete shear walls (not confirmed). Figure 6.3.30.3 below shows an elevation view of the building.



Figure 6.3.30.3 Front (north) view of the building.

6.3.30.2 Damage and Observations—2017

The building has severe damage. Severe cracks were observed, revealing infill walls. The structure has been determined to be incapable of functioning as an apartment building and the residents have been evacuated. Interior access was not possible; hence no observation of the building interior was conducted.

6.3.30.3 Discussion

The structural system and damage noted are typical for this area of the city. A number of other buildings also had similar damage and have already been evacuated ("red or yellow tagged").

6.3.30.4 Additional Information

The building was shown around by the area resident Ms. Lorena Gonzalez.

6.3.30.5 Recommendations

A complete structural evaluation of this structure must be performed by a qualified structural engineer prior to determining future course of action in relation to this building.

6.3.31 Site #31: 122 San Antonio Abad

6.3.31.1 Building Description

The building is located on 122 San Antonio Abad, between Calzada San Antonio Abad and Calle Alfredo Chavero. The general location and specific coordinates are shown on Figure 6.3.31.1. The building has nine stories above grade. It is believed to have at least one level of basement. The structure is generally rectangular, with an offset core at the south side of the building as shown in the plan satellite view in Figure 6.3.31.2. Its construction date is unknown.

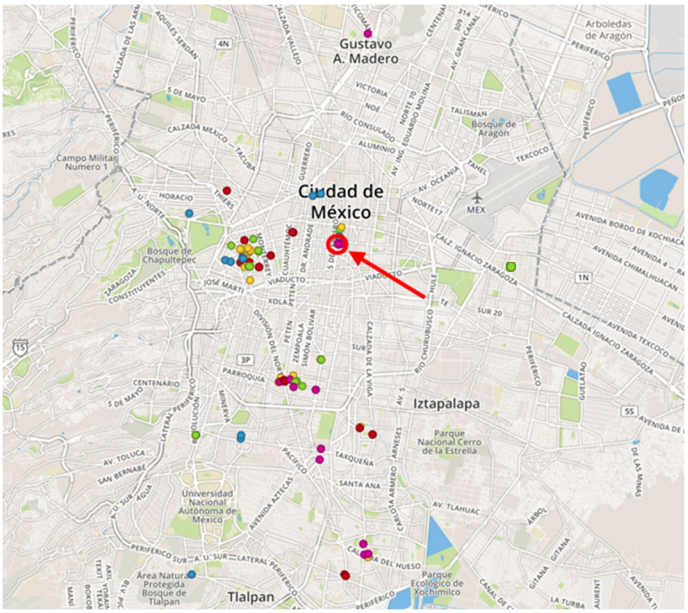


Figure 6.3.31.1 Location of site (Fulcrum Database). Coordinates: 19.416988, -99.134274.



Figure 6.3.31.2 Plan satellite view of the site (captured from Google 2017).

The building has reinforced concrete slabs supported on concrete frames. Lateral loads are resisted by the reinforced concrete moment-resisting frames and the reinforced concrete shear walls at the offset core. There are also URM infill panels at the exterior of the grade level only. Figure 6.3.31.3 below shows the elevation views of the building.



(a) Northwest corner elevation



(b) Elevation of the southeast corner



(c) Reinforced concrete core at the south face of the building



(d) Location of building elevations

Figure 6.3.31.3 Building elevations.

6.3.31.2 Damage, Repairs, and/or Rehabilitation—1985

Several columns along the north face of the building had been either repaired or retrofitted after the 1985 earthquake. It is assumed that it was likely a repair project given that the pattern of columns that were retrofitted did not follow a regular pattern. The columns had been retrofitted with a steel cage

consisting of angles at the corners with flat steel horizontal bars. It appears that the steel corner angles only extend form the top of slab to the bottom of the beam soffit above. This likely lead to the columns fracturing in flexure or shear at the top and bottom of each floor. As shown in Figure 6.3.31.4 (d), the northeast corner column above the collapsed floor had the steel cage retrofit. This retrofit strategy was proved ineffective and perhaps even contributed to column-beam interface failure at the top and bottom ends.



(a) North face exterior columns with steel plate cage retrofit



(b) NW corner – "retrofitted" column



(c) North face exterior column shows old steel angles and bar cage retrofit



(d) Close up of collapsed NE corner column above collapsed floor

Figure 6.3.31.4 Column steel cage retrofit post 1985 earthquake.

6.3.31.3 Damage and Observations—2017

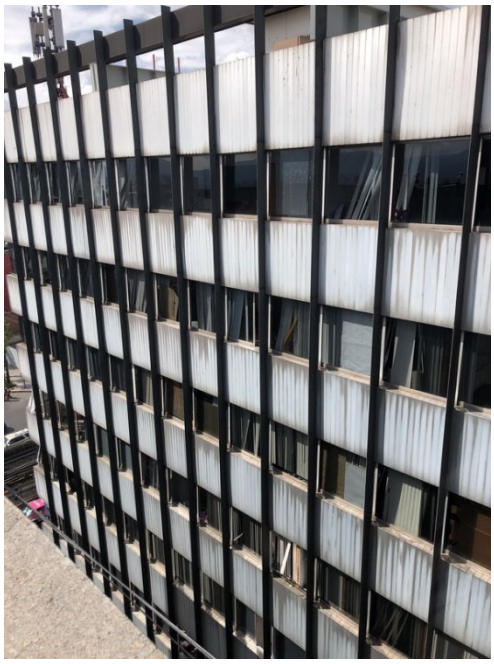
At the south elevation of the building, there was minor structural damage observed. Through the windows, several nonstructural elements were observed to have fallen.



(a) South elevation of building showed minor signs of damage



(b) South elevation of building showed minor signs of damage



(c) West section of south face from adjacent roof. No apparent damage



(d) Several nonstructural elements were observed

Figure 6.3.31.5 Minor damage to south face of building.

On the sidewalk and ground floor, fallen debris surrounded the building perimeter and made it dangerous for pedestrians. This included glass and heavy plaster that shed from the upper collapsed floor. There were also various fallen electric cables on the street.



(a) Glass and heavy plaster on the ground



(b) North face from NW corner

Figure 6.3.31.6 Nonstructural debris in the sidewalk and ground.

At the ground floor level, there were URM cracks both in the interior and exterior.



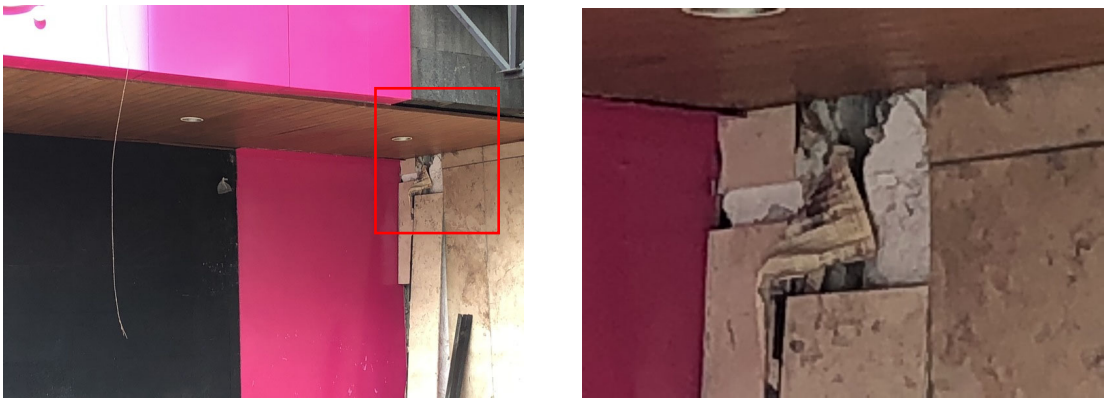
(a) Interior entry to underground parking level shows cracks in the infill walls.



(b) Brick infill on ground floor

Figure 6.3.31.7 Minor damage to south face of building.

In the northwest corner, there was damage at the canopy joint as shown below.



(a) Top of column at canopy joint at west

(b) Close up of canopy joint damage

Figure 6.3.31.8 Column-canopy joint damage.

In the northeast corner, there was damage at the column joint as shown in Figure 6.3.31.7 (a). Additionally, the steel gates at the entrance ramp to the underground parking were displaced out of and in-plane.



(a) NE corner close up of first floor column at top

(b) NE corner showing steel gates displaced out at ramp to underground parking

Figure 6.3.31.9 Damage observed on ground floor.

The most severe damage observed at the ground floor level was at the northwest corner column which experience significant concrete spalling and rebar buckling. The column was approximately 20 in x 30 in, with 1-inch diameter vertical rebars, with ties spaced at approximately 9 inches on center.



(a) NW (Main St.) ground floor corner column with buckled rebar and spalled concrete



(b) NE corner similarly buckled column rebar and failed column. Possible collapse mechanism in major aftershock

Figure 6.3.31.10 Damaged concrete column on ground floor.

At the upper floors there was significantly more damage than at the ground floor. The building suffered a partial collapse of the fifth floor, and severe damage to several other columns along the north face of the building. The collapse at the north face caused the building to lean to the north. The concrete shear wall core at the south face of the building led to an extreme torsional irregularity. This likely led to excessive deformation demands along the north face of the building. Several columns had previously been repaired or retrofitted following the 1986 earthquake, as mentioned earlier. The details of the retrofit led to weak zones in the column at the interface with the floor slabs and beams. Nonstructural damage observed included broken glass windows, damaged acoustical tile ceiling systems, damaged suspended lighting, and damage to plaster finishes, and toppled book cases.



(a) Collapsed 5th floor



(b) North face close up (5th floor collapse column) from adjacent structure roof



(c) NW face of building



(d) Looking down on NW corner



(e) Collapsed/crushed 5th floor column



(f) Totally crushed 5th floor column.



(g) Crushed exterior column at north face



(h) Crushed exterior column at north face

Figure 6.3.31.11 Story collapse and crushed columns.

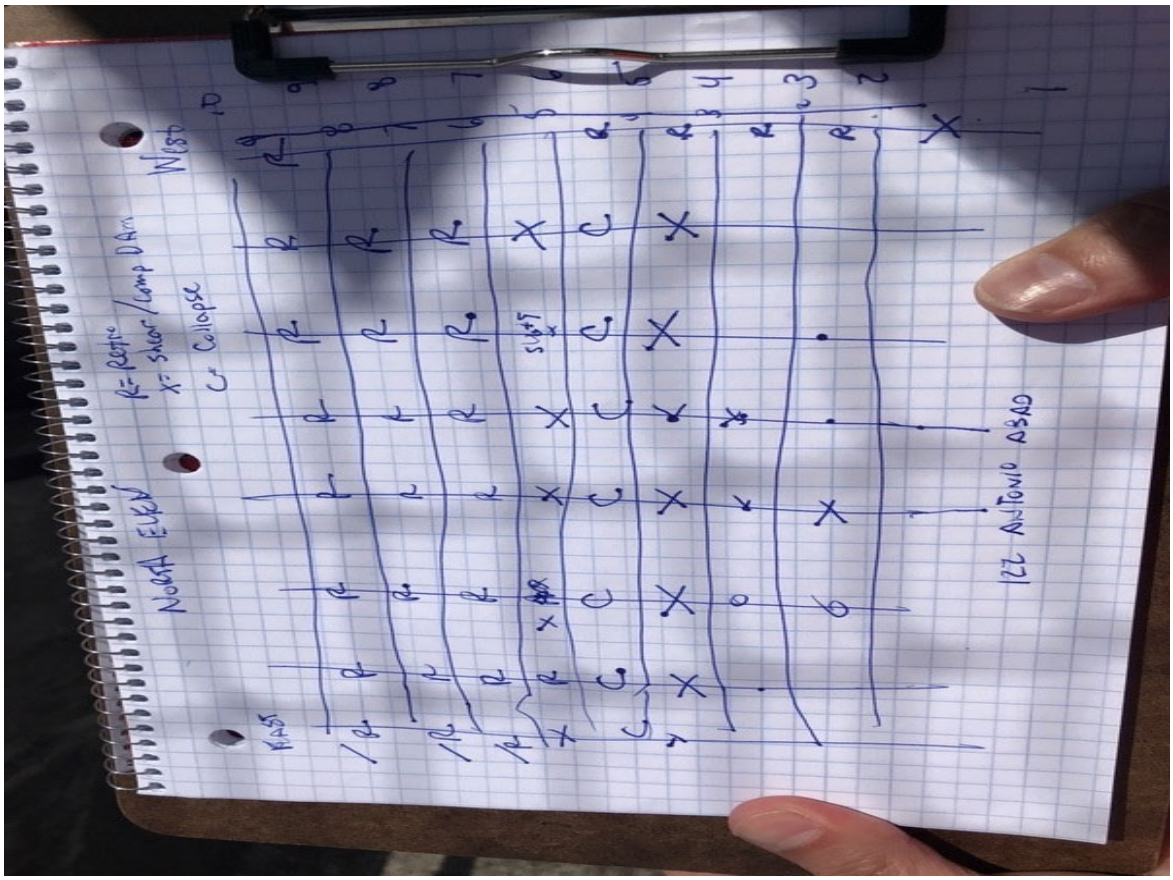
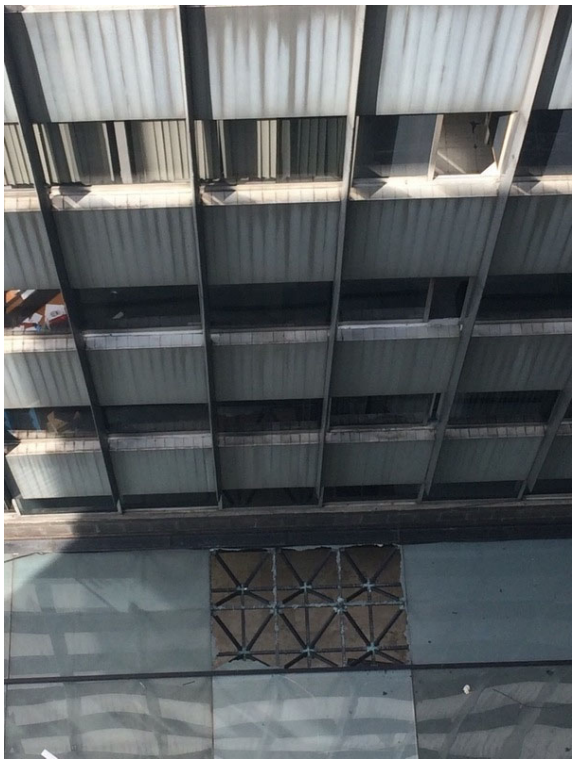
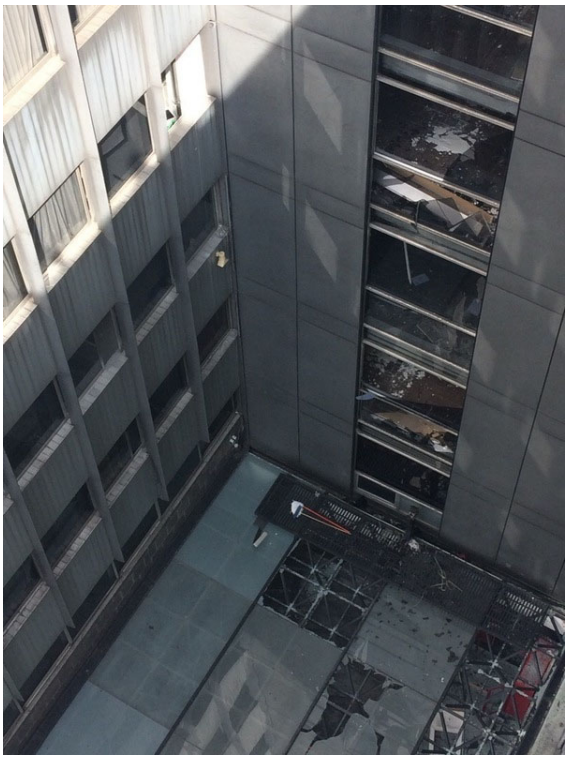


Figure 6.3.31.12 Sketch of damaged columns at the north face of the building.

The concrete shear wall core at the south face of the building creates an extreme torsional irregularity. The building likely rotated around the core, causing excessive displacements along the North face of the building. The columns at the North face of the building showed extreme damage, while those along the south face showed little sign of distress.



(a) SE face taken from adjacent office building roof. No apparent structural damage (in line with stiff concrete elevator core on South of structure.)



(b) Solid uncracked elevator core at south face which acted like a strong back causing apparent extreme torsional irregularity.



(c) Elevator shaft



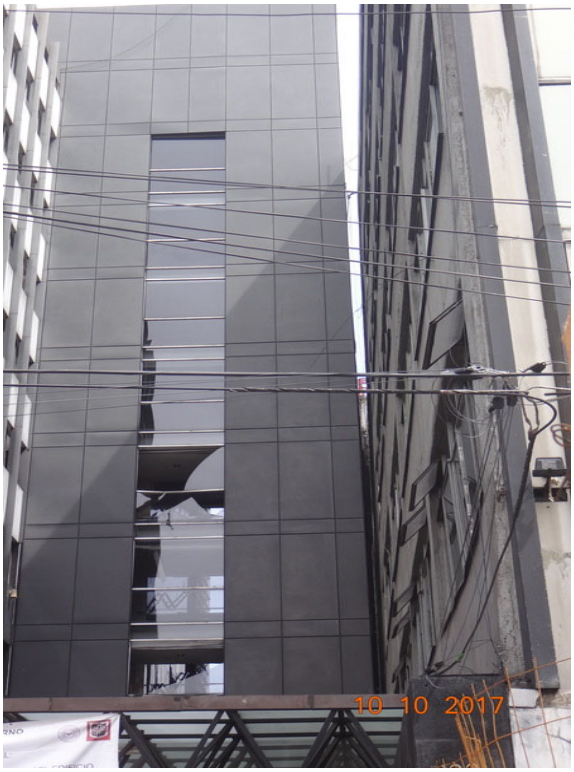
(d) Elevation of elevator shaft



(e) Elevation of elevator shaft looking west



(f) SW corner looking at elevator shaft on south face



(g) Separation joint between elevator shaft and adjacent undamaged office building. Notice lean northward.



(h) East face of elevator tower showed no major damage.

Figure 6.3.31.13 Photos of elevator shaft and courtyard.

While 122 San Antonio Abad had a story collapse, nearby buildings seemed unaffected by the earthquake.



(a) Adjacent office building to south. No major damage.



(b) Interior of adjacent building.



(c) North face and RC parking structure across street – undamaged.



(d) Parking structure across the street. Undamaged RC shear walls, RC columns, and spandrel frames with PC double T's floors/roof



(e) Parking structure SE corner



(f) NE corner with adjacent undamaged Telmex building

Figure 6.3.31.14 Undamaged adjacent buildings.

6.3.31.4 Additional Information

There were no fatalities. Interior access was possible but was deemed highly risky. The following is the government notice for the September 19, 2017 earthquake drill.

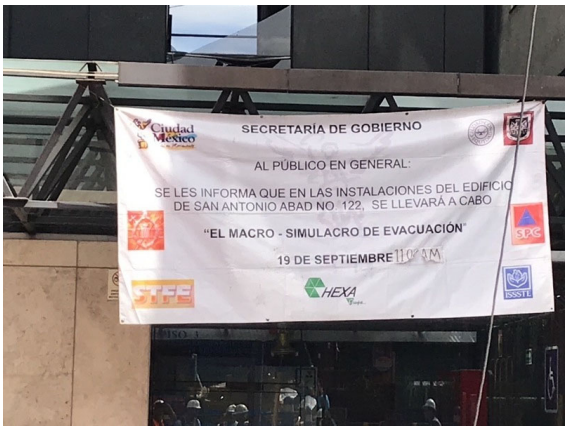


Figure 6.3.31.15 Government notice of earthquake drill on September 19, 2017.

6.3.32 Site #32: 124 Calle Amsterdam

6.3.32.1 Building Description

The building is located on 124 Calle Amsterdam, between Amsterdam and Av Michoacan. The general location and specific coordinates are shown on Figure 6.3.32.1. The plan area is irregular as shown in the plan satellite view in Figure 6.3.32.2. The building has 8 stories, one level of basement and one to two levels of bulkheads in the middle. Its construction date is unknown.

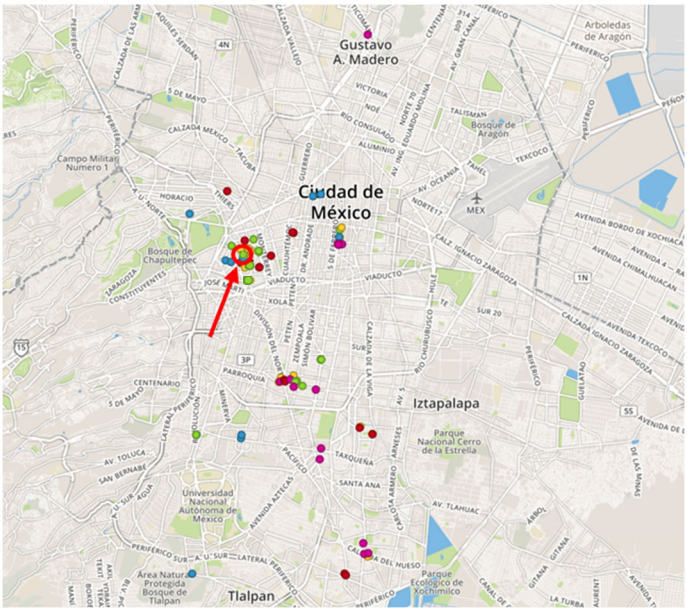


Figure 6.3.32.1 Location of site (Fulcrum Database). Coordinates: 19.412022, -99.171003.

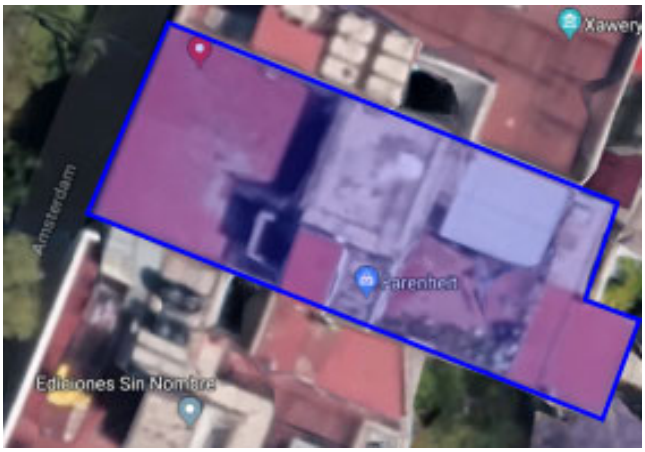


Figure 6.3.32.2 Plan satellite view of the site (captured from Google 2017).

The building appears to have a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill. Figure 6.3.32.3 below shows an elevation view of the building.



Figure 6.3.32.3 Front (west) view. The building is in the same row as 128 and 130 Amsterdam—virtually all leaning northwards like domino.

6.3.32.2 Damage and Observations—2017

The building has structural damage including a lean northward as viewed from the exterior. Ground deformation and displacement of the building superstructure towards the north resulting in narrowing/closure of the separation joint between adjacent buildings was noted. Pounding due to lateral movement of the building might have occurred during the earthquake. It was not clear if all the residents have been evacuated from the building or not. Access to the interior was not available for this particular building.



(a) Joint with building to the north



(b) Close up of north separation joint (location of subsidence)



(c) North point

Figure 6.3.32.4 Separation joint between 124 Calle Amsterdam and adjacent building 122 Calle Amsterdam located north.



(a) Joint with building to the south



(b) Close up of south joint



(c) Close up of south joint base (subsidence)

Figure 6.3.32.5 Separation joint between 124 Calle Amsterdam and adjacent building 126 Calle Amsterdam located south.



Figure 6.3.32.6 Broken (racked) window pane on west face.

6.3.32.3 Discussion

This building represents typical construction in the neighborhood. A number of buildings, including this one, have suffered similar damage which includes severe cracking in the plastered brick infills, cracking of the concrete frame members and permanent drift mostly towards the northward direction. There are also signs of soil subsidence in the main garage entrance area of the building. It was also noted that these buildings have floors which appear to slope (downwards) towards the north.

6.3.32.4 Recommendations

It is recommended that this structure undergo a close and detailed structural observation and evaluation by qualified structural engineer prior to being reoccupied for normal use.

6.3.33 Site #33: 126 Yautepec

6.3.33.1 Building Description

The building is located in 126 Yautepec, near the intersection of Yautepec and Campeche. The general location is shown on Figure 6.3.33.1. The plan area is rectangular, as shown in the plan satellite view in Figure 6.3.33.2. The building is 4 stories tall with a bulkhead level in the back and has an inner courtyard. On one side of the building is another building of similar height, but the floor elevations did not appear to be aligned, and on the other side of the building is a one story building. Its construction date is unknown.

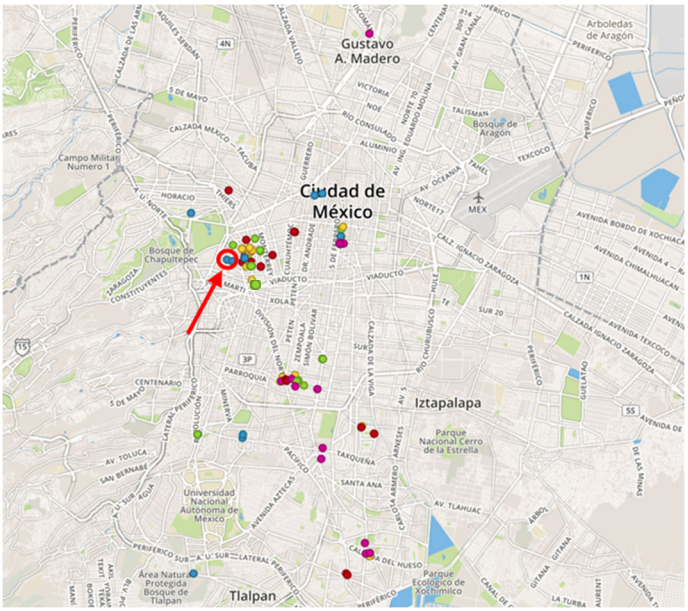


Figure 6.3.33.1 Location of site (Fulcrum Database). Coordinates: 19.411104, -99.178053.



Figure 6.3.33.2 Plan satellite view of the site (captured from Google 2017).

The building construction is unreinforced masonry. Figure 6.3.33.3 below shows a front (west) elevation view of the building.



Figure 6.3.33.3 Front (west) view of the building.

6.3.33.2 Damage and Observations—2017

The building had no observed damage. It is located in a region where relatively little damage was observed.



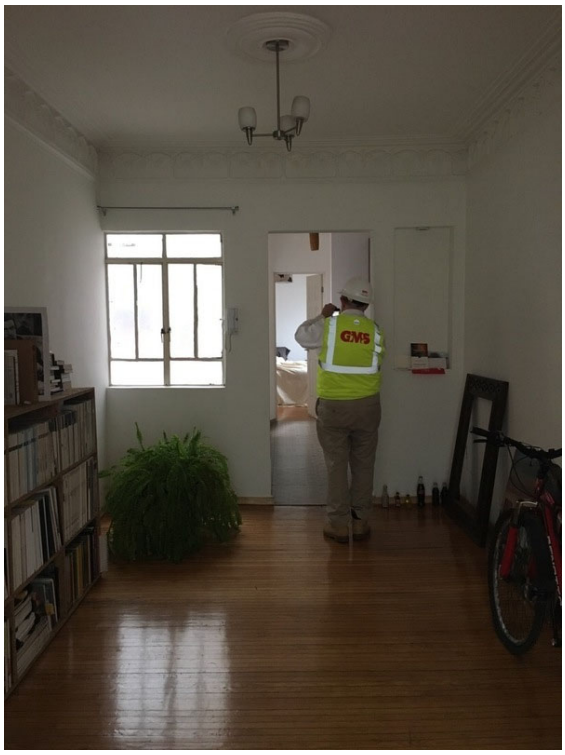
(a) Irregular shaped window well



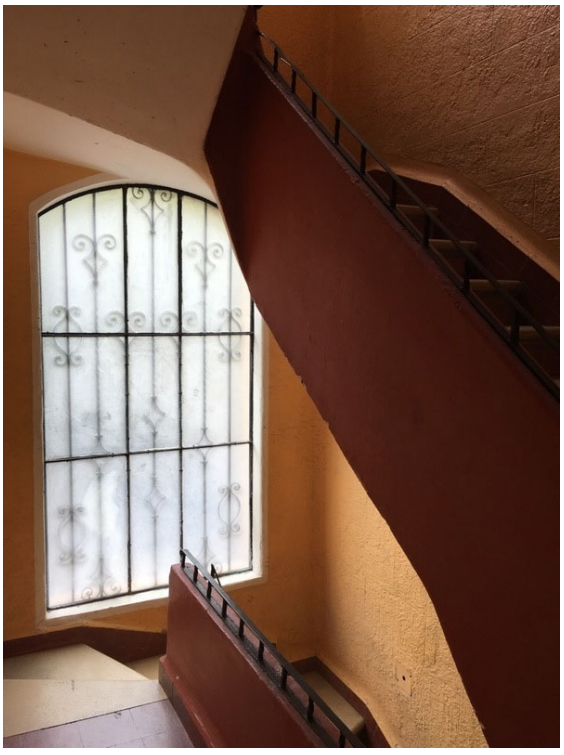
(b) View from the inner courtyard



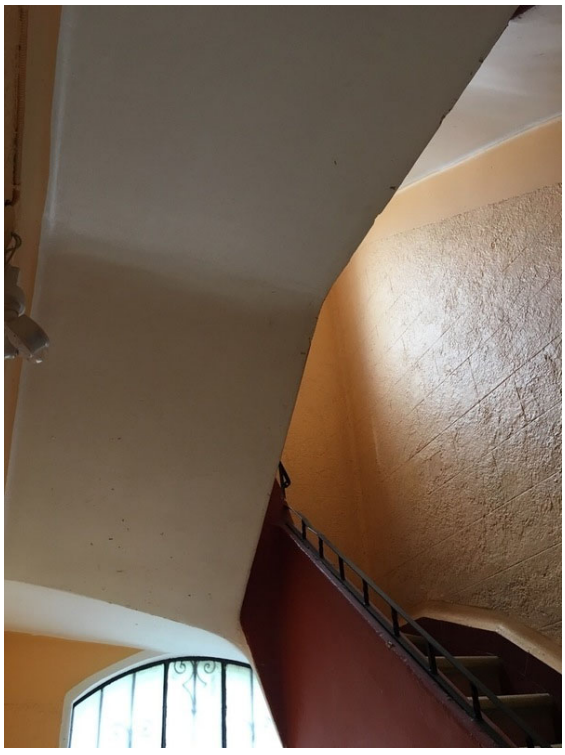
(c) Photo of an apartment unit



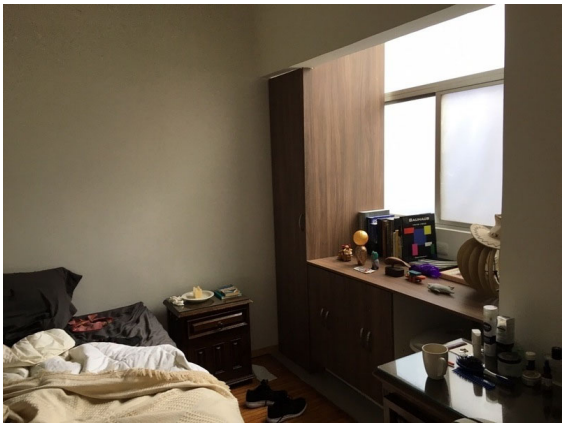
(d) Photo of an apartment unit



(e) Photo of a stairwell



(f) Photo of a stairwell



(g) Photo of an apartment unit



(h) Photo of an apartment unit



(i) Photo of apartment windows



(j) View of inner courtyard

Figure 6.3.33.4 Photos of the interior of the building.

6.3.33.3 Discussion

While this building is unreinforced masonry and should have been susceptible to damage, almost no damage was observed. A building resident said he did not observe any cracking in the masonry walls in his apartment. The building may be founded on good soil and may not have experienced large accelerations during the earthquake.

6.3.34 Site #34: 128 Calle Amsterdam

6.3.34.1 Building Description

This building is located on 128 Calle Amsterdam, between Av. Michoacan and Calle Laredo. The general location and specific coordinates are shown on Figure 6.3.34.1. As observed from the satellite maps in Figure 6.3.34.2, the plan area of this building is irregular. The building has 6 stories. Its construction date is unknown.

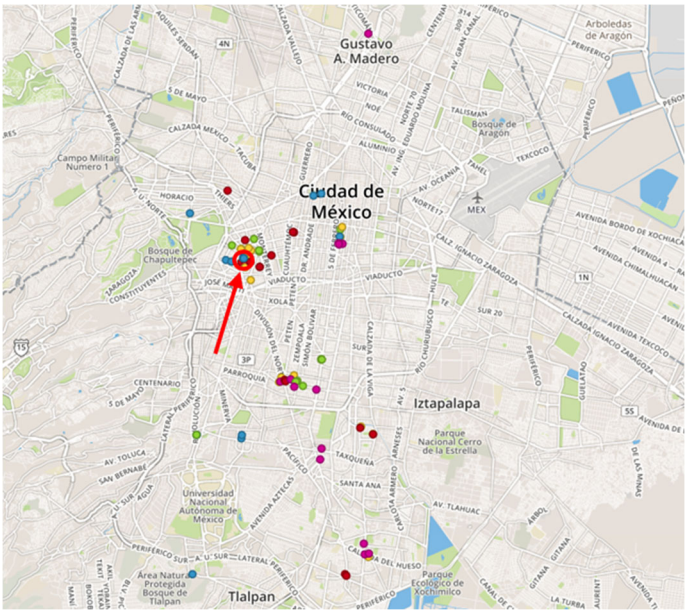
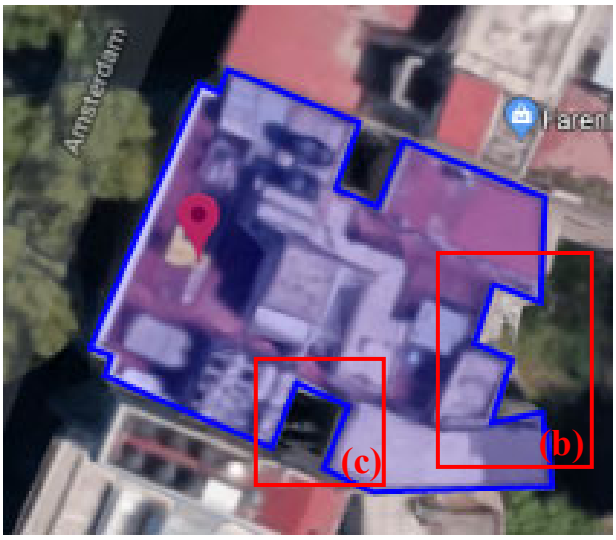


Figure 6.3.34.1 Location of site (Fulcrum Database). Coordinates: 19.4118671413, -99.1710657254.



Figure 6.3.34.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are most likely resisted by the concrete frame with URM infill in both building directions. It is not clear if the building has shear walls. The ground story has an open layout for the parking garage. Some photos of the building plan view, shown in Figure 6.3.34.3 depict the plan irregularity of the structure. The building elevation is shown in Fig 6.3.34.4.



(a) Plan view of the site with locations of photos



(b) Photo of irregular shape in the back (east)



(c) Photo of the courtyard in the side (south)

Figure 6.3.34.3 Photos of structure showing plan irregularities.



Figure 6.3.34.4 Front (west) view of the building.

6.3.34.2 Damage, Repairs, and/or Rehabilitation—1985

According to the building residents, the earthquake of 1985 initiated the building tilt towards the north that the building is currently experiencing.

6.3.34.3 Damage and Observations—2017

Overall, a major part of the damage in the structure was related to a severe tilt towards the north of the building. Additionally, pounding of the structure was observed as well as numerous cracks throughout the building height.

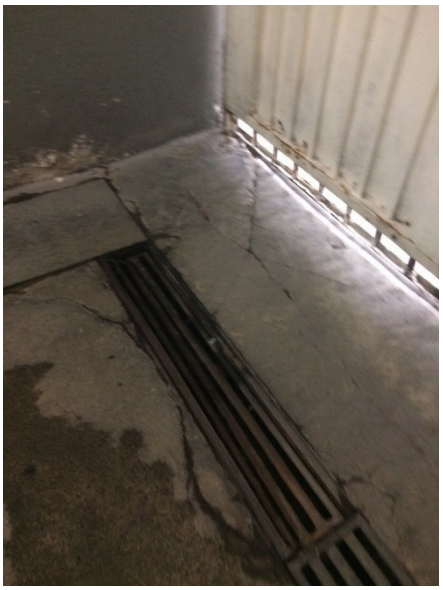
At the garage, the pavement had a total of 2.4 degrees tilt towards the north. According to the neighbors the tilt was already present although it had increased after the earthquake. The slope of the ground floor is shown on Figure 6.3.34.5.



(a) Garage pavement (photo looking west)



(b) Downward slope at garage entrance (photo looking north)



(c) Downward slope at garage entrance (photo looking south)



(d) Garage pavement (photo looking west)



(e) Garage pavement (photo looking east)

Figure 6.3.34.5 Tilt in garage pavement.

At the walls in the garage there were visible cracks as shown below.



(a) Crack in wall at northeast inner corner of garage



(b) Crack at the wall in the open portion of the garage

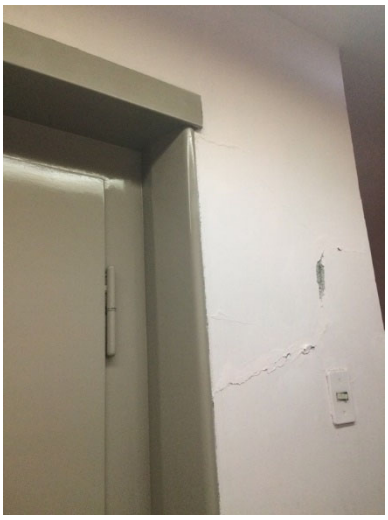
Figure 6.3.34.6 Cracks in garage walls.

While going up the stairs to the 1st floor, cracks in the wall were observed, indicating the direction (north) of the building tilt.

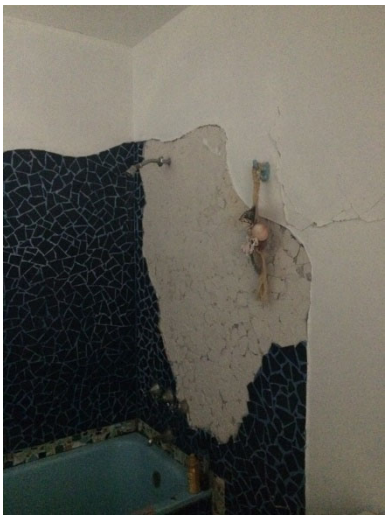


Figure 6.3.34.7 Cracks in stairs wall between ground and first floor.

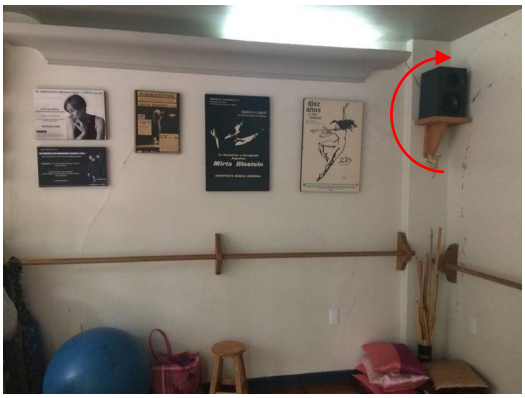
At the 1st floor, there were severe cracks in the walls and the building tilt was evident.



(a) Crack in elevator wall



(b) Fallen plaster in bathroom wall



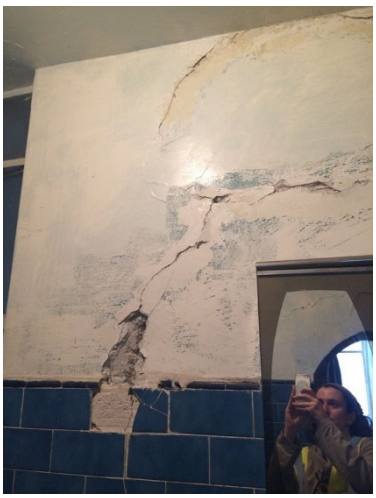
(c) Tilt observed in north direction



(d) Visible tilt and severe cracks in walls



(e) Cracks in interior wall



(f) Cracks in interior walls

Figure 6.3.34.8 Cracks and observed building tilt at the 1st floor.

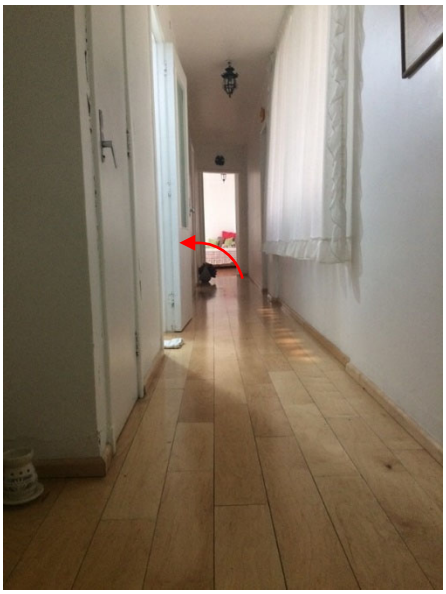


Figure 6.3.34.9 Building title observed in 1st floor hallway.

At the stairs from the 1st to the 2nd floor, there cracks in the walls. Some of these cracks started to indicate the location of where the masonry meets the concrete elements as shown in Figure 6.3.34.10.

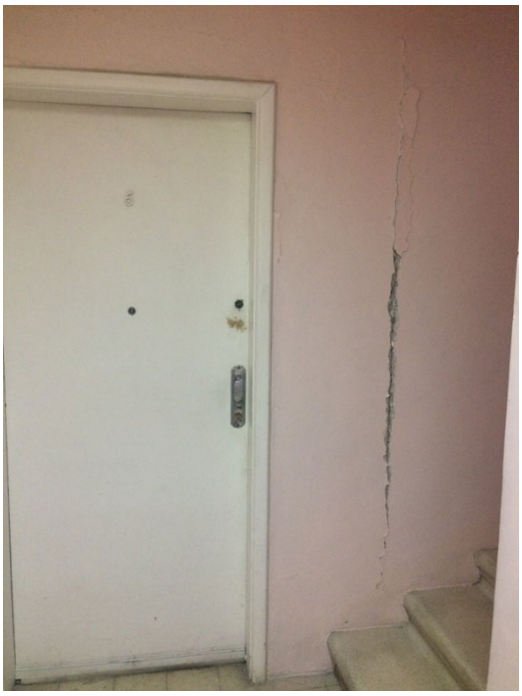


(a) Cracks in wall by stairs



(b) Cracks in wall by stairs





(c) & (d) The cracks in the walls start to indicate interface between masonry and concrete



(e) The concrete columns has spalled and the reinforced is exposed

Figure 6.3.34.10 Cracks observed going up the stairs to the 2nd floor and spalled concrete.

In the stairs at the upper floors, the cracks in the walls also showed the building tilting towards the north.

The joints between this building and the neighboring structures, 124 Calle Amsterdam (to the north) and 130 Calle Amsterdam (to the south), were observed. Figures 6.3.34.11 and 6.3.34.12 show the construction joints.



(a) Joint elevation



(b) Joint at ground floor (closed)





(c) & (d) Joint at 1st and second stories

Figure 6.3.34.11– Construction joint between 128 and 124 (adjacent north) Calle Amsterdam



Figure 6.3.34.12 Construction joint between 128 and 130 (adjacent south) Calle Amsterdam.

Poor construction practices were observed such as a concrete section with pieces of wood blocks and paper inside.

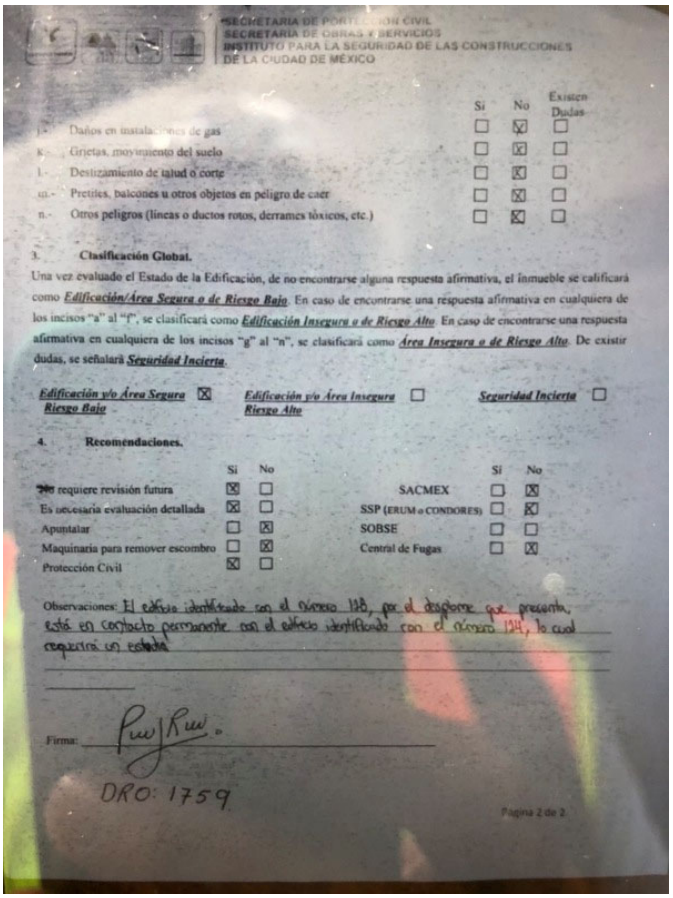


Figure 6.3.34.13 Wood block observed inside concrete section.

6.3.34.4 Discussion

At the time of the site visit, the administration and residents mentioned that they had been conversing with an engineer about the possibility of looking at retrofit solutions as well as a possible geotechnical engineering study. They showed the team a series of messages of this conversation.

There was an official document on the building stating that the building was permanently in contact with the adjacent building at 124 Calle Amsterdam and further studies would be required.



SECRETARIA DE PROTECCIÓN CIVIL
SECRETARIA DE OBRAS Y SERVICIOS
INSTITUTO PARA LA SEGURIDAD DE LAS CONSTRUCCIONES DE LA CIUDAD DE MÉXICO

	Si	No	Existen Dudas
j.- Daños en instalaciones de gas	☐	☒	☐
k.- Grietas, movimiento del suelo	☐	☒	☐
l.- Deslizamiento de talud o corte	☐	☒	☐
m.- Pretiles, balcones u otros objetos en peligro de caer	☐	☒	☐
n.- Otros peligros (líneas o ductos rotos, derrames tóxicos, etc.)	☐	☒	☐

3. **Clasificación Global.**

Una vez evaluado el Estado de la Edificación, de no encontrarse alguna respuesta afirmativa, el inmueble se calificará como ***Edificación/Área Segura o de Riesgo Bajo***. En caso de encontrarse una respuesta afirmativa en cualquiera de los incisos "a" al "f", se clasificará como ***Edificación Insegura o de Riesgo Alto***. En caso de encontrarse una respuesta afirmativa en cualquiera de los incisos "g" al "n", se clasificará como ***Área Insegura o de Riesgo Alto***. De existir dudas, se señalará ***Seguridad Incierta***.

Edificación y/o Área Segura Riesgo Bajo ☒ ***Edificación y/o Área Insegura Riesgo Alto*** ☐ ***Seguridad Incierta*** ☐

4. **Recomendaciones.**

	Si	No		Si	No
~~No~~ requiere revisión futura	☒	☐	SACMEX	☐	☒
Es necesaria evaluación detallada	☒	☐	SSP (ERUM o CONDORES)	☐	☒
Apuntalar	☐	☒	SOBSE	☐	☐
Maquinaria para remover escombro	☐	☒	Central de Fugas	☐	☒
Protección Civil	☒	☐			

Observaciones: El edificio identificado con el número 128, por el desplome que presenta, está en contacto permanente con el edificio identificado con el número 124, lo cual requerirá un estudio

Firma: Raul Rui

DRO: 1759

Página 2 de 2

Figure 6.3.34.14 Official documentation describing observations from engineer.

6.3.35 Site #35: 130 Amsterdam

6.3.35.1 Building Description

The building is located on 130 Calle Amsterdam, between Av Michoacan and Calle Laredo. The general location and specific coordinates are shown on Figure 6.3.35.1. The plan area is irregular, as shown in the plan satellite view in Figure 6.3.35.2. The building has 6 stories. It was constructed in 2002.

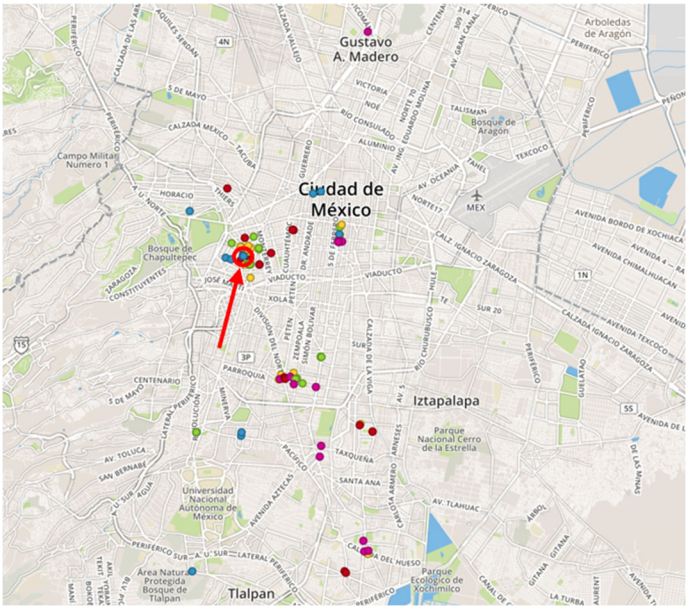


Figure 6.3.35.1 Location of site (Fulcrum Database). Coordinates: 19.411699, -99.171149.



Figure 6.3.35.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on reinforced concrete shear walls. There is a concrete wall that ends at the 2nd floor. Lateral loads are resisted by the reinforced concrete shear walls in both building directions. Building elevations are shown in Figure 6.3.35.3 below.



(a) Southwest elevation

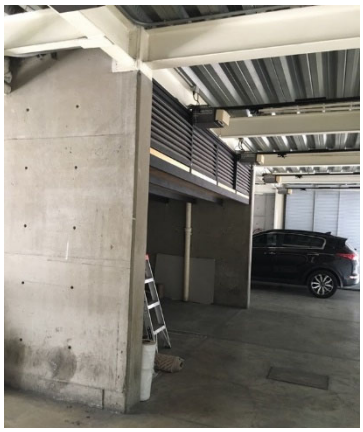


(b) South elevation

Figure 6.3.35.3 Building elevations.

6.3.35.2 Damage and Observations—2017

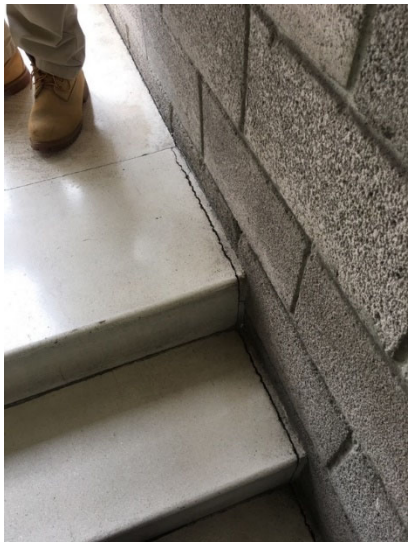
Overall, this building has minor (mostly cosmetic) damage. On the ground floor, a few new very thin cracks were observed in the entrance and middle of the stairway at the entrance of the building. On the 1st floor, more cracks were observed. On the 2nd floor, the cracks were already mended and covered. On 4th floor, there are some thin cracks in walls and ceilings, and a main door that does not open smoothly due to minor displacement. On 5th floor, there are some thin cracks in walls and ceiling. Roof has no issues. The adjacent building is tilting significantly.



(a) Shear wall core that continues to the top



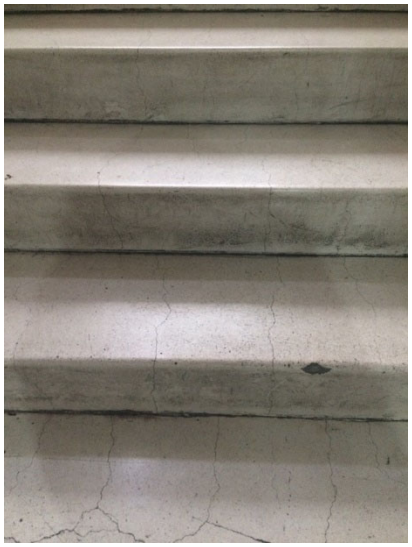
(b) Shear wall core in apartment



(c) Egress stair cracking



(d) Floor construction



(e) New thin cracks on ground floor



(f) New cracks at ground floor

Figure 6.3.35.4 Construction joint closing off at higher floors.

6.3.35.3 Discussion

This building appears to have behaved well during the earthquake. It has a continuous shear wall located in the center of the floor, which likely provided sufficient stiffness to the structure.

6.3.35.4 Additional Information

The building was instrumented during ATC's 2017 reconnaissance trip. See Chapter 4 for more information.

6.3.36 Site #36: 132 Calle Atlixco

6.3.36.1 Building Description

The building is a hotel called "Edificio María Condensa" and is located at 132 Calle Atlixco, between Calle Atlixco and Campeche. The general location and specific coordinates are shown on Figure 6.3.36.1. The corner building has 5 stories with a roof canopy extending next to the bulkhead. The plan area is rectangular, as shown in the plan satellite view in Figure 6.3.36.2. Its construction date is unknown.

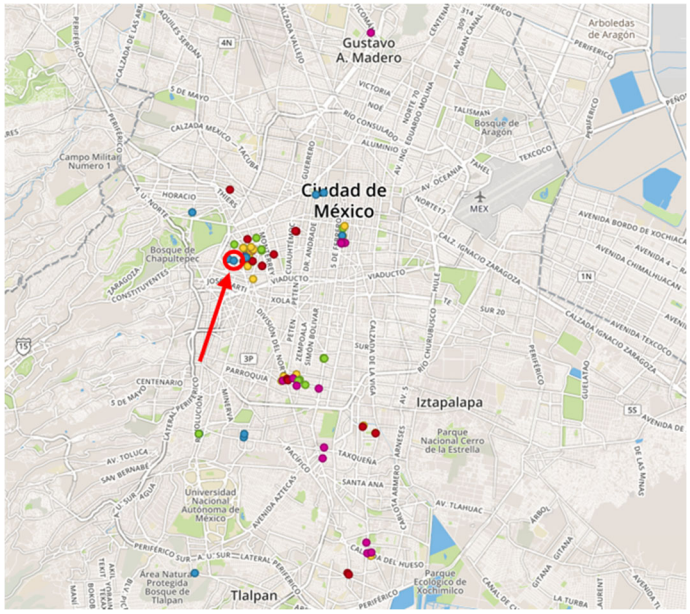


Figure 6.3.36.1 Location of site (Fulcrum Database). Coordinates: 19.410552, -99.175900.



Figure 6.3.36.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the reinforced concrete moment-resisting frame in both building directions. Figure 6.3.36.3 below shows an elevation view of the building.



(a) Front (west) building elevation.

(b) South west corner building elevation.

Figure 6.3.36.3 Building elevations.

6.3.36.2 Damage and Observations—2017

Overall, there was no visible damage to the structure. The only visible cracks in the interior of the building had been painted over following the earthquake, prior to the visit. These are shown in Figure 6.3.36.5.



(a) Exterior view of the ground floor.



(b) Exterior view of the ground floor.



(c) Restaurant at the roof.

Figure 6.3.36.4 Photos of the building exterior and interior.



Figure 6.3.36.5 Amended cracks in the interior of the building.

6.3.36.3 Discussion

This building has several vulnerabilities, such as its corner location, its unreinforced masonry walls, and its weak first story condition, and is not expected to perform well during an earthquake. However, little damage was observed in the building after the earthquake, suggesting that the building did not experience a significant level of shaking. Other buildings located in this neighborhood also appeared to be in good condition.

Since the building is used as a hotel, there are many infill walls in the building, except at the first floor. It is not clear if these walls are engaged to the slab and if they contributed to the lateral capacity of the building.

6.3.37 Site #37: 141 Avenida Sonora

6.3.37.1 Building Description

The building is located on 141 Avenida Sonora, between Avenida Sonora and Amsterdam. The general location and specific coordinates are shown on Figure 6.3.37.1. The building has 14 stories including a podium. The plan area is shown in the plan satellite view in Figure 6.3.37.2. Its construction date is unknown.

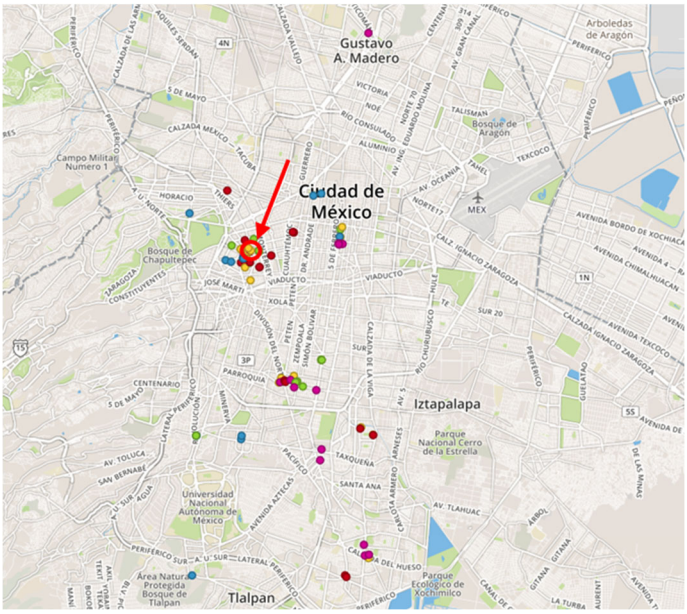


Figure 6.3.37.1 Location of site (Fulcrum Database). Coordinates: 19.415009, -99.169485.



Figure 6.3.37.2 Plan satellite view of the site (captured from Google 2017).

The building construction is concrete slab supported by concrete frame with thin columns and unreinforced masonry infill walls. The building elevation is shown in Figure 6.3.37.3.



Figure 6.3.37.3 Building north elevation.

6.3.37.2 Damage and Observations—2017

Significant diagonal cracking was noted from the exterior of this building in the apparent infill walls that are placed within reinforced concrete frames. It is not known if there are interior RC shear walls or not. The observation was

performed from the vehicle since the area was not easily accessible at the time. No access was available to the interior of this building.

6.3.37.3 Additional Information

This building was pointed out to the team by local residents who had been concerned about the visible damage but had not yet seen any action on the part of the local authorities in terms of dealing with the issue.

6.3.37.4 Recommendations

It is recommended that this building be fully evaluated by a qualified structural engineer.

6.3.38 Site #38: 143 Medellin

6.3.38.1 Building Description

The building is located in 143 Medellin, between Calle Querétaro and Zacatecas, with the back facing Avenida Insurgentes Sur. The general location is shown on Figure 6.3.38.1. The main building has 17 stories and setback to 3 stories. The central tower is approximately 20 stories tall; the last three stories in the tower seem to be unfinished. There is a podium in the back with three story columns. The plan area is irregular, as shown in the plan satellite view in Figure 6.3.38.2. Its construction date is unknown.

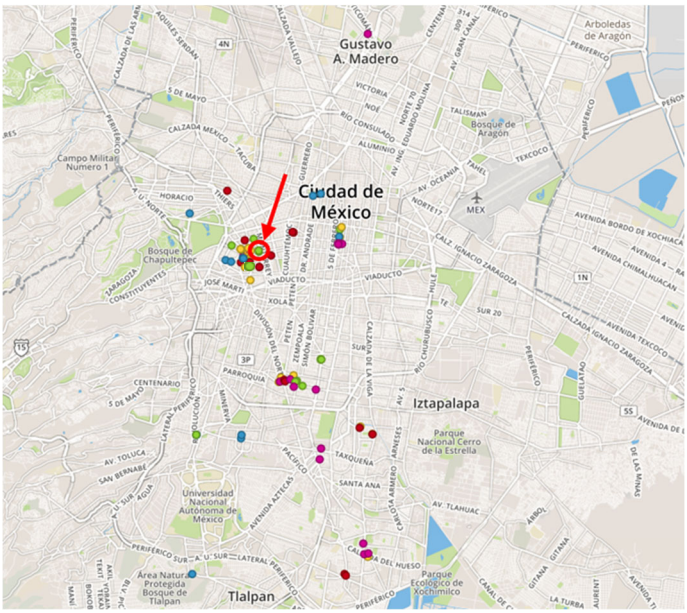


Figure 6.3.38.1 Location of site (Fulcrum Database). Coordinates: 19.414159, -99.165108.



Figure 6.3.38.2 Plan satellite view of the site (captured from Google 2017).

The building is composed of reinforced concrete frames with infill masonry walls. It is unclear whether there are any shear walls. Figure 6.3.38.3 below shows elevation views of the building.



(a) Elevation view of façade facing east



(b) Elevation of central tower



(c) Podium in the back with three story columns



(d) Top stories of central tower seem unfinished

Figure 6.3.38.3 Elevations of the building.

6.3.38.2 Damage and Observations—2017

The building was open and operational at the time of the visit. It appears to be poorly constructed and maintained, with deterioration apparent in the infilled concrete frame elements at various stories. The north face of the central tower showed cracks in the infill walls and possible in the frame elements.



Figure 6.3.38.4 Cracks in the infill walls and possibly in the frame elements.

6.3.38.3 Discussion

This is a very large residential (first floor retail/commercial) building which appeared to have suffered significant damage during the recent and past earthquakes. However, it seemed to be fully occupied and in use. The ATC team was conducting our observations from the exterior because access to the interior was not available. The quality of the construction appeared to be poor and the upper pop-up (penthouse?) portion of the structure appeared to have been left incomplete and unfinished. As noted above, cracks and spalls in the concrete frames, joints, infill walls, plaster etc. were clearly visible and fairly extensive.

6.3.38.4 Additional Information

Due to the size of this building the number of occupants is expected to be rather large and therefore the risk exposure emanating from compromising structural damage during past earthquakes is probably more significant than for other structures we have observed in the city.

6.3.38.5 Recommendations

It is recommended that this building be fully evaluated by a qualified structural engineer at the earliest possible date.

6.3.39 Site #39: 149 Avenida Sonora

6.3.39.1 Building Description

The building is located on 149 Avenida Sonora, between Avenida Mexico and Amsterdam. The general location and specific coordinates are shown on Figure 6.3.39.1. The building has 8 stories and one to three story bulkheads as shown in Figure 6.3.39.2. However, it suffered a collapse above the fourth story. The structure has plan irregularity with a courtyard on the side facing east and a re-entrant southeast corner, as shown in the plan satellite view in Figure 6.3.39.3. Reportedly, the top three stories had been added on by the owner to the original 5-story structure. Its construction date is unknown.

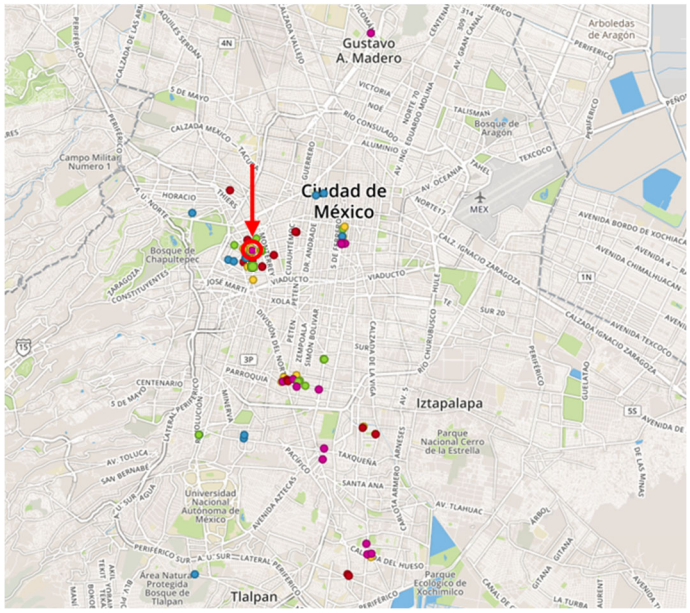


Figure 6.3.39.1 Location of site (Fulcrum Database). Coordinates: 19.414546, -99.169264.

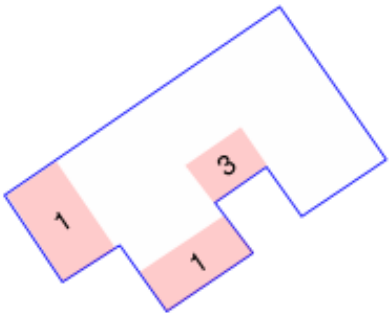


Figure 6.3.39.2 Number of stories at each bulkhead.



Figure 6.3.39.3 Plan satellite view of the site (captured from Google 2017).

As is typically the case with such buildings in this area of town it appears that the structure had an RC frame with URM infills and was used as a residential building above the storefront at the first/ground floor (street) level.



Figure 6.3.39.4 Front (northeast) elevation of the building.

6.3.39.2 Damage, Repairs, and/or Rehabilitation—1985

At the collapsed floor, there are cages around a ruptured column which could have been added as a retrofit solution to reinforce the column.

6.3.39.3 Damage and Observations—2017

The gap with the adjacent north building seemed to decrease along the building height, as observed in Figure 6.3.39.5. Pounding may have occurred.

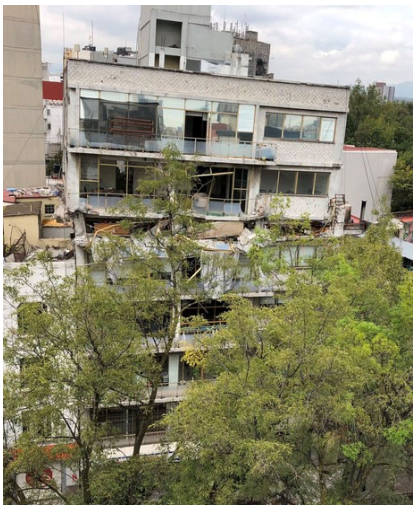


Figure 6.3.39.5 Construction joint closing off at higher floors.

The sixth story completely collapsed. This was the first level added after the original construction. Figures 6.3.39.6 and 6.3.39.7 show the collapsed floor from distinct angles. The rupture column is also shown, with signs of apparently ineffective steel cage retrofitting.



Figure 6.3.39.6 Close up view of crushed 6th floor and the upper floor (7^{th}, 8^{th}) portion collapsed and offset (Photo Saif Hussain).



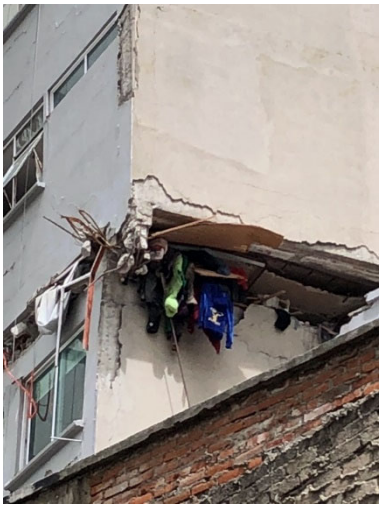
(a) Collapsed floor at a distance



(b) Ruptured reinforced column with cage



(c) Rear view of collapsed floor.



(d) Lost column at the corner of collapsed floor.



(e) Collapsed 6th story.



(f) Collapsed 6th story.

Figure 6.3.39.7 Photos of the partial collapse.

6.3.39.4 Discussion

The partial collapse of the structure could have been impacted by the following factors: (1) pounding with the adjacent building (matched with the roof levels of the adjacent buildings on both sides), (2) change in stiffness at the 6th floor due to 3-story addition. Complete (progressive) collapse of the building may have been prevented by the presence of adjacent structures on both sides of the building.

6.3.39.5 Additional Information

According to some of the local residents, this building was originally a 5-story structure. However, some years ago, the owner added three additional stories to the building. This information could not be verified.

6.3.39.6 Recommendations

It appears unlikely that this building can be salvaged, however a detailed evaluation along with extensive testing of the apparently undamaged portions of the structure should be carried out by a qualified structural engineer in order to decide the next course of action related to the building. Nevertheless, this building poses a collapse hazard to the neighbors and local area in case of strong aftershocks or other earthquakes happen in the area.

6.3.40 Site #40: 158 Avenida Emperadores

6.3.40.1 Building Description

The building is located on 158 Avenida Emperadores, between Saratoga and Eje Central Lazaro Cardenas. The general location and specific coordinates are shown on Figure 6.3.40.1. The building has 8 stories. The plan area is irregular, as shown in the plan satellite view in Figure 6.3.40.2. Its construction date is unknown.

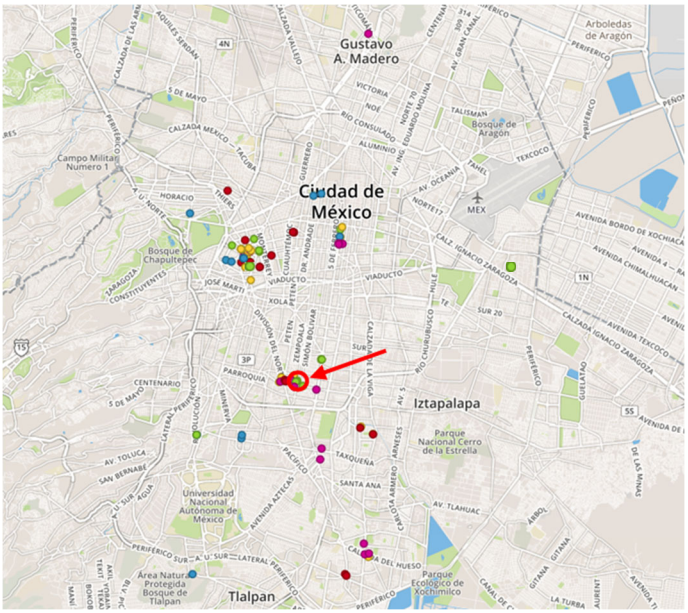


Figure 6.3.40.1 Location of site (Fulcrum Database). Coordinates: 19.366742, -99.150813



Figure 6.3.40.2 Plan satellite view of the site (captured from Google 2017).

The building construction was not apparent from outside—most likely a concrete slab/beam/column system with infill masonry. The building elevation is shown in Figure 6.3.40.3.



Figure 6.3.40.3 Front (south) view of the building.

6.3.40.2 Damage and Observations—2017

Horizontal setback at the middle and in plane damage of infill walls was observed. However, no significant structural damage was visible from outside.

6.3.40.3 Recommendations

It is recommended that this building be fully evaluated by a qualified structural engineer. If the contact information for the building manager/owner can be obtained, this building can be a candidate for further studies and instrumentation because of its characteristics (height, corner position, H-shape and building construction). However, at this point, information about the structure is very limited.

6.3.41 Site #41: 162 Avenida Sonora

6.3.41.1 Building Description

The building is located in 162 Avenida Sonora, between Avenida Mexico and Amsterdam near the Plaza Popocatépetl. The general location and specific coordinates is shown on Figure 6.3.41.1. There seems to be a courtyard opening in the middle from the satellite view in Google Maps but is unclear, as shown in the plan satellite view in Figure 6.3.41.2. The building has 10 stories in the front half (white area) and 8 stories in the back (red area). Its construction date is unknown.

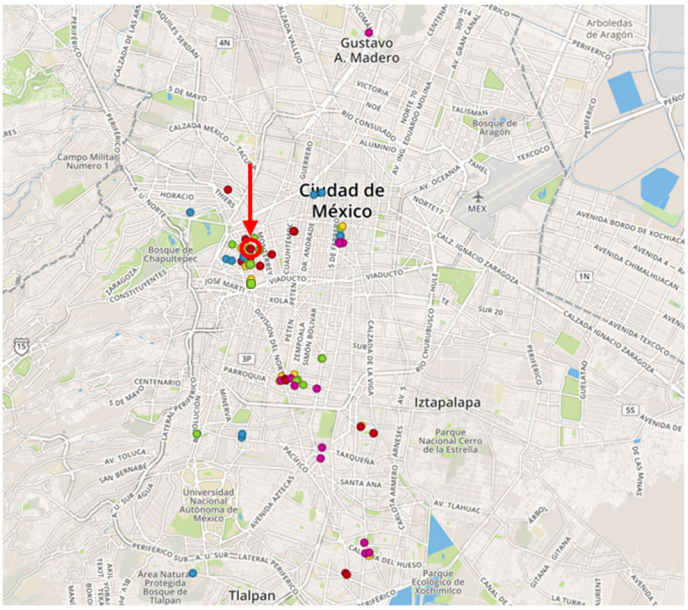


Figure 6.3.41.1 Location of site (Fulcrum Database). Coordinates: 19.4142637868, -99.168628771.



Figure 6.3.41.2 Plan satellite view of the site (captured from Google 2017).

The structural system of this building is reinforced concrete. Figure 6.3.41.3 below shows the elevation views of the building.



Figure 6.3.41.3 Front (west) building elevation

6.3.41.2 Damage and Observations—2017

The building was observed to be leaning against the adjacent structure to the north. As observed in Figure 6.3.41.4 (a), the construction joint to the neighboring structure at the north seems to have closed off. There might also have been potential pounding with the adjacent building to the south, where the cladding at the ground floor column spalled off as shown in Figure 6.3.41.5.





(a) & (b) Construction joint with adjacent (north) building seems to have closed off





(c) & (d) Construction joint with adjacent (south) building shows potential pounding

Figure 6.3.41.4 Construction joint at adjacent buildings on both sides.



Figure 6.3.41.5 Potential pounding at south joint possibly caused spalling of cladding at column.

Finally, another observed condition was the depression of the sidewalk in front of the building. As shown in Figure 6.3.41.6, the sidewalk is depressed at the southwest corner.



Figure 6.3.41.6 Sidewalk depression at SW corner (photo looking south).

6.3.41.3 Discussion

This building is located in an area of the City which seems to have suffered widespread building damage including partial and total building collapses. Interior access to this building was not available but it seems apparent that the structure has a permanent first floor racking displacement towards the north-northwest direction accompanied by subsidence at the sidewalk level. The building adjacent on the north side is a two-story structure and seems to have been impacted by the taller subject building resulting in pounding damage. It is assumed that the structural system (RC frames with URM brick/block infill) of this building is similar to that found in similar nearby structures which were examined much more closely (e.g. 105 Ave Mexico). It appeared that this building had been evacuated and was not in use at the time, which in the team's opinion would be the appropriate action to take until a detailed structural investigation and evaluation has been performed for this structure by a qualified structural engineer.

6.3.41.4 Recommendations

A full structural investigation and detailed evaluation of the building is recommended prior to declaring it safe for continued occupancy and normal use.

6.3.42 Site #42: 187 Camino Santa Teresa

6.3.42.1 Building Description

This is the building for the “Colegio De Ingenieros Civiles De Mexico AC”. It is located on 187 Camino Santa Teresa, between Av. Zacatepel and Av. Insurgentes Sur. The general location and specific coordinates are shown on Figure 6.3.42.1. The plan satellite view is shown in Figure 6.3.42.2. The building is 2 stories tall. Its construction date is unknown.

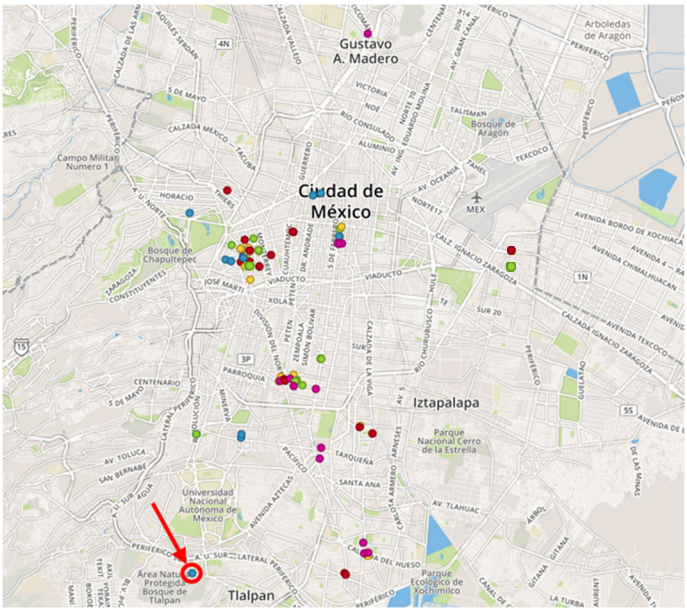


Figure 6.3.42.1 Location of site (Fulcrum Database). Coordinates: 19.2967558745475, -99.1909739189774.



Figure 6.3.42.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete shear walls. Lateral loads are resisted by the reinforced concrete shear walls in both building directions. Figure 6.3.42.3 below shows the front view of the building.



Figure 6.3.42.3 Front (south) building elevation.

6.3.42.2 Damage and Observations—2017

The building was not inspected in detail. From what was observed, the structure had no observed damage. No evidence of retrofit was found.



Figure 6.3.42.4 Photos of building interior.

6.3.43 Site #43: 200 Campos Eliseos

6.3.43.1 Building Description

The building is located at 200 Campos Eliseos, between Calle Arquimedes and Jorge Eliot. The general location and specific coordinates are shown on Figure 6.3.43.1. The plan is shown in the plan satellite view in Figure 6.3.43.2. There are two buildings on this site that share a lobby space and are also connected through a bridge at the higher floors. The taller building has more than 25 story towers plus 7 basements that are connected via a ramp. The basements are mainly used for parking. There is a walkway bridge connecting the towers at the top, which has a sliding connection at one end

that allows for differential movement of the towers during an earthquake. The building was constructed in 2014.

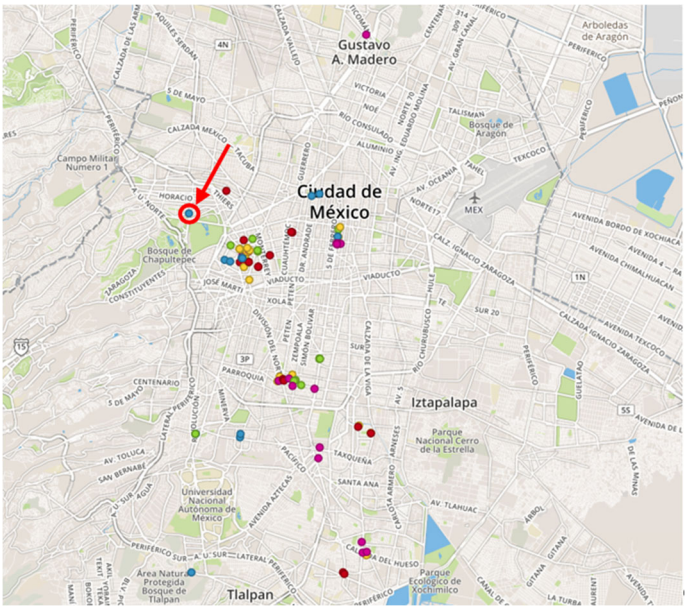


Figure 6.3.43.1 Location of site (Fulcrum Database). Coordinates: 19.427985, -99.192277.



Figure 6.3.43.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on reinforced concrete beams and columns. Lateral loads are resisted by the concrete moment-resisting frame in both building directions. The building elevations are shown in Figure 6.3.43.3.



Figure 6.3.43.3 Front (north) elevations.

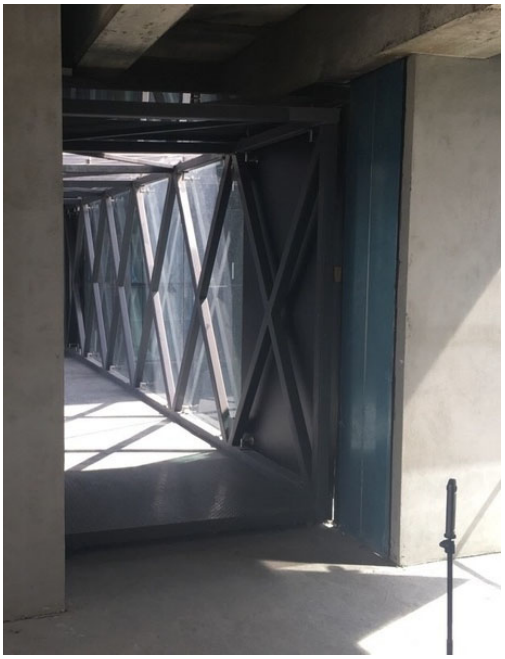


Figure 6.3.43.4 Bridge between two buildings showing sliding joint.

6.3.43.2 Damage and Observations—2017

Overall, this building's structural system was not damaged. A window was broken but did not fall out, and minor damages were observed in the connections of the elevator masonry core to the concrete frame. Figure

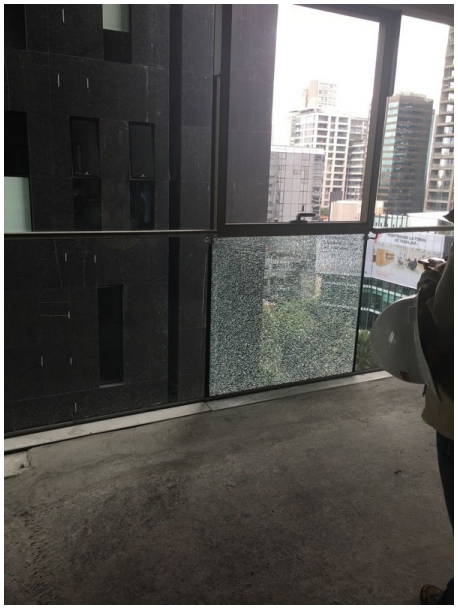
6.3.43.5 below shows these minor damages. The elevator was functional, and the building resumed functioning as its intended purpose.



(a) Minor damage in connections of elevator masonry core to concrete frame



(b) Underside of slab, no damage was observed



(c) Broken window



(d) Connection between glass panels

Figure 6.3.43.5 Building interior.

6.3.43.3 Discussion

The building was located in a neighborhood where relatively little damage was observed. During the site visit, it was noted that the glass façade had little built-in tolerance for structural movement. The bridge connecting the two buildings, however, has a sliding connection at one support and is designed to absorb some differential movement between the two buildings.

6.3.44 Site #44: 224 Avenida Emperadores

6.3.44.1 Building Description

The building is located on 224 Avenida Emperadores, between Dr. Jose Maria Vertiz and Calle Azores. The general location and specific coordinates are shown on Figure 6.3.44.1. The building has 6 stories. As shown in the plan satellite view in Figure 6.3.44.2, there are 3 interior courtyards. The building was constructed in 1975.

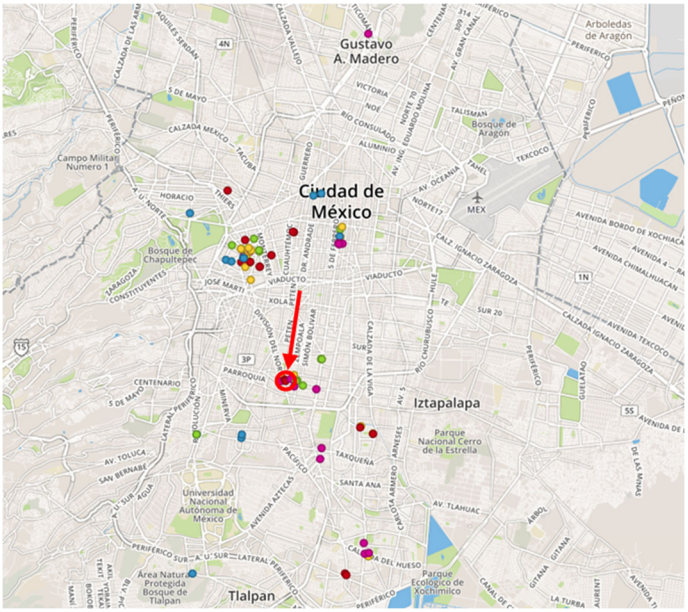


Figure 6.3.44.1 Location of site (Fulcrum Database). Coordinates: 19.3675149372028, -99.1553250980556.



Figure 6.3.44.2 Plan satellite view of the site (captured from Google 2017).

The building has reinforced concrete slabs supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. Figure 6.3.44.3 below shows a front (north) view of the building.

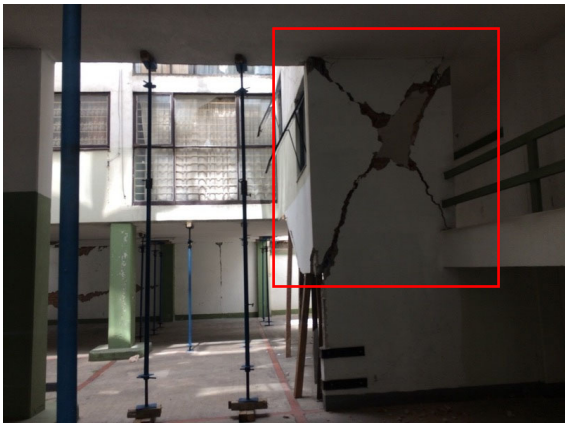


Figure 6.3.44.3 Front (north) view of the building. There is soft story with severe damage to first floor columns.

6.3.44.2 Damage and Observations—2017

The building has severe damage. At the ground level the perimeter walls are masonry infill except for the front of the building, which is open. In the longitudinal direction, the structural system consists of concrete columns and masonry infill. Damage is mostly in transverse direction/parallel to street direction.

The interior columns are damaged at the ground floor. There is significant spalling, especially in the front columns. Upper floor infill is severely damaged. In the transverse direction there is significant in plane infill failure.



(a) Cracks in the infill masonry



(b) Interior of ground floor is open for parking.



(c) Relatively light damage to perimeter infill walls at ground floor



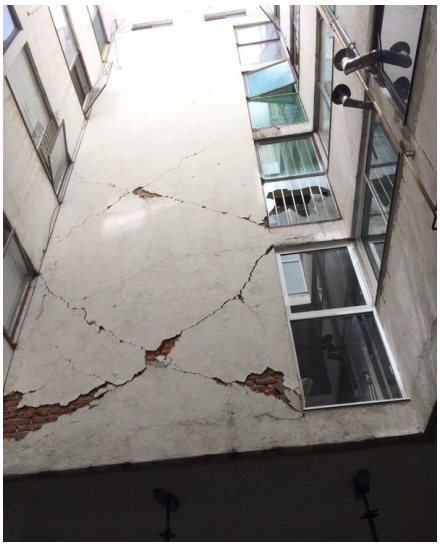
(d) Severe concrete spalling in ground floor column



(e) Column damage spalling



(f) Exposed rebar due to concrete spalling



(g) Infill wall at interior courtyard damaged



(h) Transverse direction infill wall at interior courtyard damaged

Figure 6.3.44.4 Photo of damage to the building.

6.3.44.3 Recommendations

A full structural investigation and detailed evaluation of the building is recommended prior to declaring it safe, to determine retrofit solutions or demolishment.

This building can potentially be a candidate for a study focused on the impact of courtyards (building plan openings) on the structural performance of a building.

6.3.45 Site #45: 232 Calle Amsterdam

6.3.45.1 Building Description

The building is located in 232 Amsterdam, between Avenida Michoacán and Iztaccihuatl. The general location and specific coordinates are shown on Figure 6.3.45.1. The building has 9 stories and no basement. The structural plan is a C-shape, as shown in the plan satellite view in Figure 6.3.45.2. Its construction date is unknown.

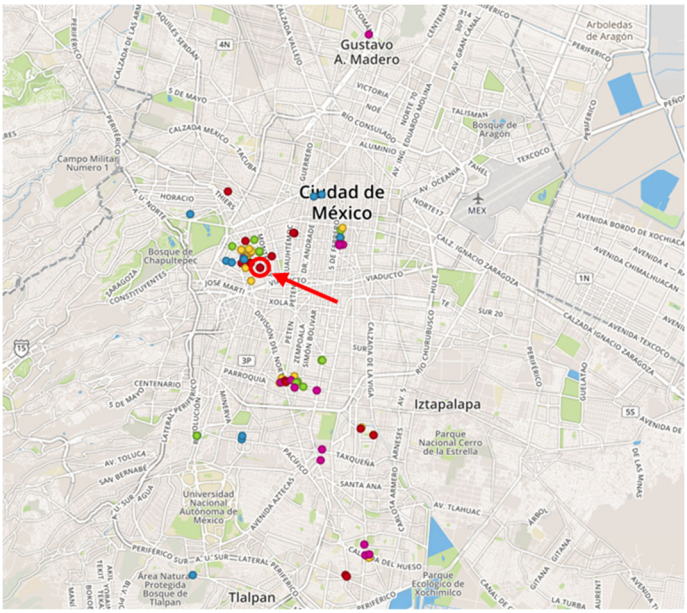


Figure 6.3.45.1 Location of site (Fulcrum Database). Coordinates: 19.410346130535, -99.1686115041375.



Figure 6.3.45.2 Plan satellite view of the site (captured from Google 2017).

The building is composed of reinforced concrete frames with unreinforced masonry infill walls. Although the central elevator appears to be of concrete construction (a concrete core walls), the lateral force resisting system of the building is primarily concrete frame with infill masonry (model building type C3A). Figure 6.3.45.3 below shows the front (southeast) view of the building.



Figure 6.3.45.3 Front (southeast) view of the building.

6.3.45.2 Damage and Observations—2017

The building had significant structural and nonstructural damage. The building has been evacuated and access is restricted. No evidence of seismic retrofit was observed.

Overall there was severe damage to the infill masonry walls in the transverse direction (north-south) in the upper floors and severe pounding damage against adjacent buildings was observed. The damage in the infill walls could have been caused by the pounding. The separation joint between the adjacent buildings, as observed on Figure 6.3.45.5, closed off at the 6th floor. Part of the stucco and marble façade had failed. There was relatively minor damage in the longitudinal direction of the building, and generally minor damage to the structure at ground floor level.



(a) Front (east) side of building



(b) Damage in the transverse masonry infill walls

Figure 6.3.45.4 Front exterior wall damage.



(a) Front view of closed separation joint.



(b) Interior courtyard view of closed separation joint.

Figure 6.3.45.5 Closed separation joint at the upper levels.

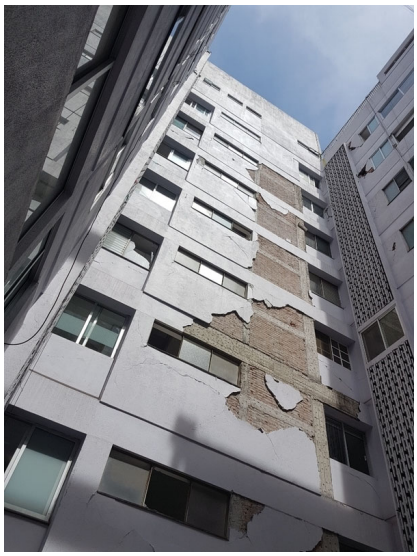


(a) Rear view (wall facing northwest) (b) Front view (wall facing southeast)

Figure 6.3.45.6 Damage due to pounding between the adjacent south building.



(a) Interior courtyard damage at 5th and 6th floors (b) Interior courtyard damage in transverse direction



(c) Interior courtyard with cosmetic damage in the longitudinal exterior wall



(d) Cosmetic damage only at side (north) longitudinal wall

Figure 6.3.45.7 Rear and side exterior wall damage.

The ground floor had a soft story with large openings for parking purposes. However, there was very little structural damage at this level, as shown in 6.3.45.8. In general, damage became more severe at the higher floors.



(a) Parking garage at ground level



(b) Front view of lower level



(c) Minor damage at the wall



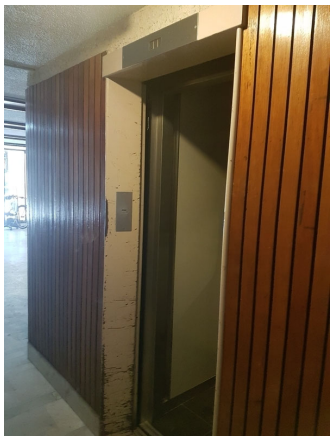
(d) Cosmetic damage at the first elevated floor



(e) No visible damage in the interior



(f) Minor damage at the wall on this level



(g) No visible damage at the elevator core



(h) Detail of beam to column connection at ground level



(i) Longitudinal wall at ground floor at courtyard



(j) Longitudinal wall at ground floor with no noticeable damage

Figure 6.3.45.8 Minor damage at the ground floor.

In the upper floors, there was significantly more damage. In the 4th and 5th floors there was minor damage. However, progressing to the high floors, the

6th to 8th floors had the most severe damage. At these levels, there were cracked and spalled concrete columns as well as in plane and out of plane failure of the masonry infill. At the 6th floor, the damage could have been due to soft story, pounding as well as plan irregularity.



(a) Small damage at infill walls inside the 4th floor



(b) No major damage at the 5th floor

Figure 6.3.45.9 Minor damage at the 4th and 5th floors.



(a) Damage to infill wall



(b) Damage in column at 6th floor

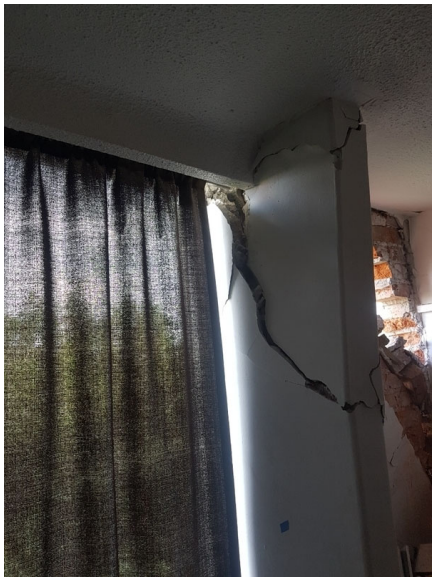
Figure 6.3.45.10 Damage at the 6th floor.



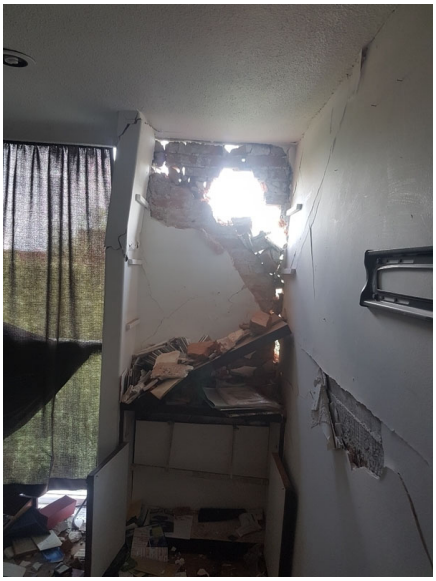
(a) Interior damage



(b) Significant cracking in infill wall



(c) Severe column crack



(d) Out of plane failure of exterior masonry infill wall



(e) Damaged interior masonry wall



(f) Detail of the damaged concrete column at 8th floor

Figure 6.3.45.11 Damage at the 8th floor.



(a) Longitudinal walls at 9th floor with cosmetic damage



(b) Minor damage at the interior corner



(c) Cracks on the masonry at the 9th floor



(d) Undamaged wall inside the unit

Figure 6.3.45.12 Damage at the 9th floor.

6.3.45.3 Discussion

As mentioned above the building has sustain very little damage at the ground level which has soft/weak story characteristics, minor damage at lower floors and extensive structural damage at upper floors, primarily in the transverse directions. It is important to note that the ground floor, although having soft story/weak condition, had few walls in transverse and longitudinal directions that provided support for that story. Some of the transverse direction damage can be attributed to the pounding with the neighboring building at levels 6 and above.

6.3.46 Site #46: 245 Tehuantepec

6.3.46.1 Building Description

The building is located in 245 Tehuantepec, between Tuxpan and Chilpancingo. The general location and specific coordinates are shown on Figure 6.2.46.1. The plan area is C-shape, as shown in the plan satellite view in Figure 6.3.46.2. The building has 5 stories and a courtyard on the east side. Its construction date is not known.

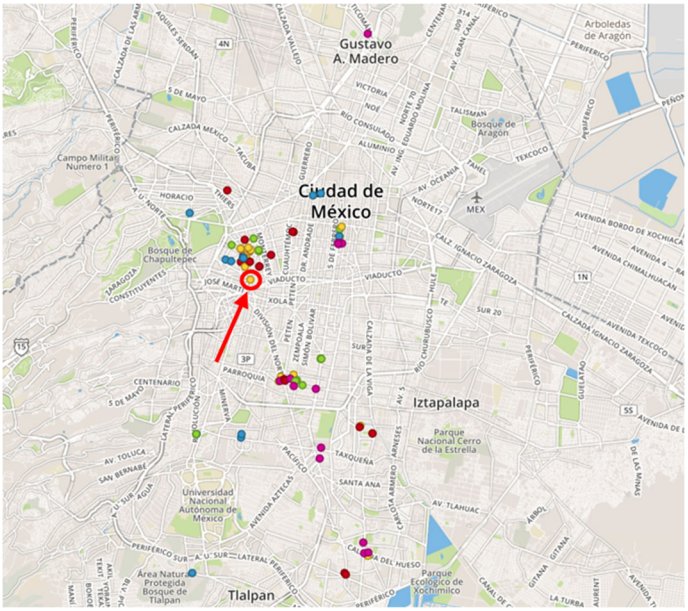


Figure 6.3.46.1 Location of site (Fulcrum Database). Coordinates: 19.4038241, -99.1684384.

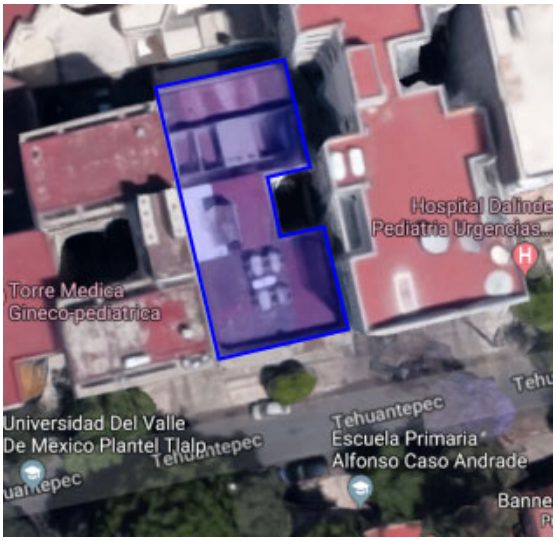


Figure 6.3.46.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads appear to be resisted by the concrete frame with URM infill in both building directions. Figure 6.3.46.3 below shows the front view of the building.



Figure 6.3.46.3 Front (south) view of the building.

6.3.46.2 Damage and Observations—2017

Access to the building was denied hence no observations of the interior were completed. No visible structural damage was observed in the exterior. As for nonstructural components, the finish layer of the façade fell off. Overall, the building seems to be leaning west, as observed from the gap show in Figure 6.3.46.4 (d).



(a) The finish layer of the façade fell off



(b) Detail of the right building gap



(c) Detail of the left gap at the ground floor level



(d) Closure of the left gap between the buildings

Figure 6.3.46.4 Noticeable damage and building gap.

6.3.47 Site #47: 275 Campeche

6.3.47.1 Building Description

The building is located in 275 Calle Campeche, between Chilpancingo and Culiacan. The general location and specific coordinates are shown on Figure 6.3.47.1. The plan area is square, as shown in the plan satellite view in Figure 6.3.47.2. The building has 5 stories. Its construction date is unknown.

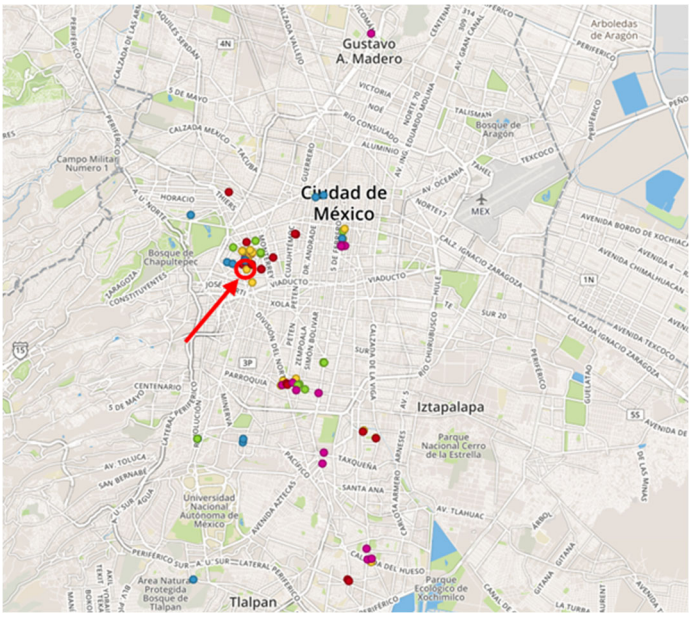


Figure 6.3.47.1 Location of site (Fulcrum Database). Coordinates: 19.4085016, -99.1705569.



Figure 6.3.47.2 Plan satellite view of the site (captured from Google 2017).

The building appeared to have a reinforced concrete slab supported on concrete frames. Lateral loads appeared to be resisted by the concrete frame with URM infill in both building directions. The first story has a larger story height than the rest of the floors. Additionally, the second story also seems to be taller than the stories above. Figure 6.3.47.3 below shows the elevation view of the building.

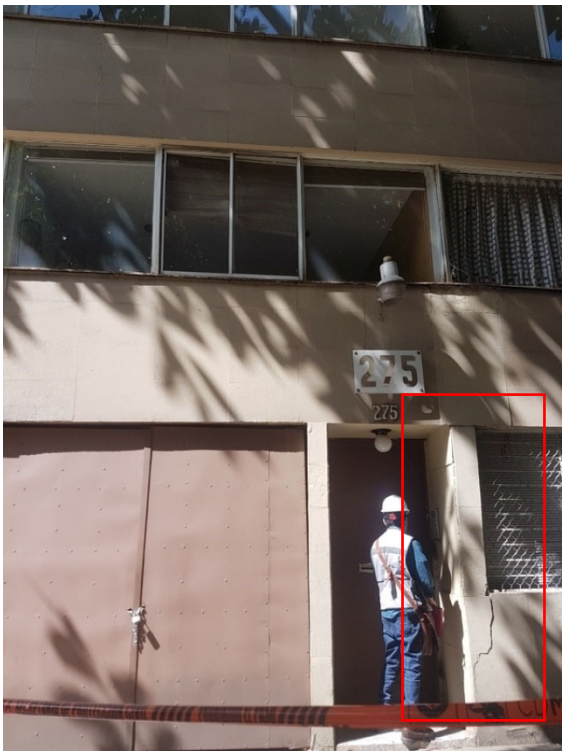


Figure 6.3.47.3 Front (south) view of the building.

6.3.47.1 Damage and Observations—2017

The building interior was not observed due to restricted access. The building had no apparent lateral force resisting system in the transverse direction as observed from the sidewalk. Some evidence of damage in the transverse direction was found.

Overall, the building is leaning east toward the neighboring building and appears to have soft story and possibly plan irregularity. There is a column at the ground floor that is damaged due to drift. Additionally, the ground floor near the deformed column exhibits lateral displacement, as demonstrated by the buckled window frames. There were broken windows from the upper floors which resulted in falling glasses. No evidence of retrofit was found.



(a) Front view of the building



(b) Deformed perimeter column in the front



(c) Building is slightly leaning west in transverse direction



(d) Opened construction gap at the lower level



(e) & (f) Ground floor deformed horizontally as demonstrated by column

Figure 6.3.47.4 Observed damage.

6.3.48 Site #48: 285 Gral. Emiliano Zapata

6.3.48.1 Building Description

The building is located in 285 General Emilano Zapata, between Prol Tajín and Prol. Petén. The general location and specific coordinates are shown on Figure 6.3.48.1. The plan area is rectangular, as shown in the plan satellite view in Figure 6.3.48.2. The building has 4 stories with a bulkhead on the northern fourth. Its construction date is unknown.

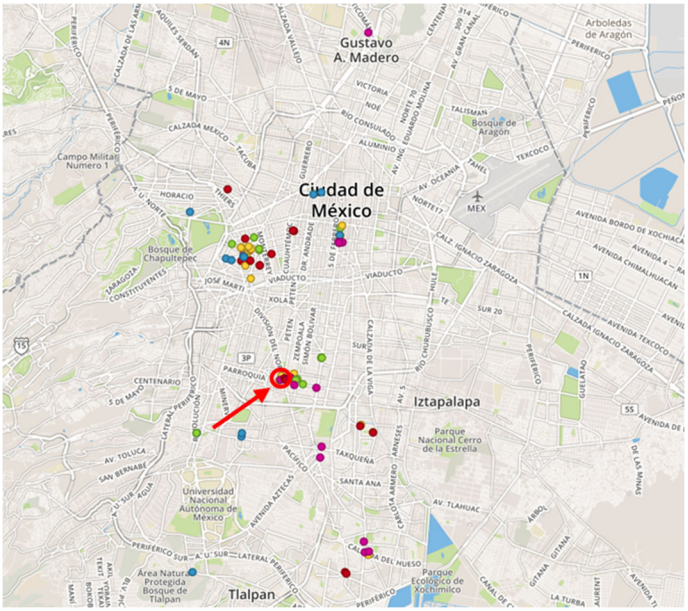


Figure 6.3.48.1 Location of site (Fulcrum Database). Coordinates: 19.3667219672532, -99.1574639921069.



Figure 6.3.48.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete columns (or frames). The lateral load resisting system is unclear as access to the interior was restricted. The building elevation is shown in Figure 6.3.48.3.



Figure 6.3.48.3 Building elevation.

6.3.48.2 Damage and Observations—2017

This building was not observed in detail. The building has severe cracks. Concrete columns were visible, but it was not sufficient to identify whether the building is concrete flat slab or concrete frame system. Evidence of retrofit was not observed.

There was a large vertical crack at what it seems to be the construction joint between the interior concrete wall and the concrete column at the first story, shown on Figure 6.3.48.4; it is unclear from a distance.



(a) Damage to wall/column construction joint (b) Damage to wall/column construction joint

Figure 6.3.48.4 Photos of damage to the building.

6.3.48.3 Recommendations

It is recommended that this building be fully evaluated by a qualified structural engineer.

6.3.49 Site #49: 405 Calle Sevilla

6.3.49.1 Building Description

This building is located on 405 Calle Sevilla, between Av. Municipio Libre and Av. Presidentes. The general location is shown on Figure 6.3.49.1. The building has 5 stories. As observed from the satellite maps in Figure 6.3.49.2,

the building has five courtyards along the perimeter. Its construction date is unknown.

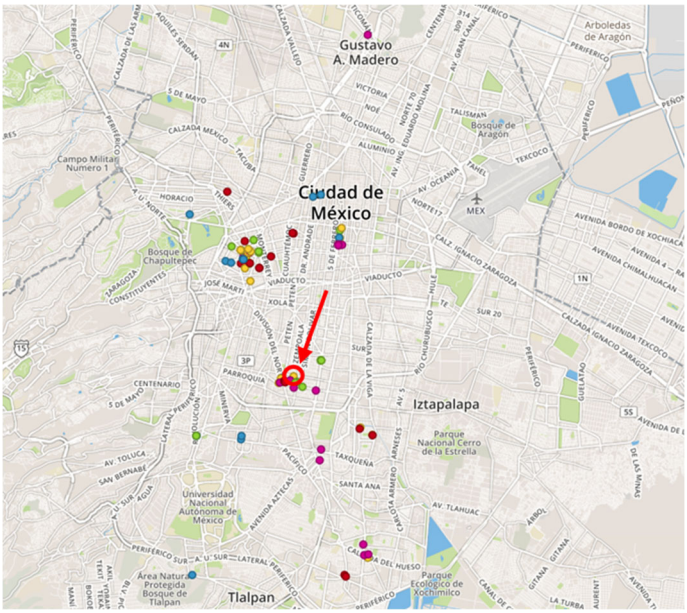


Figure 6.3.49.1 Location of site (Fulcrum Database). Coordinates: 19.3691648729326, -99.1516806465566.



Figure 6.3.49.2 Plan satellite view of site (Google Maps, 2017).

The building floors and roof appear to be supported by reinforced concrete slab supported on concrete beams/columns. The front of the building has a full height window layout. The interior of the building was not observed. The building elevation is shown in Fig 6.3.49.3.



Figure 6.3.49.3 West elevation.

6.3.49.2 Damage and Observations—2017

The structure was observed from the exterior as access was restricted to the interior of the building. Damage to the front stair core was observed. The rest of the damage observed was nonstructural; at the first floor there was in-plane failure of the exterior infill walls. The first level is shored for additional safety measure.



(a) Shored for safety



(b) Nonstructural damage at exterior infill wall

Figure 6.3.49.4 Ground floor observations.

6.3.49.3 Recommendations

Since there is limited information about the building, the structure is not a good candidate for further individual structural studies, unless more information is obtained. However, since the building has a typical plan area,

which is composed of a long rectangle with exterior courtyard openings, it would be of interest to gather qualitative information about the performance of these structures in Mexico City.

6.3.50 Site #50: 480 Calz. Del Hueso

6.3.50.1 Building Description

This is a corner building located on 480 Calzada del Hueso, at the intersection of Calz. del Hueso and Canal de Miramontes. The general location and specific coordinates are shown on Figure 6.3.50.1. The area is shown on the satellite maps in Figure 6.3.50.2. It is unclear how the structure is connected to its neighboring retail space structure at the east side. This building has 2 stories. It was constructed in the late 1980s.

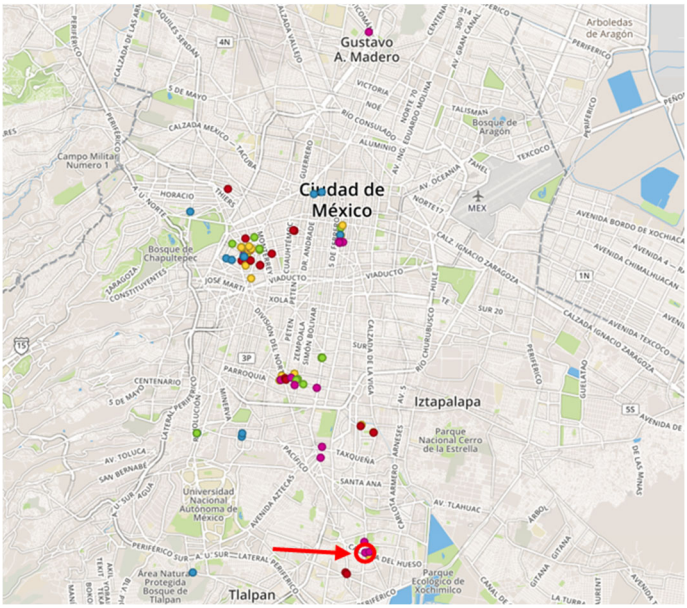


Figure 6.3.50.1 Location of site (Fulcrum Database). Coordinates: 19.3040031194867, -99.1243289039462.

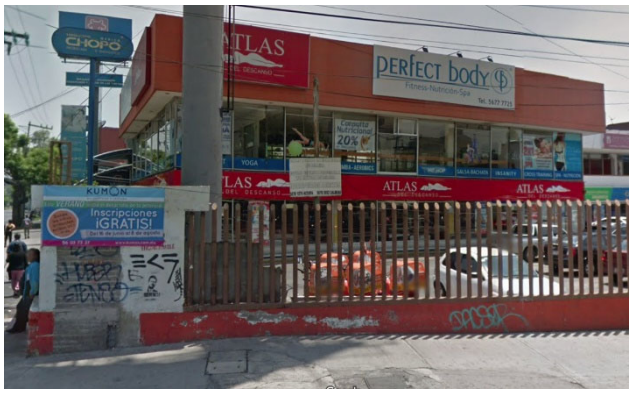


Figure 6.3.50.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced waffle concrete slab supported on concrete columns. The building elevations before and after the earthquake are shown in Fig 6.3.50.3.



(a) Photo captured after the earthquake



(b) Photo obtained from Google Maps, 2017

Figure 6.3.50.3 Front (south) elevation of structure.

6.3.50.2 Damage and Observations—2017

Even though the extent of the structure in the east direction is unclear, the following boundary conditions were visible: The two back sides facing the adjacent buildings were infilled with unreinforced masonry walls while the front sides were open with a continuous glass façade with visible columns inside. This difference in stiffness creates a severe torsional irregularity which could have contributed to the collapse.

Additionally, the concrete of the floor/roof slab seemed to be of low quality as opposed to the column. Possibly, punching shear failure in the corner column could have occurred. There was gravel on the roof, which added to the mass of the roof.



(a) Infill masonry walls at the building sides facing adjacent buildings



(b) Column that may have failed in punching shear



(c) Floor/roof concrete seem of very low quality



(d) Floor/roof construction is of two-way ribbed slab

Figure 6.3.50.4 Photos of building failure.

6.3.51 Site #51: 517 Calle Tokio

6.3.51.1 Building Description

This building is located in 517 Calle Tokio, between Av. Presidentes and Av. Emperadores. This site is composed of three blocks of buildings with similar construction, separated by a courtyard. The general location and specific coordinates are shown on Figure 6.3.51.1. The building layout is shown on the satellite maps in Figure 6.3.51.2. Each building has 5 stories. The construction year is 1982.

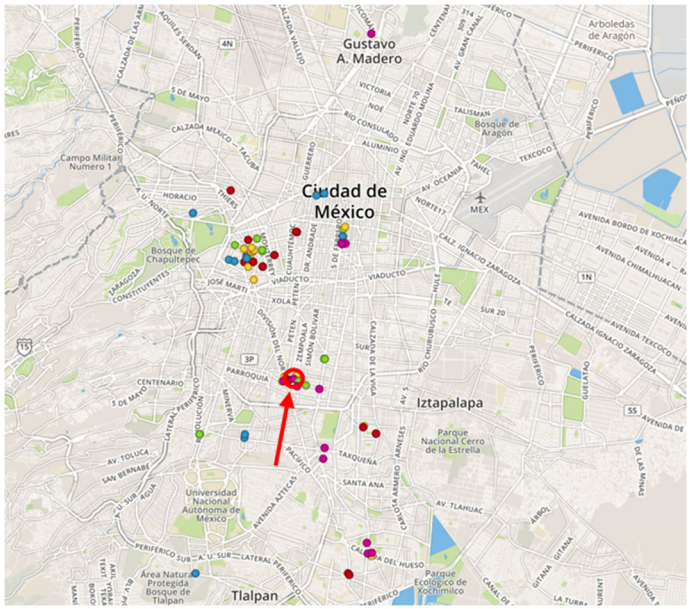


Figure 6.3.51.1 Location of site (Fulcrum Database). Coordinates: 19.3676628777938, -99.1529893130987.



Figure 6.3.51.2 Plan satellite view of site (Google Maps, 2017).

The buildings are composed of reinforced concrete frames with unreinforced infill masonry walls. In the transverse direction the infill has numerous openings. The building elevation for the building along the street (on the west) is shown in Fig 6.3.51.3.



(a) The front block (west)



(b) Front view (west elevation)

Figure 6.3.51.3 Building elevations.

6.3.51.2 Damage and Observations—2017

The front and middle buildings have adjacent structures on both sides (north and south) while the building in the back only has an adjacent structure on the north. All three buildings have a parking garage open layout at the ground story.

The middle and back building had a first story collapse. The collapse may have been caused by soft story and/or pounding. The middle (collapsed) building block was observed to have a detached corner column at the third floor as shown on Figure 6.3.51.4 (a).



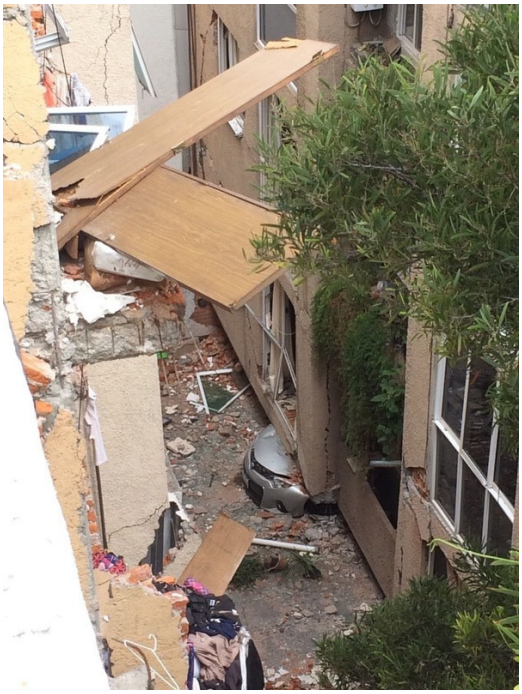
(a) View of collapsed building from neighbor's backyard



(b) View of front standing block on left; collapsed middle block on right



(c) Collapsed (back/east) third building



(d) Crushed car in the (back) third building

Figure 6.3.51.4 Damage visible from side and above.

The building that did not collapse was heavily shored at the ground floor. The adjacent buildings sustained very little damage even though they were pounded by the collapsed buildings.



Figure 6.3.51.5 First floor shored in the front (west) building block.

6.3.51.3 Discussion

It is unclear why two out of three buildings with the same construction type, plan area and height collapsed, leaving one standing.

6.3.52 Site #52: 519 Calzada Del Hueso

6.3.52.1 Building Description

This structure is a commercial mall called “Galerias Coapa” located on 519 Calz. del Hueso, between Calz. de los Tenorios and Canal de Miramontes. The general location and specific coordinates are shown on Figure 6.3.52.1. The structure appears to have 2 stories. The plan view can be observed from the satellite map in Figure 6.3.52. Its construction date is unknown, but is estimated to be in the late 1980s.

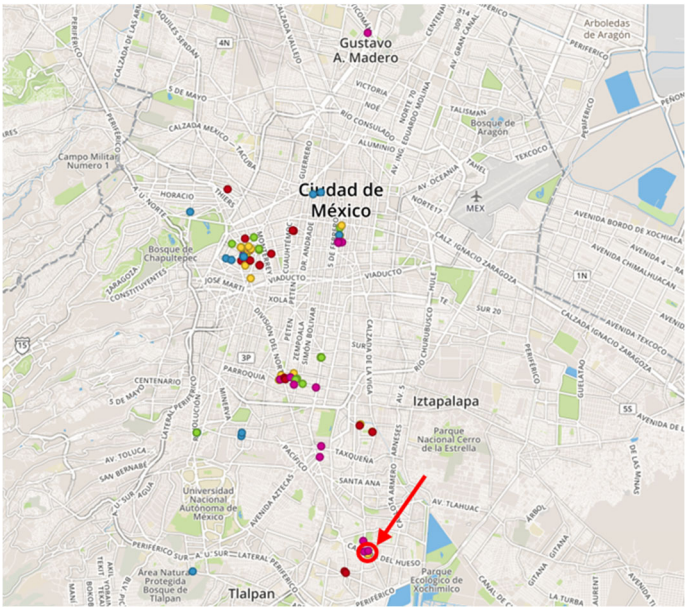


Figure 6.3.52.1 Location of site (Fulcrum Database). Coordinates: 19.303045, -99.122876.



Figure 6.3.52.2 Plan satellite view of site (Google Maps, 2017).

The building system was not clearly evident from outside. However, there were steel columns supporting exposed steel trusses, and concrete wall panels/piers were visible from outside. The building elevations are shown in Fig. 6.3.52.3.



(a) Exterior view from outside (b) Sliding of wall panels

Figure 6.3.52.3 Front view of mall. Sliding at horizontal construction joints caused damage.

6.3.52.2 Damage and Observations—2017

The mall center was evacuated, however access was allowed to construction workers. Sliding failure of the wall panels at apparently the horizontal construction joints or panel edges was observed as shown on Figure 6.3.52.3 (b). No major structural damage was visible from outside.

6.3.53 Site #53: 521 Eje Central Lazaro Cardenas

6.3.53.1 Building Description and Observations

This is a new building that was under construction at the time of the earthquake as well as the site visit. It is located on 521 Eje Central Lazaro Cardenas, between Av. Presidentes and Av. Emperadores. The general location and specific coordinates are shown on Figure 6.3.53.1. The building has 8 stories. A satellite plan view of the site is unavailable.

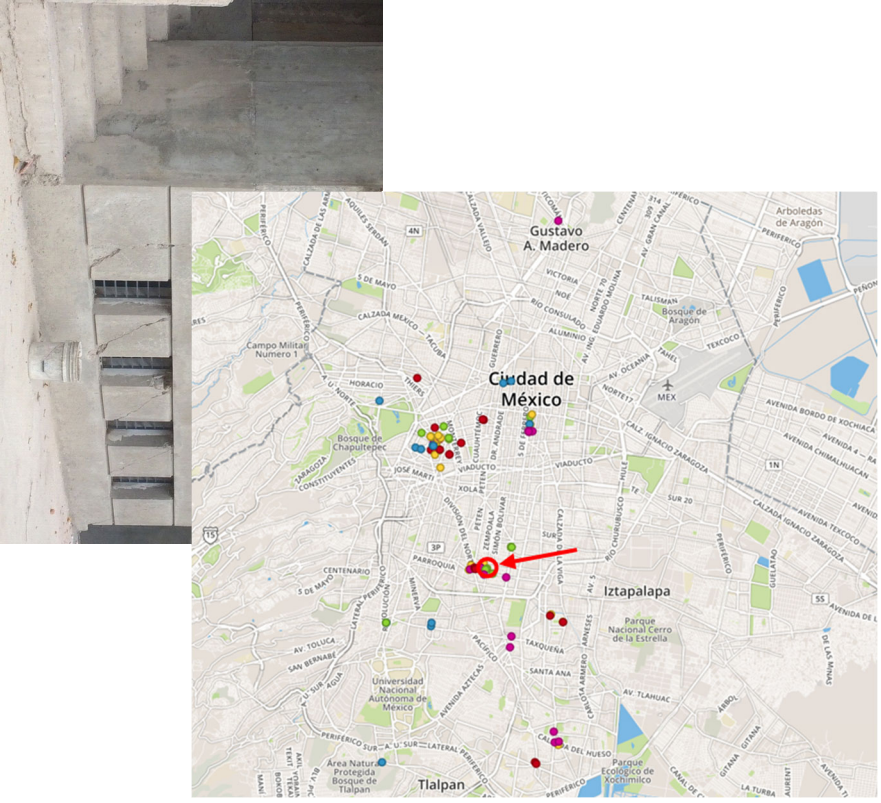


Figure 6.3.53.1 Location of site (Fulcrum Database). Coordinates: 19.3671615142556, -99.1503786855369.

Access into the building was denied. The building has a reinforced concrete slab and beams supported on concrete columns and masonry infill walls at the front. There were large shear cracks in the short columns at the front. No other structural damage was visible.



(a) Front (west) elevation (b) Short columns with shear cracks

Figure 6.3.53.2 Building elevation and damage.

6.3.54 Site #54: 586 Prolongacion Peten

6.3.54.1 Building Description

This building is located on 224 Avenida Emperadores, at the intersection between Prol. Petén, Prol. Tajín and Av. Division del Norte. The general location and specific coordinates are shown on Figure 6.3.54.1. As observed from the satellite maps in Figure 6.3.54.2, the plan area of this building is triangular. The building has 4 stories. Its construction date is unknown.

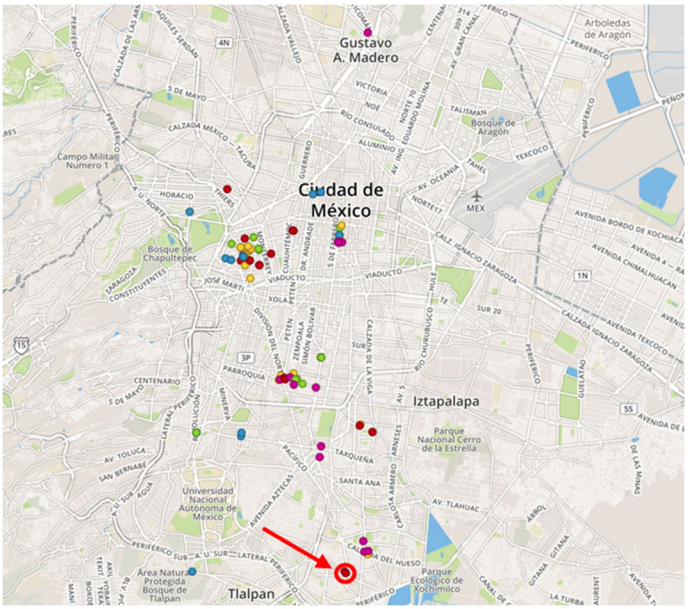


Figure 6.3.54.1 Location of site (Fulcrum Database). Coordinates: 19.3684120942088, -99.1566021648228.



Figure 6.3.54.2 Plan satellite view of site (Google Maps, 2017).

The building has a reinforced concrete slab supported on concrete frames. Lateral loads are resisted by the concrete frame with URM infill in both building directions. The building elevation (west side) is shown in Fig 6.3.54.3.



Figure 6.3.54.3 Building elevation (west). There seems to be no damage to the short columns above the exterior grade to west side.

6.3.54.2 Damage and Observations—2017

The structure was observed from the exterior only as access to the interior was restricted. No significant structural damage was visible. However, there was severe nonstructural damage and partial collapse. The infill plane on the east side had out of plane collapse, as shown in Figure 6.3.54.4 (a). Additionally, on the west side, there was minor out-of-plane collapse of the brick wall at the second story, as shown in Figure 6.3.54.4 (b).



(a) Infill panel collapsed out of plane



(b) Minor out of plane failure of brick

Figure 6.3.54.4 Nonstructural building damage.

6.3.55 Site #55: 609 Calle Azores

6.3.55.1 Building Description

These are two buildings located on 609 Calle Azores, between Av. Emperadores and Gral. Emiliano Zapata. The general location and specific coordinates are shown on Figure 6.3.55.1. The plan areas are shown on the satellite maps in Figure 6.3.55.2. The construction date is unknown.

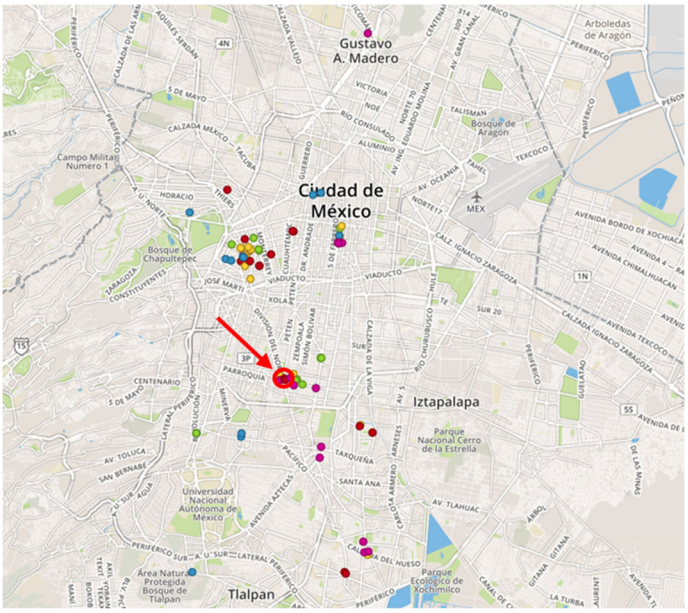


Figure 6.3.55.1 Location of site (Fulcrum Database). Coordinates: 19.366972, -99.154973.



Figure 6.3.55.2 Plan satellite view of site (Google Maps, 2017).

There are two building blocks that are part of the same residential complex. Building block (1) is 5 stories tall and has an open layout at its ground floor for parking. Building block (2) is 4 stories tall and does not have a parking garage open layout at its ground floor.

The buildings have similar construction systems and overall layout. Both structures are composed of a reinforced concrete waffle slab supported on concrete columns and masonry infill walls. The building elevation of building (1), which faces the street, is shown in Fig 6.3.55.3.



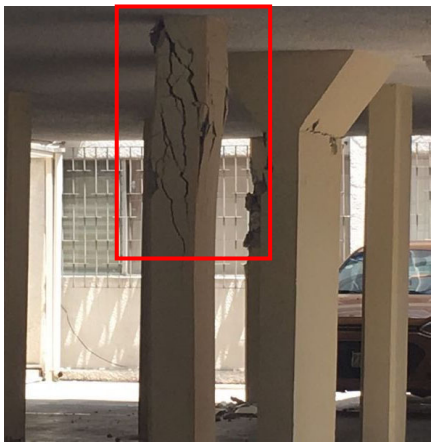
Figure 6.3.55.3 Front (west) building elevation.

6.3.55.2 Damage and Observations—2017

Observations were made from the exterior as access was restricted to the interior. The front block (1) has parking at the ground floor which resulted in significant damage in the first floor columns. The back block (2) does not have parking and does not appear to sustain serious damage, according to the resident. Overall, building block (1) is severely damaged, with soft story and severe column spalling at the ground floor. The column damage, spalling, bending and buckling of rebar at the first floor columns are shown on Figure 6.3.55.4.



(a) Spalling and bending of columns



(b) Cracking and spalling of column



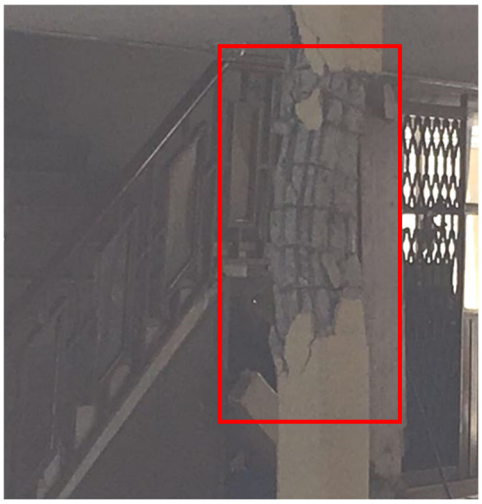
(c) Spalling and bending of columns



(d) Severe spalling of concrete and bent rebar



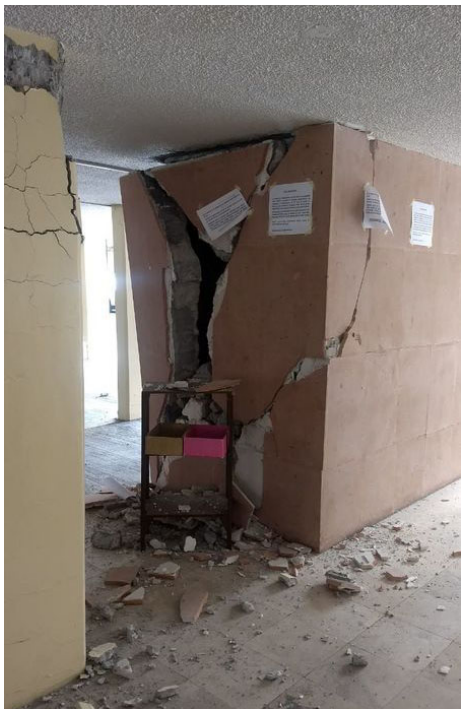
(e) Column cracking. Column size change at 1st floor



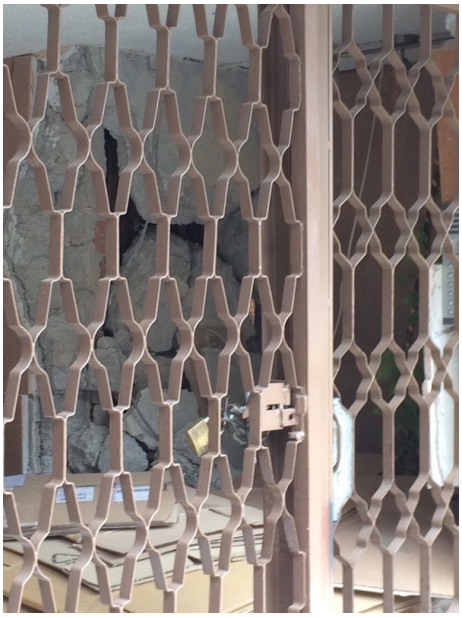
(f) Severe bending of column and spalling of concrete

Figure 6.3.55.4 Damage at the ground floor columns (photos obtained from building resident).

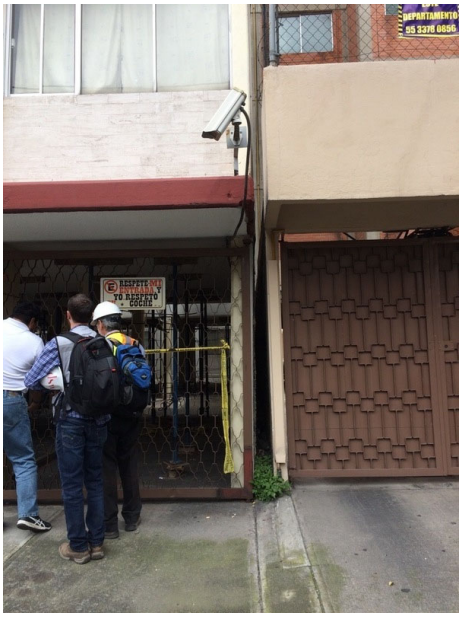
Additionally, severe spalling, of what it seems like a concrete wall at the ground floor, was observed from the exterior, as shown in Figure 6.3.55.5 (b). Finally, possible leaning was observed, as shown in Figure 6.3.55.5 (c).



(a) Nonstructural wall at ground floor (photo obtained from resident)



(b) Front concrete wall severely cracked

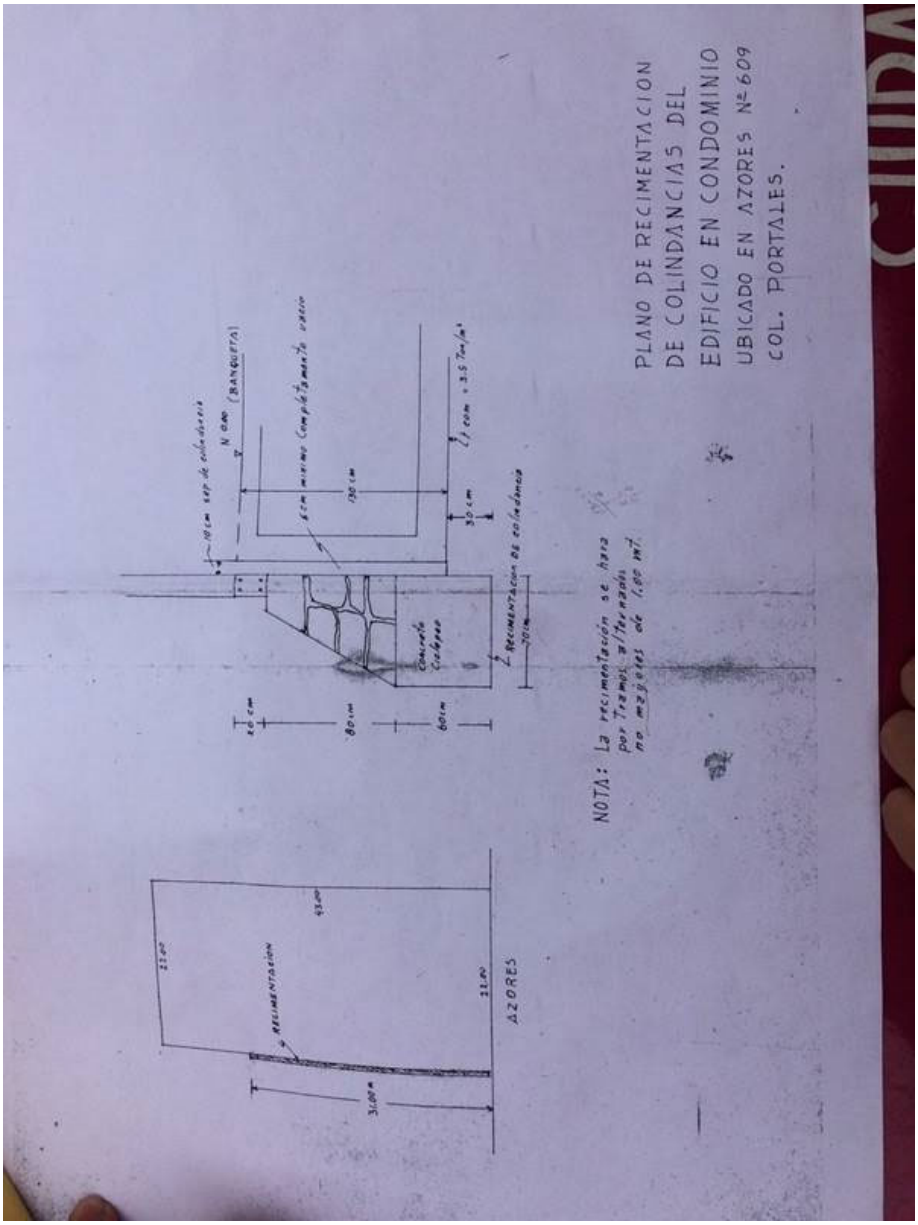


(c) Photo suggests that building may be leaning

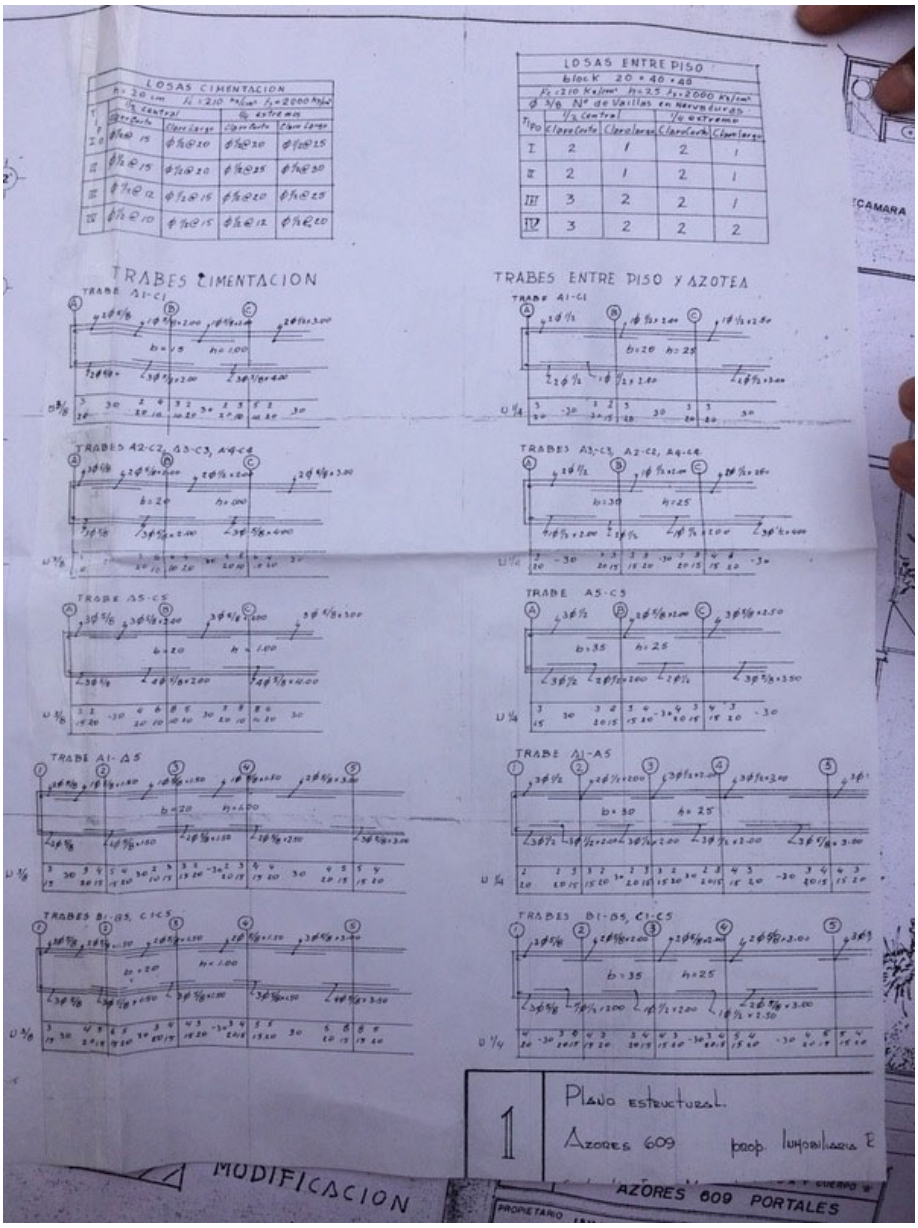
Figure 6.3.55.5 Damaged building.

6.3.55.2 Additional Information

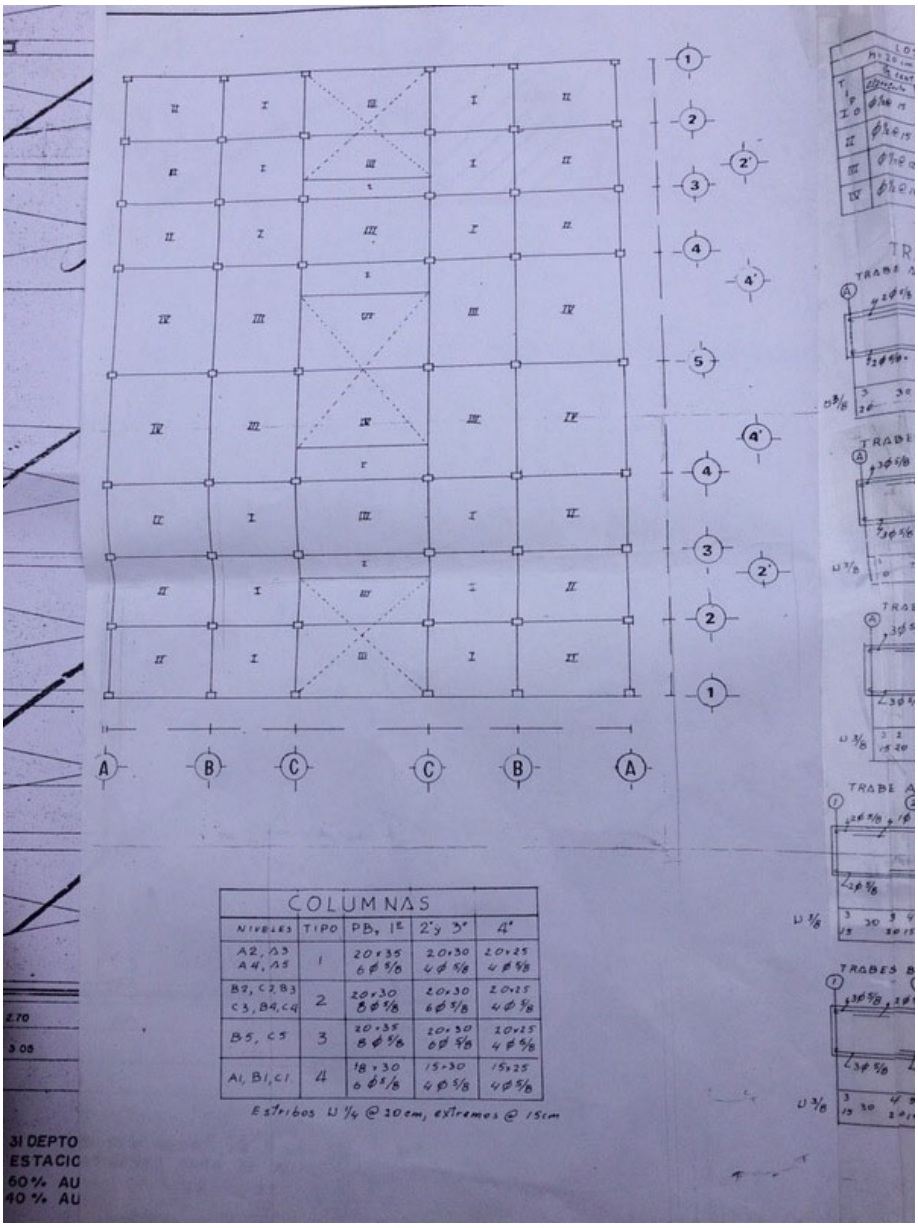
According to the property manager, there is only minor damage at the upper floors. The following drawings were obtained from the building resident.



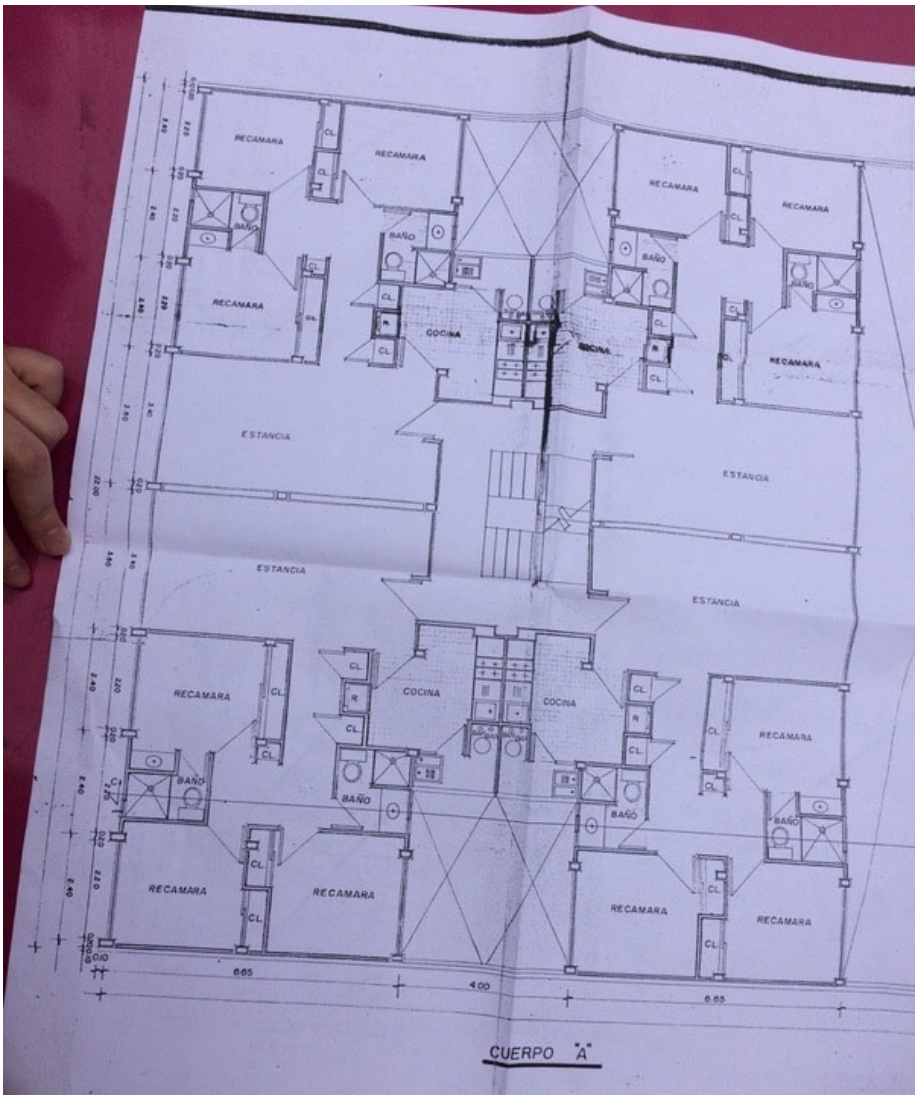
(a) Foundation detail at neighboring structure



(b) Slab and beam reinforcement



(c) Column dimensions and reinforcement



(d) Architectural layout of typical floor

Figure 6.3.55.6 Building drawings.

6.3.56 Site #56: 617 Calle Filipinas

6.3.56.1 Building Description

This building is located on 617 Calle Filipinas (or 117 gran Emiliano Zapata). The general location and specific coordinates are shown on Figure 6.3.56.1. The plan area of the structure is shown in the satellite maps in Figure 6.3.56.2. There is a slender tower on its north part connected to the main structure by stairs. The building has 6 stories and 1 basement. The building was approximately 8 years old at the time of the earthquake, according to a neighbor.

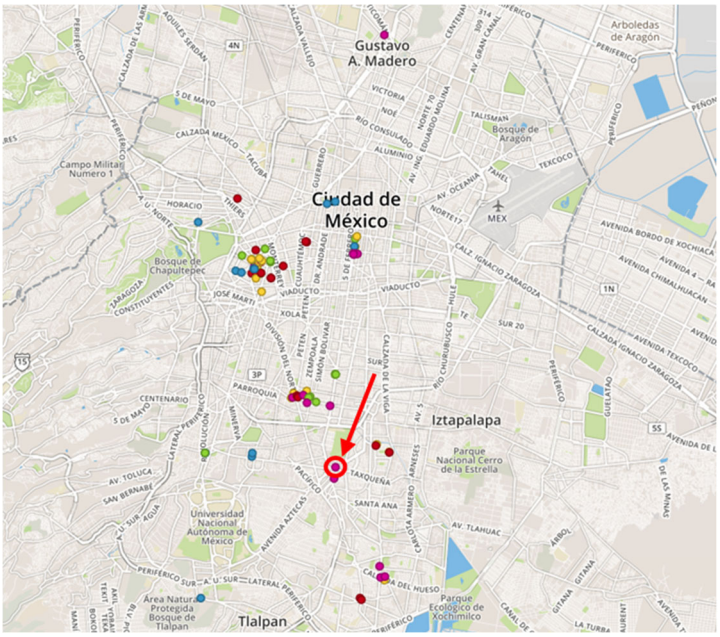


Figure 6.3.56.1 Location of site (Fulcrum Database). Coordinates: 19.365302, -99.148245.



Figure 6.3.56.2 Plan satellite view of site (Google Maps, 2017).

The building elevation is shown in Fig 6.3.56.3.



Figure 6.3.56.3 Building elevation.

6.3.56.2 Damage and Observations—2017

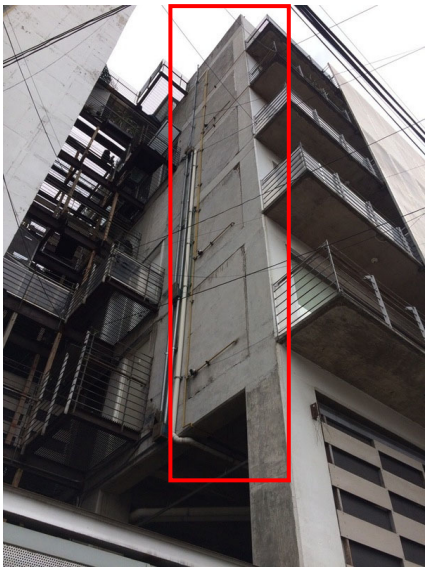
The building has minor damage (nonstructural out of plane infill walls) and does not appear to have severe structural damage from outside. The ground floor was observed to be taller than upper floors. As seen in Figure 6.3.56.4, the masonry infill panel at the ground floor has moved out of plane. The panel is separated from the concrete frame with compressible material; therefore, no structural strut action was possible. There are cracks in the architectural infill at ground floor and damage to building façade (buckling) at upper floors (levels 2 and 3) indicating building drift primarily in building longitudinal direction.



(a) Masonry infill panel has moved out of plane



(b) Cracks in architectural infill



(c) Nonstructural infill walls in the back with out-of-plane failure



(d) These appear to be architectural infill



(e) These appear to be architectural infill

Figure 6.3.56.4 Building damage observations.

6.3.57 Site #57: 714 Calle Saratoga

6.3.57.1 Building Description

The building is located on 714 Calle Saratoga, between Gral. Emiliano Zapata and Av. Repúblicas. The general location and specific coordinates are shown on Figure 6.3.57.1. The plan area is shown on the plan satellite view in Figure 6.3.57.2. The building has an interior courtyard in the middle of the plan area and 5 courtyards along the perimeter. The building has 5 stories. Its construction date is unknown.

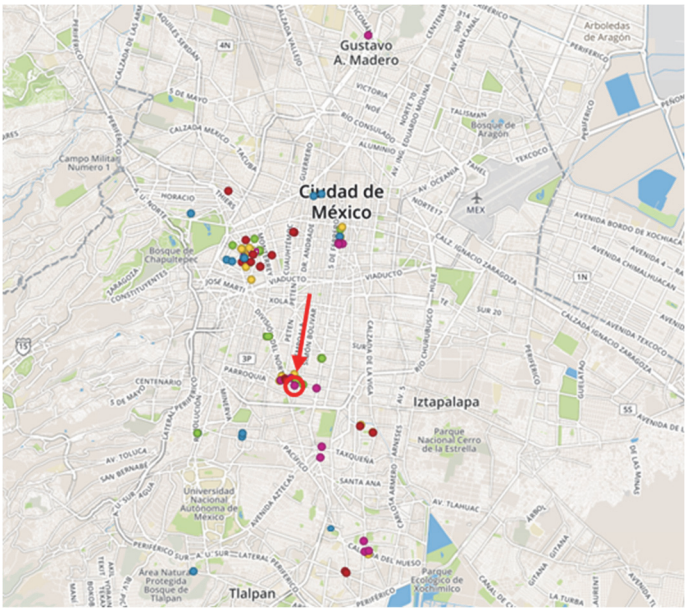


Figure 6.3.57.1 Location of site (Fulcrum Database). Coordinates: 19.3649984803231, -99.1516142618835.



Figure 6.3.57.2 Plan satellite view of the site (captured from Google 2017).

The building has a reinforced concrete slab supported on concrete beams/columns, with masonry infill walls. The first story was a parking garage level with concrete columns only. The building elevations are shown in Figure 6.3.57.3.



(a) Front view of collapsed structure



(b) Front view of original structure (Google Maps, 2017)



(c) Side view of structure after the earthquake

Figure 6.3.57.3 Building elevations.

6.3.57.2 Damage and Observations—2017

This building had complete collapse of its first two stories due to soft story, causing at least one casualty. The building showed no evidence of retrofit.

Observed columns are approximately 20 cm x 20 cm with ties at 20 cm on center. Perimeter beams seemed to be approximately 20 cm deep. Footprint was 25-30 meters in longitudinal direction.



Figure 6.3.57.4 Generally poor quality of construction and no ductile detailing.

6.3.57.3 Discussion

The collapse could have been caused by inadequate seismic detailing, as well as the absence of a robust lateral load resisting system. In other buildings observed in Mexico City, the infill masonry walls significantly contributed to the lateral load resistance. However, in the longitudinal direction of this structure, there were openings along the exterior for courtyard space which discontinued the exterior infill walls along the north and south faces.

6.3.58 Site #58: 911 Coquimbo

6.3.58.1 Building Description

These residential buildings are located on 911 Coquimbo, between Sierra Vista and Calz. Ticomán. The general location and specific coordinates are shown on Figure 6.3.58.1.

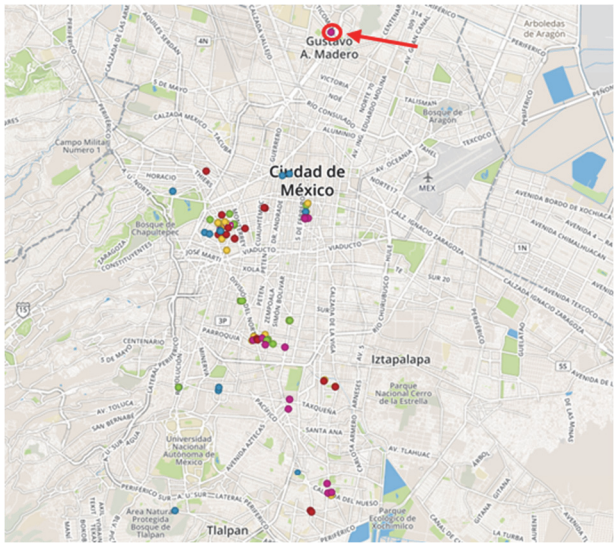


Figure 6.3.58.1 Location of site (Fulcrum Database). Coordinates: 19.4934492738, -99.1229428723.

There were three buildings on the same block of similar construction type. Building 1 has 7 stories while building 2 and 3 have 8 stories. The two end buildings, 1 and 3, have a larger plan area than building 2 as observed from the satellite maps in Figure 6.3.58.2. All of the structures have a ground floor parking garage level. The middle building (Building 2) suffered a total collapse while the other two remained standing. The building construction date is approximately 1983.



Figure 6.3.58.2 Plan satellite view of site (Google Maps, 2017).

The buildings are comprised of reinforced concrete frames with unreinforced masonry infill walls, except at the first (ground) floor level where parking spaces are located and most wall infills drop off. Fig 6.3.58.3 below shows the northwest corner of the street view from Google Maps in 2016.



Figure 6.3.58.3 Street view of northwest corner (Google Maps, 2016).

6.3.58.2 Damage and Observations—2017

The middle building had suffered a total collapse. The other two buildings seemed to have moderate damage from the exterior. The police did not permit the team to go close to the collapsed structure and refused to allow any photography at the site. The collapsed structure was not observed in detail due to such restricted access.

Subsequently, the team visited the District Government Buildings office and spoke to several officials who were very hesitant to provide any information since there are lawsuits in progress. However, some public record information was made available.

6.3.58.3 Discussion

It appears likely that a soft/weak story contributed to the collapse of the middle building. However, without a detailed examination of the collapsed structure as well as the adjacent buildings along with an in-depth review of the building construction documents, it is virtually impossible to ascertain the cause of the collapse (and non-collapse) which occurred at this site with any degree of confidence.

6.3.58.4 Additional Information

Due to ongoing high-profile litigation as well as the apparent political sensitivities of this project, it might be difficult to uncover the information required to complete a full and accurate third-party investigation of this dramatic collapse.

6.3.58.5 Recommendations

The team should remain in contact with the stakeholders and municipal authorities connected with this project to gain access to additional information whenever it becomes available.

6.3.59 Site #59: 915 Prolongacion Peten

6.3.59.1 Building Description

This corner building is located on 915 Prolongacion Peten, at the intersection of Prol. Petén and Gral. Emiliano Zapata. The general location and specific coordinates are shown on Figure 6.3.59.1. As observed from the satellite maps in Figure 6.3.59.2, the plan area of this building was C-shape. The building had 7 stories. Its construction date is unknown.

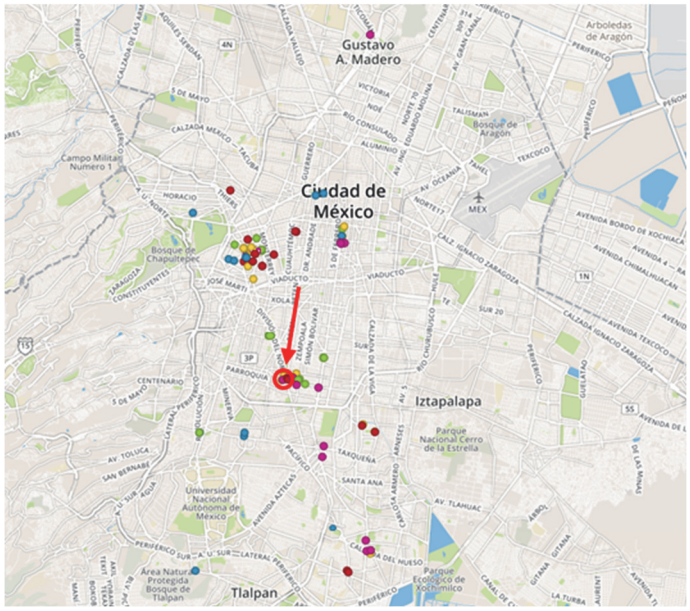


Figure 6.3.59.1 Location of site (Fulcrum Database). Coordinates: 19.366858, -99.156991.



Figure 6.3.59.2 Plan satellite view of site (Google Maps, 2017).

The construction type of the building is unknown. The building elevation is shown in Fig 6.3.59.3.

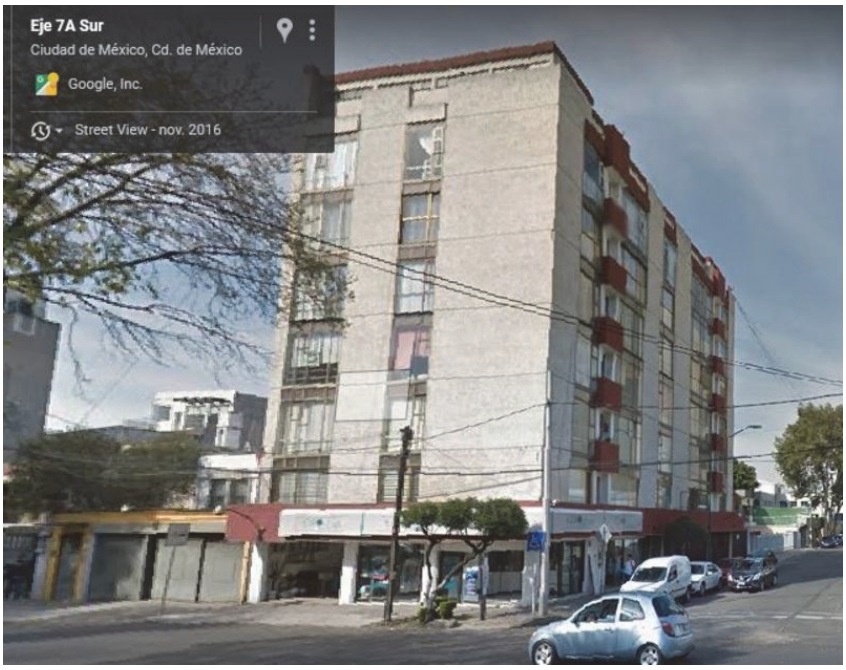


Figure 6.3.59.3 Building elevation from Google Map 2016.

6.3.59.2 Damage and Observations—2017

The building collapsed due to the Sept. 19, 2017 earthquake. At the time of the visit, the building had already been demolished and cleared. The building's collapse damaged the adjacent structure, which was being repaired at the time of the visit, are shown in Figure 6.3.59.4.



(a) Adjacent building lost part of roof and exterior wall



(b) Corner view of nonexistent building



(c) Damaged adjacent building

Figure 6.3.59.4 Adjacent building damaged due to the collapse of 915 Prolongacion Peten.

6.3.60 Site #60: 1171 Calz. de Tlalpan

6.3.60.1 Building Description

This building is located on at 1171 Calz. de Tlalpan, between Ing. Pascual O. Rubio and Avenida Antonio Rodríguez. The general location and specific coordinates are shown on Figure 6.3.60.1. The building has 11 stories and a podium. As observed from the satellite maps in Figure 6.3.60.2, the plan is an H-shape. The building was constructed in 1970.

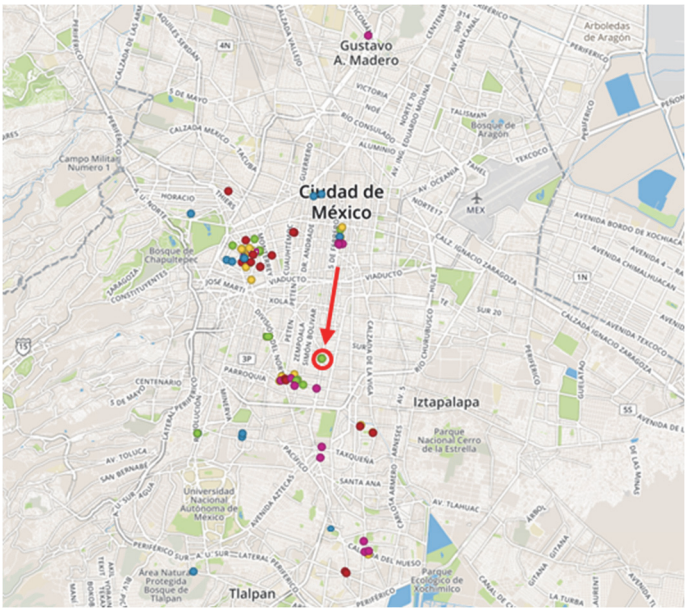


Figure 6.3.60.1 Location of site (Fulcrum Database). Coordinates: 19.37492, -99.140936.



Figure 6.3.60.2 Plan satellite view of site (Google Maps, 2017).

The building is composed of reinforced concrete frames with unreinforced masonry infill walls. Since there was no access available to the interior of this structure and drawings were not available either, additional information about the structural/lateral system could not be ascertained. Signs of damage that was probably preexisting (prior to the 2017 earthquake) were apparent. The building elevation is shown in Fig 6.3.60.3.



(a) Front left (southeast) (b) Front (east) (c) Front right (northeast)

Figure 6.3.60.3 Front (east) building elevation.

6.3.60.2 Damage and Observations—2017

Overall, this building appears to have cosmetic, nonstructural and minor structural damages. However, viewed from the ground adjacent to the building entrance, significant settlement was observed. The degree of settlement prior to the subject earthquake is unclear. There were also preexisting cracks in the pavement that were amplified by the earthquake as per the comparison between the photos and the street view in Google Maps from August 2017. However, there were some cracks that appeared after the earthquake.



(a) View looking south (b) View of front (east) building elevation and sidewalk interface

Figure 6.3.60.4 Sloped sidewalk in front of building. It is unclear if the slope changed due to the earthquake.

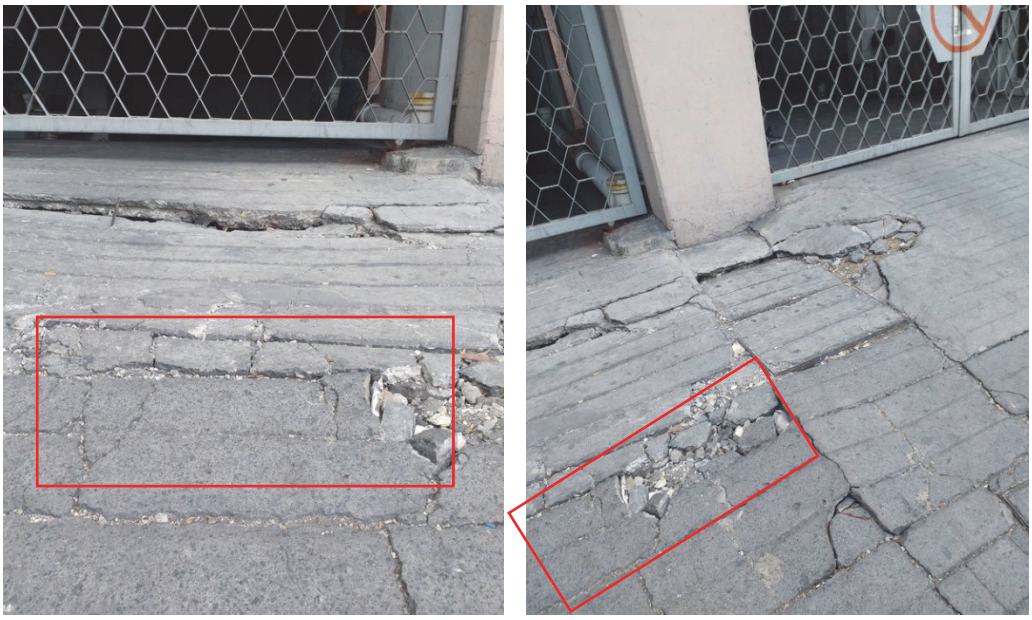


Figure 6.3.60.5 Amplified cracks in the pavement on the sidewalk entering the parking garage. Outlined cracks seem to be new.

In the northeast corner of the building, at the separation joint, there was an area with spalling. This appears to be an existing condition from old exposed rebar at the joint.



Figure 6.3.60.6 Spalling in column at the separation joint.

Lastly, there was some cosmetic damage which includes intensive chipping of the paint at the front façade as shown on Figure 6.3.60.3. However, this

too might be a preexisting damage. No other damage was observed from the exterior of the structure.

6.3.60.3 Discussion

Further investigation of this building might reveal additional damage. However, from a cursory view of the structure from the outside, the building does not appear to have suffered a significant structural damage during the subject earthquake.

6.3.60.4 Recommendations

A detailed structural investigation/evaluation of this building would be advisable.

6.3.61 Site #61: 2050 Calz. de Tlalpan

6.3.61.1 Building Description

This building is located on 2050 Calz. de Tlalpan between Calz. Taxqueña, Cerro del Músico, and Puerto Rico. The general location and specific coordinates are shown on Figure 6.3.61.1. As observed from the satellite maps in Figure 6.3.61.2, the plan area of this building is rounded at its ends. The building was a commercial facility occupied by the Soriana retailer. It has one story and an interior mezzanine (assumed). Its construction date is unknown.

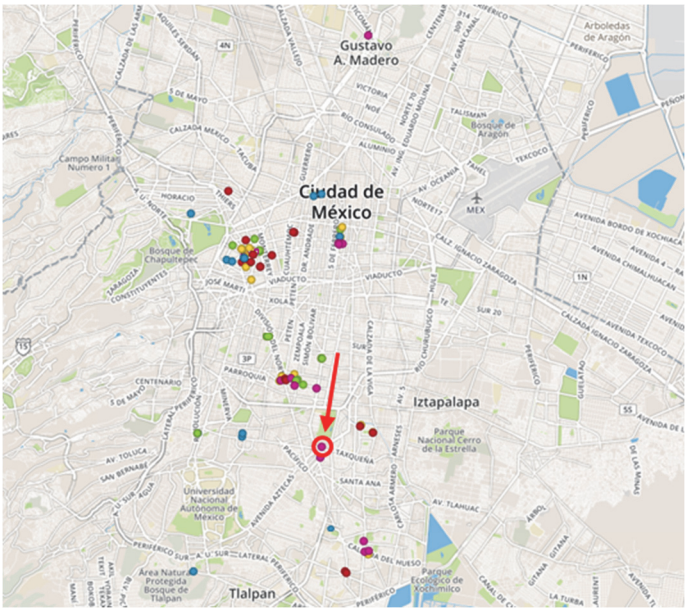


Figure 6.3.61.1 Location of site (Fulcrum Database). Coordinates: 19.3425007816584, -99.1410297621965.



Figure 6.3.61.2 Plan satellite view of site (Google Maps, 2017).

The building roof framing is composed of steel joists supported by steel trusses, supported by concrete columns. There are infill unreinforced masonry walls along the perimeter. There is an intermediate cantilever platform on the exterior. There was partial collapse at the east portion of the structure. The collapsed portion of the building is shown in Figure 6.3.61.3.



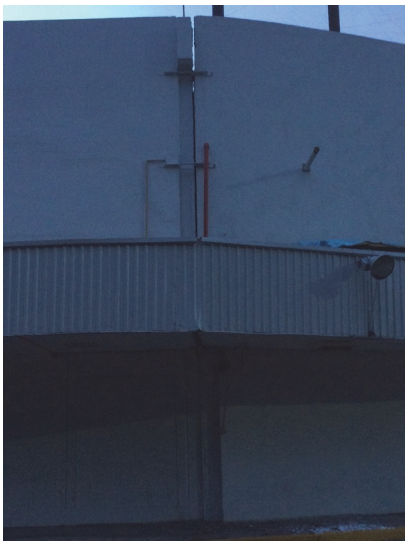
Figure 6.3.61.3 Front view of the building. Collapsed roof and columns.

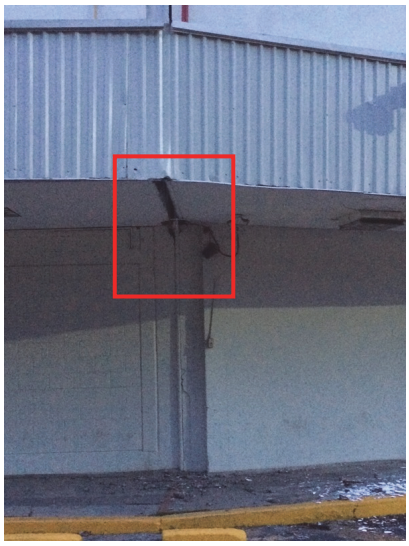
6.3.61.2 Damage and Observations—1985

Evidence of retrofit was found in interior columns (not visible) which had steel plates. These retrofitted columns were not damaged.

6.3.61.3 Damage and Observations—2017

The structure was only observed from the exterior. The structure is divided into three segments. The typical joint is shown on Figure 6.3.61.4.





(a) Exterior joint (b) Joint in the canopy at segment connection

Figure 6.3.61.4 Side view of building separation joint.

Partial collapse occurred in the middle segment of the structure. The roof collapsed on one side of the building. The exterior columns were leaning and detached from the roof metal framing. One noticeable deficiency is lack of diaphragm ties in the roof perimeter. It is unclear whether there was a soft story or other plan irregularity.





(a) East side of structure collapsed (b) West side of structure did not collapse

Figure 6.3.61.5 Side view of building separation joint.

Out of plane failure of parapets and infill walls was observed at the other segment (west) of the building, posing nonstructural damage (Figure 6.3.61.6).



Figure 6.3.61.6 Nonstructural damage of infill wall and parapet.

6.3.62 Site #62: 2065 Canal de Miramontes

6.3.62.1 Building Description

This corner building is located on 2065 Canal de Miramontes, at the intersection of Calle Rancho Mante and Calle Rancho Tollocan. The general location and specific coordinates are shown on Figure 6.3.62.1. The building has 2 stories and a rooftop canopy structure. As observed from the satellite maps in Figure 6.3.62.2, the plan area of this building is regular. Its construction date is unknown.

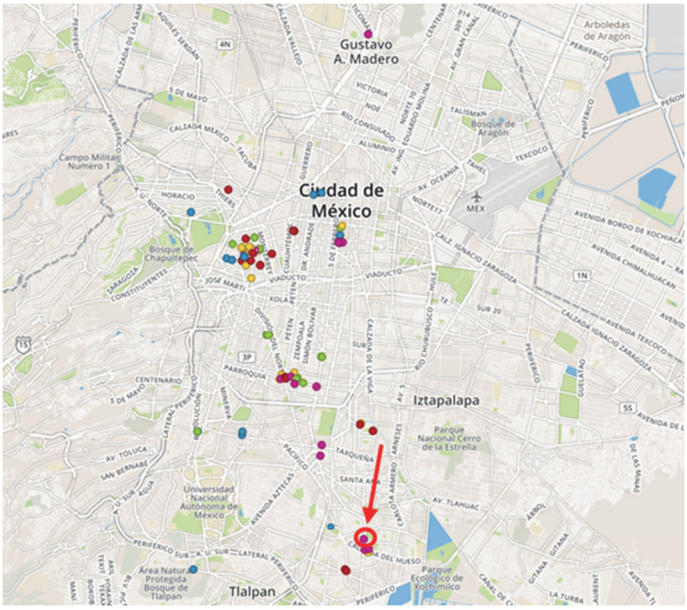


Figure 6.3.62.1 Location of site (Fulcrum Database). Coordinates: 19.307874, -99.124685.



Figure 6.3.62.2 Plan satellite view of site (Google Maps, 2017).

The building appears to have reinforced concrete slab and beams supported on concrete columns. The roof canopy seems to be a flat plate supported on thin columns. The building elevation is shown in Fig 6.3.62.3.



Figure 6.3.62.3 View of the building.

6.3.62.2 Damage and Observations—2017

The building has had a partial collapse of the roof canopy structure. It collapsed while the supporting perimeter columns remained in place showing a lack of connection between the floor and the columns. From the exterior, the building seems to be open and the lower levels seem to be unrestricted.



(a) Building elevation (north side)



(b) Collapsed roof canopy with columns standing

Figure 6.3.62.4 Building elevation and damage.

6.3.62.3 Discussion

The failure at the roof is very similar to that of building at 2050 Calz. de Tlalpan, where the metal deck detached from the concrete columns and there was no evident element tying the columns along the façade.

6.3.63 Site #63: 4353 Avenida Division Del Norte

6.3.63.1 Building Description

This corner building is located on 4353 Avenida Division Del Norte, at the intersection of Avenida Division del Northe and Hacienda de La Escalera. The general location and specific coordinates are shown on Figure 6.3.63.1. As observed from the satellite maps in Figure 6.3.63.2, the plan area of this building is not symmetrical and there is an interior courtyard on the west portion. The building has 5 stories. This structure was constructed in the early 1980s.

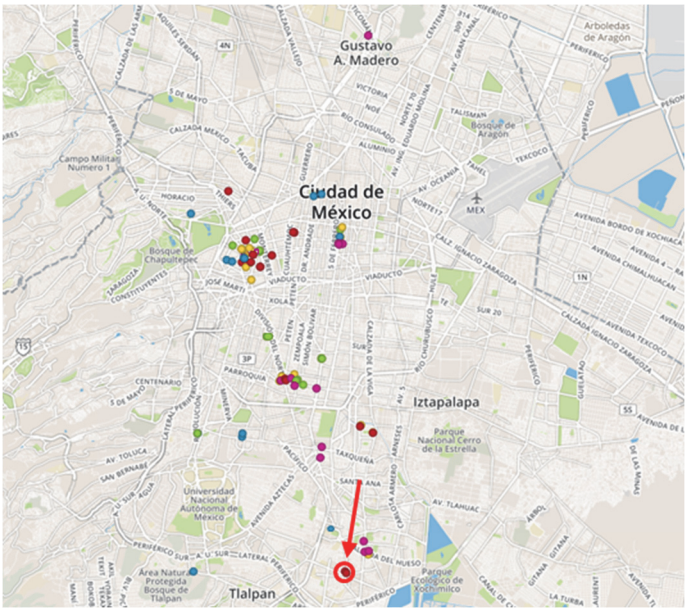


Figure 6.3.63.1 Location of site (Fulcrum Database). Coordinates: 19.296200, -99.131438.



Figure 6.3.63.2 Plan satellite view of site (Google Maps, 2017).

The building appears to have reinforced concrete slab/beam system supported on concrete columns, with unreinforced masonry infill walls. The building elevation is shown in Fig 6.3.63.3.



(a) Building elevation (southeast)



(b) Out of plane damage of infill walls

Figure 6.3.63.3 Building elevation and damage.

6.3.63.2 Damage and Observations—2017

The building has suffered extensive damage with significant out of plane failure of the masonry infill walls and cracking in the structural elements. It has been tagged unsafe, hence the residents are evacuated. No evidence of retrofit was observed. The interior was not inspected due to restricted access.

6.3.63.3 Recommendations

A full structural investigation and detailed evaluation of the building is recommended prior to declaring it safe, to determine retrofit solutions or demolishment.

6.3.64 Site #64: Edificio Centauro

6.3.64.1 Building Description

This complex is composed of several buildings, three of which are similar in construction types and cross footprint geometry. The building complex starts at the intersection of Calle Dr. Lucio and Calle Dr. Liceaga. It occupies the block between Calle Dr. Liceaga and Dr. J. Navarro. The general location and specific coordinates of the building complex are shown on Figure 6.3.64.1.

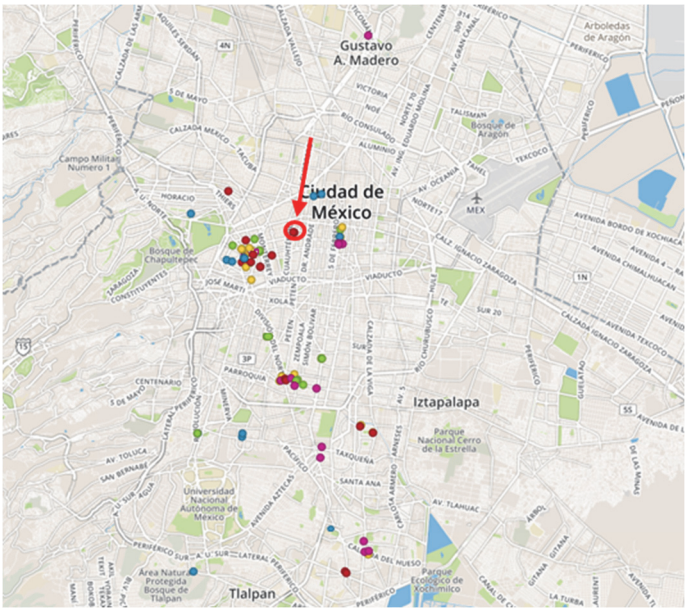


Figure 6.3.64.1 Location of site (Fulcrum Database). Coordinates: 19.421225, -99.151854.

Two buildings in this complex, Edificio Centauro and Osa Mayor (see section 6.3.65), were observed. Figure 6.3.64.2 shows the building locations within the complex.



Figure 6.3.64.2 Plan satellite view of building complex (Google Maps, 2017)

The Edificio Centauro described in this section has 16 stories and a basement. This is a corner building and the plan area is a cruciform shape, as shown in the plan satellite view in Figure 6.3.64.2. The year built of this building is 1969.



Figure 6.3.64.3 Plan satellite view of the building Centauro (Google Maps, 2017). For elevations (a) and (b), see Figure 6.3.64.4.

The Edificio Centauro has reinforced concrete frames supported on concrete columns, with unreinforced masonry infill walls. The building has a cruciform shape in plan which consists of two seismically separated L-shape structures. The seismic joints between structures occur at the stair landing at every floor level of one of the structures. The building elevation is shown in Figure 6.3.64.4.



(a) Looking northwest



(b) Looking east

Figure 6.3.64.4 Building elevation.

6.3.64.2 Damage, Repairs, and/or Rehabilitation—1985

According to residents, the red façade had been installed to replace the original brick façade that fell after the 1985 earthquake. It is more flexible than the original masonry infill.

6.3.64.3 Damage and Observations—2017

Overall, this building is severely damaged and cannot function as its intended purpose. Concrete spalling and cracks were observed in the structural members in the building. The masonry infill is severely damage and collapsed at some locations. The new façade installed after the 1985 earthquake is more flexible than the original brick façade and therefore sustained less damage.

The neighboring similar building, Osa Mayor, was entered and inspected in detail. See section 6.3.65 for more information.



(a) Concrete spalling



(b) Brick façade out-of-plane failure

Figure 6.3.64.5 Building damage observed from exterior.

6.3.64.4 Additional Information

According to an article from Excelsior, a major news reporting company in Mexico, following the earthquake on the 30th of March of 2014, a thorough inspection of the building was completed (excelsior.com.mx, 2017). Upon inspection, it was determined that this building did not comply with the safety and service requirements in the building code of Mexico “Reglamento de Construcciones y Normas Complementarias”. The study concluded that the structure should be reinforced and repair strategies were advised. However, these were not executed.

The drawings for the Osa Mayor building, the replica of this building, are available. See Section 6.3.65 for more information.

6.3.64.5 Recommendations

It is recommended that all of the buildings in this complex be fully evaluated by a qualified structural engineer at the earliest possible date.

6.3.65 Site #65: Osa Mayor

6.3.65.1 Building Description

This building named “Osa Mayor” is located in the building complex described in Section 6.3.64. This building is located at the intersection of Calle Dr. Lucio and Calle Dr. Liceaga. The general location and specific coordinates are shown on Figure 6.3.65.1. The structure has 16 stories and a basement. Similarly to the building “Centauro”, this is a corner building and the plan area is a cruciform shape, as shown in the plan satellite view in Figure 6.3.65.2.

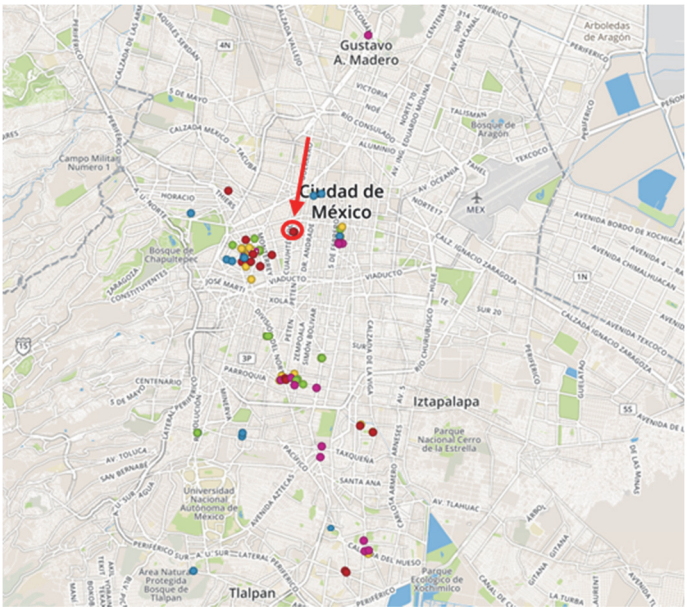


Figure 6.3.65.1 Location of site (Fulcrum Database). Coordinates: 19.421250, -99.152288.



Figure 6.3.65.2 Plan satellite view of the site(Google Maps, 2017). See Figure 6.3.64.3 for elevations (a) and (b).

The building has reinforced concrete frames supported on concrete columns, with unreinforced masonry infill walls. The building has a cruciform shape in plan which consists of two seismically separated L-shape structures. The seismic joints between structures occur at the stair landing at every floor level of one of the structures. The building elevation is shown in Figure 6.3.65.3.



(a) View looking northeast



(b) View looking northwest

Figure 6.3.65.3 Building elevation.

6.3.65.2 Damage and Observations—2017

Overall, from the exterior there was significant structural damage visible. There was spalling of the façade in the infill wall panels on the exterior as shown in Figure 6.3.65.4

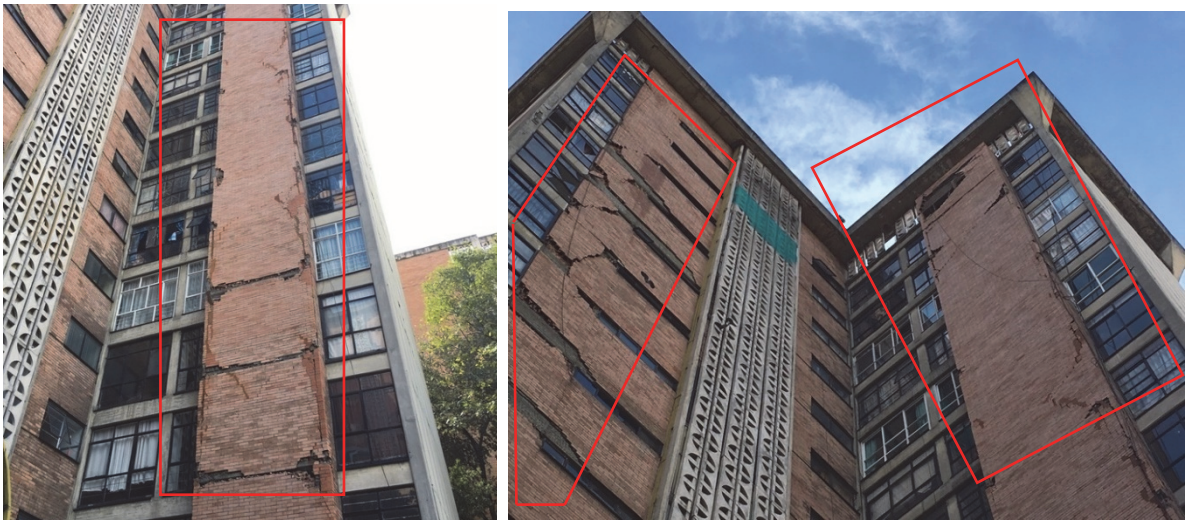


Figure 6.3.65.5 Building elevation.

This building is leaning and is significantly damaged due to ground deformation. The seismic joints opened due to the rigid body rotation caused by differential settlement of the ground. This gap was between the stairs (on one structure) and the landing (on the other structure). At the 3rd floor, the separations at the seismic joint caused by the earthquake were 6” and 8” in north and south directions respectively. At 7th floor, the separations were 11” and 15” in north and south directions respectively. These measured deformations indicate that the building tilted linearly with the height due to the foundation deformation. The measured displacements correspond to approximately the rotations of 0.01 to 0.018 radian.



(a) Location of gap between isolated L-shaped structures.



(b) Gap at the 3rd floor (6″-8″)

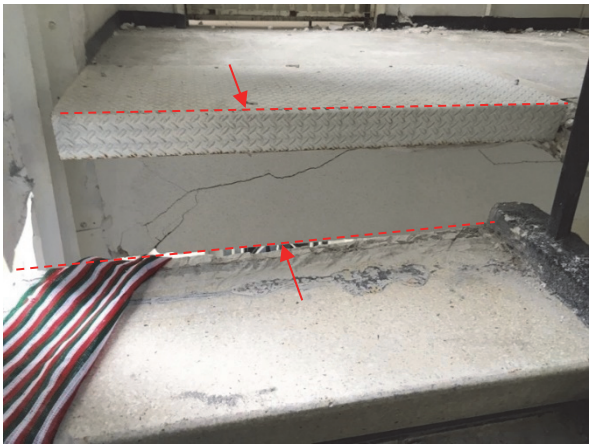


(c) Separation at the 7th floor (11″-15″)



(d) Walls do not align anymore





(e) & (f) Separation at the 7th floor (11″-15″)



(g) Separation at the 7th floor (11″-15″)



(h) Walls do not align anymore (3″ gap)

Figure 6.3.65.6 Gap between isolated L-shaped structures that make up building.

There was one minor column with large cracks and spalled concrete. Some cracks in the bottom of the slabs were visible. Several of the URM infill panels were cracked, showing evidence of both in-plane and out-of-place damage.

6.3.65.3 Discussion

The primary structural damage in the building appears to be caused by the failure of soil underneath the building. It is the only building in the complex that appears to be visibly leaning, suggesting that the ground failure is limited to soil underneath this building only.

6.3.65.4 Recommendations

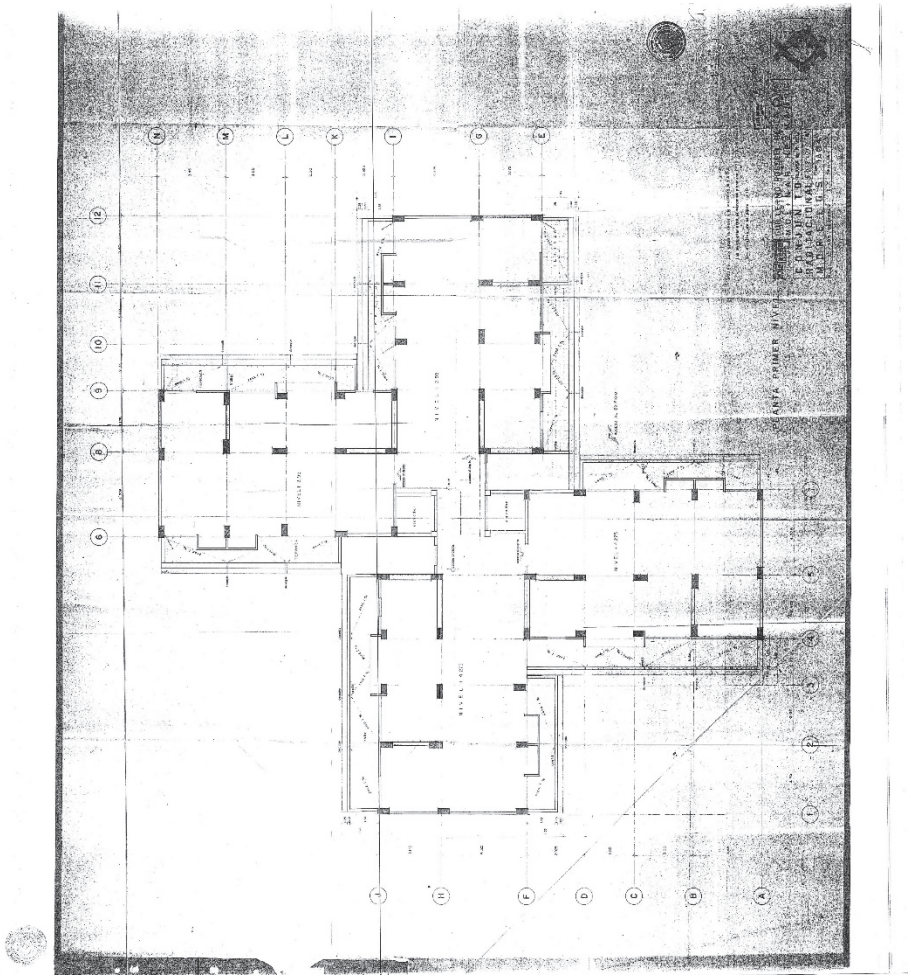
As observed in many other buildings, the nonstructural masonry walls appear to have absorbed a significant amount of force during the earthquake. If there is enough information available from the site visit, this building may be modeled to analyze the effect of the nonstructural walls.

Additionally, as stated in the report for the Centauro building, the remaining structures of similar plan area in the complex (excluding Centauro and Osa Mayor) can be candidates for long term studies (and potential instrumentation and monitoring).

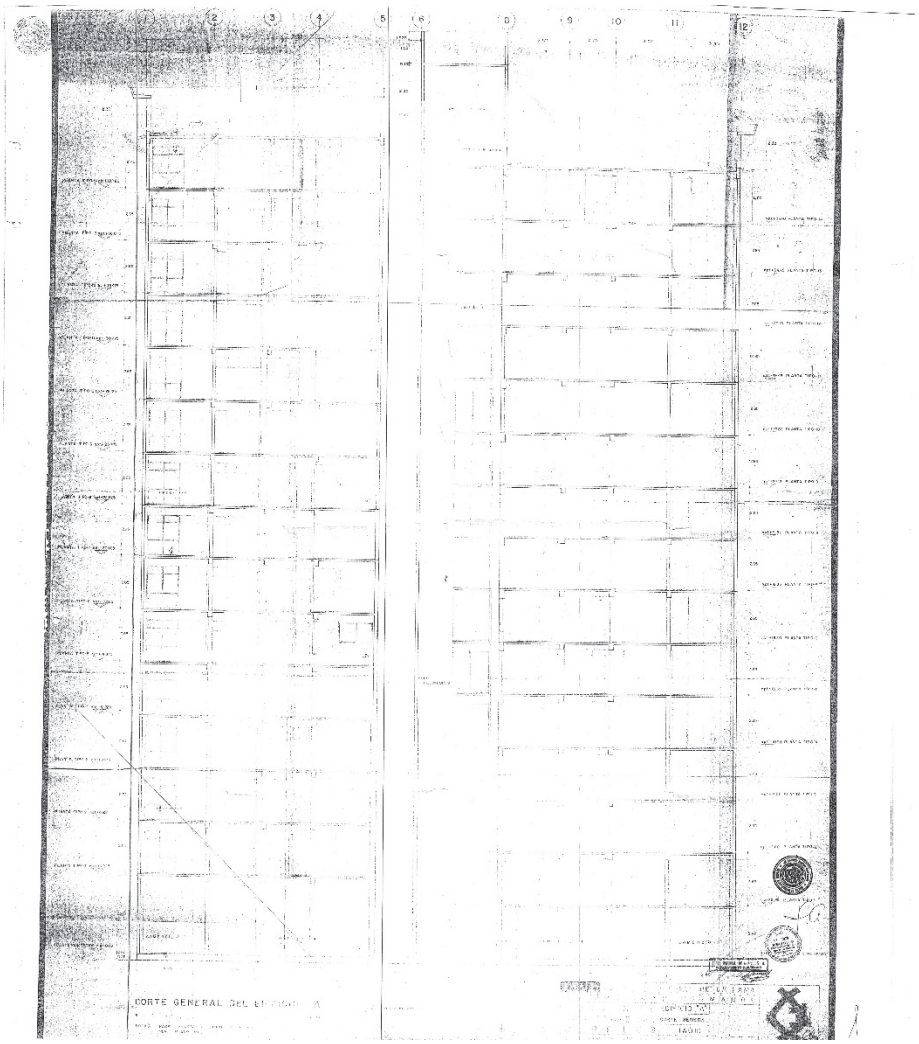
6.3.65.5 Additional Information

The demolition of the building Osa Mayor is scheduled to start on the 17th of January, 2018 (huffingtonpost.com.mx, 2018).

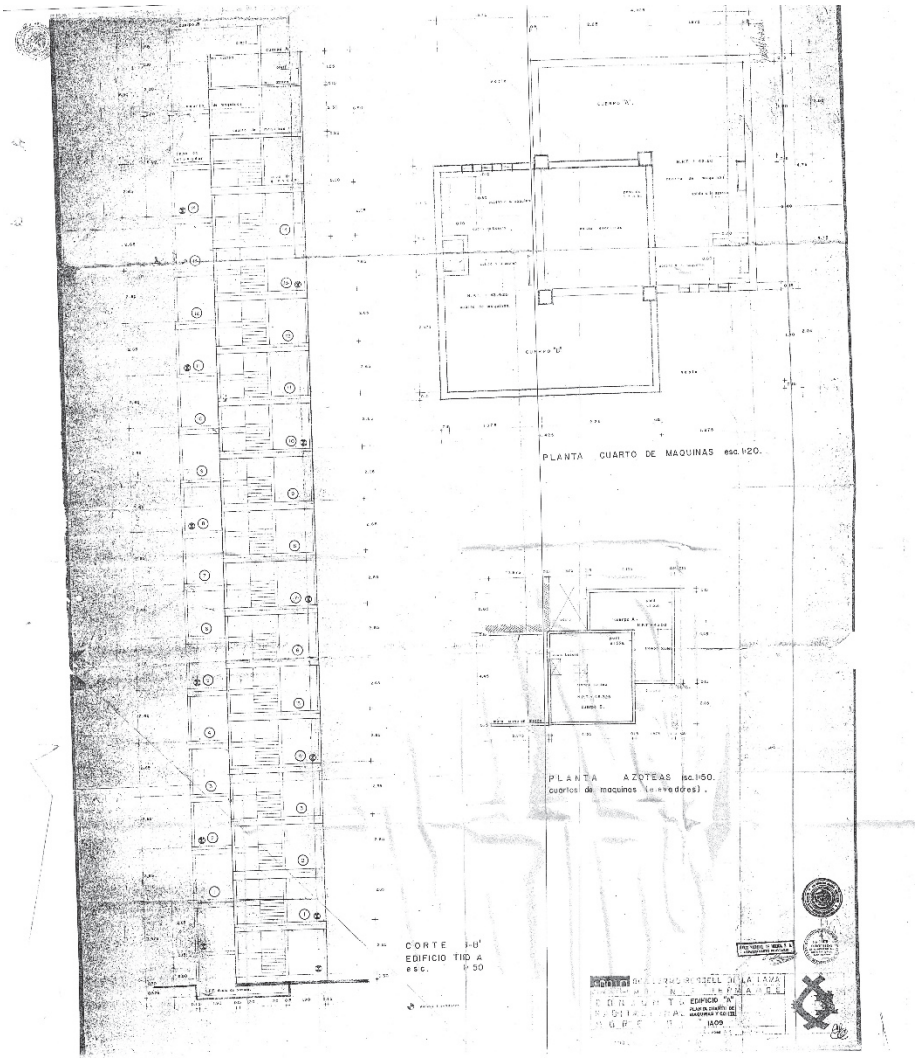
6.3.65.6 Drawings



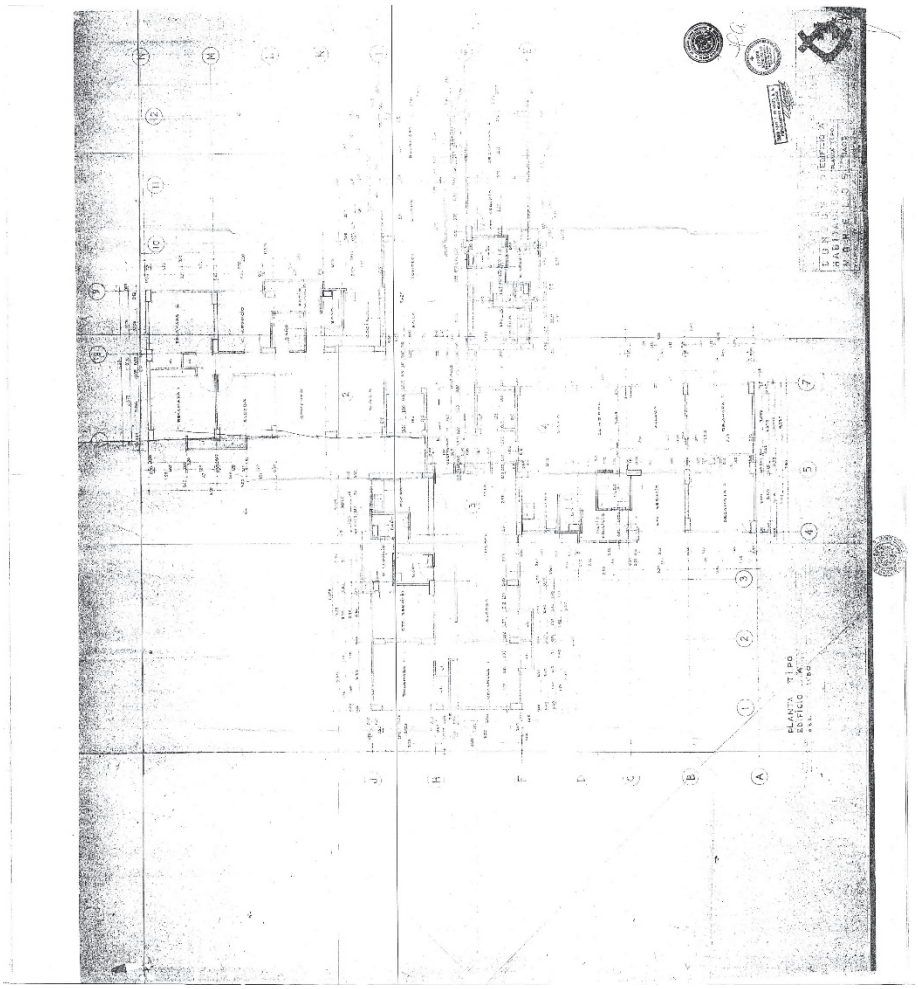
(a) Plan of first level



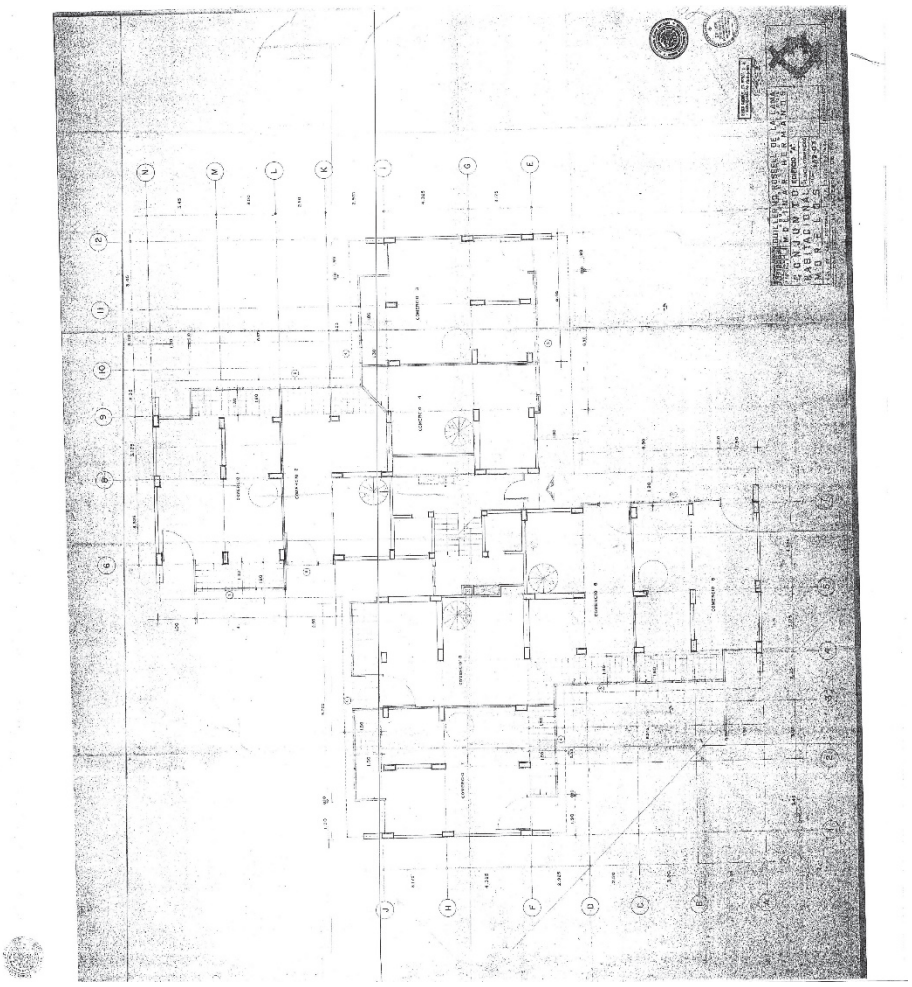
(b) Building elevation



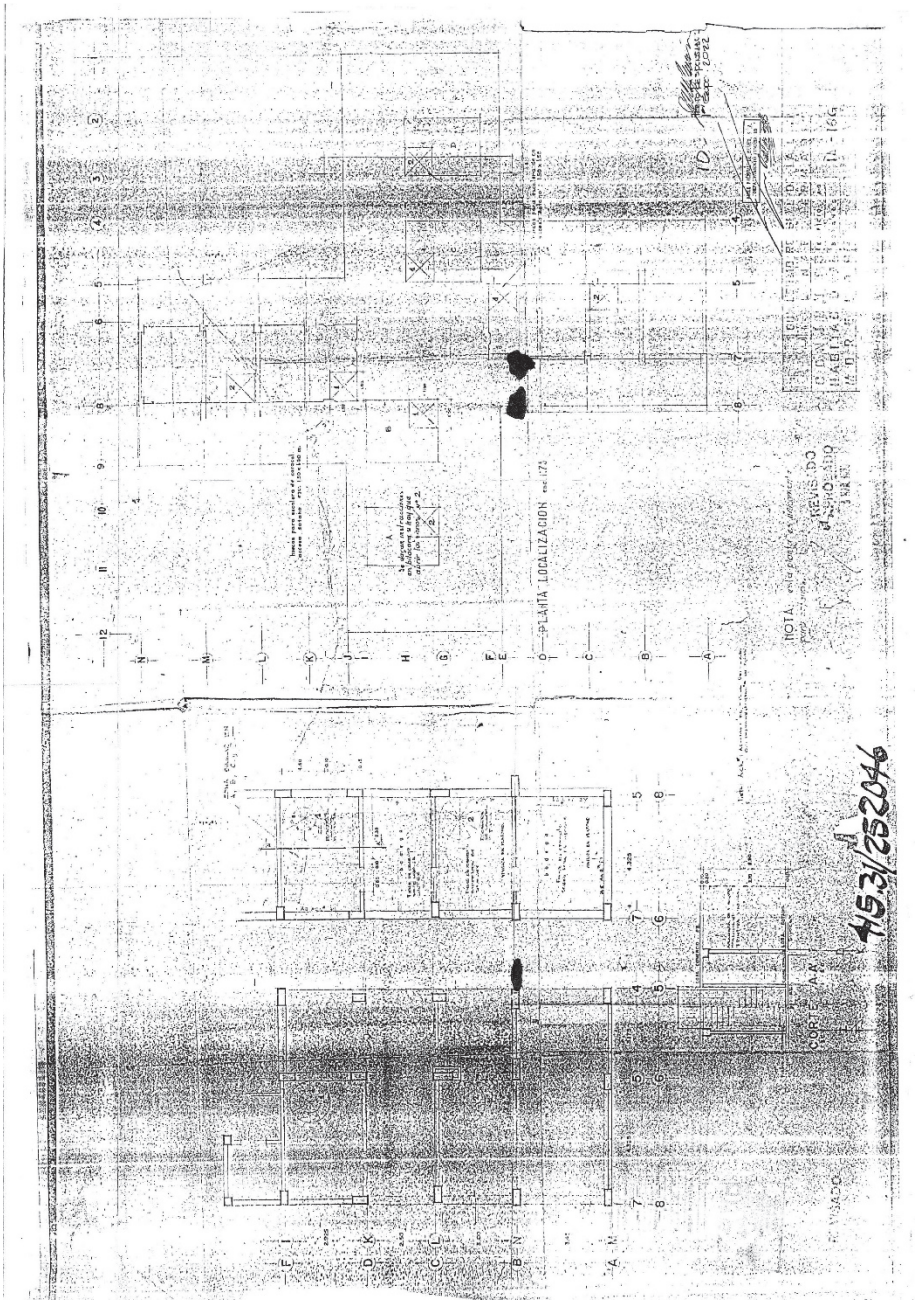
(c) Stair elevation and plan of machine rooms



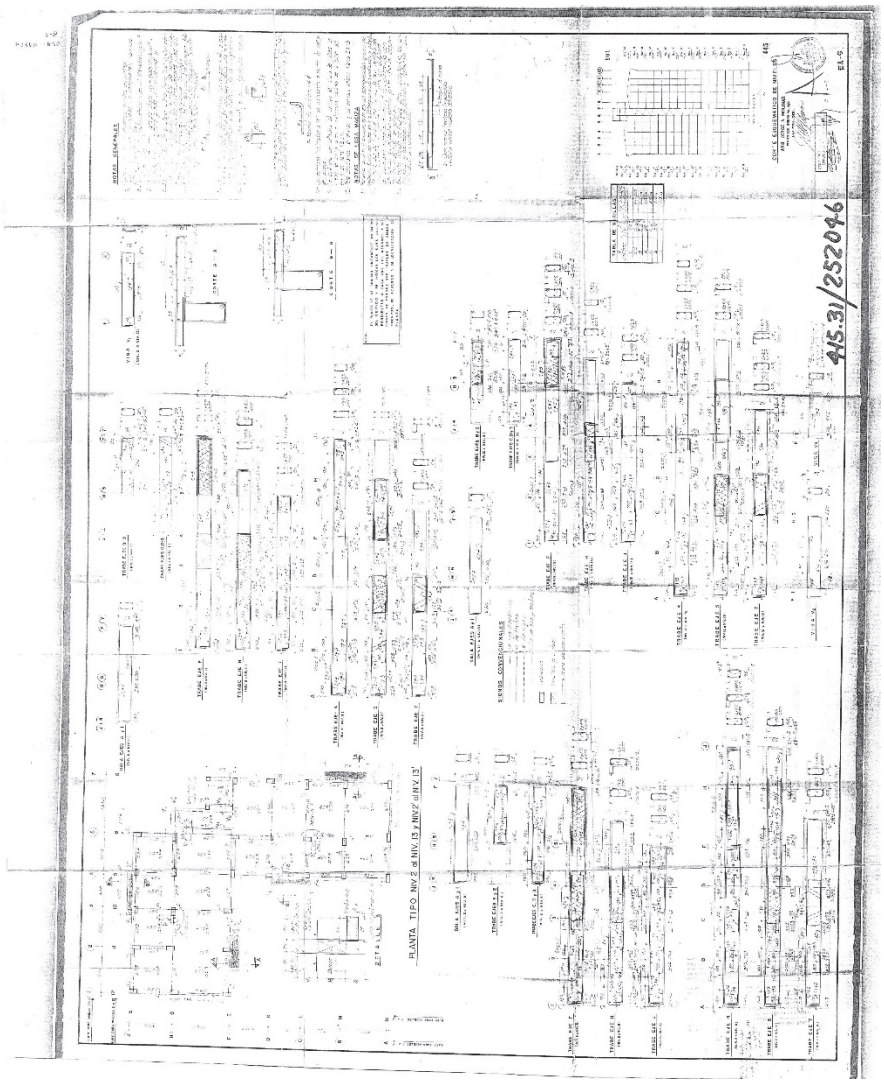
(d) Structural plan view of typical floor



(e) Room layout in typical floor



(f) Rooms and basement layout



(g) Structural sections and details

Figure 6.3.65.7 Building drawings.

There are also electrical and hydraulic drawings available, not shown on this report.

6.3.66 Site #66: Colegio Bilingue Heroes (Bilingual School)

6.3.66.1 Building Description

The site is a bilingual school composed of different buildings with grade classes from kindergarten through high school. This building is located on 139 Escondida, between Escondida and Tata Vasco along Avenida Miguel Ángel. The general location and specific coordinates are shown on Figure 6.3.66.1. The plan view and approximate site extent is as shown in the plan satellite view in Figure 6.3.66.2. Its construction date is unknown.

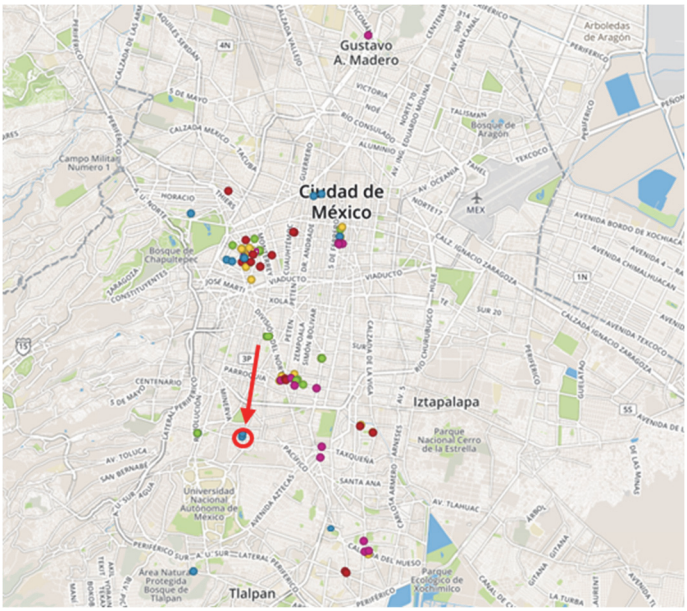


Figure 6.3.66.1 Location of site (Fulcrum Database). Coordinates: 19.346183, -99.172050.



Figure 6.3.66.2 Plan satellite view of the site (captured from Google 2017).

The school is composed of a few buildings of different heights varying from one to four stories, primarily constructed of reinforced concrete with infill masonry walls.

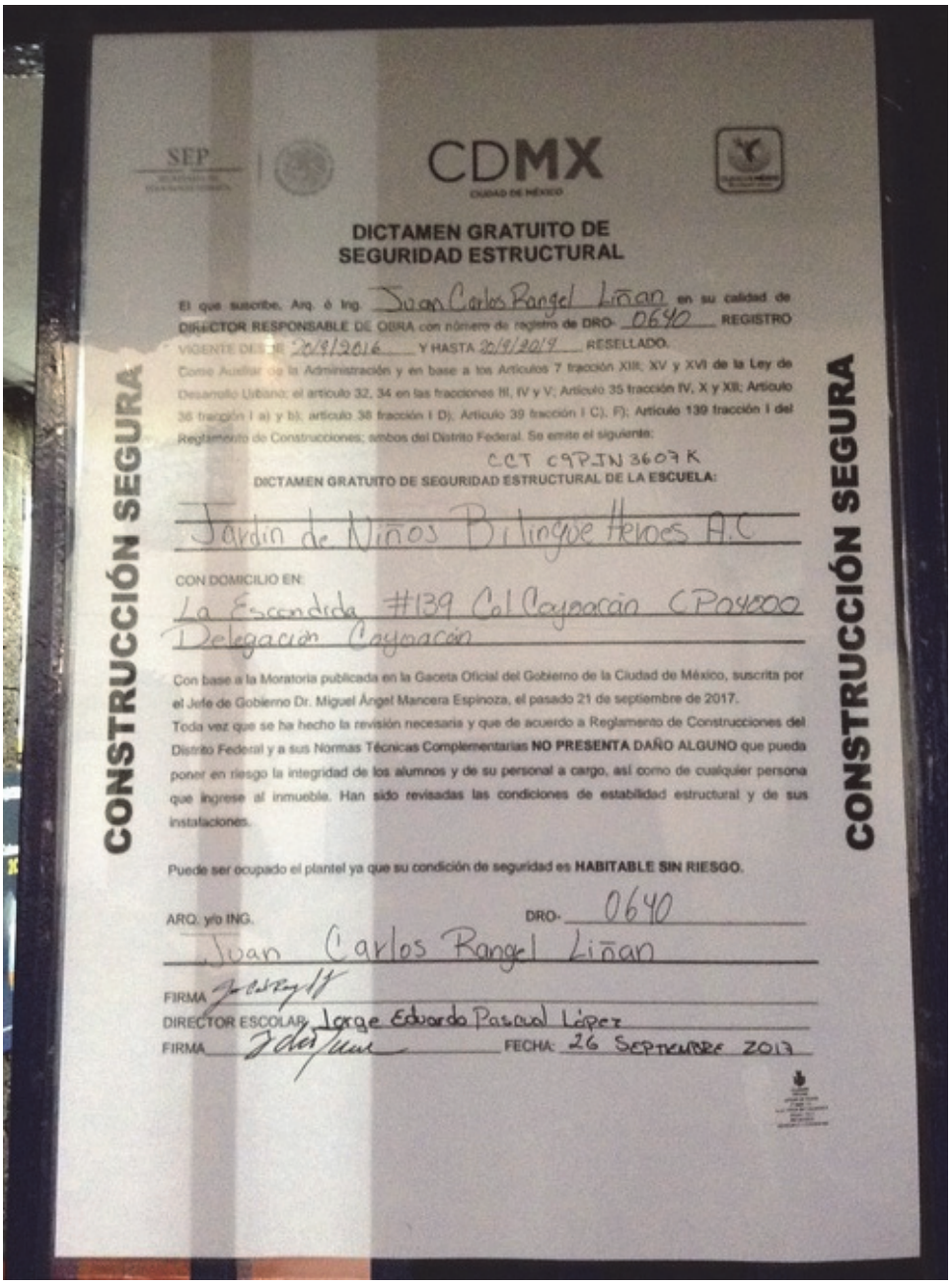


Figure 6.3.66.3 3D view of site (Google Maps, 2017).

6.3.66.2 Damage and Observations—2017

The structure was not inspected and no photos were taken because it was dark. However, no visible damage was observed from what could be seen.

At the time of the visit, the building occupied by the younger kids (kindergarten) had already been inspected by a certified architect/engineer and was given the ruling of safe occupancy. The certificate said that the building complied with the rules of the construction of the federal district and its respective complementary technical norms. It also says that there is no danger to anyone who enters the building. It is unknown whether the rest of the school had been inspected.



SEP

CDMX
CIUDAD DE MÉXICO

DICTAMEN GRATUITO DE SEGURIDAD ESTRUCTURAL

El que suscribe, Arq. ó Ing. Juan Carlos Rangel Liñan en su calidad de DIRECTOR RESPONSABLE DE OBRA con número de registro de DRO- 0640 REGISTRO VIGENTE DESDE 26/9/2016 Y HASTA 26/9/2019 RESELLADO.
Como Auxiliar de la Administración y en base a los Artículos 7 fracción XIII; XV y XVI de la Ley de Desarrollo Urbano; el artículo 32, 34 en las fracciones III, IV y V; Artículo 35 fracción IV, X y XII; Artículo 36 fracción I a) y b); artículo 38 fracción I D); Artículo 39 fracción I C), F); Artículo 139 fracción I del Reglamento de Construcciones; ambos del Distrito Federal. Se emite el siguiente:

CCT C9PJN3607K

DICTAMEN GRATUITO DE SEGURIDAD ESTRUCTURAL DE LA ESCUELA:

Jardin de Niños Bilingue Heroes A.C

CON DOMICILIO EN:

La Escondida #139 Col Cuauhtémoc CP04200 Delegación Coyoacán

Con base a la Moratoria publicada en la Gaceta Oficial del Gobierno de la Ciudad de México, suscrita por el Jefe de Gobierno Dr. Miguel Ángel Mancera Espinoza, el pasado 21 de septiembre de 2017.
Toda vez que se ha hecho la revisión necesaria y que de acuerdo a Reglamento de Construcciones del Distrito Federal y a sus Normas Técnicas Complementarias **NO PRESENTA DAÑO ALGUNO** que pueda poner en riesgo la integridad de los alumnos y de su personal a cargo, así como de cualquier persona que ingrese al inmueble. Han sido revisadas las condiciones de estabilidad estructural y de sus instalaciones.

Puede ser ocupado el plantel ya que su condición de seguridad es **HABITABLE SIN RIESGO.**

ARQ. y/o ING. DRO- 0640
Juan Carlos Rangel Liñan
FIRMA
DIRECTOR ESCOLAR Jorge Eduardo Pascual López
FIRMA FECHA: 26 SEPTIEMBRE 2017

CONSTRUCCIÓN SEGURA

CONSTRUCCIÓN SEGURA

Figure 6.3.66.4 Official ruling following inspection of kindergarten building.

6.3.67 Site #67: Jardin Guadalupe Servin De La Mora (Nursery School)

6.3.67.1 Building Description

The corner building is located on 77 Dulce Olivia, in the intersection of Dulce Olivia and Escondida. The general location and specific coordinates are shown on Figure 6.3.67.1. The building has 2 stories. The plan area is irregular, as shown in the plan satellite view in Figure 6.3.67.2. Its construction date is unknown.

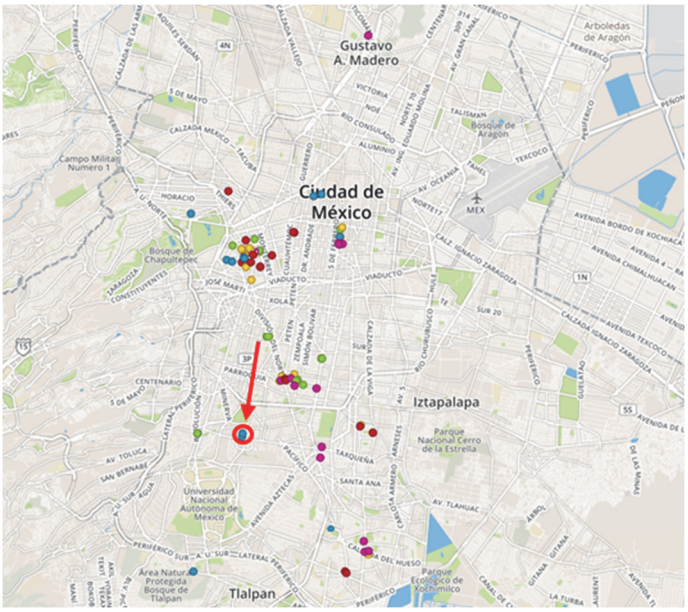


Figure 6.3.67.1 Location of site (Fulcrum Database). Coordinates: 19.347438, -99.171857.

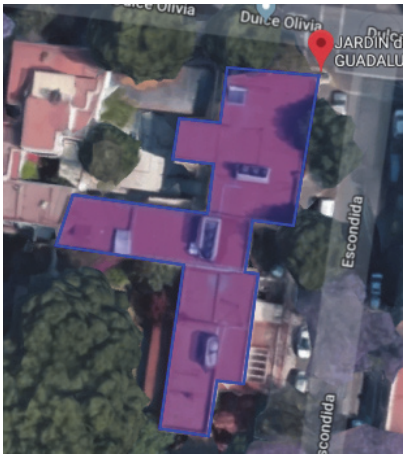


Figure 6.3.67.2 Plan satellite view of the site (captured from Google 2017).

The school is composed of a few two-story reinforced concrete buildings that are combined to make one space. The front view of the north face is shown in Figure 6.3.67.3.

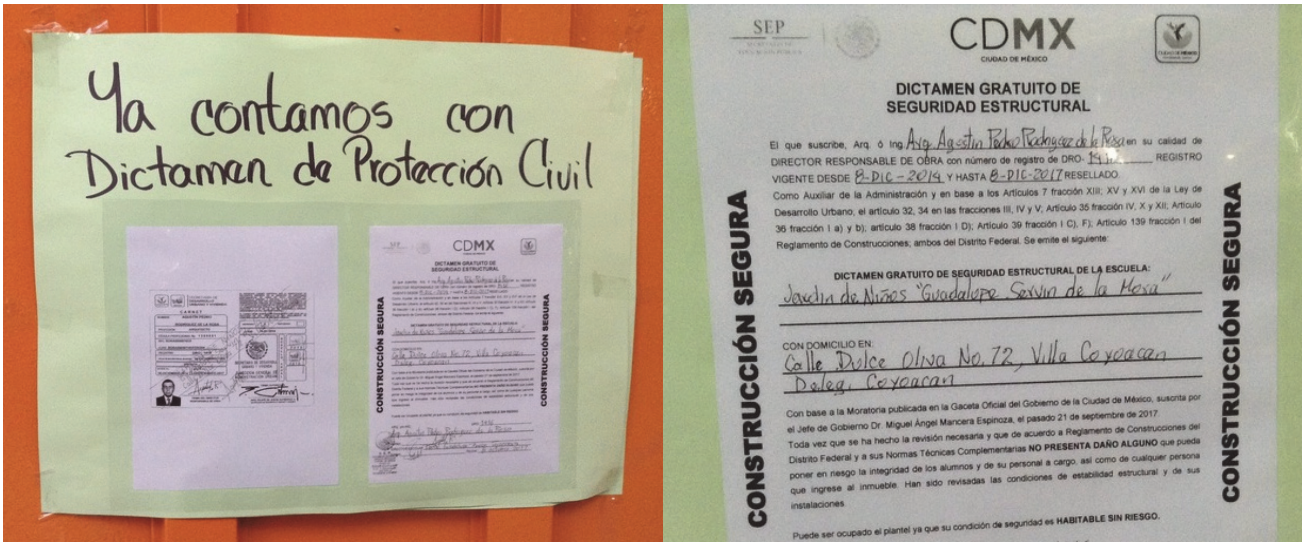


Figure 6.3.67.3 Front (north) view of the building.

6.3.67.2 Damage and Observations—2017

The structure was not inspected in detail, although from the exterior there was no visible structural or nonstructural damage.

At the time of the visit, the building had already been inspected by a certified architect and was given the ruling of safe occupancy. Certificate is shown in Figure 6.3.67.4. The certificate said that the building complied with the rules of the construction of the federal district and its respective complementary technical norms. It also says that there is no danger to anyone who enters the building.



(a) Translation: We have received the ruling from civil protection

(b) Description of ruling declaring the building safe

Figure 6.3.67.4 Official ruling following inspection.

6.3.68 Site #68: Iglesia Fatima (Church)

6.3.68.1 Building Description

This is a church located on 107 Calle de Chiapas, between Avenida Yucatan and Jalapa. The general location and specific coordinates are shown on Figure 6.3.68.1. The plan shape is shown on the plan satellite view in Figure 6.3.68.2. The construction of the church was completed in 1972.

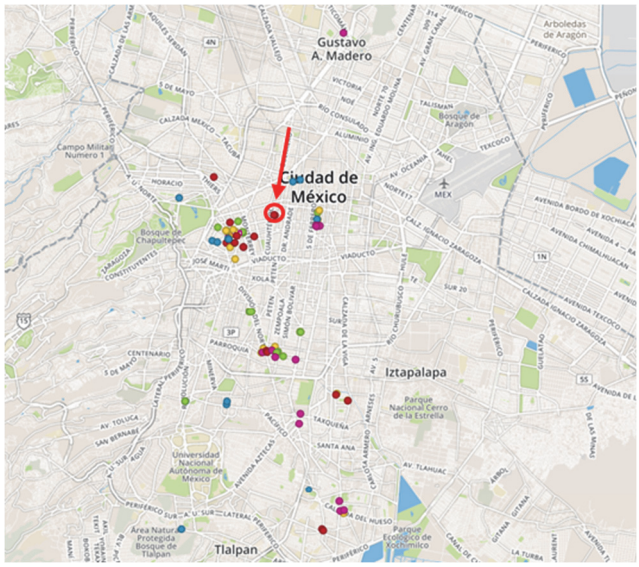


Figure 6.3.68.1 Location of site (Fulcrum Database). Coordinates: 19.412791, -99.160432.



Figure 6.3.68.2 Plan satellite view of site (Google Maps, 2017).

The exterior walls on the longitudinal sides (east and west) are sloping inwards towards the top. The structure is composed of reinforced concrete frames with sloped columns in the transverse direction with brick infill on the exterior, with a saw-tooth type roof. The infill is covered by cement plaster finish material. The building elevation is shown in Figure 6.3.68.3.

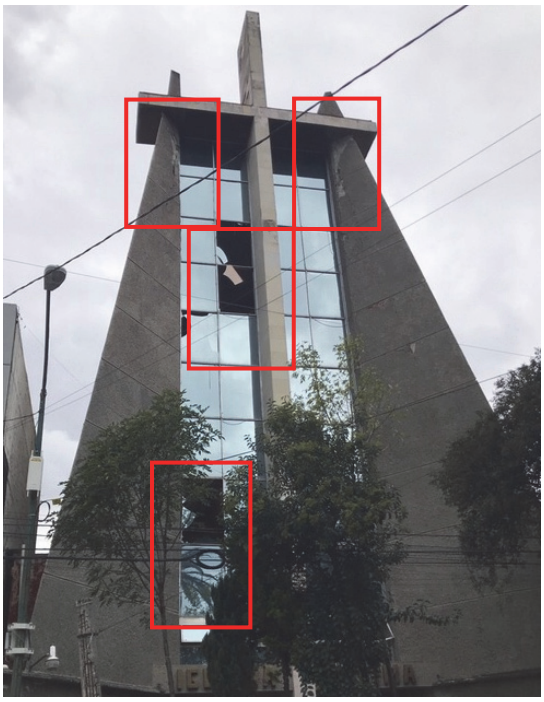


(a) West elevation (b) Front (south) elevation (c) East elevation

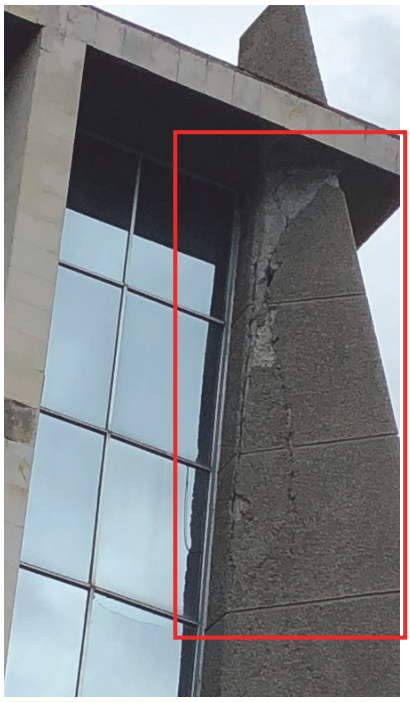
Figure 6.3.68.3 Building elevations.

6.3.68.2 Damage and Observations—2017

Significant cracks were observed on the south side upper corners of the structure, as per Figure 6.3.68.5, which seems to be plaster covered infill masonry. Cracking in the saw tooth concrete frame was also observed from a distance, evident from one particular angle. Also, there were missing/broken window panels at the front façade. Access was restricted, therefore the interior of the church was not observed.



(a) Cracks in the concrete and fallen windows



(b) Cracks in the corner at the SE corner

Figure 6.3.68.5 Damage in the front (south) of the church.

6.3.68.3 Discussion

Based on limited observations from one side of the building's exterior, it seems that structural damage to the building might be discovered through additional investigations including close and careful observations made from the interior as well as all sides of the exterior of the building.

6.3.68.4 Additional Information

Drawings for this building were not available; however, these would be necessary for any further investigation/evaluation of the structure.

6.3.68.5 Recommendations

A full structural investigation and evaluation of this building should be performed by an appropriately qualified Structural Engineer.

6.3.69 Site #69: Notary Historical Heritage of Mexico City

6.3.69.1 Building Description

The building is a historical notary in Mexico City. It is located on 44 Avenida Juárez, between Luis Moya and Dolores, on the historic center of the city. The general location and specific coordinates are shown on Figure 63.69.1. The building has 2 to 3 stories. The plan satellite view in shown in Figure 6.3.69.2. Its construction date is not known.

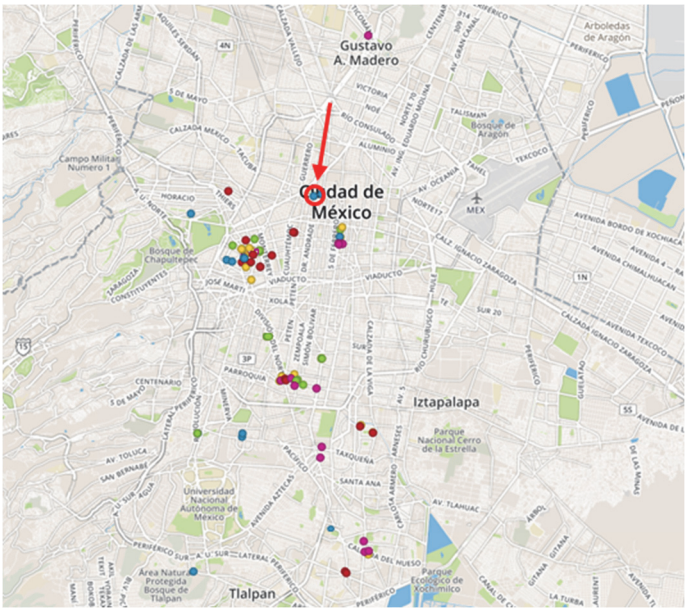


Figure 6.3.69.1 Location of site (Fulcrum Database). Coordinates: 19.434550, -99.144167.



Figure 6.3.69.2 Plan satellite view of the site (captured from Google 2017).

The building construction is not known. The building was observed from the street only.



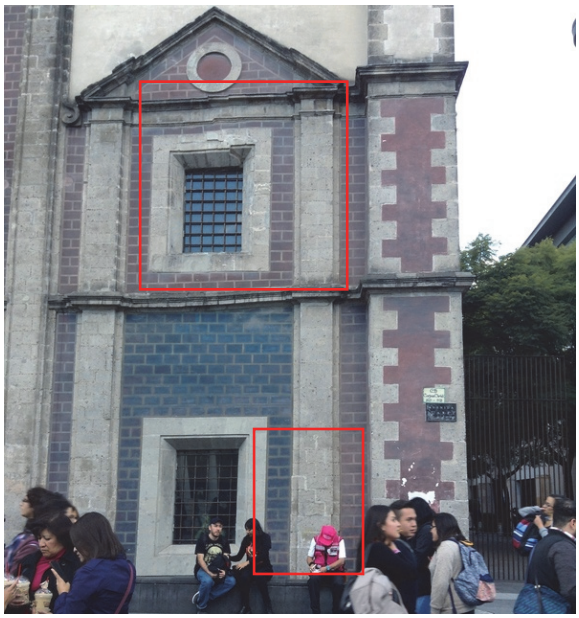
Figure 6.3.69.3 Front (north) view of the building.

6.3.69.2 Damage and Observations—2017

Overall, there was no visible damage to the structure. However, there was pre-existing ground settlement on the right (west) side of the building. At the top right window, there was significant distortion of the frame. At the façade there was also a slight shift in the vertical element, as observed in Figure 6.3.69.4.

In addition to these observations, ground settlement can also be seen at the interface of the structure with the sidewalk on the west face of the building. A gap is present between the façade and the ground level, as shown on Figure 6.3.69.5.

In the front entrance, the sidewalk crack patterns also demonstrate that there has been ground deformation on the west side only. As observed from Figure 6.3.69.6, there are pre-existing cracks on the west side of the sidewalks while on the east side there are none.



(a) Right (west) side of the front view



(b) Distorted window frame



(c) Distorted vertical stones

Figure 6.3.69.4 Distortion of right (west) side of north façade.



(a) Existing gap (b) Sidewalk has settled

Figure 6.3.69.5 Ground settlement on the west side of the building.



(a) Cracks in entrance sidewalk (looking west) (b) No cracks observed in the entrance sidewalk (looking east)

Figure 6.3.69.6 Sidewalk crack differentiation between west and east side.

6.3.70 Site #70: Palacio de Bellas Artes

6.3.70.1 Building Description

The building is a historic cultural center in Mexico City. It is located on Eje Central Lázaro Cárdenas, between Avenida Juárez and Avenida Hidalgo, on the historic center of the city. The general location and specific coordinates are shown on Figure 6.3.70.1. The satellite plan view is shown on Figure 6.3.70.2. Its construction was completed in 1934.

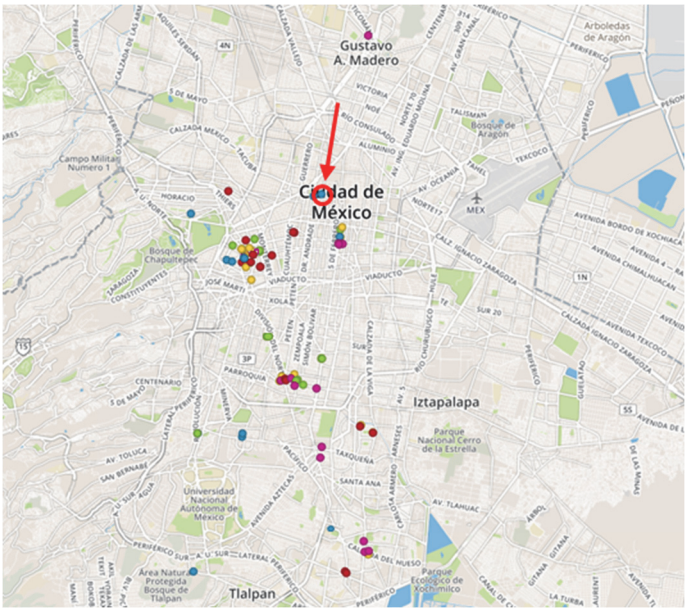


Figure 6.3.70.1 Location of site (Fulcrum Database). Coordinates: 19.435278, -99.141111.

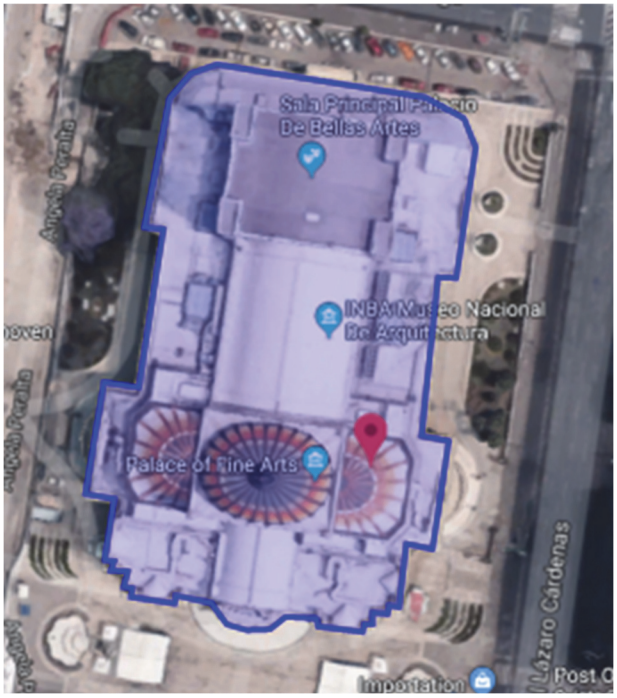


Figure 6.3.70.2 Plan satellite view of site (Google Maps, 2017).

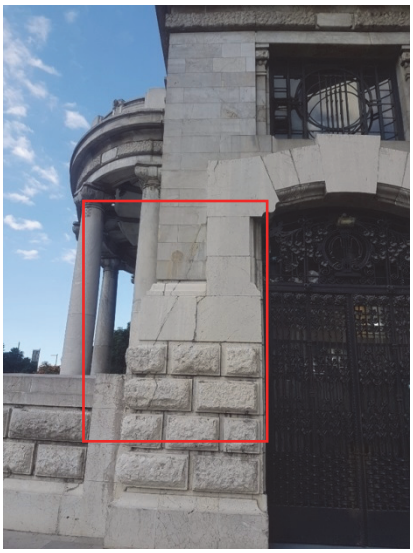
The building construction is most likely concrete or masonry. A waffle slab (evident in one partial photo taken from the exterior) and unreinforced masonry infill walls are observed. The lateral load resisting system is unknown. The building elevations are shown in Figure 6.3.70.3.



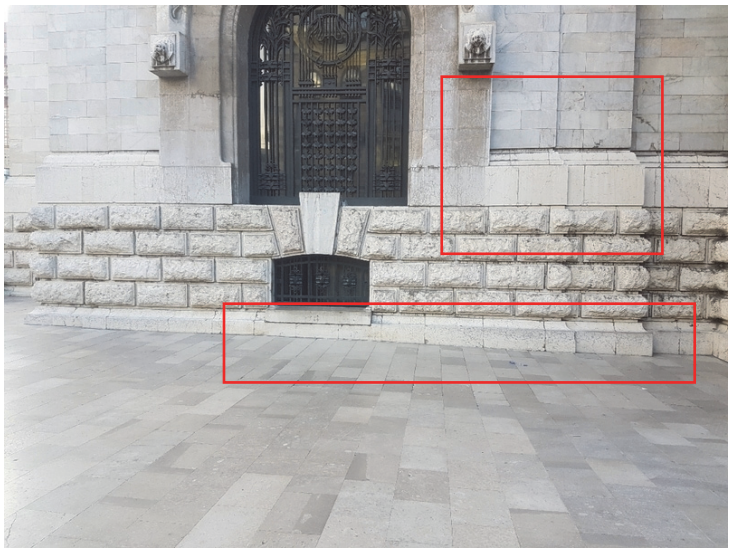
Figure 6.3.70.3 Front (south) view of the building.

6.3.70.2 Damage and Observations—2017

There were some cracks on the exterior stone. However, after comparing to the 3D view from Google maps in 2015, it is clear that these were existent prior to the earthquake.



(a) Existing cracks



(b) Existing cracks in the interface to sidewalk



(c) Existing cracks



(d) Drainage opening in sidewalk



(e) Existing cracks



(f) Existing cracks

Figure 6.3.70.4 Existing cracks prior to 2017 Earthquake.

Chapter 7

Summary

In the aftermath of the September 19th, 2017 M_w7.1 Puebla-Morelos Earthquake in Mexico City, the Applied Technology Council (ATC) deployed an interdisciplinary team of seismologists, structural, and geotechnical engineers. The ATC team was tasked with performing reconnaissance and collect information to generate a large set of building performance data that can enhance and validate existing and ongoing ATC projects, and advance the knowledge and practice of earthquake engineering.

7.1 Observations and Data Collected

The main highlights and conclusions of the ATC team are shown below, with details provided in individual chapters of this report:

- A total of 70 buildings, ranging from 1 to 25 stories high were observed by the ATC team, most of which were constructed of reinforced concrete (RC) with masonry infill walls. In limited cases, building plans or drawings were obtained .
- The degree of detail in the observations depended on accessibility. Specifically, ATC had interior access to 21 buildings that the team observed in detail. The remaining 49 buildings were either observed from the exterior due to limited access, or in passing as they were of general interest as additions to the body of Mexico City building performance data.
- The observed structural damage ranged from none to severe damage or complete collapse in mainly pre-1985 buildings. The damage state extended from cosmetic to severe nonstructural (e.g., cracking and collapse of unreinforced masonry infill walls), cracking and spalling in concrete structural elements, plastic hinging of concrete columns, pounding and leaning, local failures of vertical load carrying elements, column and story partial collapses, and complete structural collapses. Sidewalk detachment, ground settlements and soil-structure interaction phenomena such as foundation or building rotations were also observed.
- Nonstructural unreinforced concrete masonry partition walls that were damaged appeared, in many cases, to have resisted part of the seismic demands. Some walls may have offered significant lateral strength, thus

preventing further damage and collapse. Few damaged masonry walls were being replaced with light gauge construction during the ATC visit. Without the masonry partitions, the buildings would likely have performed differently.

- Instrumented monitoring of microtremors was performed in 7 buildings during the ATC visit and a second visit by University at Buffalo researchers funded by the National Science Foundation. For these buildings, periods of the first 3 modes of vibration were identified, ranging from 0.34 to 2.6 seconds.
- The collaborating local agencies UNAM (National Autonomous University of Mexico) and CIRES (Center of Instrumentation and Seismic Records) provided ATC with a total of 71 (unprocessed) strong ground motion records with 3 components each (2 horizontal and vertical) from the main event, at the locations shown on the map of Fig. 7.1 and the following details:
  - Seven (7) records were provided by the Seismic Instrumentation group and IT infrastructure at the IINGEN (Instituto de Ingeniería) of UNAM and its Strong Ground Motion Database System. Details are available in the IINGEN-UNAM preliminary ground motion report dated 9/19/17.
  - Sixty-four (64) records were provided by CIRES through the Accelerographic Network (Red Acelerográfica de la Ciudad de México-RACM), a technological resource funded by the Mexico City government through the Institute of Security in Constructions (Instituto para la Seguridad de las Construcciones en el Distrito Federal-ISCDF).
- The horizontal components of the provided raw strong motion recordings were processed by the ATC team following the procedure presented in PEER (2013) and are presented in Appendices A and B in the form of acceleration, velocity, and displacement time histories, acceleration response spectra, and summary tables of peak recorded values, epicentral distance and site conditions.
- Site-specific ground motions at the ground surface were derived for each ATC-observed building by performing one-dimensional (1D) equivalent-linear amplification analyses for simplified soil columns, representative of the code-specified seismic zones, using the CUP5 record of the UNAM network as input. Comparisons with actual records at stations with similar subsurface conditions showed satisfactory agreement.

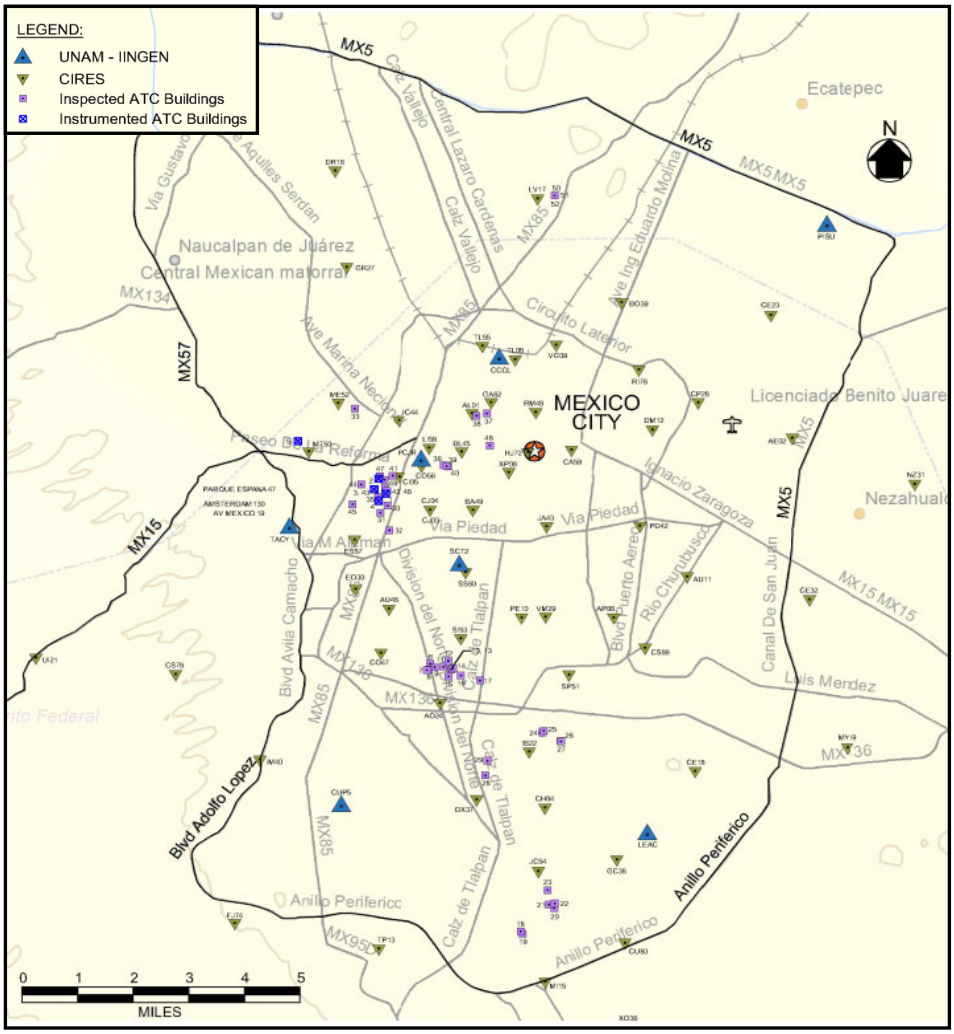


Figure 7.1.1 Location map of UNAM and CIRES recording stations (triangles) and ATC-observed buildings (squares).

7.2 Data Visualization

GIS maps, such as the ones shown on Figs. 7.2.1 and 7.2.2 were compiled by the ATC team to visualize relative structural and geotechnical characteristics at the visited sites. The mapped data include the number of stories in the buildings from which approximate building periods can directly be extracted. Also, the predominant soil periods and the code-specified seismic zones are mapped. The multidisciplinary data allow for correlation between the vibrational characteristics of the soil and structures, to identify potential resonance effects and associate the collected data with the UNAM and CIRES seismological recordings and the damage state, presented by colors as per ATC-20 criteria.

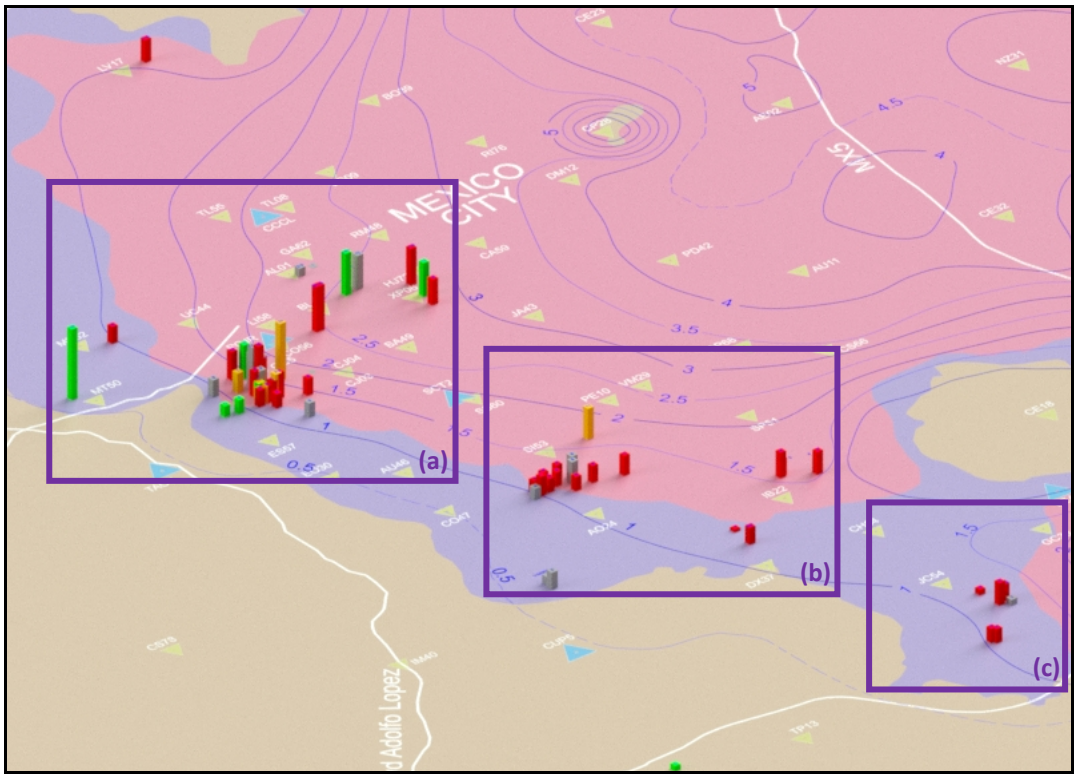
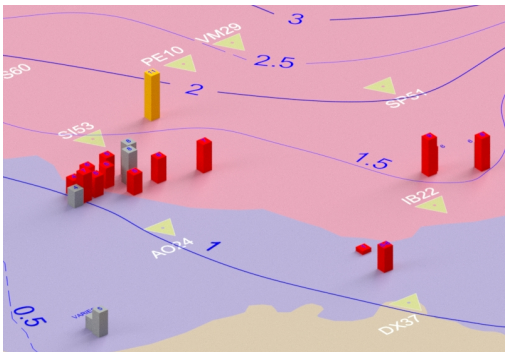


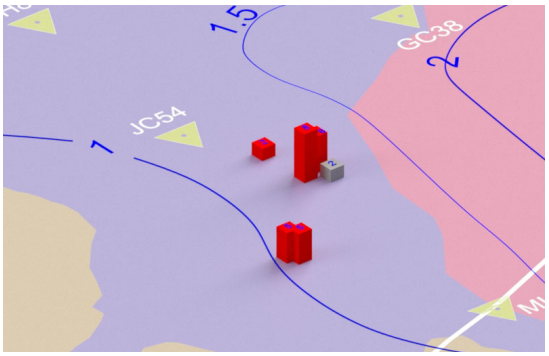
Figure 7.2.1 GIS map correlating structural, geotechnical and seismology data collected by the ATC team.



(a)



(b)



(c)

Figure 7.2.2 Areas (a), (b), (c) of the map on Fig. 7.2 and types of data and symbols used in the mapping.

7.3 Opportunities for Further Studies

Although all observations and extensive data sets provide useful knowledge, the ATC team identified selected cases as good candidates for potential further studies to validate and enhance ATC projects. Specifically:

- FEMA P-2018, *Seismic Evaluation of Older Concrete Buildings for Collapse Potentia*l, (FEMA, 2018) presents a methodology that was developed under the ATC-78 project. The following reinforced concrete (RC) buildings may be applicable to this methodology:
  - Site #8, 19 Avenida Mexico: Regular plan area and structural system of reinforced concrete slabs, beams, columns and shear walls and partial retrofit following 1985.
  - Site #35, 130 Amsterdam: rectangular plan area and reinforced concrete slab supported on reinforced concrete shear walls. The building was instrumented during the ATC visit.
  - Site #43, 200 Campos Eliseos: irregular plan area, with reinforced concrete slab supported on reinforced concrete beams and columns and lateral moment-resisting concrete frame. One floor was instrumented during the ATC reconnaissance.
- ATC-134 is an ongoing project funded by the National Institute of Standards and Technology, studying seismic evaluation procedures and benchmarking them across multinational building codes, standards and guidelines. The following RC buildings are potential candidates to enhance this study:
  - Site #8, 19 Avenida Mexico: See above.
  - Site #14, 47 Parque España: Regular plan area and structural system of a RC slab supported on RC columns and walls, and steel columns, with lateral resisting system of RC walls and moment frames.
  - Site #31, 122 San Antonio Abad: Regular plan area with elevator core. RC slabs supported on concrete frames and lateral system of moment-resisting frames and shear walls at the core. Few columns were retrofitted after the 1985 earthquake.
  - Site #43, 200 Campos Eliseos: See above.

Appendix A
Ground Motion Recordings from IINGEN UNAM

This Appendix presents 64 ground motion records from the 2017 M_w7.1 Puebla-Morelos earthquake. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM and its Strong Ground Motion Database System. Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) are the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.

Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.

Figure A.1 shows a map with the locations of the IINGEN UNAM stations. The following pages present time histories and spectral acceleration information for the following stations (in alphabetical order):

1. CCCL
2. CUP5
3. LEAC
4. PCJR
5. PISU
6. SCT2
7. TACY

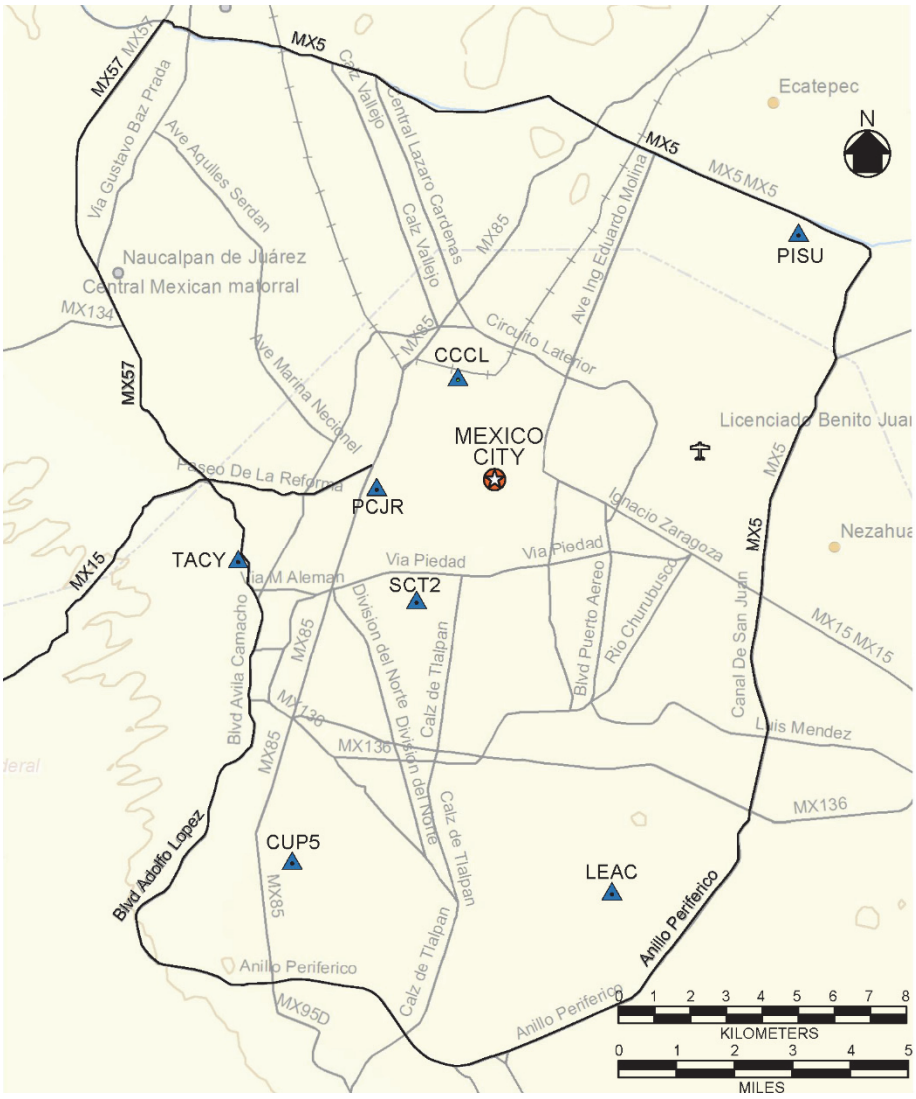
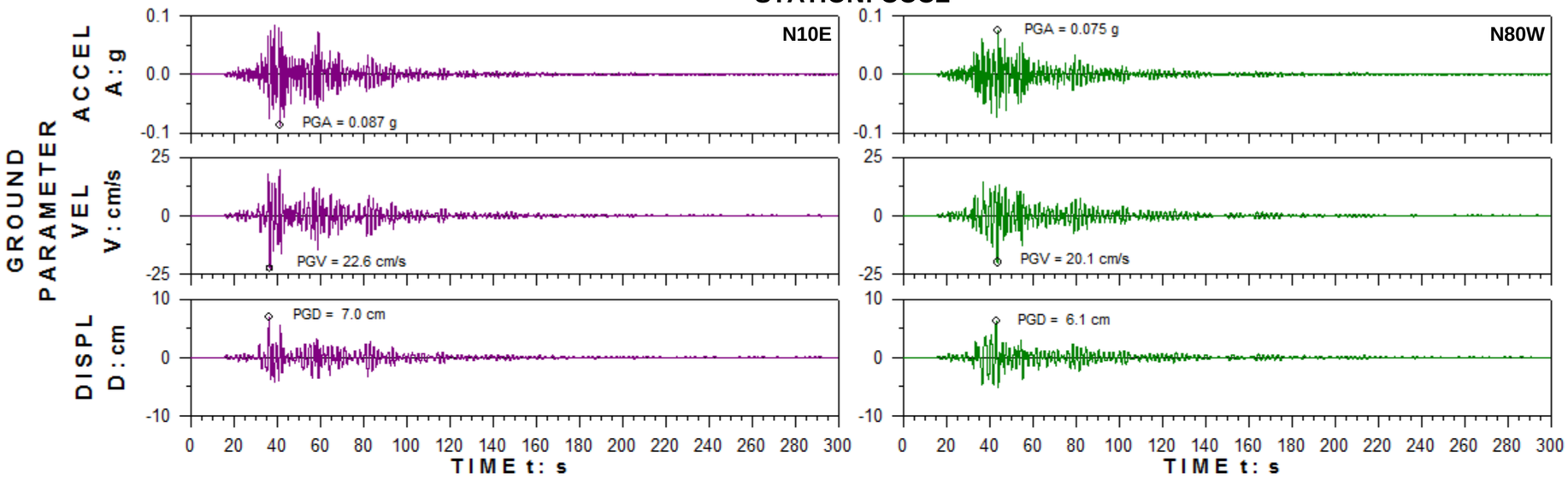
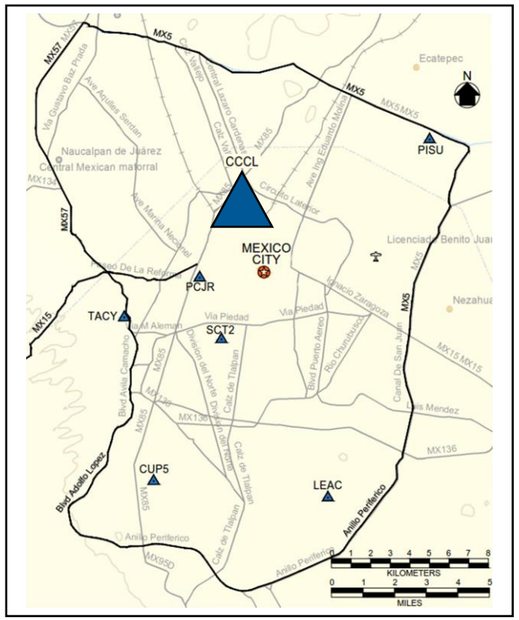
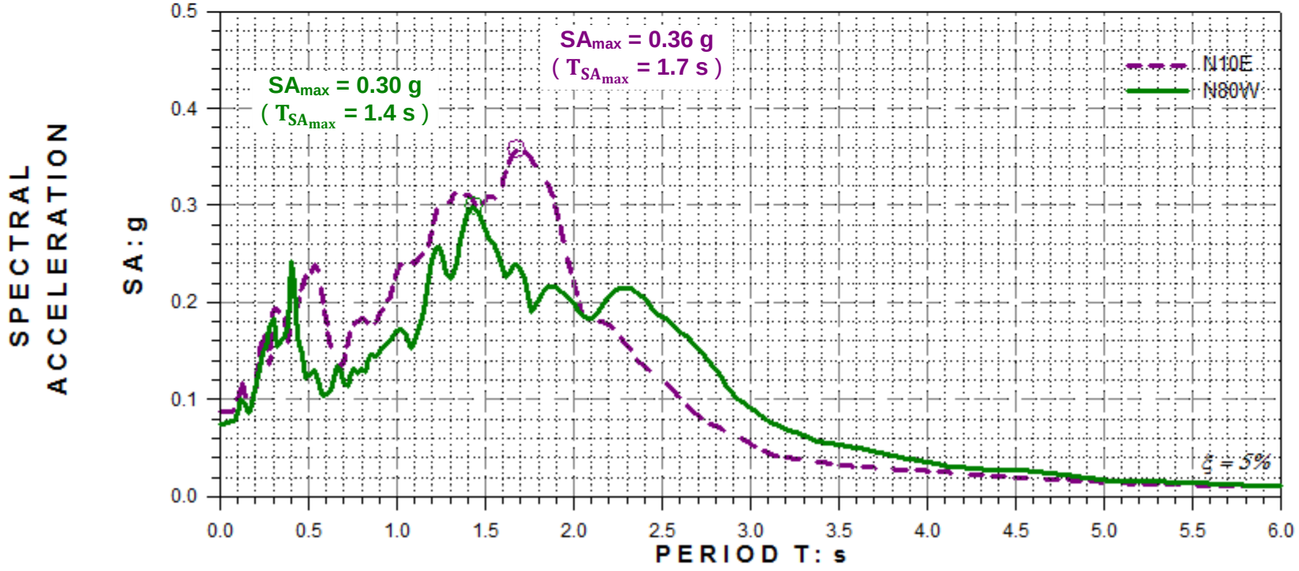


Figure A.1 Map showing location of IINGEN UNAM stations.

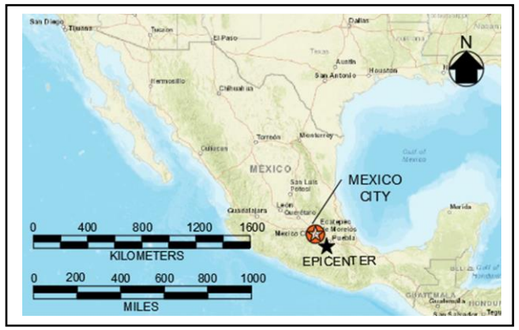
STATION: CCCL







Parameter	N10E	N80W
PGA (g)	0.087	0.075
PGV (cm/s)	22.6	20.1
PGD (cm)	7.0	6.1
Period of Highest Spectral Peak (s))	1.7	1.4
Arias Intensity (m/s)	0.523	0.370
R_e (km)	-	



NOTES

1. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico). Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) have been the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.
2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

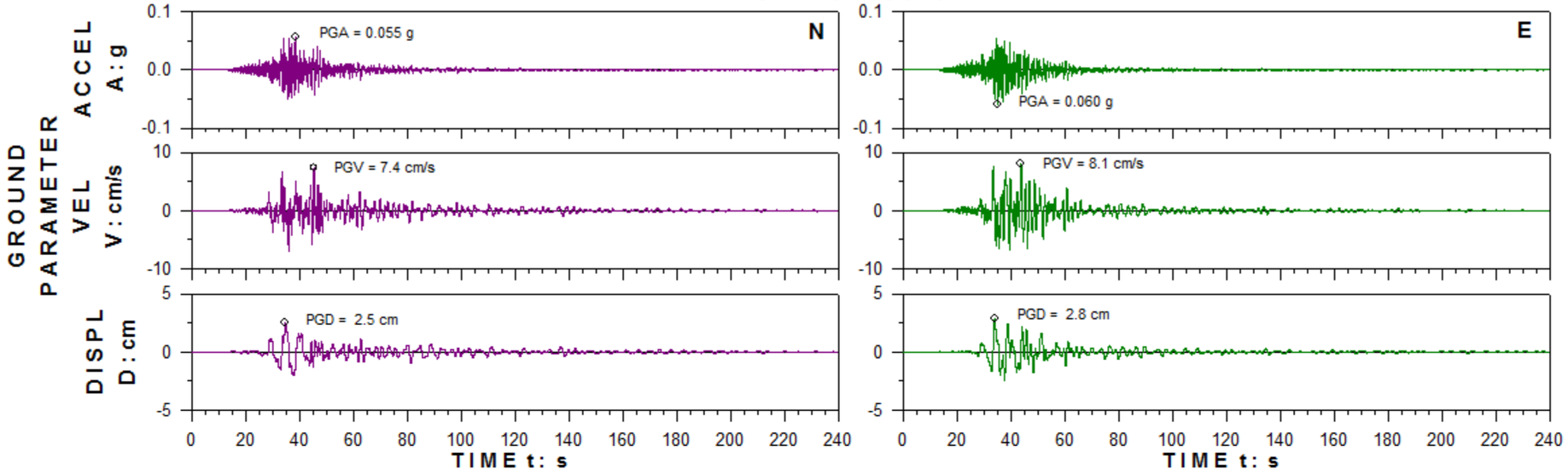
ATC-MEXICO RECONNAISSANCE

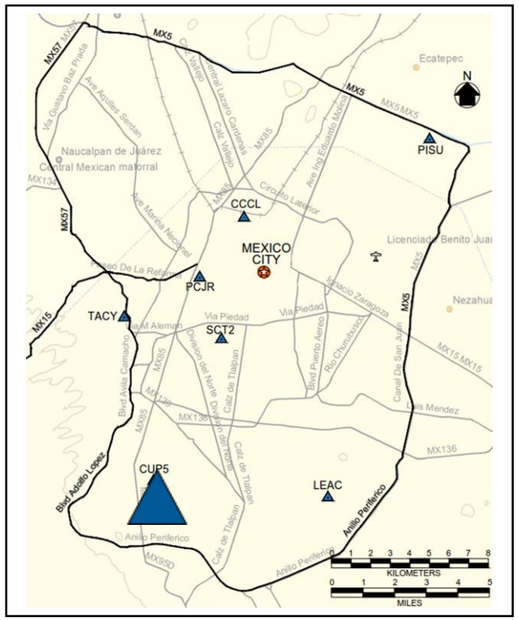
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

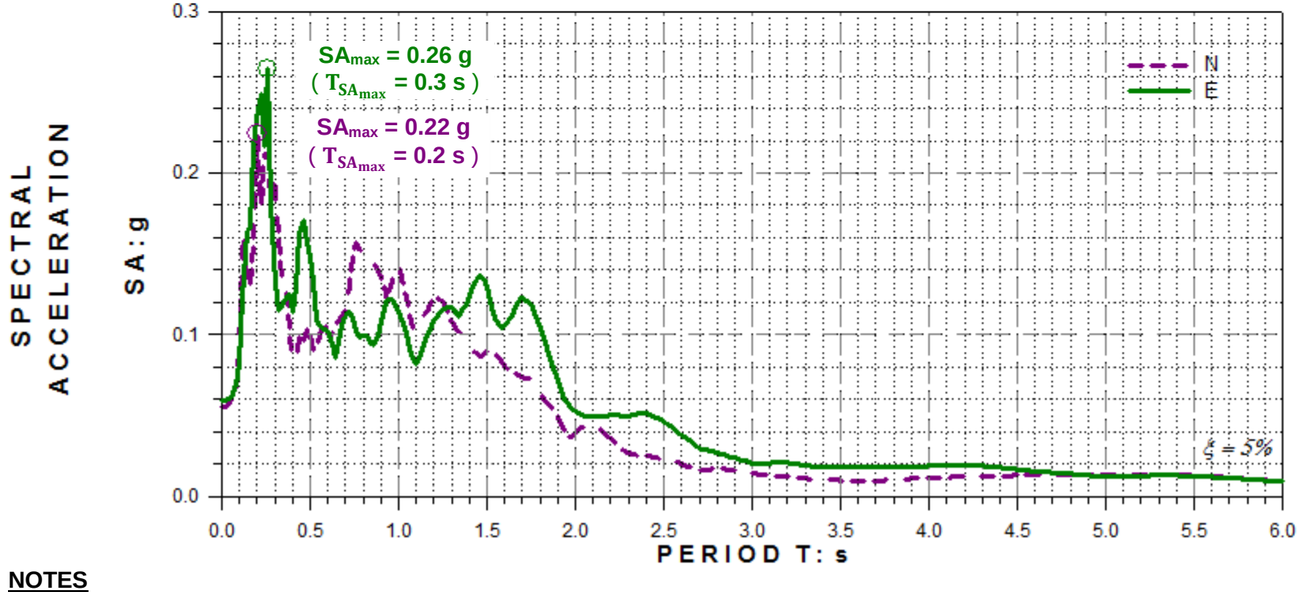
IINGEN-UNAM GROUND MOTIONS

CCCL STATION (19.450° N, 99.138° W) MEXICO CITY, MEXICO	STATION CCCL

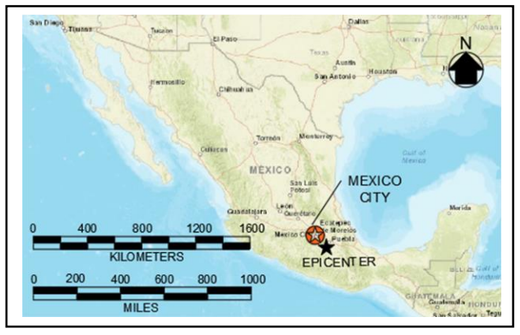
STATION: CUP5







Parameter	N	E
PGA (g)	0.055	0.060
PGV (cm/s)	7.4	8.1
PGD (cm)	2.5	2.8
Period of Highest Spectral Peak (s)	0.2	0.3
Arias Intensity (m/s)	0.105	0.127
R_e (km)	209	



NOTES

1. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico). Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) have been the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.
2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

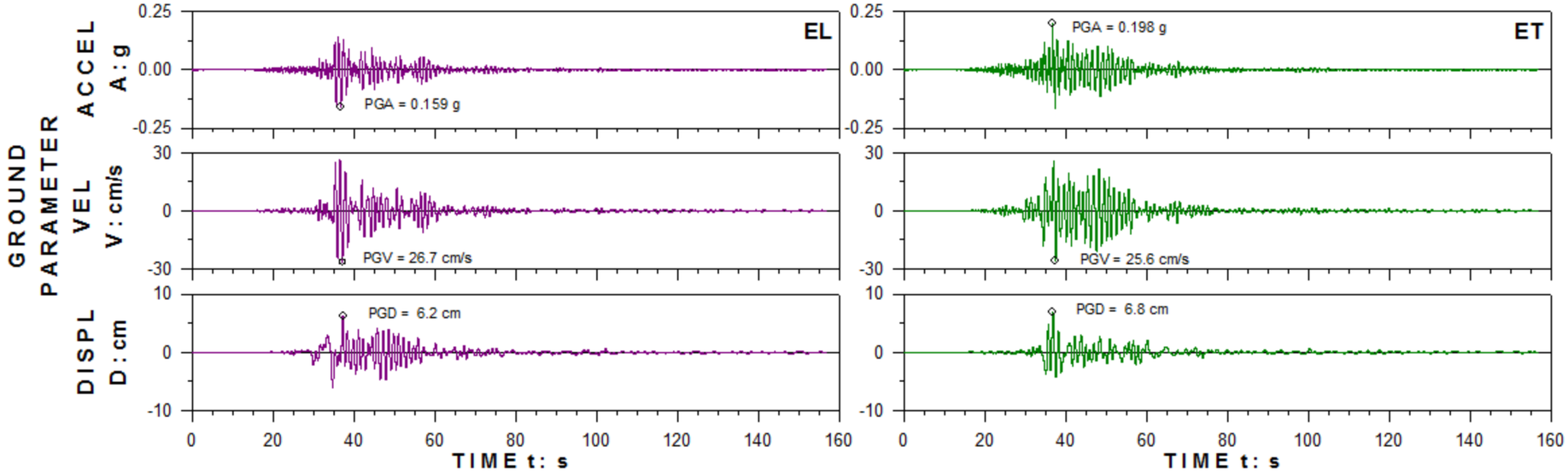
ATC-MEXICO RECONNAISSANCE

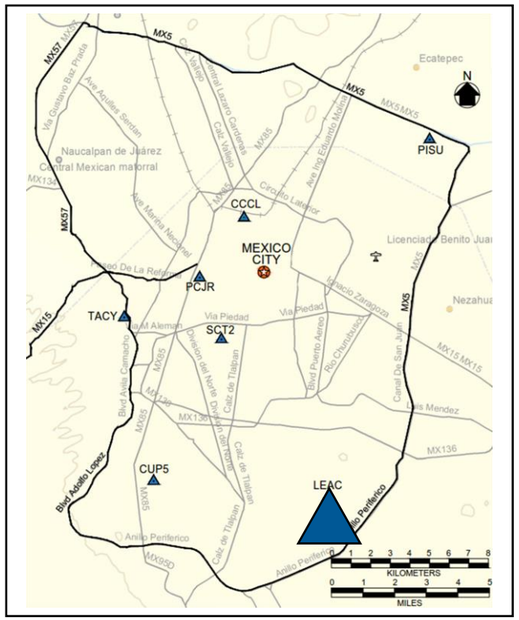
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

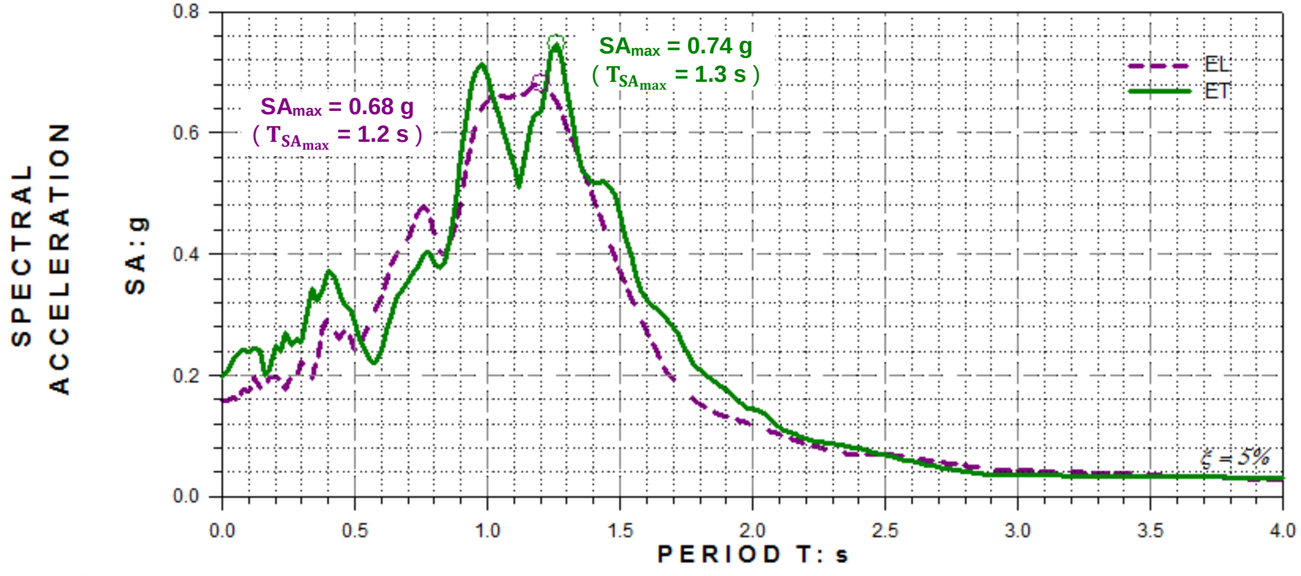
IINGEN-UNAM GROUND MOTIONS

CUP5 STATION (19.330° N, 99.181° W) MEXICO CITY, MEXICO	STATION CUP5

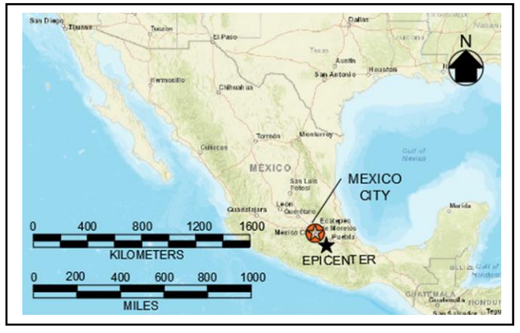
STATION: LEAC







Parameter	EL	ET
PGA (g)	0.159	0.198
PGV (cm/s)	26.7	25.6
PGD (cm)	6.2	6.8
Period of Highest Spectral Peak (s)	1.2	1.3
Arias Intensity (m/s)	0.805	1.242
R_e (km)	71	



NOTES

1. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico). Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) have been the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.
2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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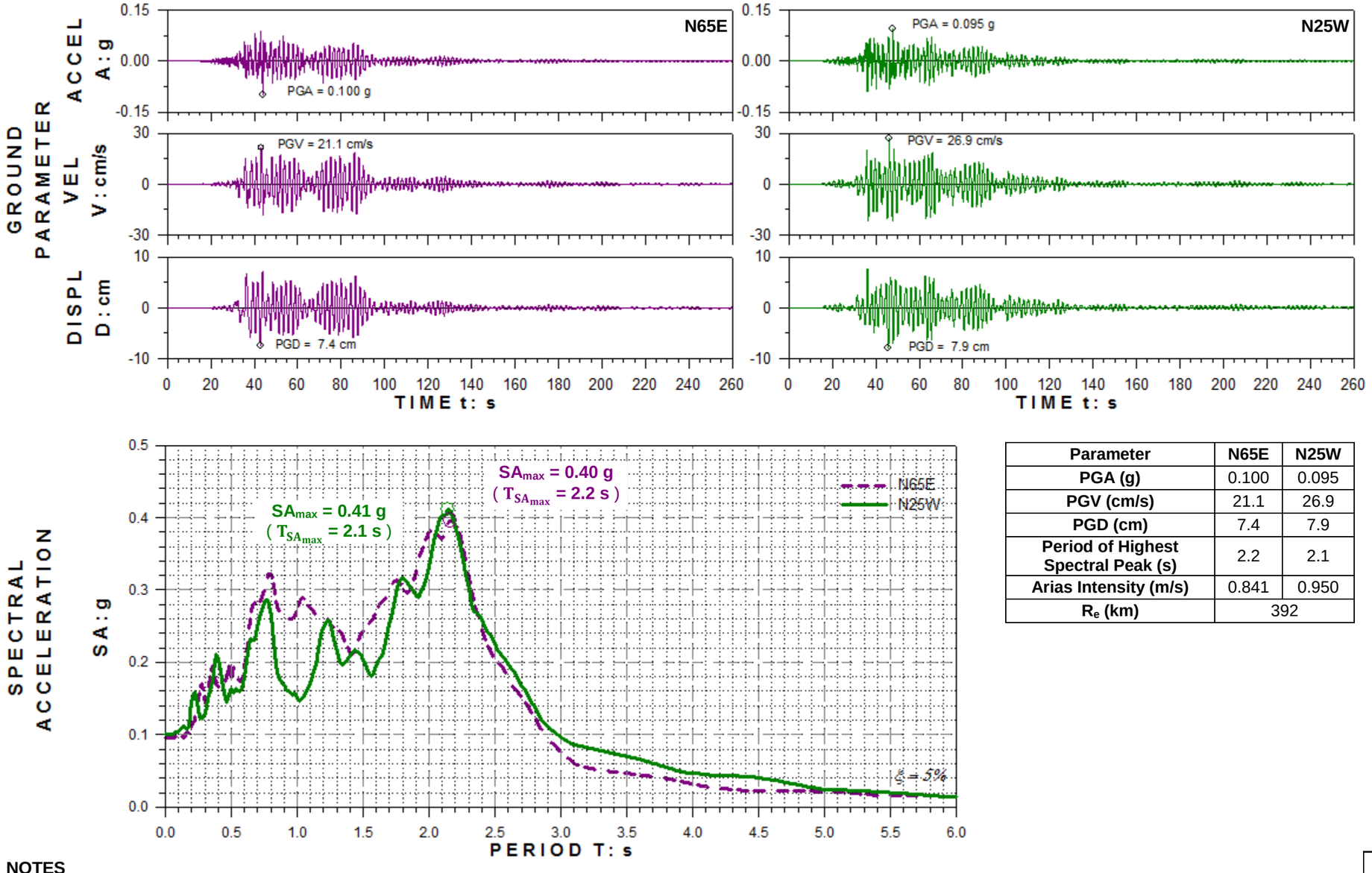
ATC-MEXICO RECONNAISSANCE

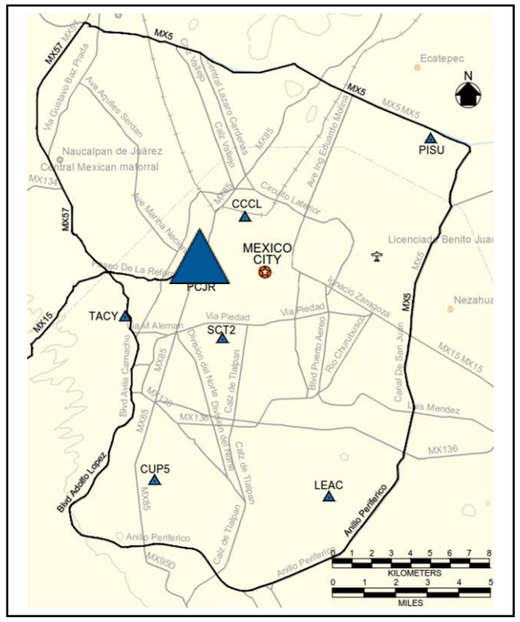
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

IINGEN-UNAM GROUND MOTIONS

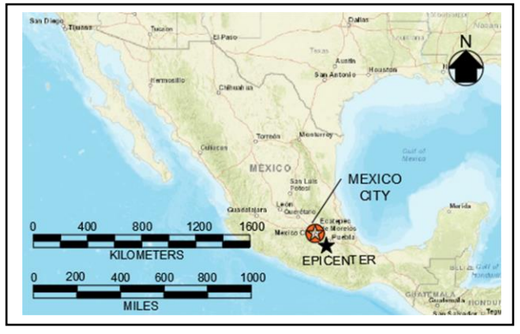
CUP5 STATION (19.323° N, 99.098° W) MEXICO CITY, MEXICO	STATION CUP5

STATION: PCJR





Parameter	N65E	N25W
PGA (g)	0.100	0.095
PGV (cm/s)	21.1	26.9
PGD (cm)	7.4	7.9
Period of Highest Spectral Peak (s)	2.2	2.1
Arias Intensity (m/s)	0.841	0.950
R_e (km)	392	



NOTES

1. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico). Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) have been the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.
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3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
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Applied Technology Council

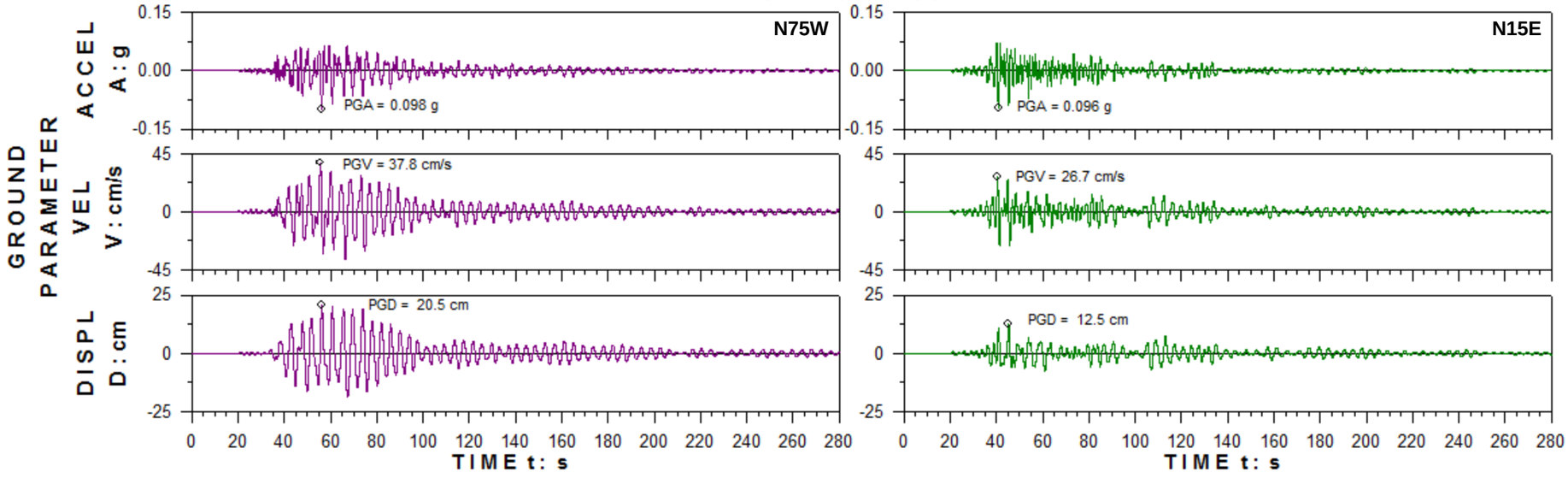
ATC-MEXICO RECONNAISSANCE

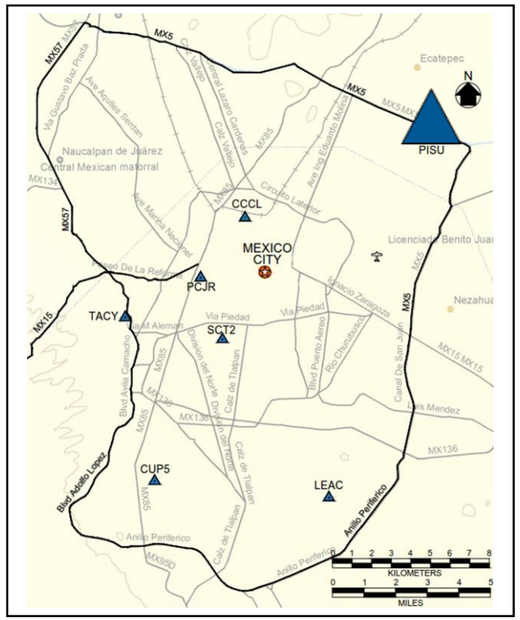
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

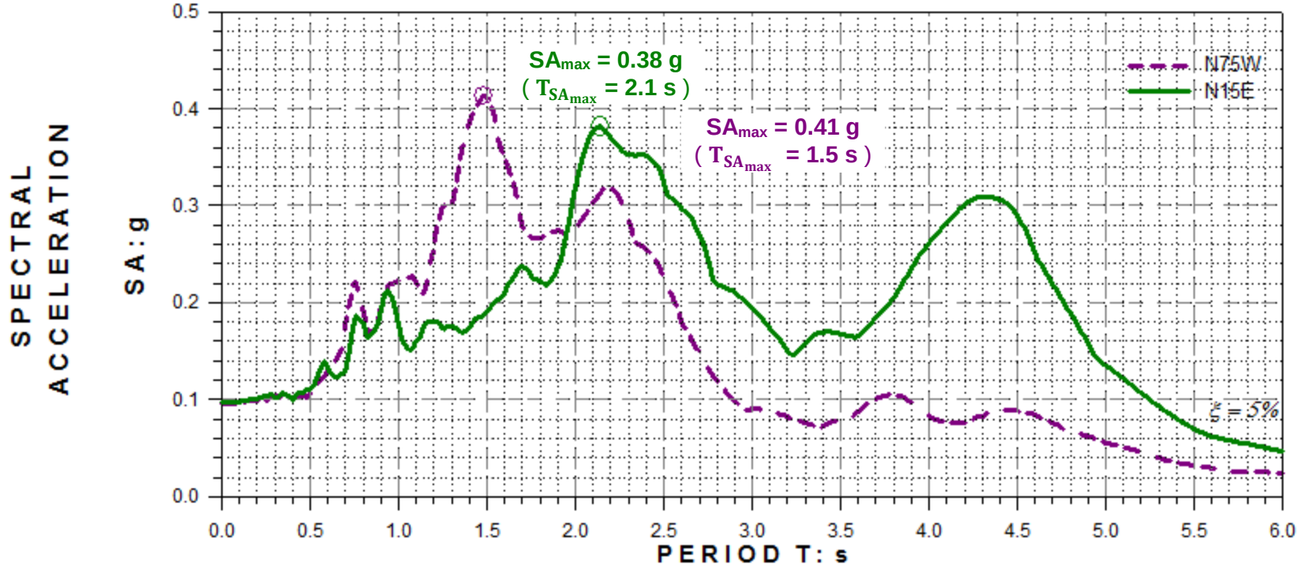
IINGEN-UNAM GROUND MOTIONS

PCJR STATION (19.423° N, 99.159° W) MEXICO CITY, MEXICO	STATION PCJR

STATION: PISU







Parameter	N75W	N15E
PGA (g)	0.098	0.096
PGV (cm/s)	37.8	26.7
PGD (cm)	20.5	12.5
Period of Highest Spectral Peak (s)	1.5	2.1
Arias Intensity (m/s)	0.957	0.638
R_e (km)	103	



NOTES

1. Raw ground motions were provided to ATC Team Mexico co-Leader Dr. Rodolfo Valles by IINGEN (Instituto de Ingeniería) of UNAM (National Autonomous University of Mexico). Details are provided in the IINGEN-UNAM (2017) ground motion report. Raw seismic data provided by the Strong Ground Motion Database System (http://aplicaciones.iingen.unam.mx/AcelerogramasRSM/) have been the work product of the Seismic Instrumentation group at the IINGEN-UNAM and its IT infrastructure.
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Applied Technology Council

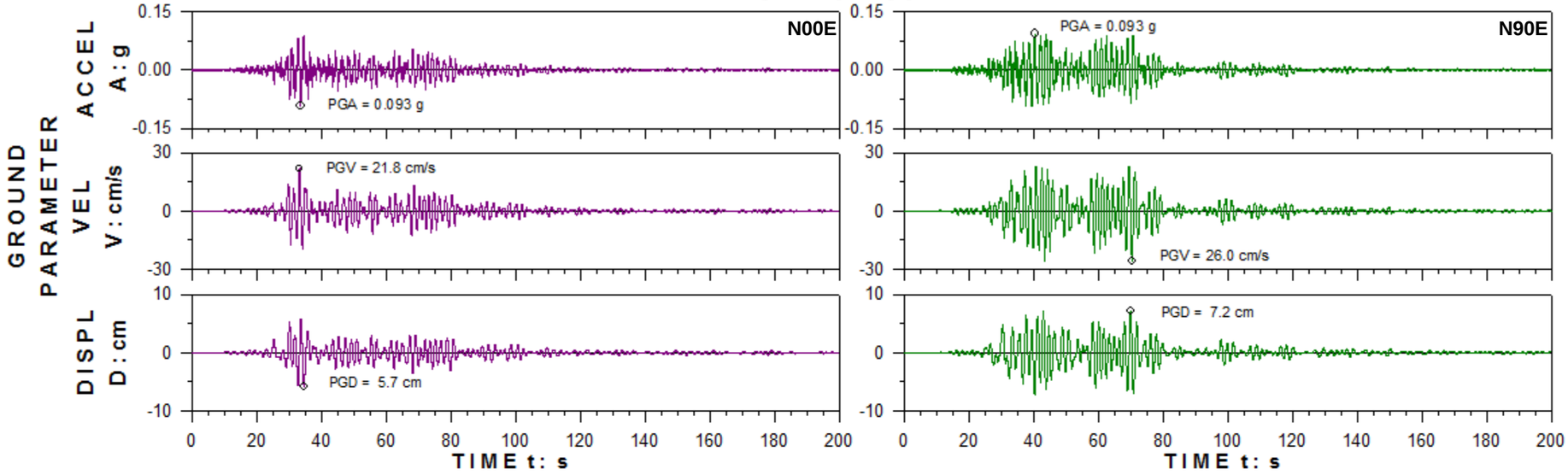
ATC-MEXICO RECONNAISSANCE

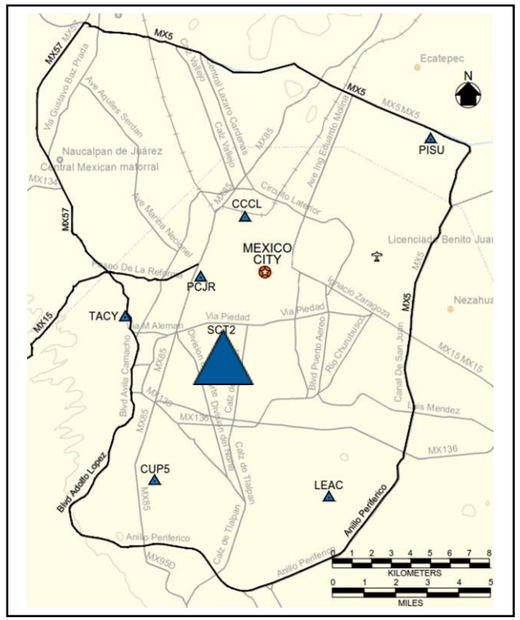
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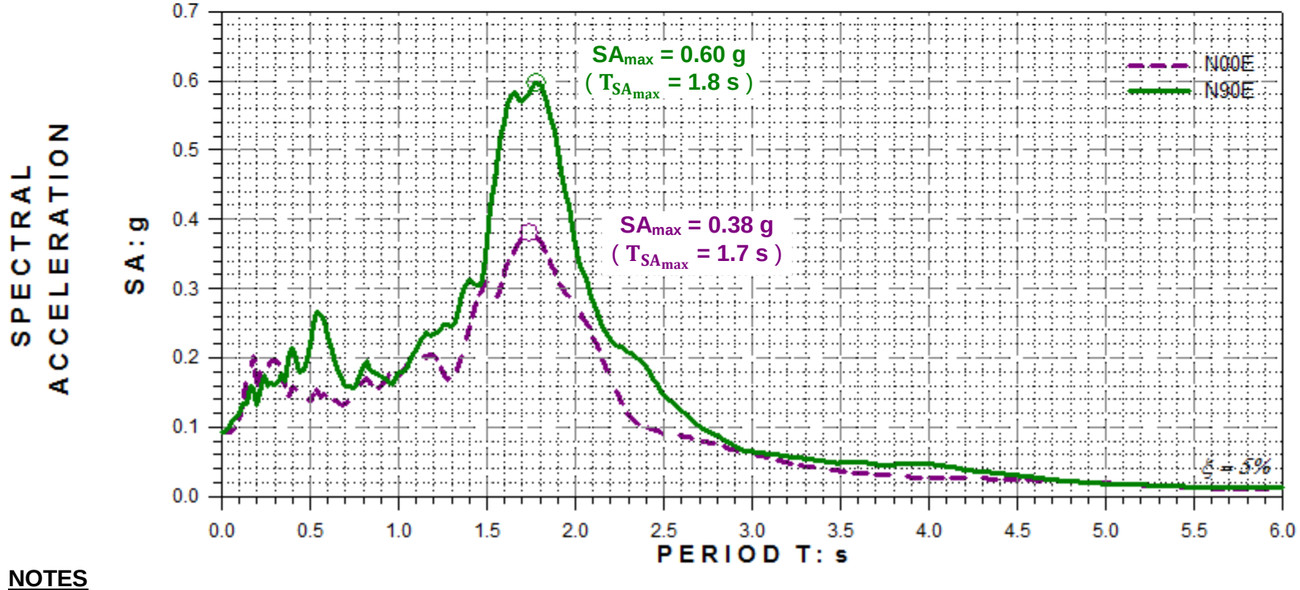
IINGEN-UNAM GROUND MOTIONS

PISU STATION (19.486° N, 99.049° W) MEXICO CITY, MEXICO	STATION PISU

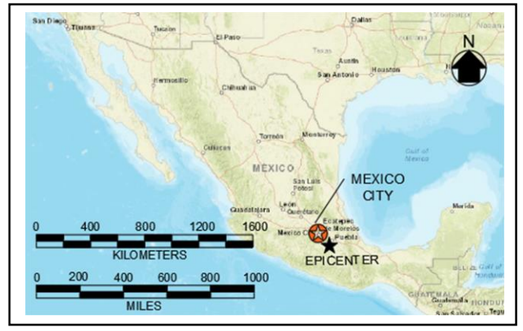
STATION: SCT2







Parameter	N00E	N90E
PGA (g)	0.093	0.093
PGV (cm/s)	21.8	26.0
PGD (cm)	5.7	7.2
Period of Highest Spectral Peak (s)	1.7	1.8
Arias Intensity (m/s)	0.538	1.242
R_e (km)	121	



NOTES

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2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

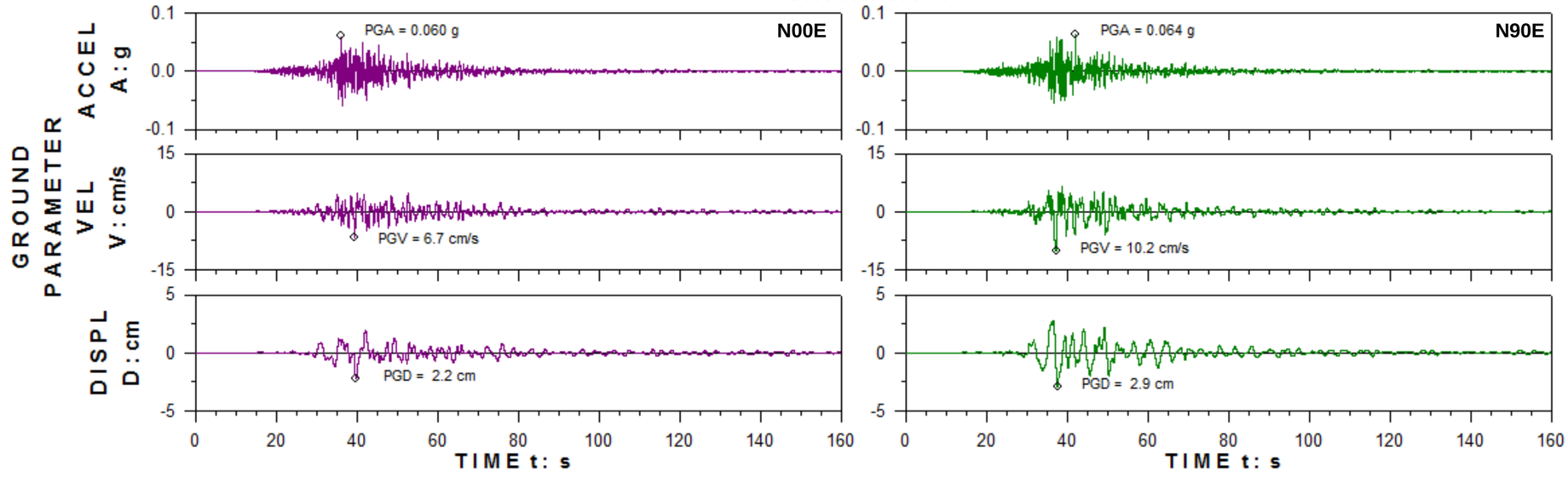
ATC-MEXICO RECONNAISSANCE

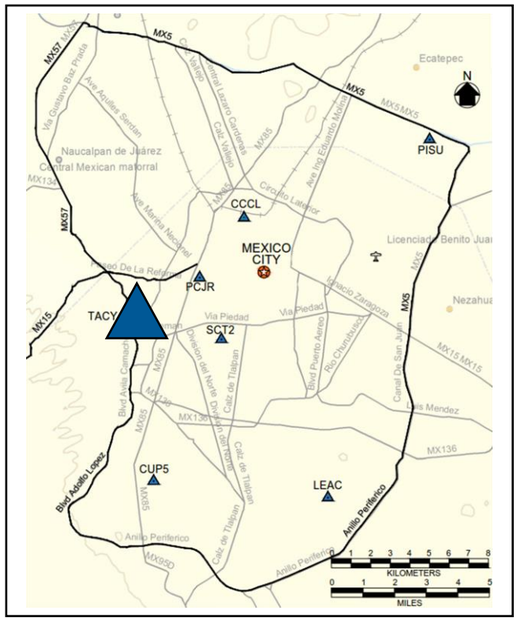
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

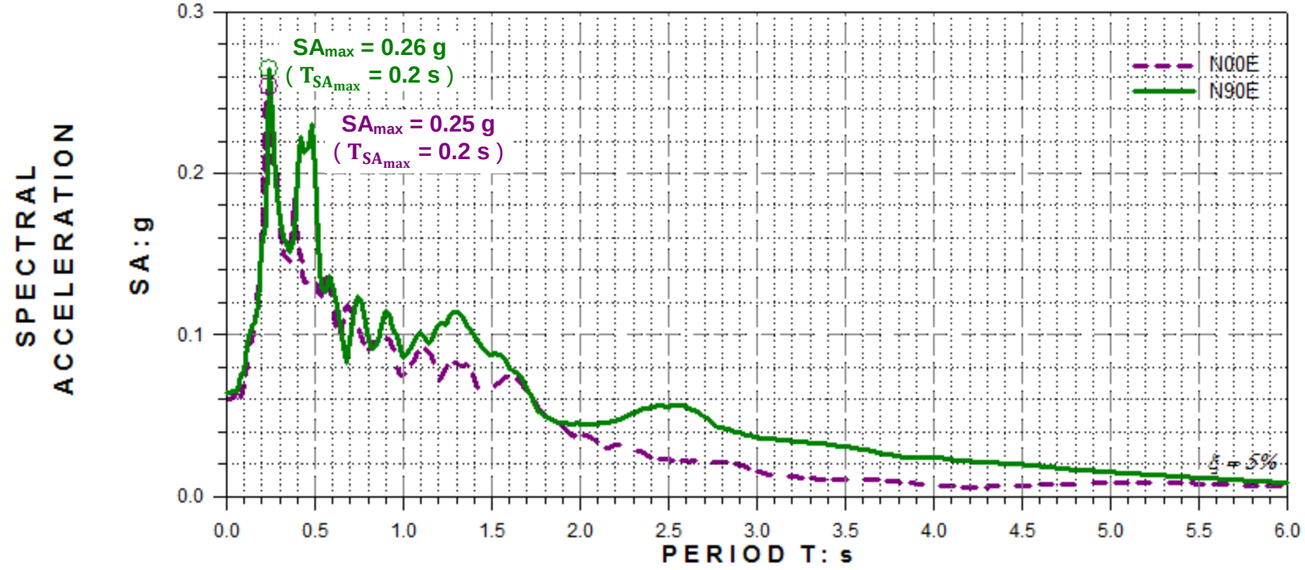
IINGEN-UNAM GROUND MOTIONS

SCT2 STATION (19.395° N, 99.149° W) MEXICO CITY, MEXICO	STATION SCT2

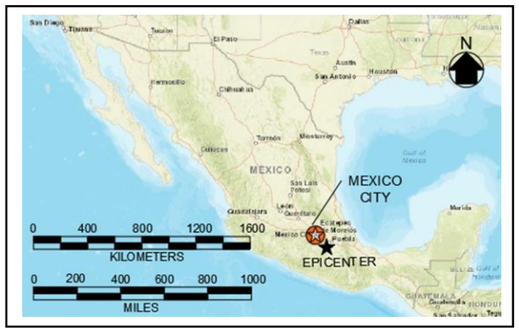
STATION: TACY







Parameter	N00E	N90E
PGA (g)	0.060	0.064
PGV (cm/s)	6.7	10.2
PGD (cm)	2.2	2.9
Period of Highest Spectral Peak (s)	0.2	0.2
Arias Intensity (m/s)	0.111	0.119
R_e (km)	101	



NOTES

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2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bp 0.1-23 Hz, ord. 4) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

ATC-MEXICO RECONNAISSANCE

M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

IINGEN-UNAM GROUND MOTIONS

TACY STATION (19.405° N, 99.195° W) MEXICO CITY, MEXICO	STATION TACY

Appendix B
Ground Motion Recordings from CIRES

This Appendix presents 64 ground motion records from the 2017 M_w7.1 Puebla-Morelos earthquake. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).

Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-32 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.

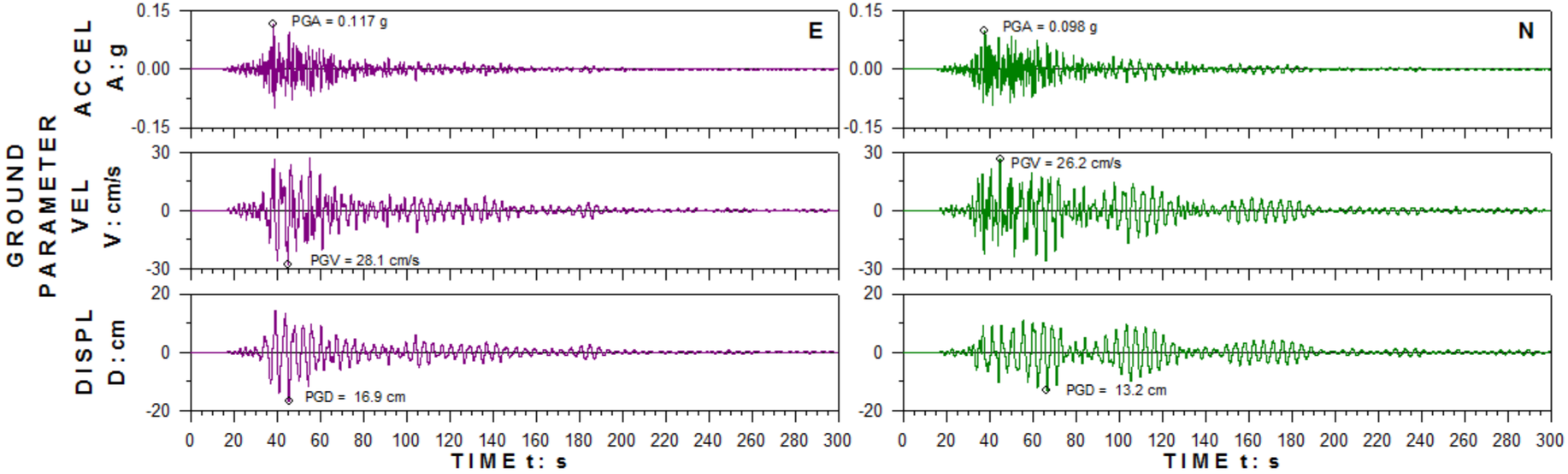
Figure B.1 shows a map with the locations of the CIRES stations. The following pages present time histories and spectral acceleration information for the following stations (in alphabetical order):

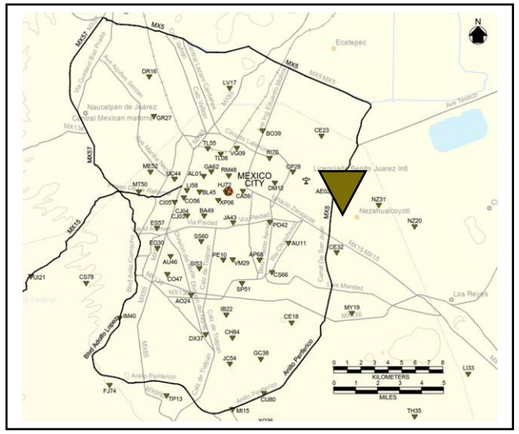
1. AE02
2. AL01
3. AO24
4. AP68
5. AU11
6. AU46
7. BA49
8. BL45
9. BO39
10. CA59
11. CE18
12. CE23
13. CE32
14. CH84
15. CI05
16. CJ03
17. CJ04
18. CO47
19. CO56
20. CP28
21. CS66
22. CS78
23. CU80
24. DM12
25. DR16
26. DX37
27. EO30
28. ES57
29. FJ74
30. GA62
31. GC38
32. GR27
33. HJ72
34. IB22
35. IM40
36. JA43
37. JC54
38. LI33
39. LI58
40. LV17
41. ME52
42. MI15
43. MT50
44. MY19
45. NZ20
46. NZ31
47. PA34
48. PD42
49. PE10
50. RI76
51. RM48
52. SI53
53. SP51
54. SS60
55. TH35
56. TL08
57. TL55
58. TP13
59. UC44
60. UI21
61. VG09
62. VM29
63. XO36
64. XP06

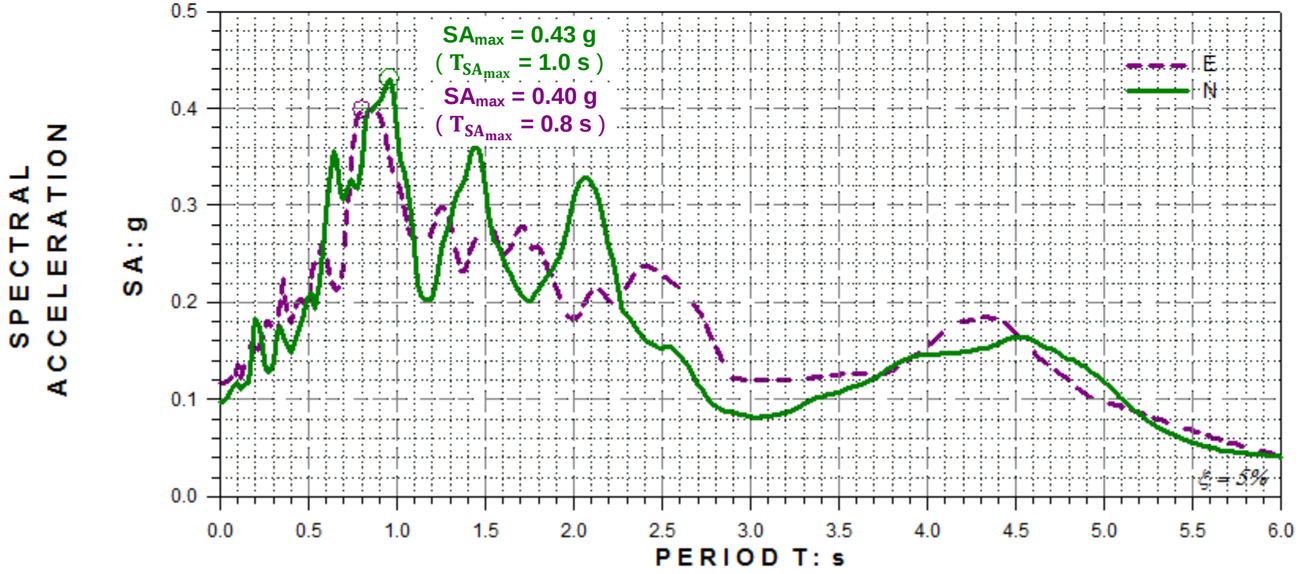


Figure B.1 Map showing location of CIRES stations.

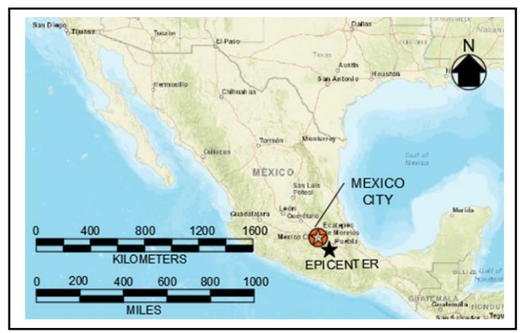
STATION: AE02







Parameter	E	N
PGA (g)	0.117	0.098
PGV (cm/s)	28.1	26.2
PGD (cm)	16.9	13.2
Period of Highest Spectral Peak (s)	0.8	1.0
Arias Intensity (m/s)	0.710	0.962
R_e (km)	120	



NOTES

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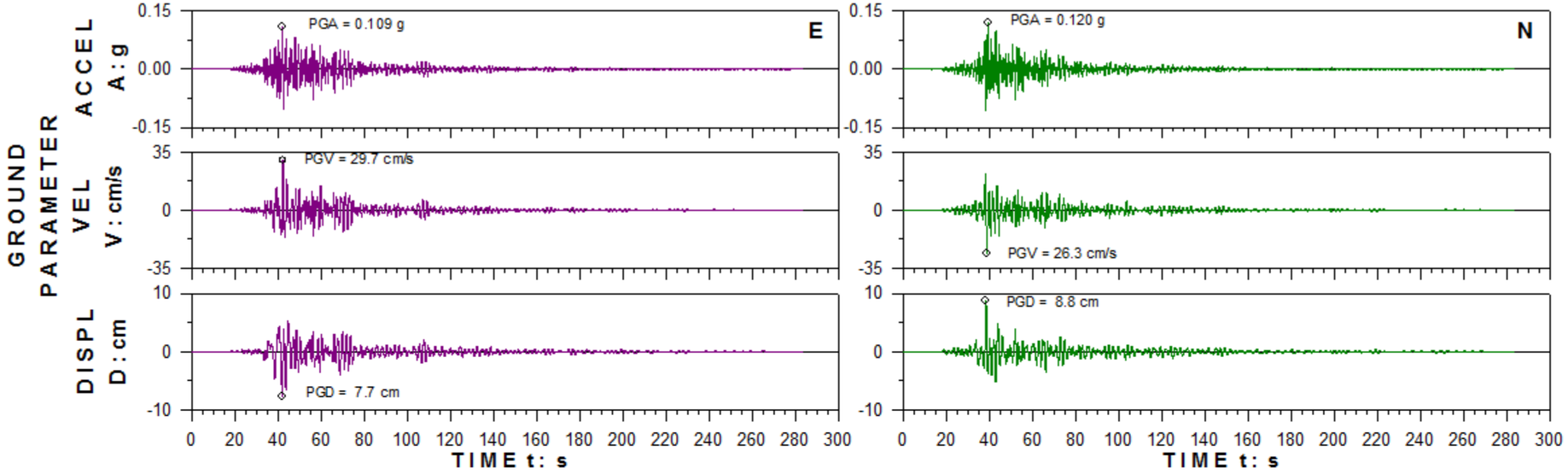
ATC-MEXICO RECONNAISSANCE

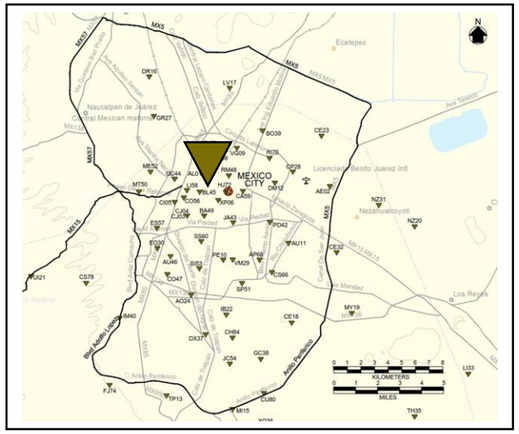
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

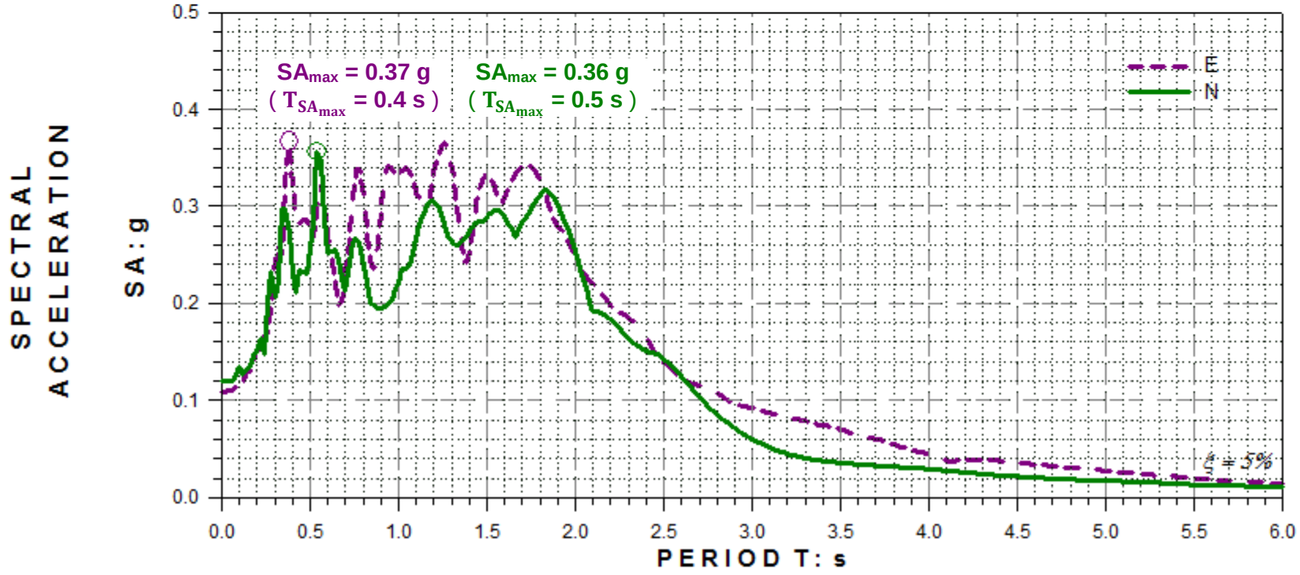
CIRES GROUND MOTIONS

AE02 STATION (19.429° N, 98.942° W) MEXICO CITY, MEXICO | STATION AE02

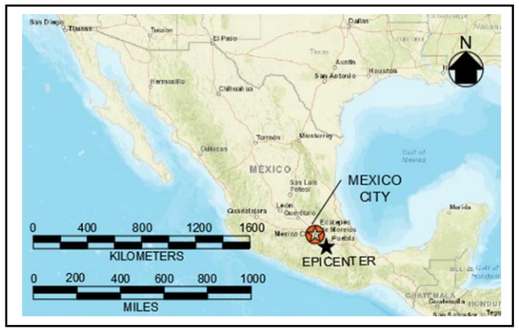
STATION: AL01







Parameter	E	N
PGA (g)	0.109	0.120
PGV (cm/s)	29.7	26.3
PGD (cm)	7.7	8.8
Period of Highest Spectral Peak (s)	0.4	0.5
Arias Intensity (m/s)	0.665	0.555
R_e (km)	123	



NOTES

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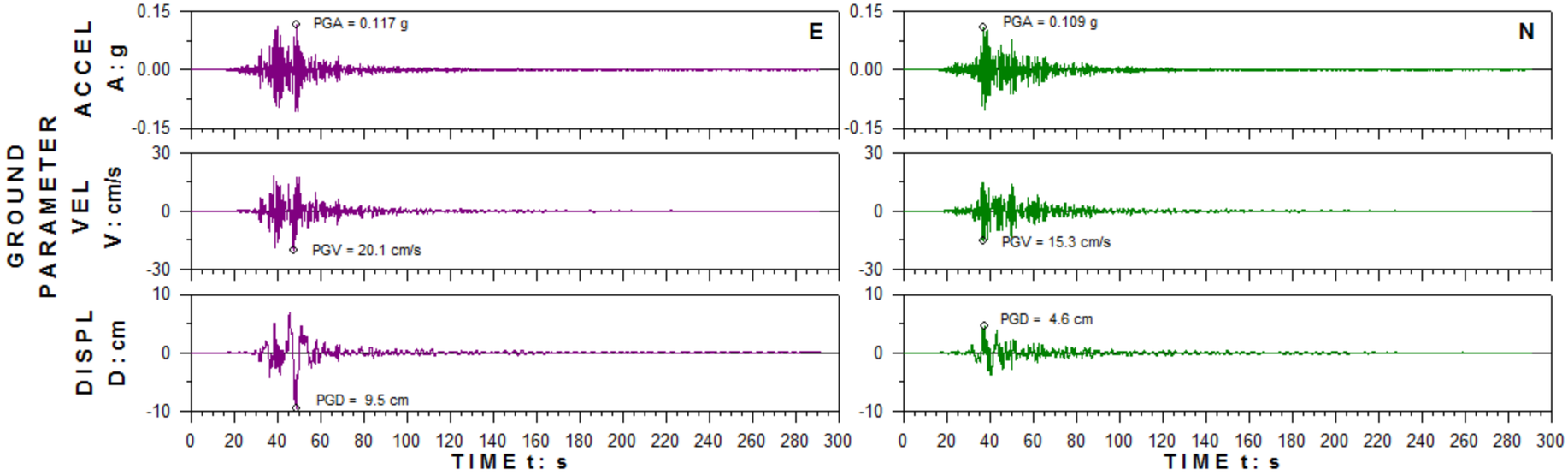
ATC-MEXICO RECONNAISSANCE

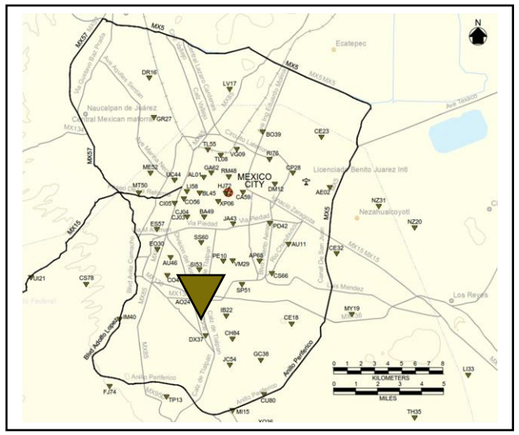
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

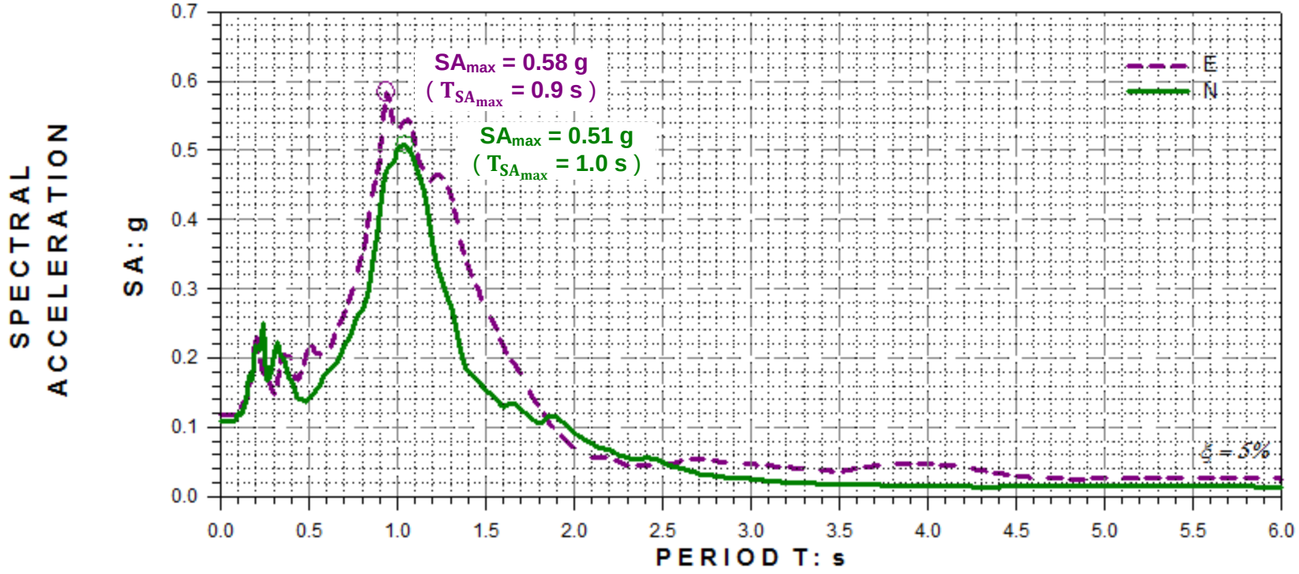
CIRES GROUND MOTIONS

AL01 STATION (19.436° N, 98.855° W) MEXICO CITY, MEXICO	STATION AL01

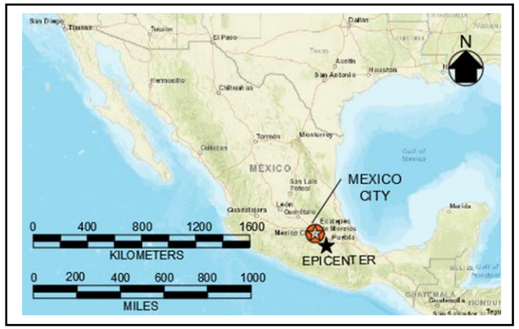
STATION: AO24







Parameter	E	N
PGA (g)	0.117	0.109
PGV (cm/s)	20.1	15.3
PGD (cm)	9.5	4.6
Period of Highest Spectral Peak (s)	0.9	1.0
Arias Intensity (m/s)	0.644	0.496
R_e (km)	116	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
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Applied Technology Council

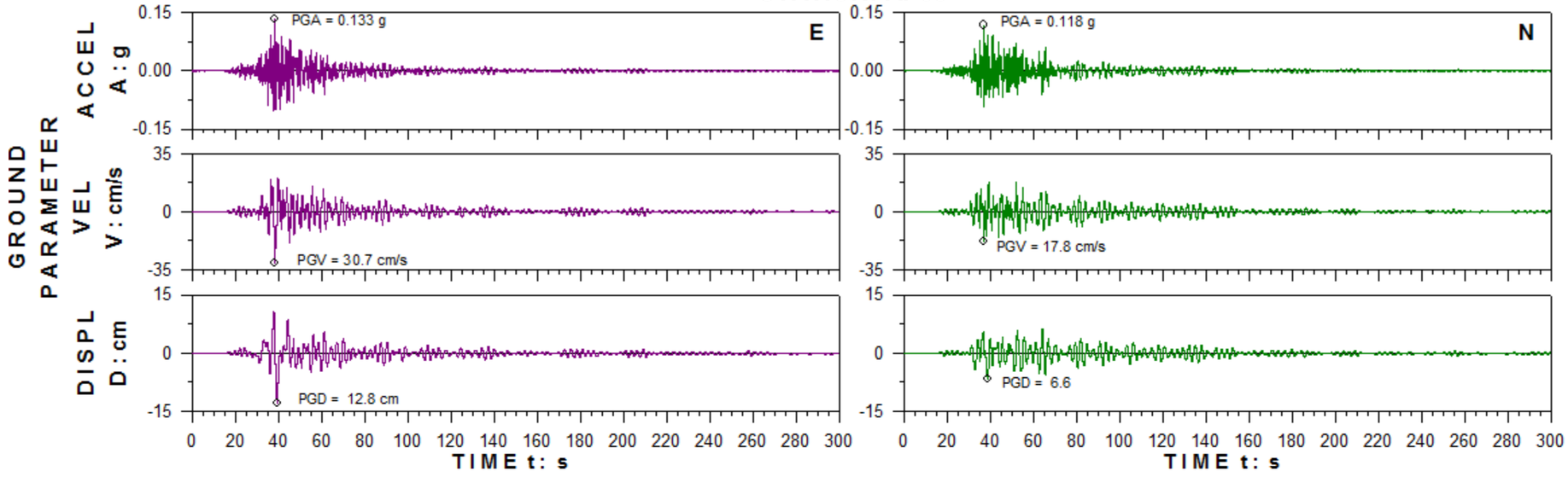
ATC-MEXICO RECONNAISSANCE

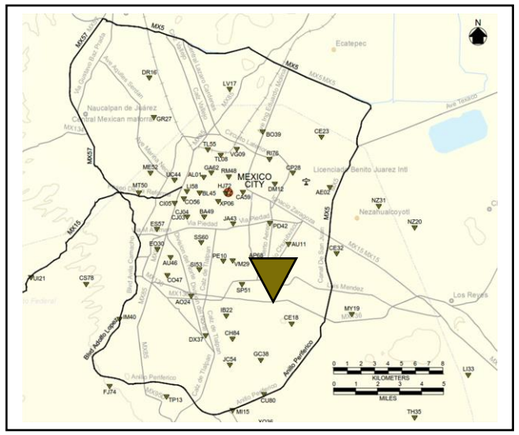
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

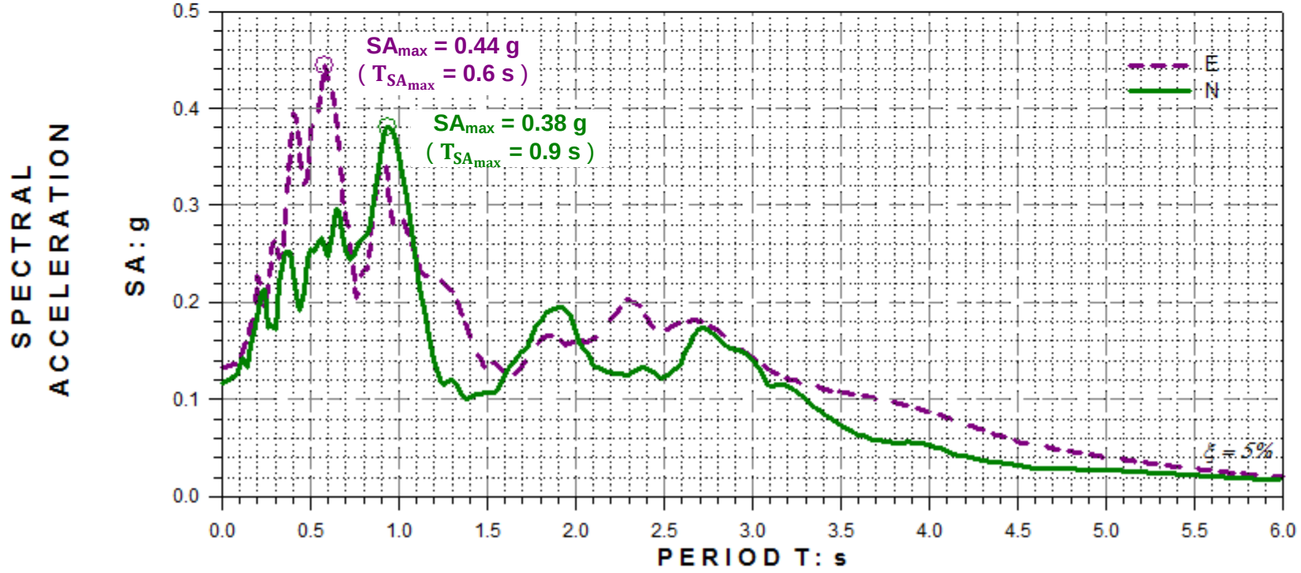
CIRES GROUND MOTIONS

AO24 STATION (19.358° N, 98.846° W) MEXICO CITY, MEXICO	STATION AO24

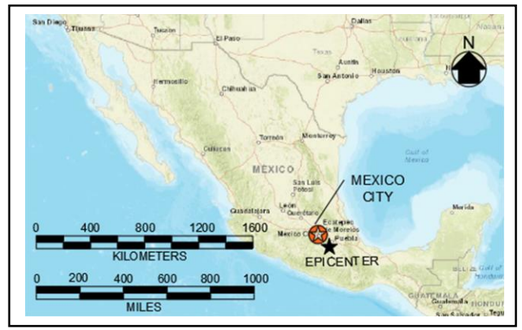
STATION: AP68







Parameter	E	N
PGA (g)	0.133	0.118
PGV (cm/s)	30.7	17.8
PGD (cm)	12.8	6.6
Period of Highest Spectral Peak (s)	0.6	0.9
Arias Intensity (m/s)	0.660	0.567
R_e (km)	116	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.09-19 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

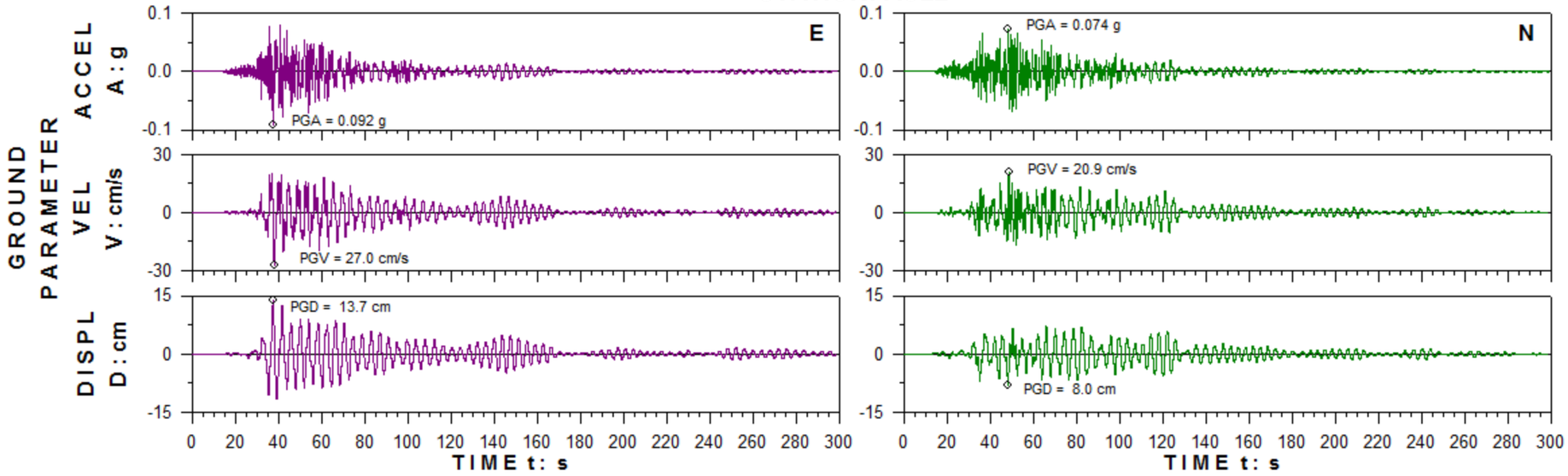
ATC-MEXICO RECONNAISSANCE

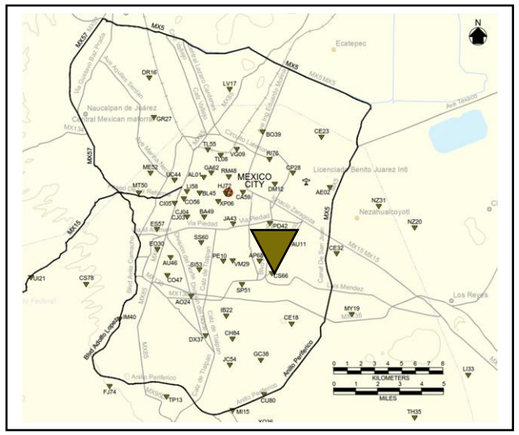
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

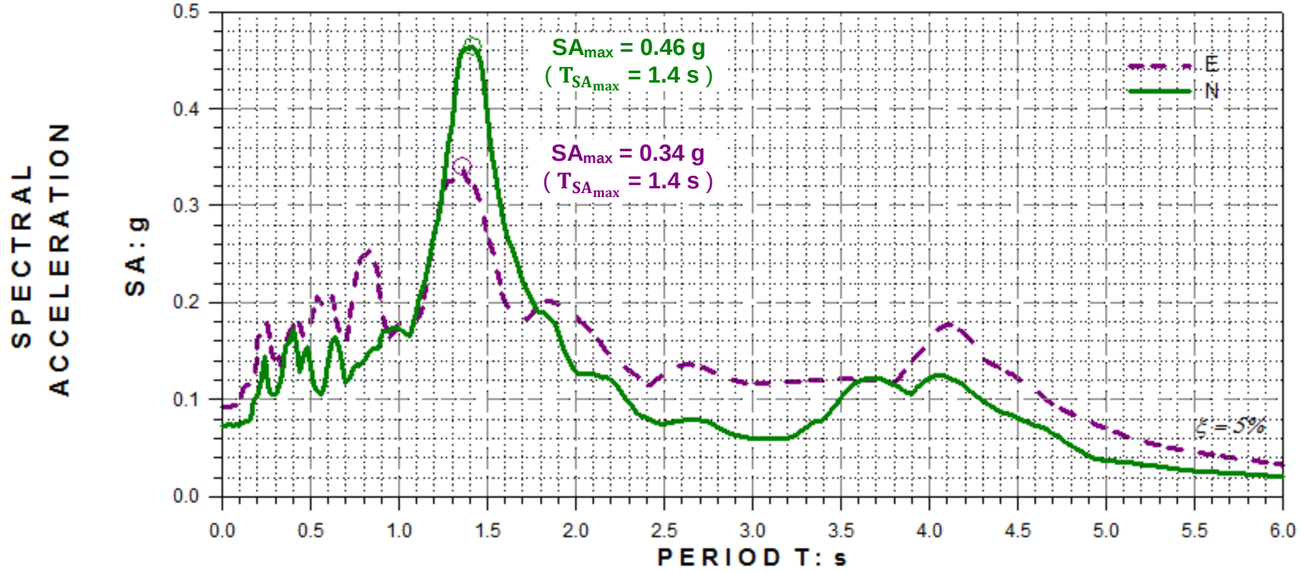
CIRES GROUND MOTIONS

AP68 STATION (19.381° N, 98.893° W) MEXICO CITY, MEXICO	STATION AP68

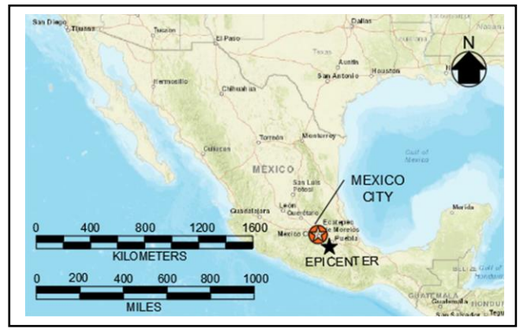
STATION: AU11







Parameter	E	N
PGA (g)	0.092	0.074
PGV (cm/s)	27.0	20.9
PGD (cm)	13.7	8.0
Period of Highest Spectral Peak (s)	1.4	1.4
Arias Intensity (m/s)	0.615	0.591
R_e (km)	117	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were done by ATC-Mexico team members using Butterworth filter (bandpass 0.07-20 Hz, 4 poles, 2 passes) and linear base line correction. A structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

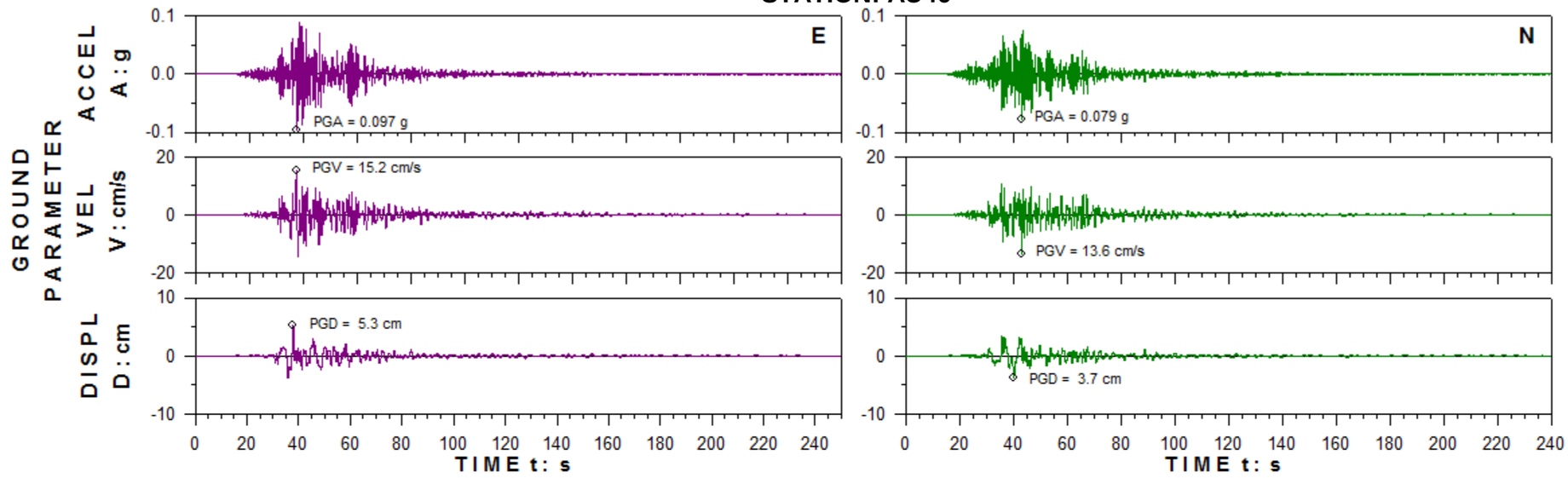
ATC-MEXICO RECONNAISSANCE

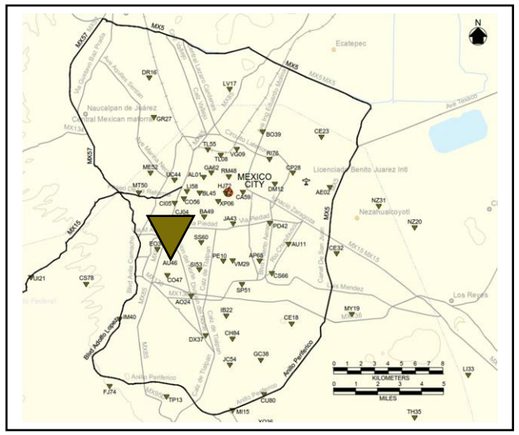
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

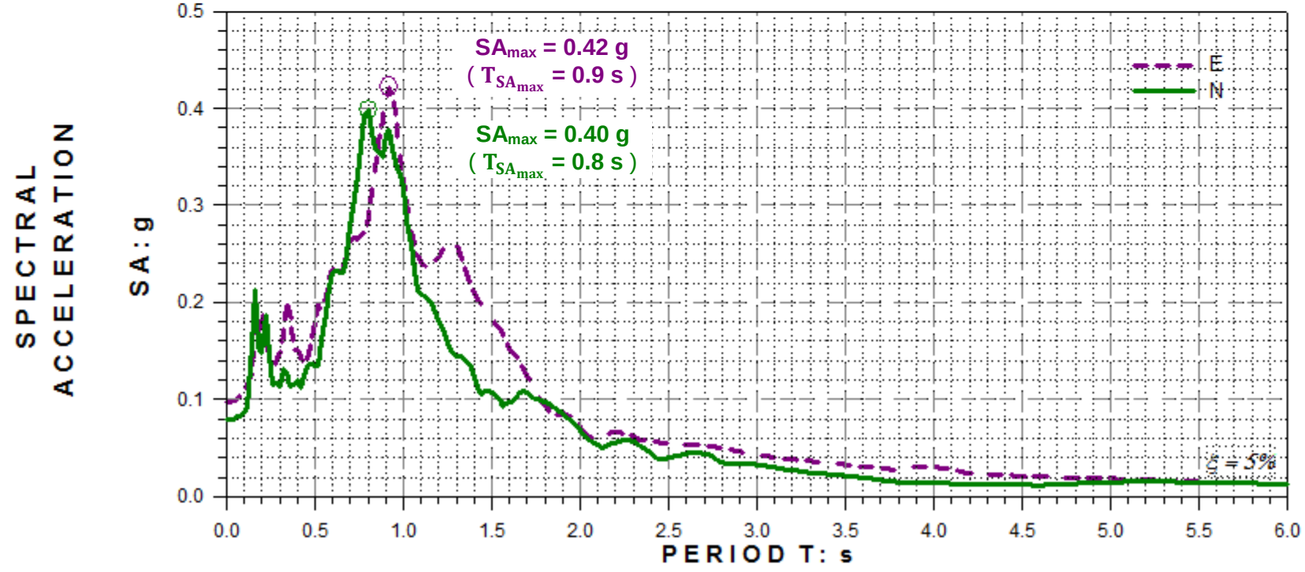
CIRES GROUND MOTIONS

AU11 STATION (19.392° N, 98.913° W) MEXICO CITY, MEXICO	STATION AU11

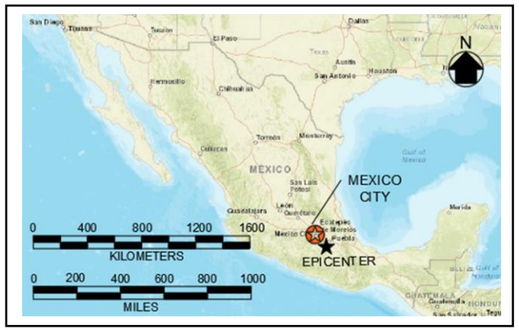
STATION: AU46







Parameter	E	N
PGA (g)	0.097	0.079
PGV (cm/s)	15.2	13.6
PGD (cm)	5.3	3.7
Period of Highest Spectral Peak (s)	0.9	0.8
Arias Intensity (m/s)	0.388	0.329
R_e (km)	119	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-36 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

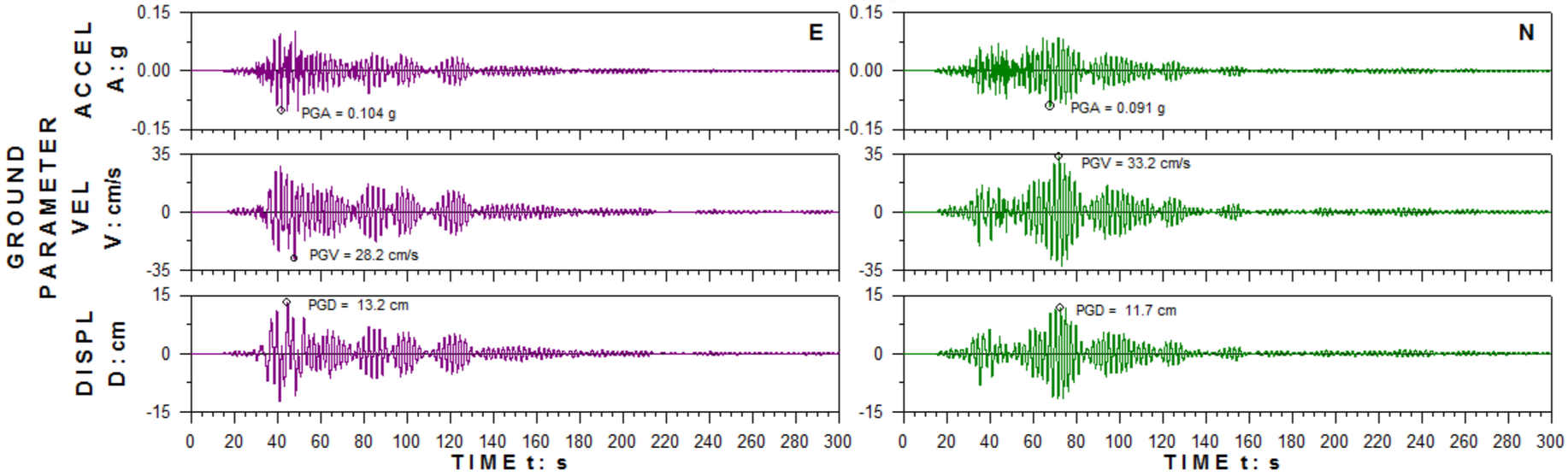
ATC-MEXICO RECONNAISSANCE

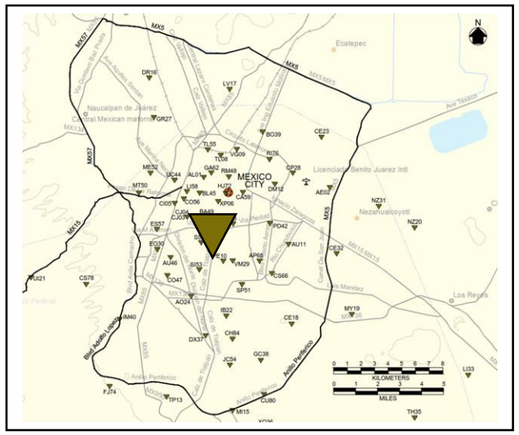
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

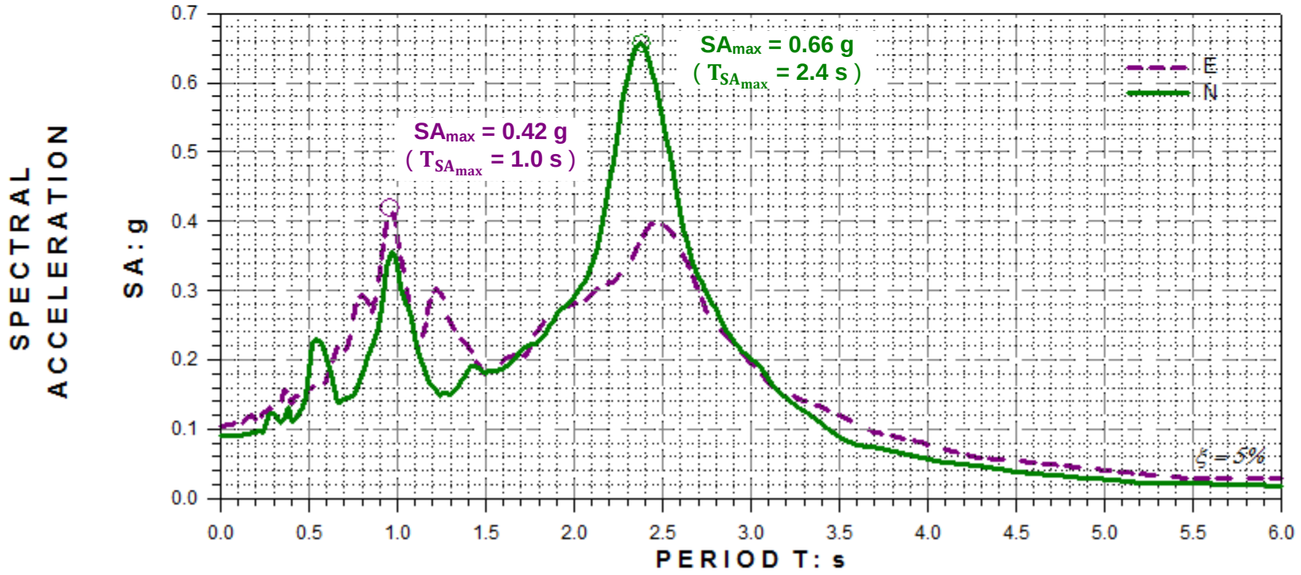
CIRES GROUND MOTIONS

AU46 STATION (19.383° N, 98.832° W) MEXICO CITY, MEXICO	STATION AU46

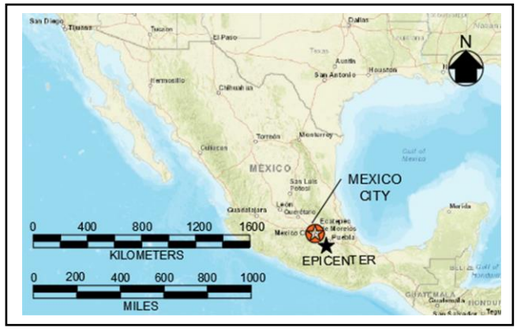
STATION: BA49







Parameter	E	N
PGA (g)	0.104	0.091
PGV (cm/s)	28.2	33.2
PGD (cm)	13.2	11.7
Period of Highest Spectral Peak (s)	1.0	2.4
Arias Intensity (m/s)	1.101	1.314
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-39 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

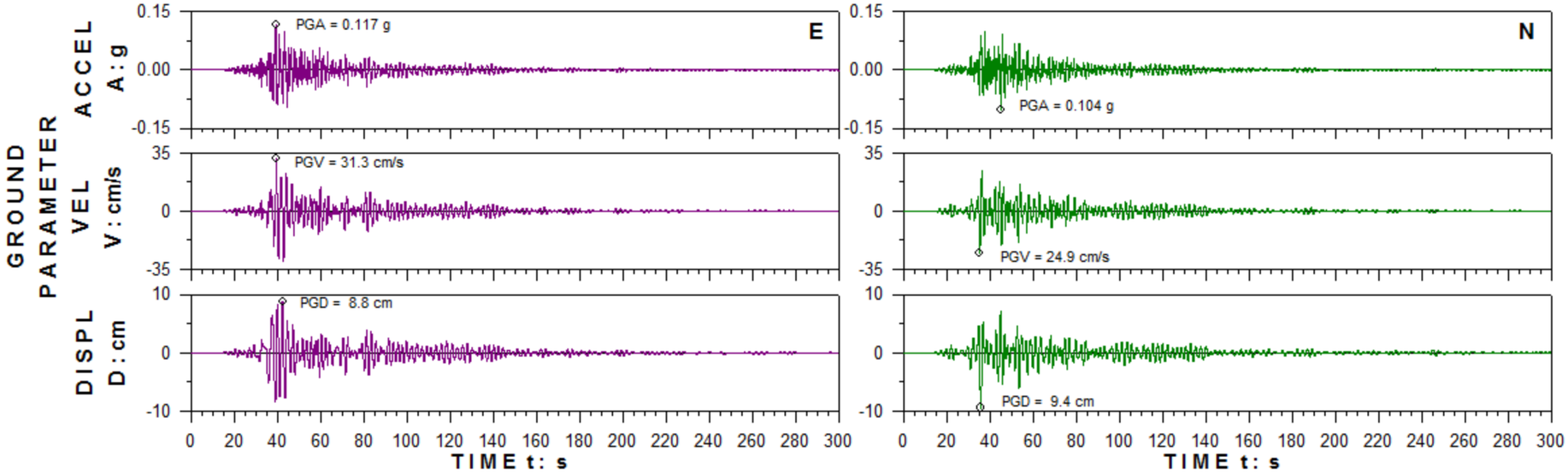
ATC-MEXICO RECONNAISSANCE

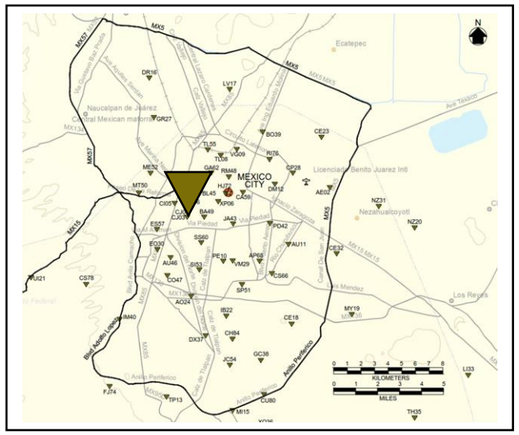
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

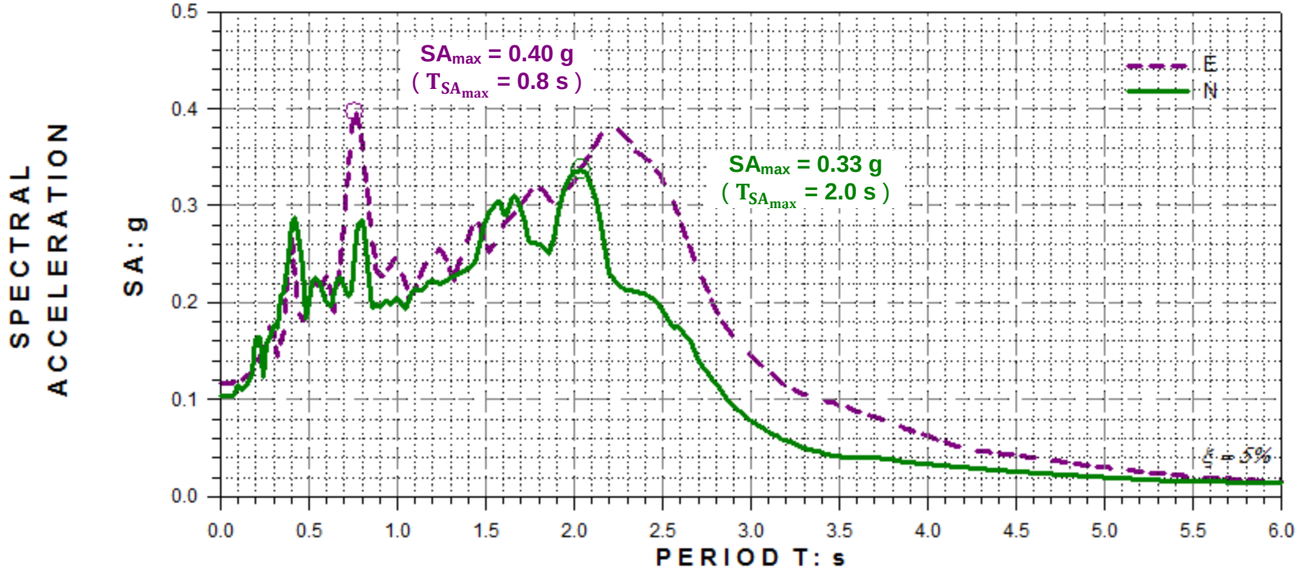
CIRES GROUND MOTIONS

BA49 STATION (19.410° N, 98.855° W) MEXICO CITY, MEXICO	STATION BA49

STATION: BL45







Parameter	E	N
PGA (g)	0.117	0.104
PGV (cm/s)	31.3	24.9
PGD (cm)	8.8	9.4
Period of Highest Spectral Peak (s)	0.8	2.0
Arias Intensity (m/s)	0.719	0.612
R_e (km)	122	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.16-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

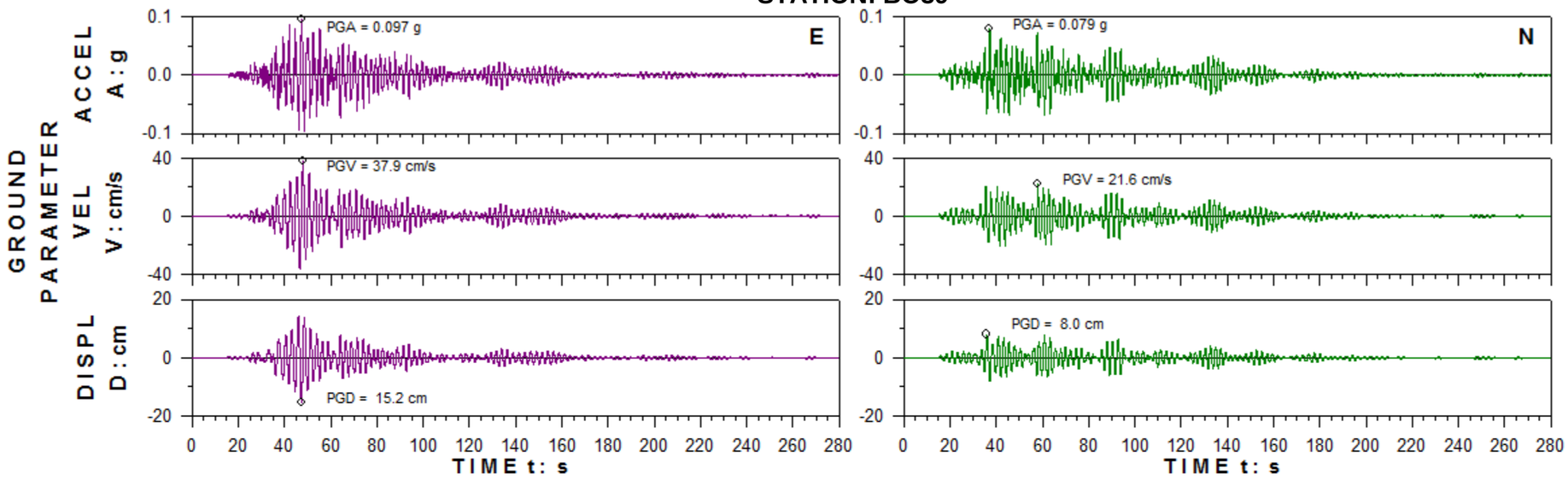
ATC-MEXICO RECONNAISSANCE

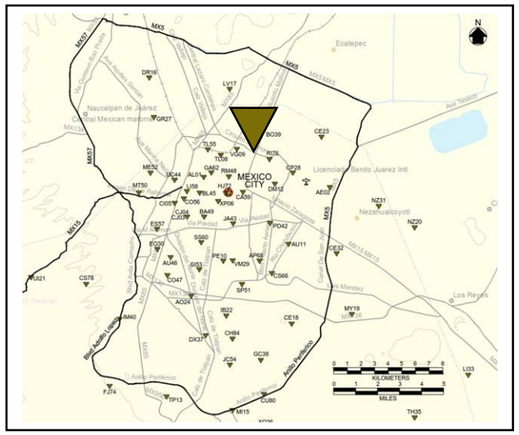
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

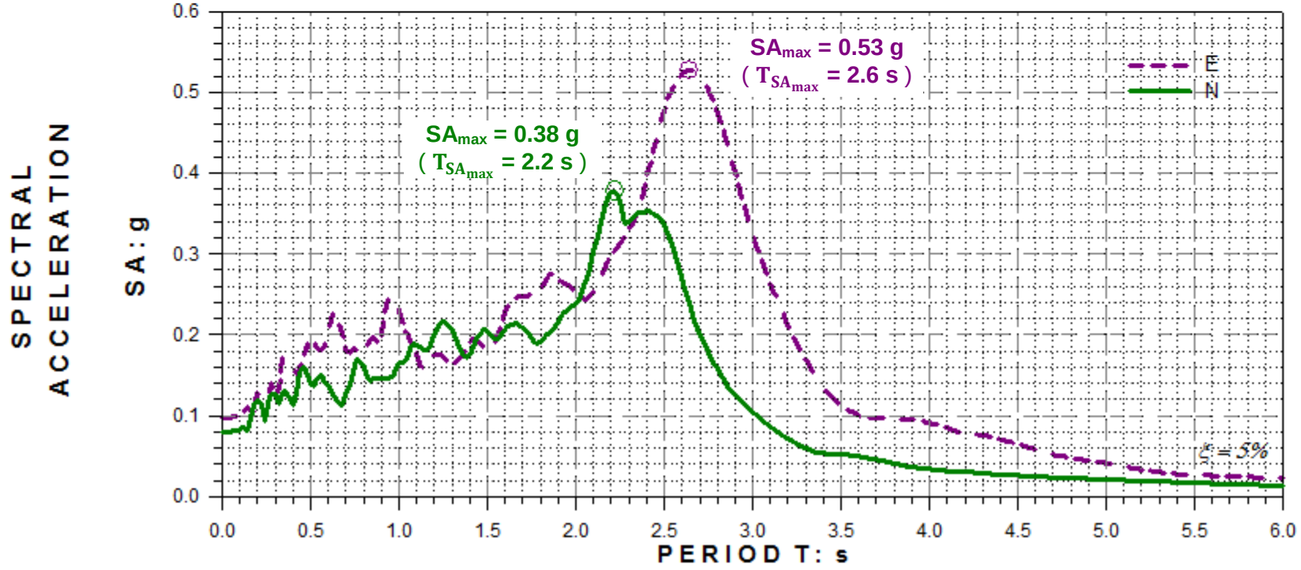
CIRES GROUND MOTIONS

BL45 STATION (19.425° N, 98.852° W) MEXICO CITY, MEXICO	STATION BL45

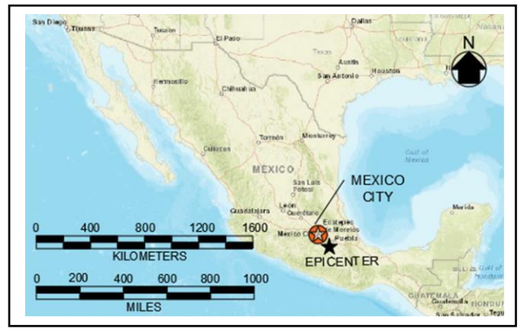
STATION: BO39







Parameter	E	N
PGA (g)	0.097	0.079
PGV (cm/s)	37.9	21.6
PGD (cm)	15.2	8.0
Period of Highest Spectral Peak (s)	2.6	2.2
Arias Intensity (m/s)	1.106	0.855
R_e (km)	125	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-33 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

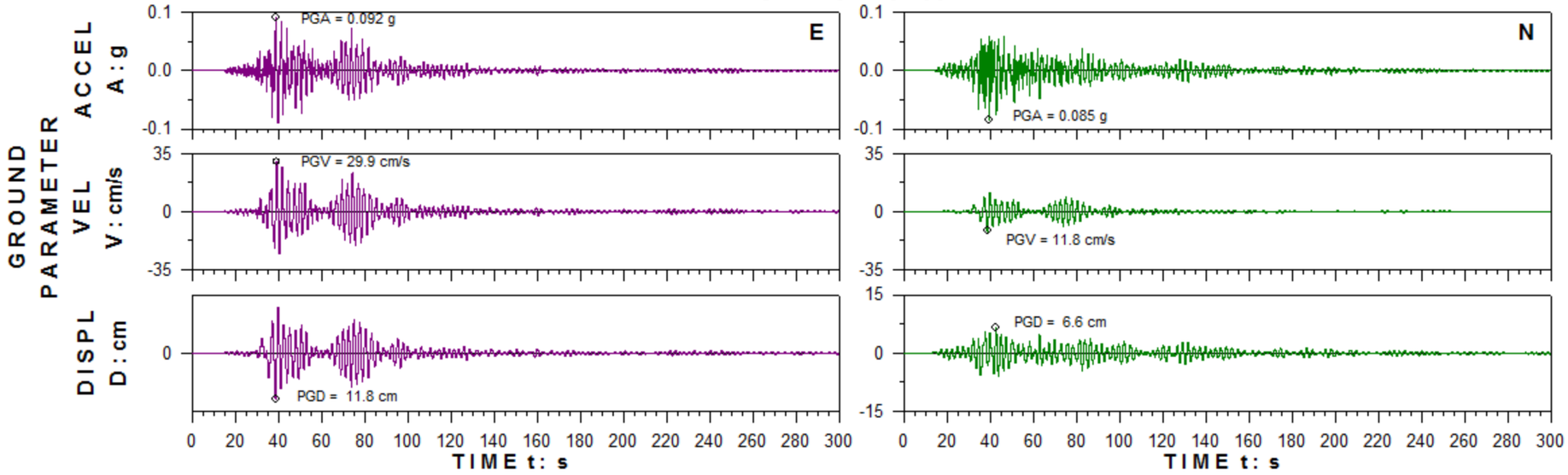
ATC-MEXICO RECONNAISSANCE

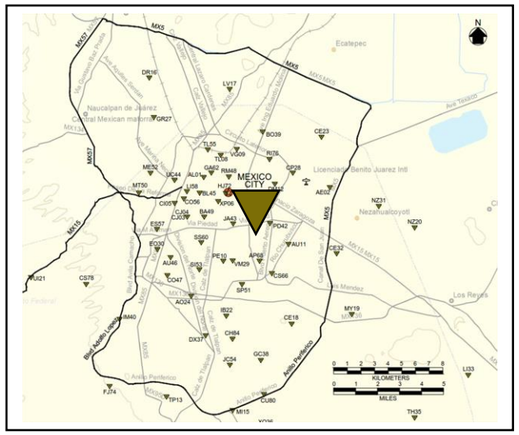
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

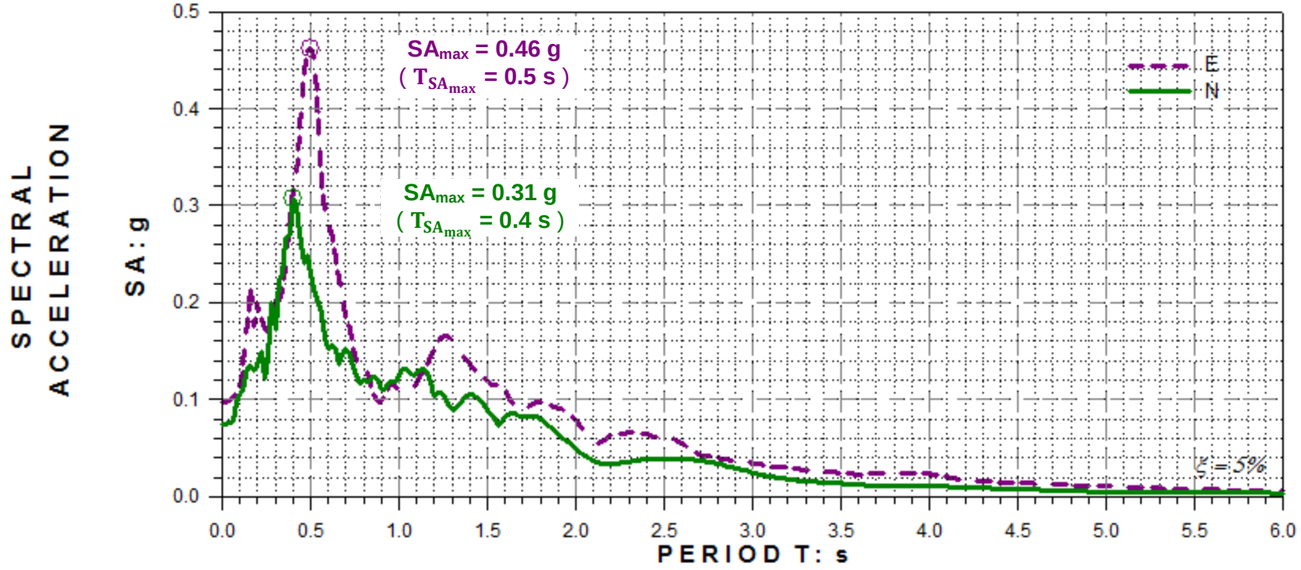
CIRES GROUND MOTIONS

BO39 STATION (19.465° N, 98.895° W) MEXICO CITY, MEXICO	STATION BO39

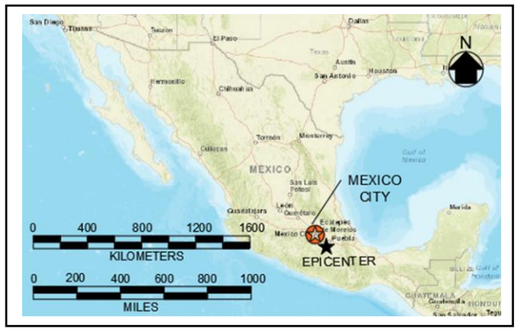
STATION: CA59







Parameter	E	N
PGA (g)	0.092	0.085
PGV (cm/s)	29.9	11.8
PGD (cm)	11.8	6.6
Period of Highest Spectral Peak (s)	0.5	0.4
Arias Intensity (m/s)	0.248	0.182
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.07-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

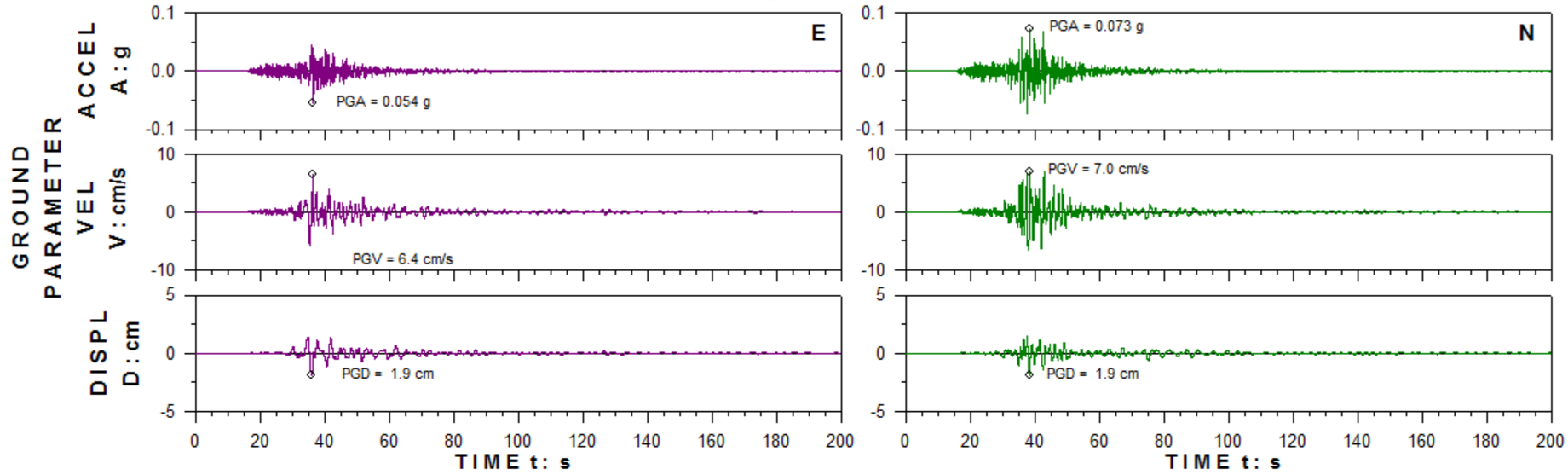
ATC-MEXICO RECONNAISSANCE

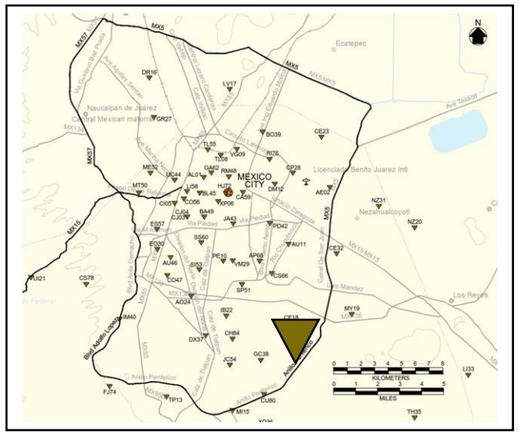
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

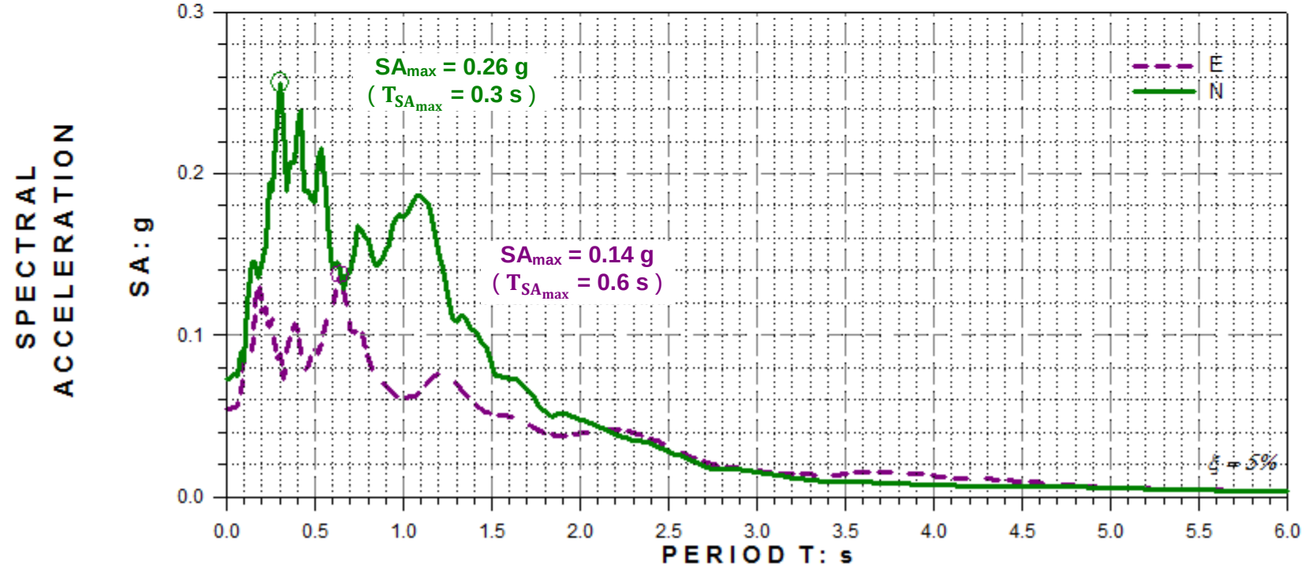
CIRES GROUND MOTIONS

CA59 STATION (19.426° N, 98.882° W) MEXICO CITY, MEXICO	STATION CA59

STATION: CE18







Parameter	E	N
PGA (g)	0.054	0.073
PGV (cm/s)	6.4	7.0
PGD (cm)	1.9	1.9
Period of Highest Spectral Peak (s)	0.6	0.3
Arias Intensity (m/s)	0.048	0.128
R_e (km)	111	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.23-30 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

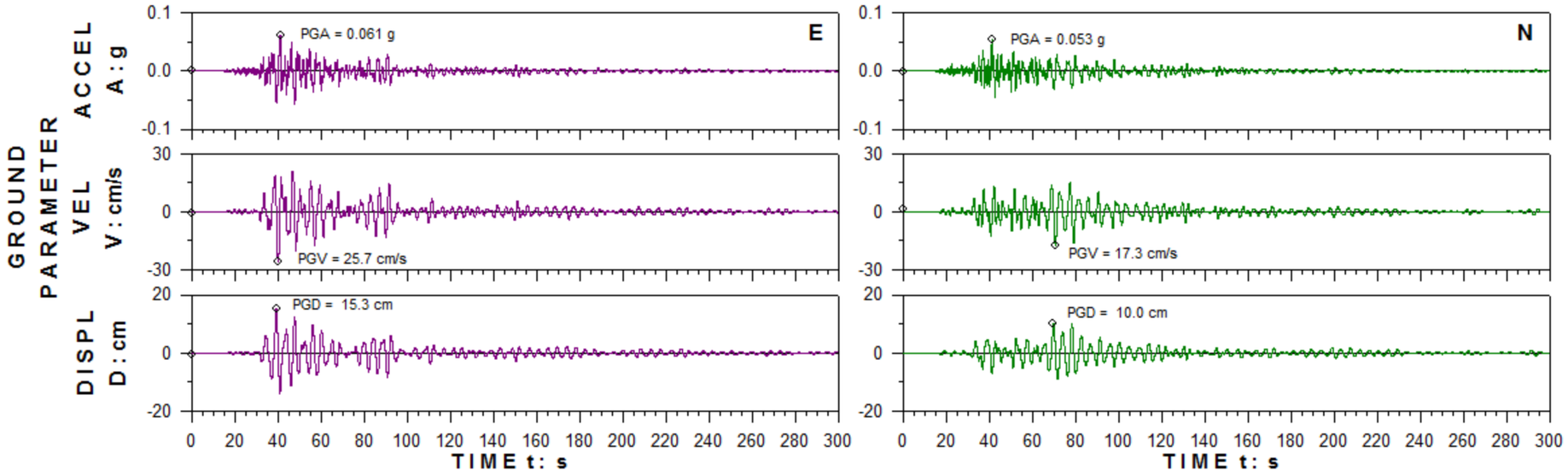
ATC-MEXICO RECONNAISSANCE

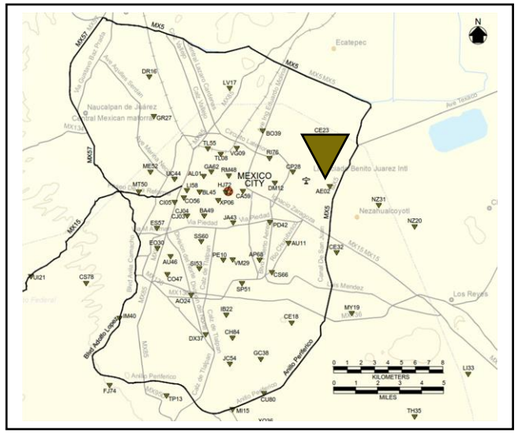
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

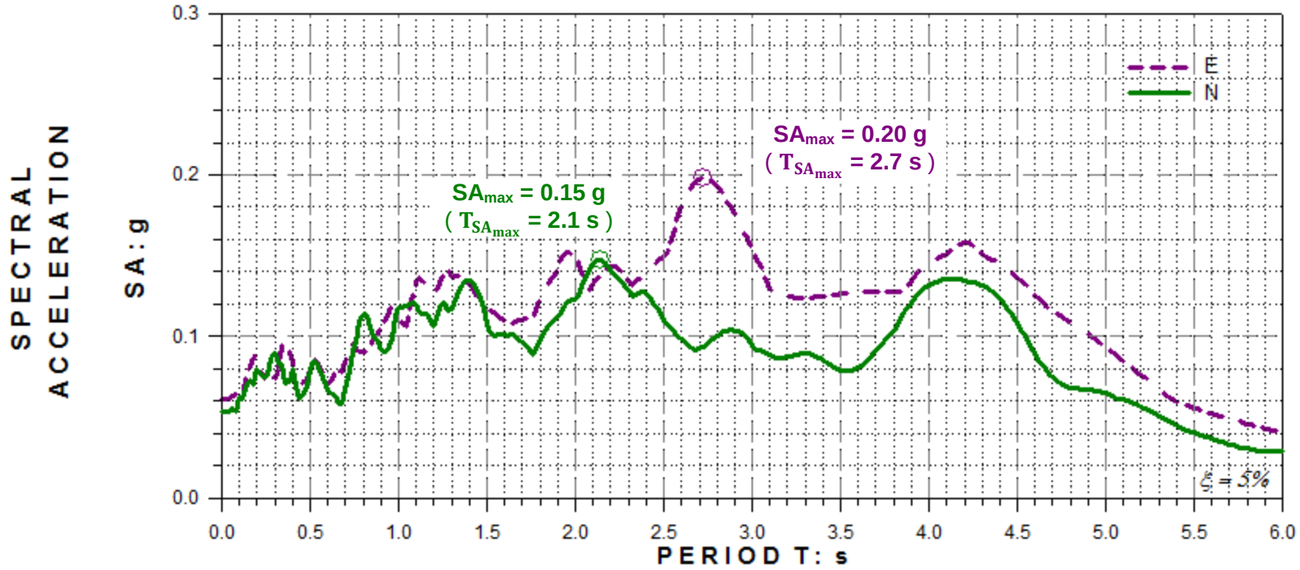
CIRES GROUND MOTIONS

CE18 STATION (19.340° N, 98.915° W) MEXICO CITY, MEXICO	STATION CE18

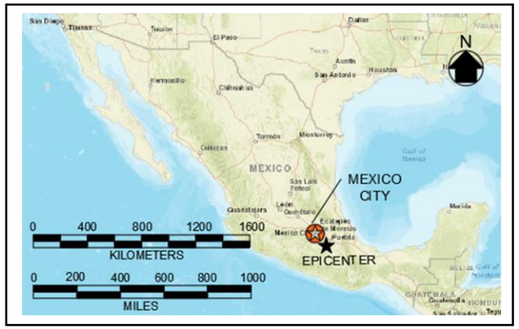
STATION: CE23







Parameter	E	N
PGA (g)	0.061	0.053
PGV (cm/s)	25.7	17.3
PGD (cm)	15.3	10.0
Period of Highest Spectral Peak (s)	2.7	2.1
Arias Intensity (m/s)	0.289	0.209
R_e (km)	123	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-22 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

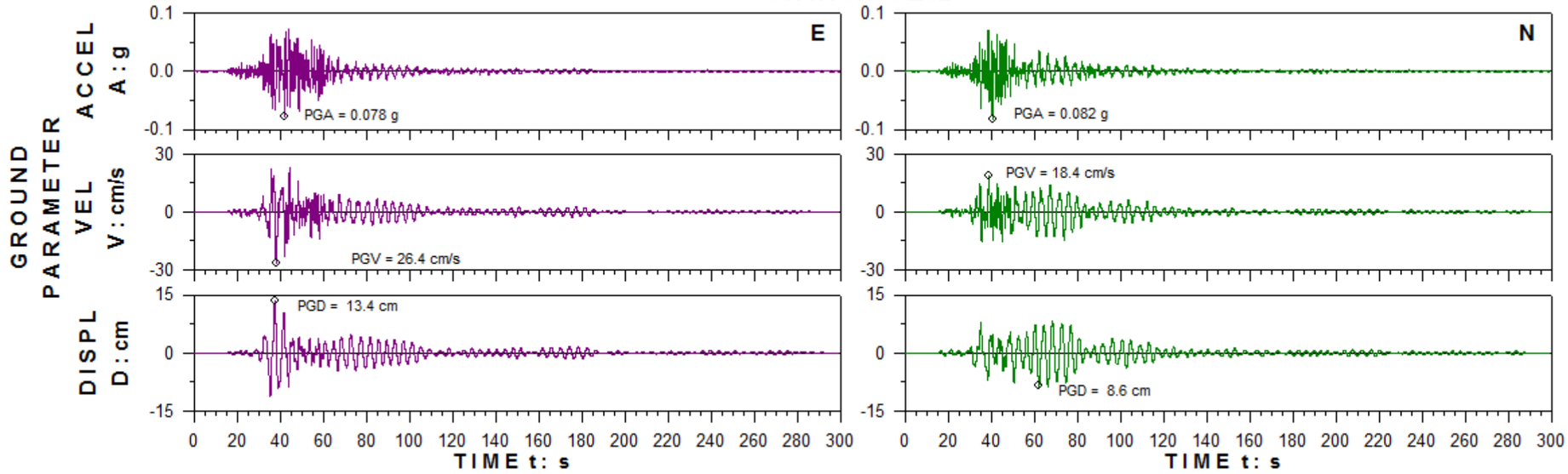
ATC-MEXICO RECONNAISSANCE

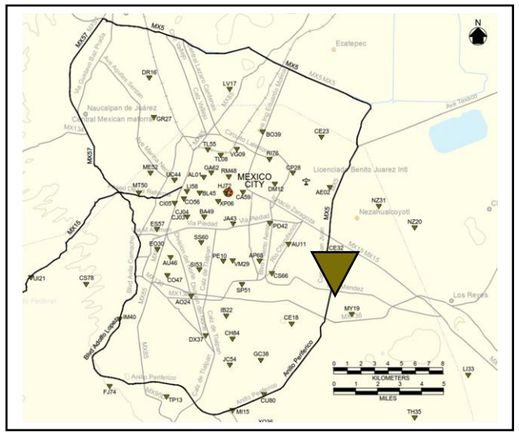
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

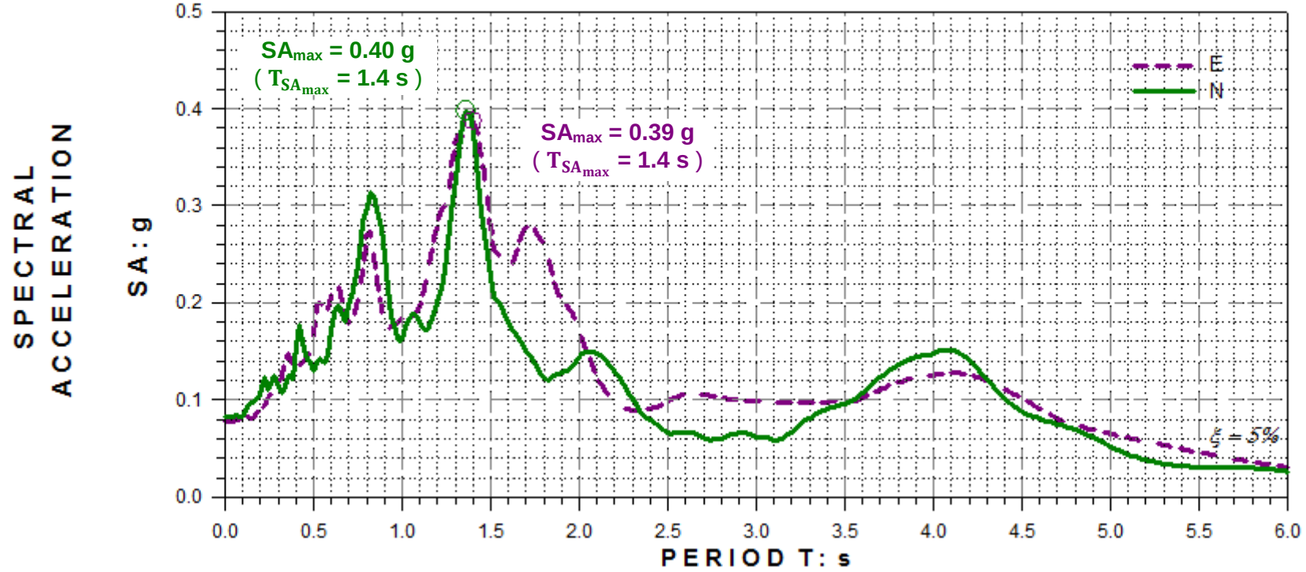
CIRES GROUND MOTIONS

CE23 STATION (19.462° N, 98.936° W) MEXICO CITY, MEXICO	STATION CE23

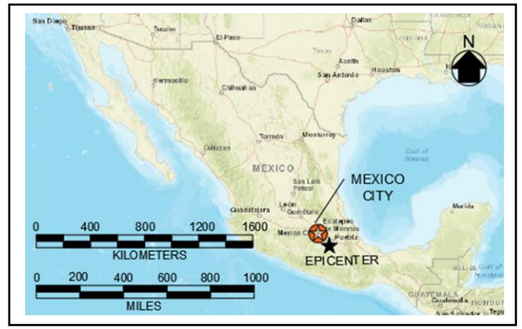
STATION: CE32







Parameter	E	N
PGA (g)	0.078	0.082
PGV (cm/s)	26.4	18.4
PGD (cm)	13.4	8.6
Period of Highest Spectral Peak (s)	1.4	1.4
Arias Intensity (m/s)	0.480	0.384
R_e (km)	115	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.09-30 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

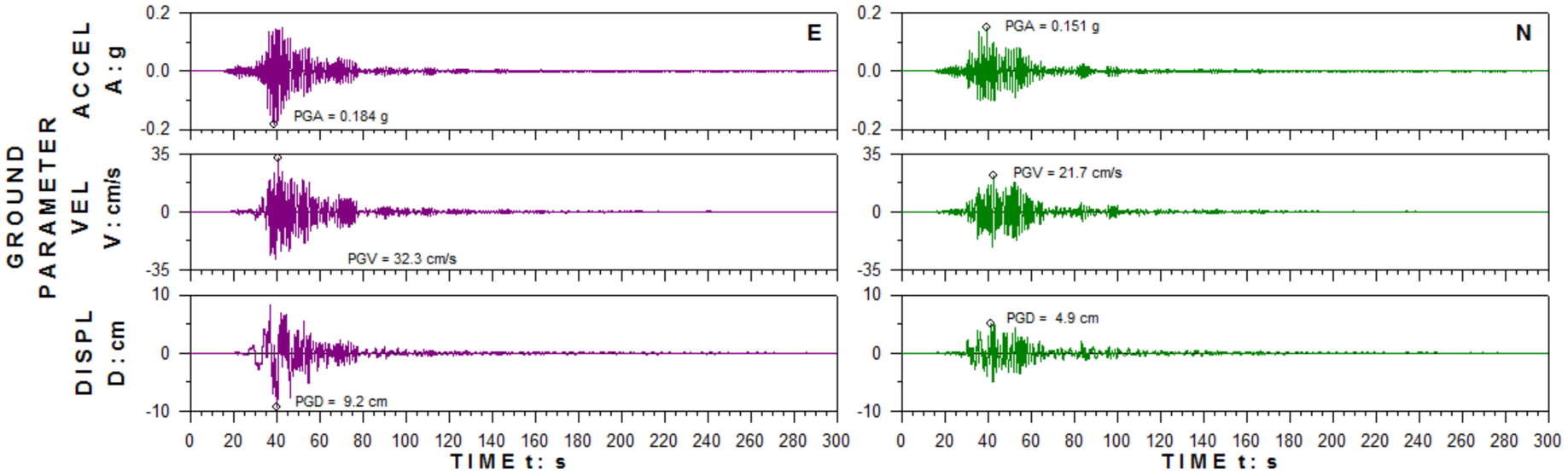
ATC-MEXICO RECONNAISSANCE

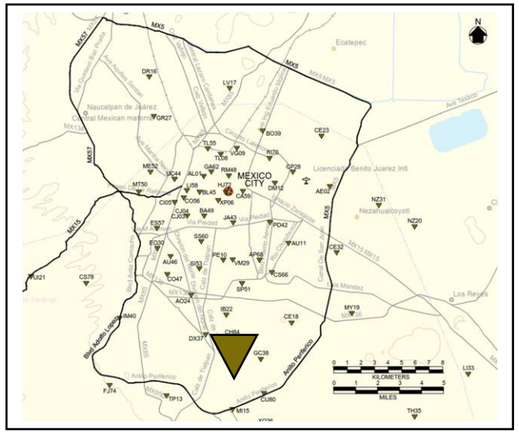
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

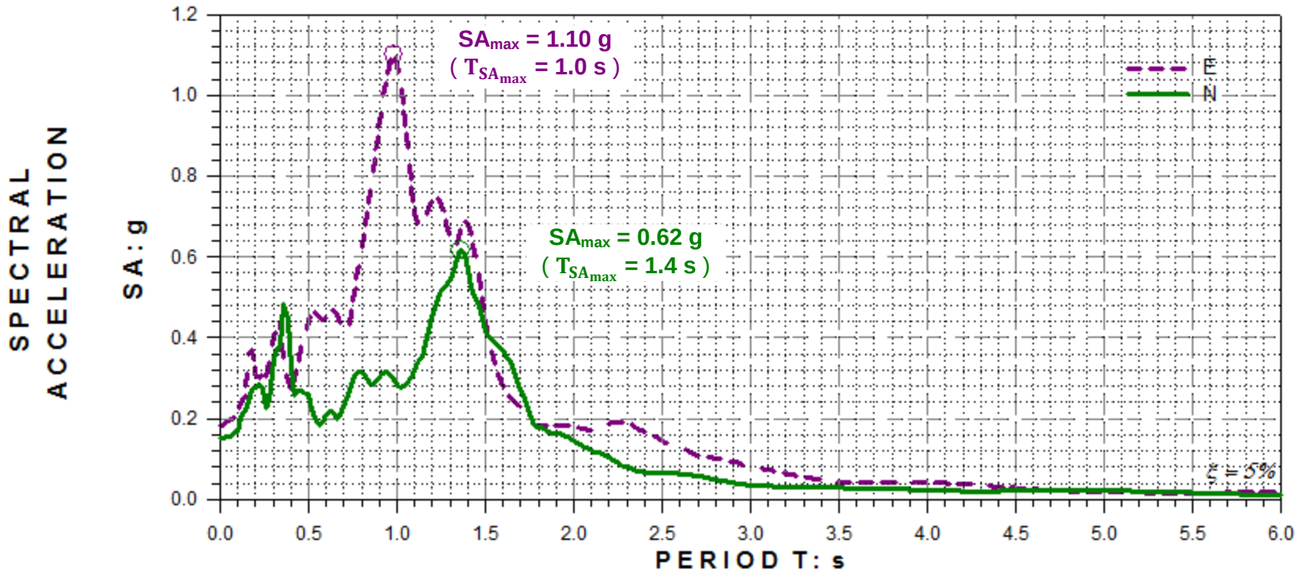
CIRES GROUND MOTIONS

CE32 STATION (19.386° N, 98.946° W) MEXICO CITY, MEXICO	STATION CE32

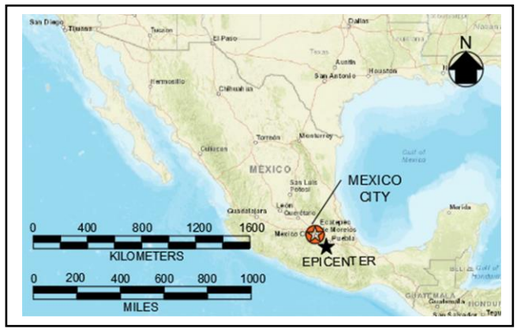
STATION: CH84







Parameter	E	N
PGA (g)	0.184	0.151
PGV (cm/s)	32.3	21.7
PGD (cm)	9.2	4.9
Period of Highest Spectral Peak (s)	1.0	1.4
Arias Intensity (m/s)	1.862	1.002
R_e (km)	112	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-33 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

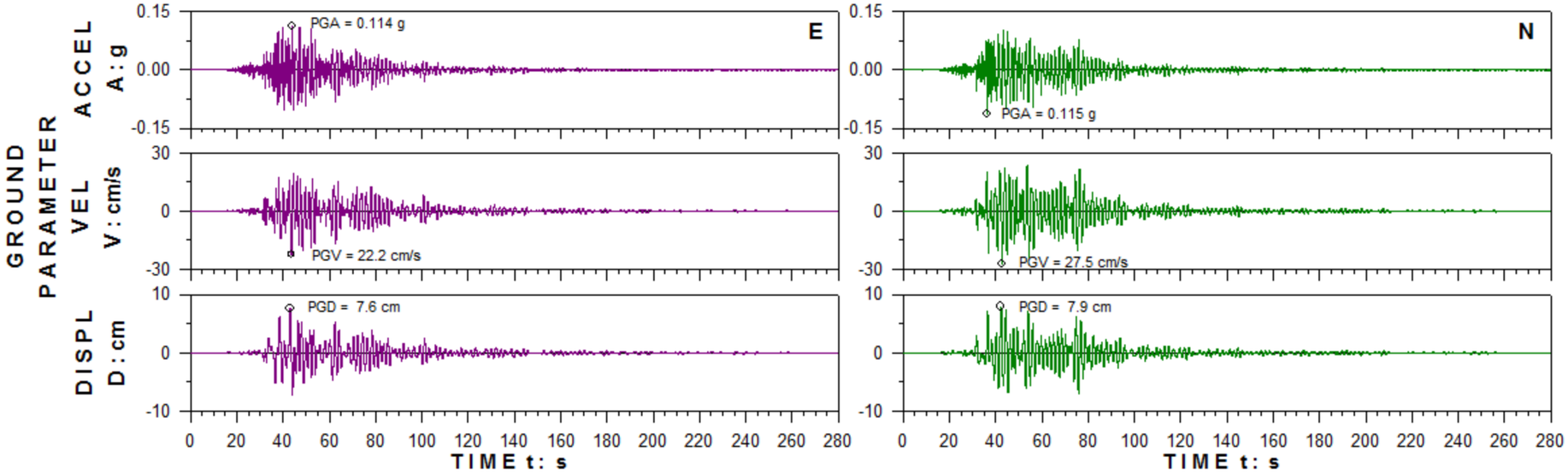
ATC-MEXICO RECONNAISSANCE

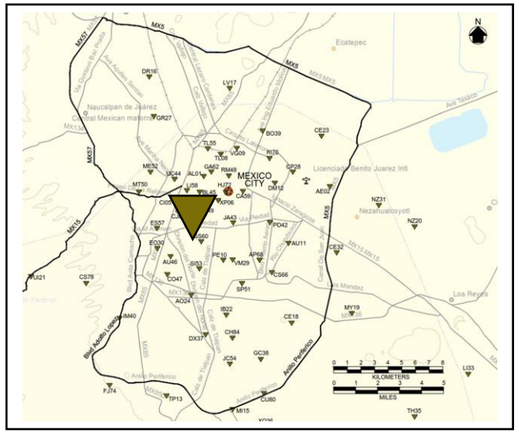
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

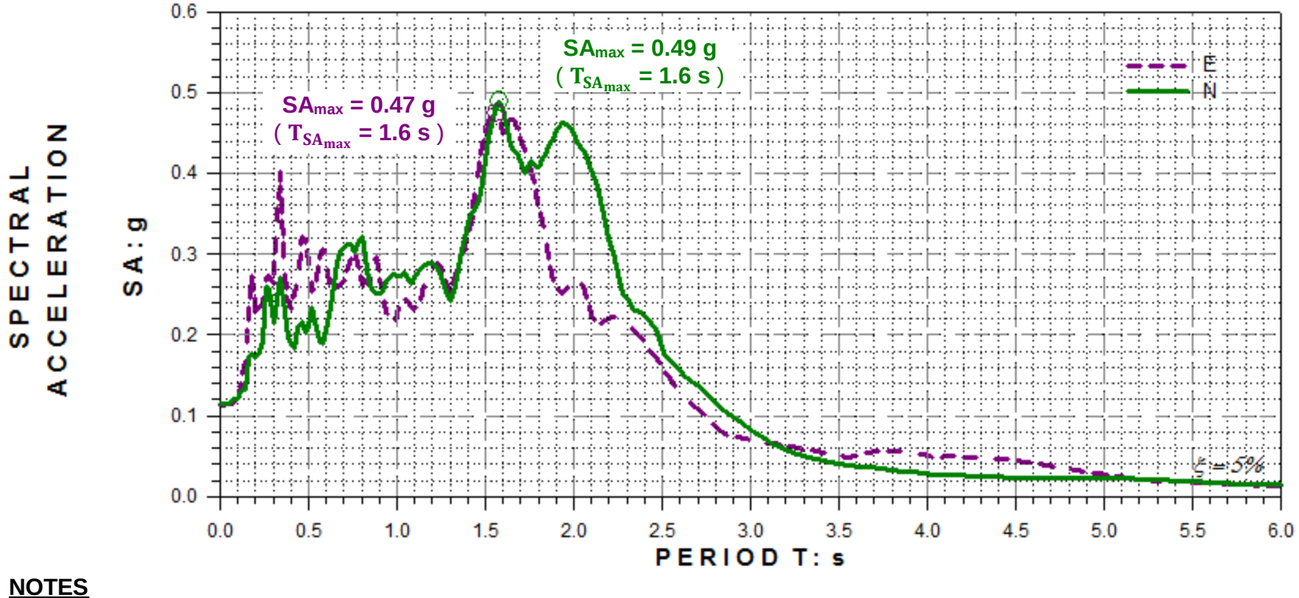
CIRES GROUND MOTIONS

CH84 STATION (19.330° N, 98.875° W) MEXICO CITY, MEXICO	STATION CH84

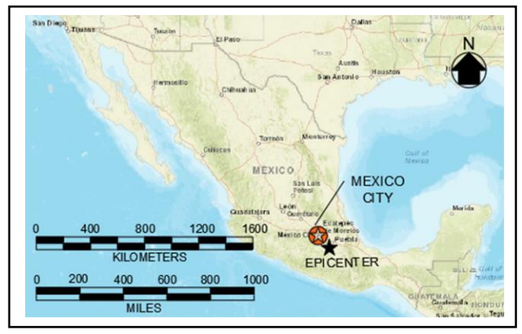
STATION: CI05







Parameter	E	N
PGA (g)	0.114	0.115
PGV (cm/s)	22.2	27.5
PGD (cm)	7.6	7.9
Period of Highest Spectral Peak (s)	1.6	1.6
Arias Intensity (m/s)	0.975	1.226
R_e (km)	122	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.13-24 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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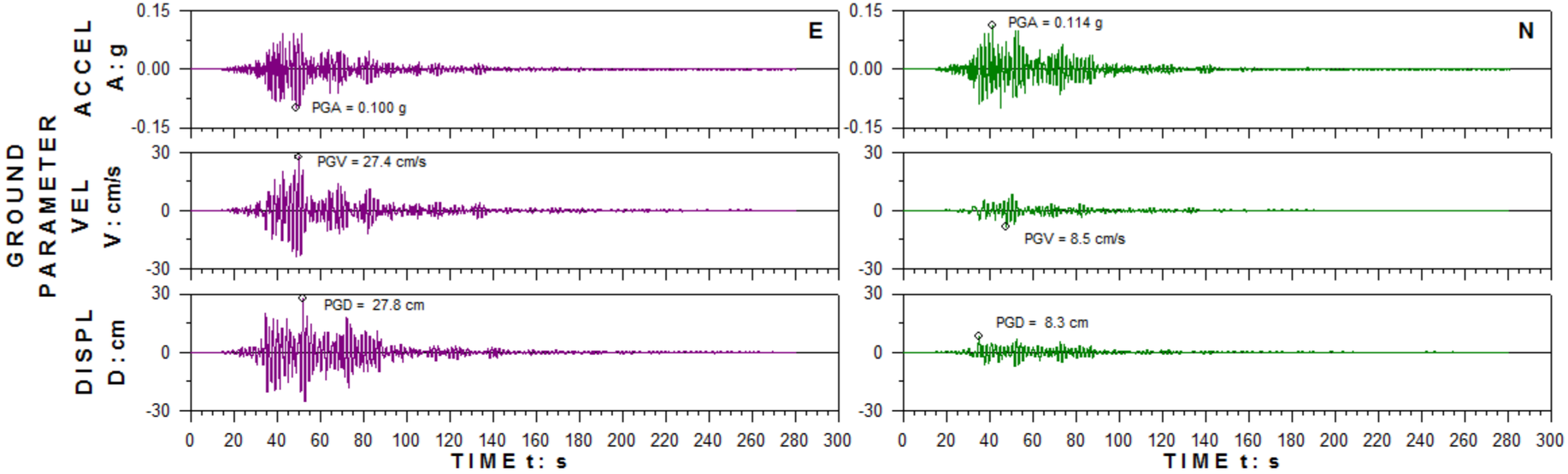
ATC-MEXICO RECONNAISSANCE

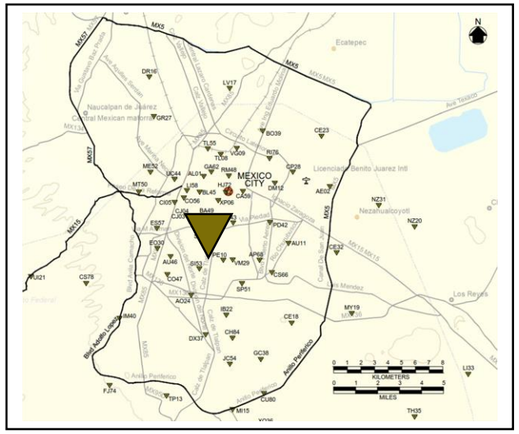
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

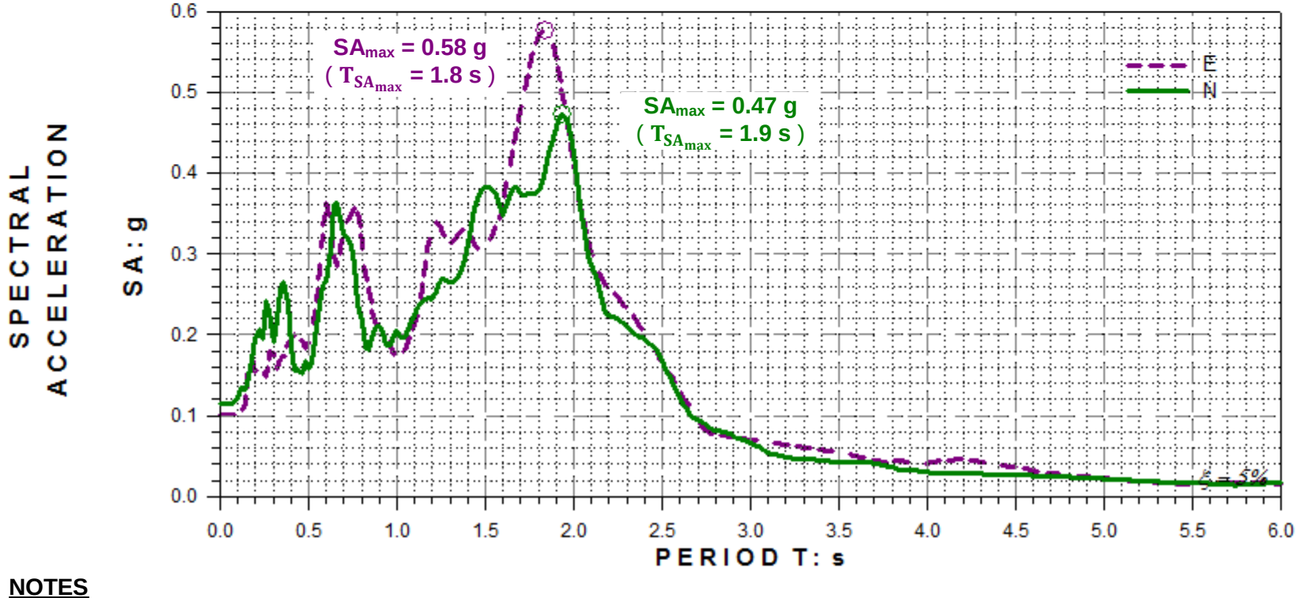
CIRES GROUND MOTIONS

CI05 STATION (19.419° N, 98.835° W) MEXICO CITY, MEXICO	STATION CI05

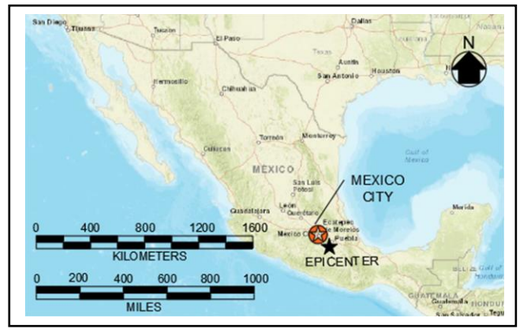
STATION: CJ03







Parameter	E	N
PGA (g)	0.100	0.114
PGV (cm/s)	27.4	8.5
PGD (cm)	27.8	8.3
Period of Highest Spectral Peak (s)	1.8	1.9
Arias Intensity (m/s)	0.843	0.993
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.10-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

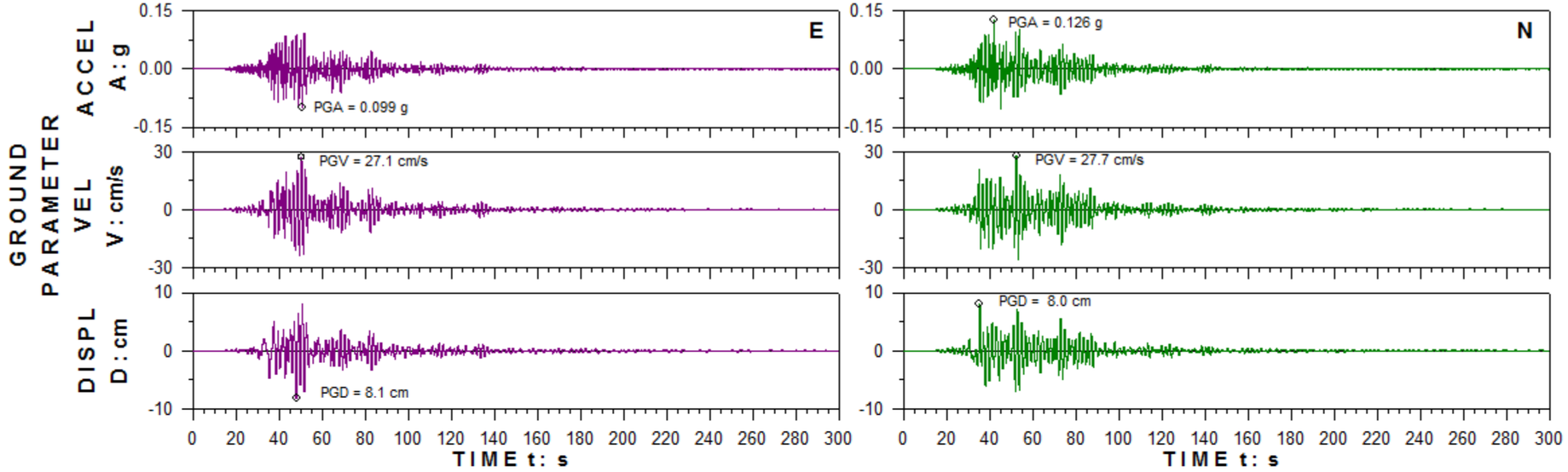
ATC-MEXICO RECONNAISSANCE

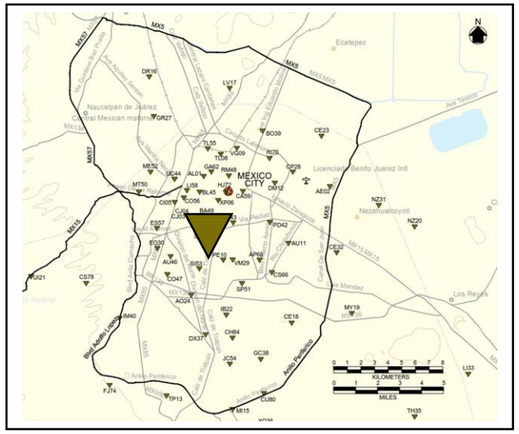
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

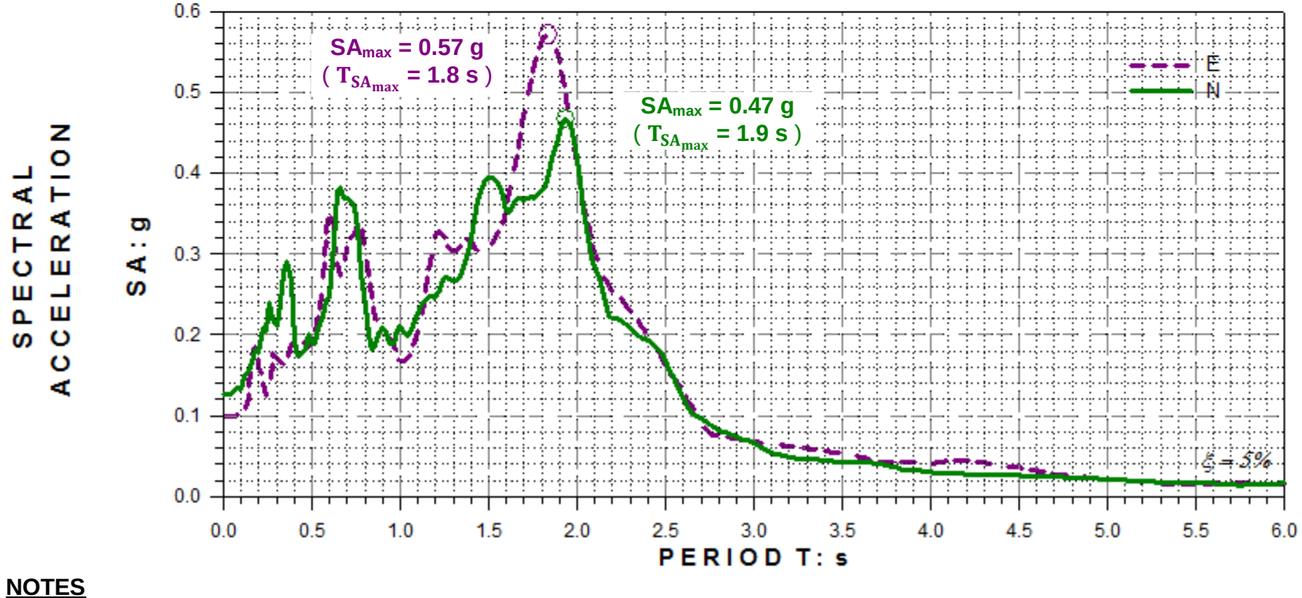
CIRES GROUND MOTIONS

CJ03 STATION (19.410° N, 98.843° W) MEXICO CITY, MEXICO	STATION CJ03

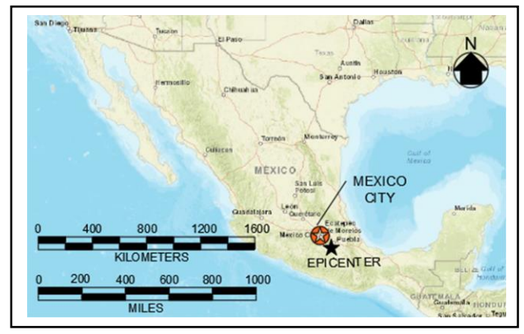
STATION: CJ04







Parameter	E	N
PGA (g)	0.099	0.126
PGV (cm/s)	27.1	27.7
PGD (cm)	8.1	8.0
Period of Highest Spectral Peak (s)	1.8	1.9
Arias Intensity (m/s)	0.995	0.993
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.12-30 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

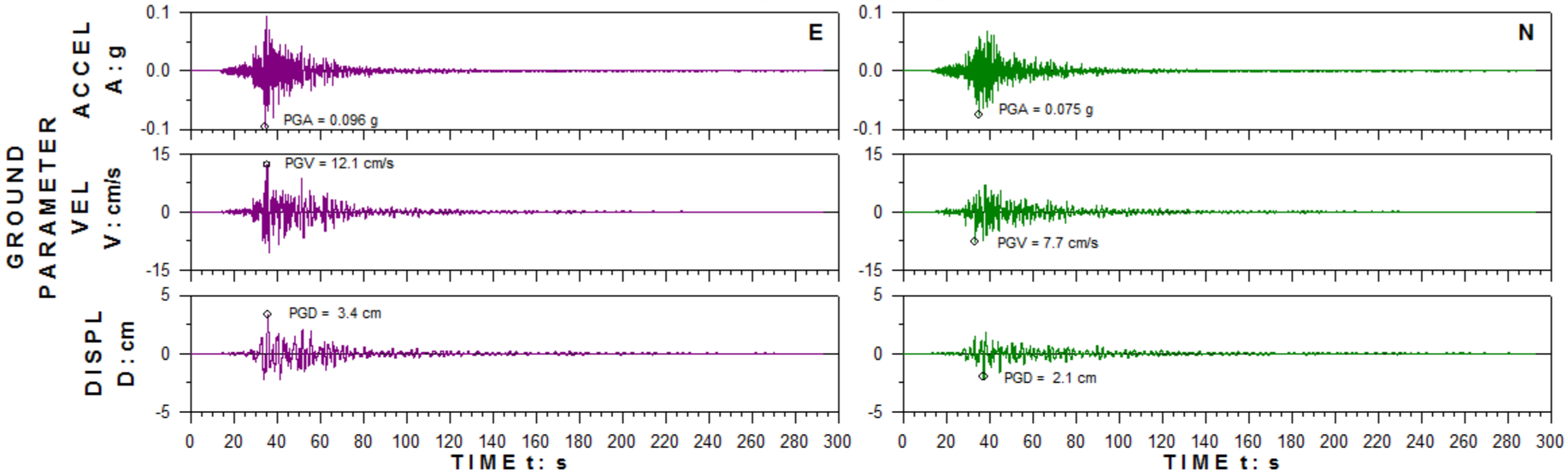
ATC-MEXICO RECONNAISSANCE

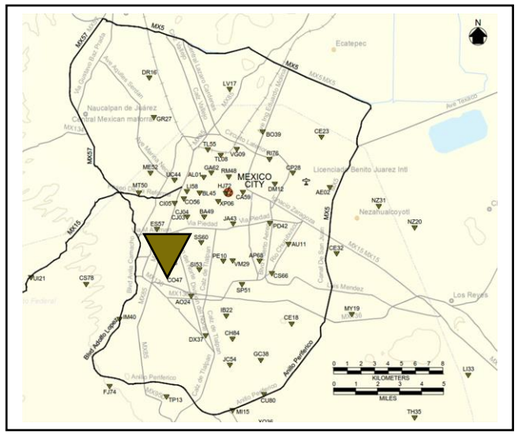
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

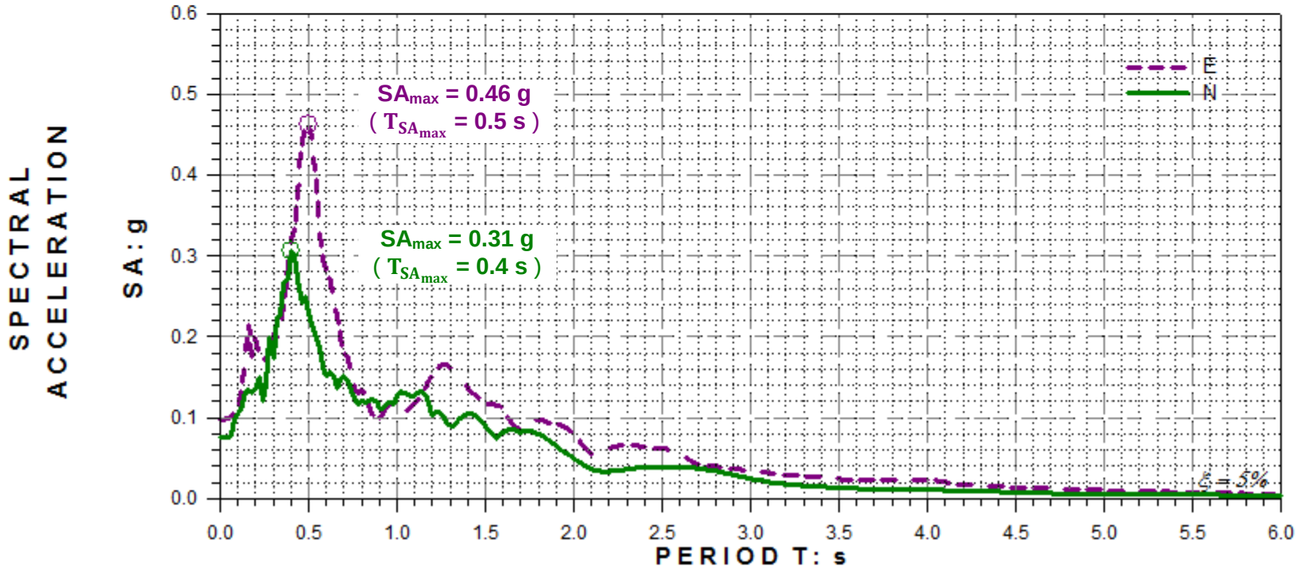
CIRES GROUND MOTIONS

CJ04 STATION (19.410° N, 98.843° W) MEXICO CITY, MEXICO	STATION CJ04

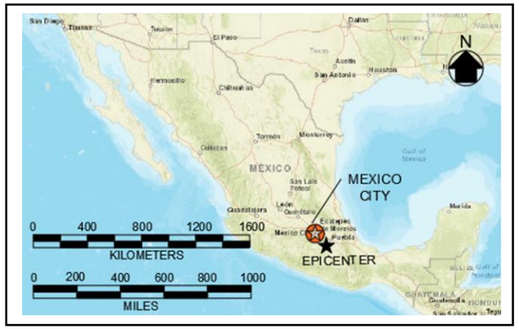
STATION: CO47







Parameter	E	N
PGA (g)	0.096	0.075
PGV (cm/s)	12.1	7.7
PGD (cm)	3.4	2.1
Period of Highest Spectral Peak (s)	0.5	0.4
Arias Intensity (m/s)	0.248	0.182
R_e (km)	118	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.22-21 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

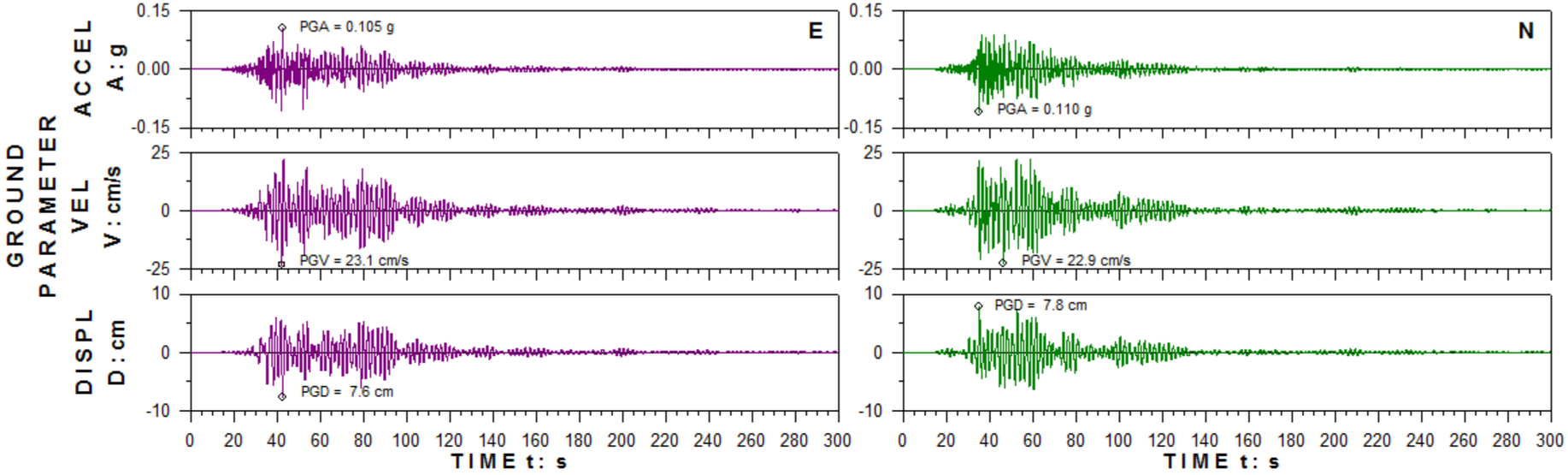
ATC-MEXICO RECONNAISSANCE

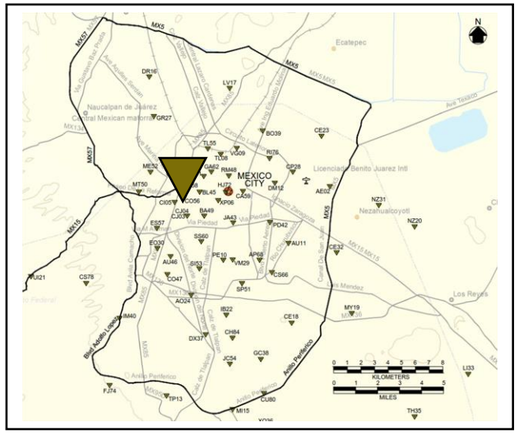
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

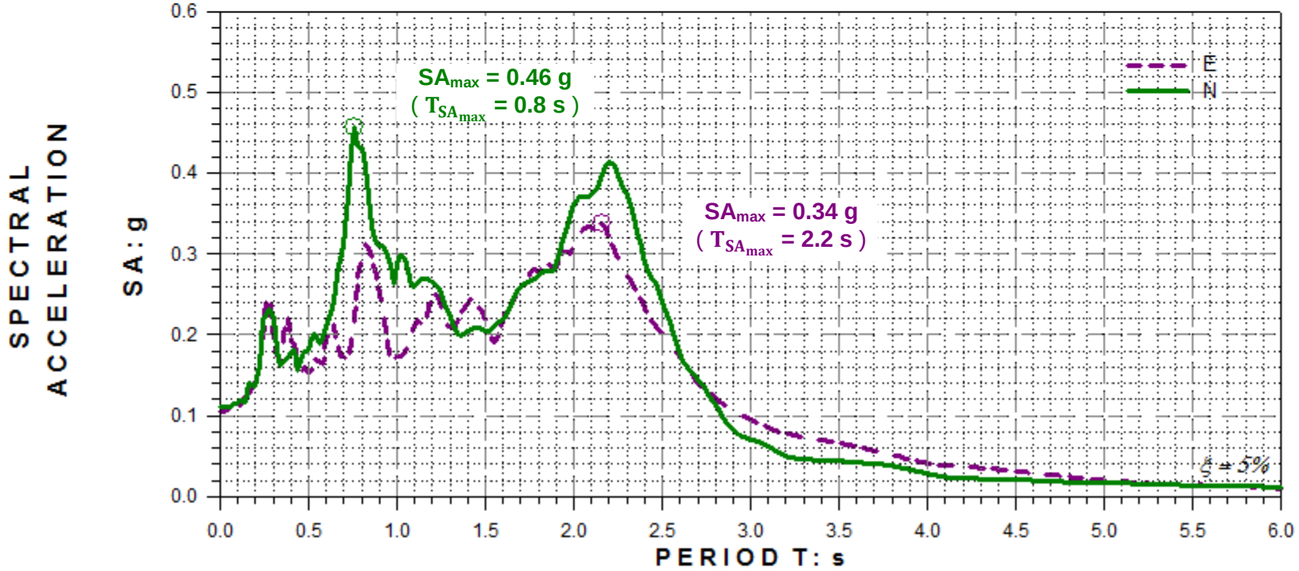
CIRES GROUND MOTIONS

CO47 STATION (19.371° N, 98.830° W) MEXICO CITY, MEXICO	STATION CO47

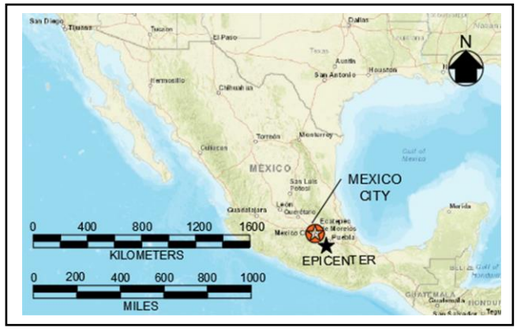
STATION: CO56







Parameter	E	N
PGA (g)	0.105	0.110
PGV (cm/s)	23.1	22.9
PGD (cm)	7.6	7.8
Period of Highest Spectral Peak (s)	2.2	0.8
Arias Intensity (m/s)	0.819	0.914
R_e (km)	122	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.18-36 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

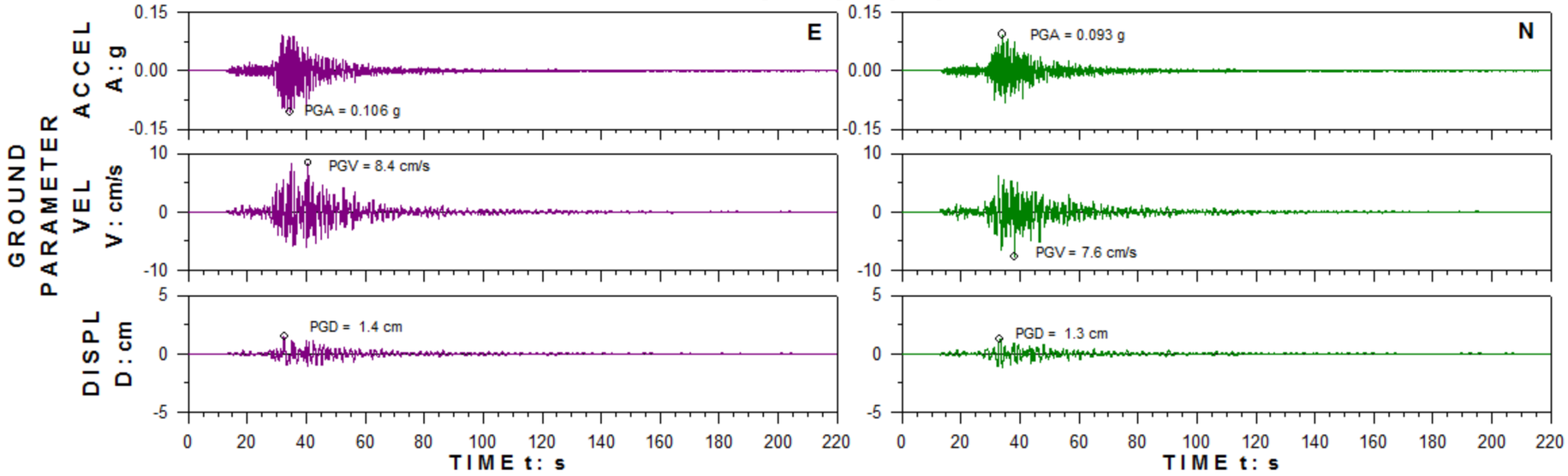
ATC-MEXICO RECONNAISSANCE

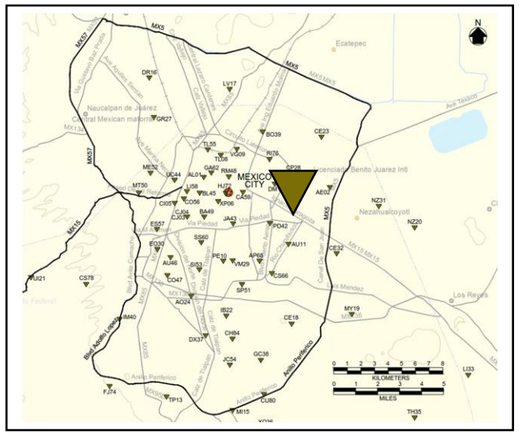
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

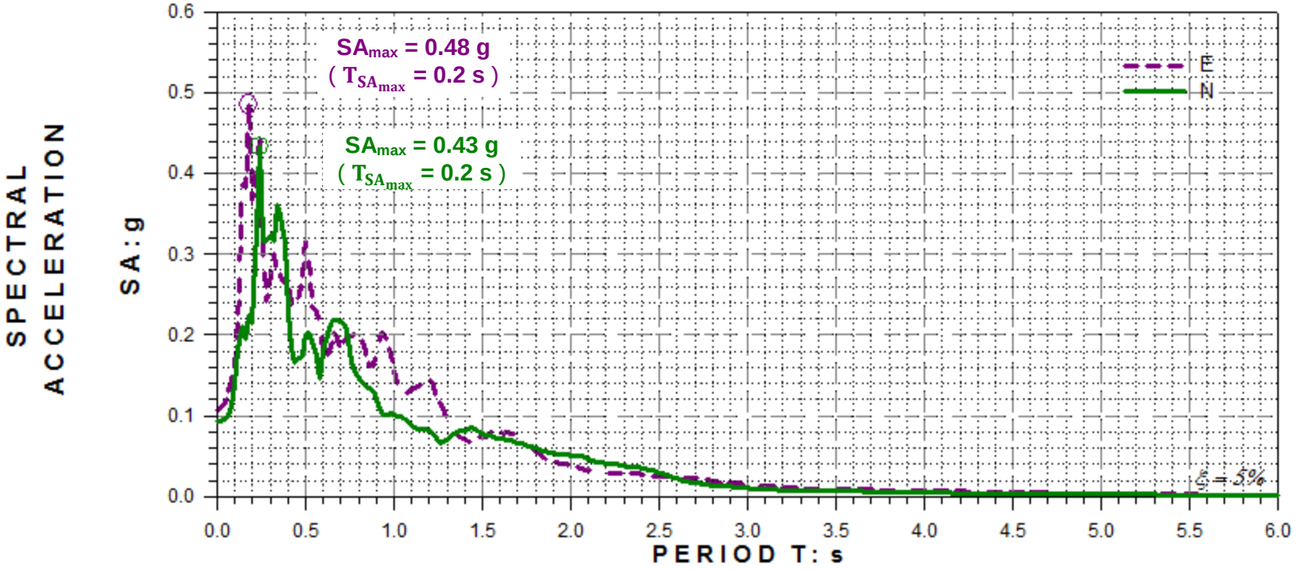
CIRES GROUND MOTIONS

CO56 STATION (19.422° N, 98.841° W) MEXICO CITY, MEXICO	STATION CO56

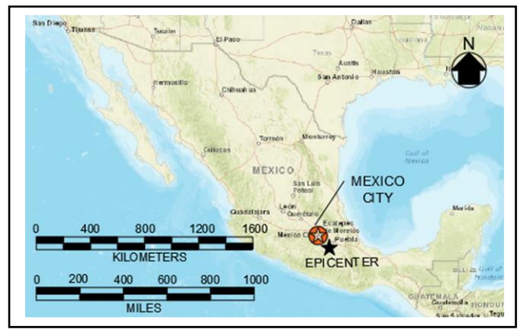
STATION: CP28







Parameter	E	N
PGA (g)	0.106	0.093
PGV (cm/s)	8.4	7.6
PGD (cm)	1.4	1.3
Period of Highest Spectral Peak (s)	0.2	0.2
Arias Intensity (m/s)	0.332	0.232
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.26-32 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

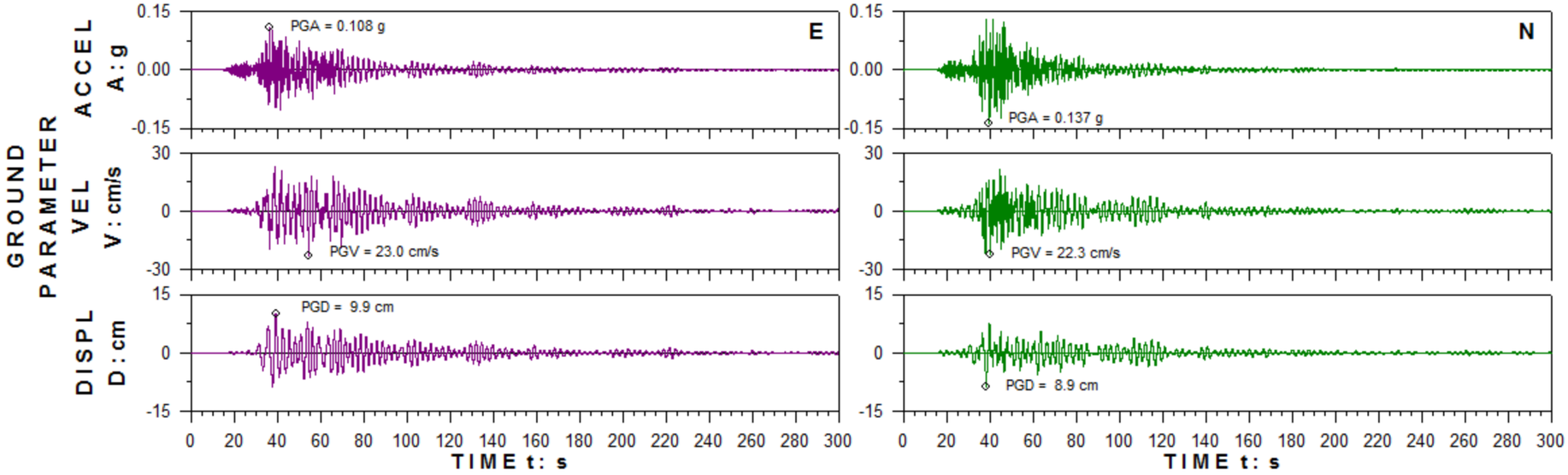
ATC-MEXICO RECONNAISSANCE

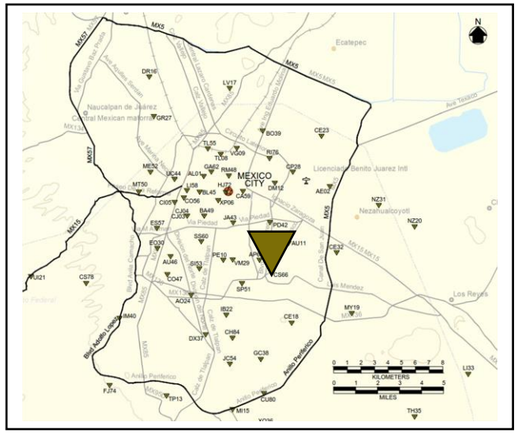
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

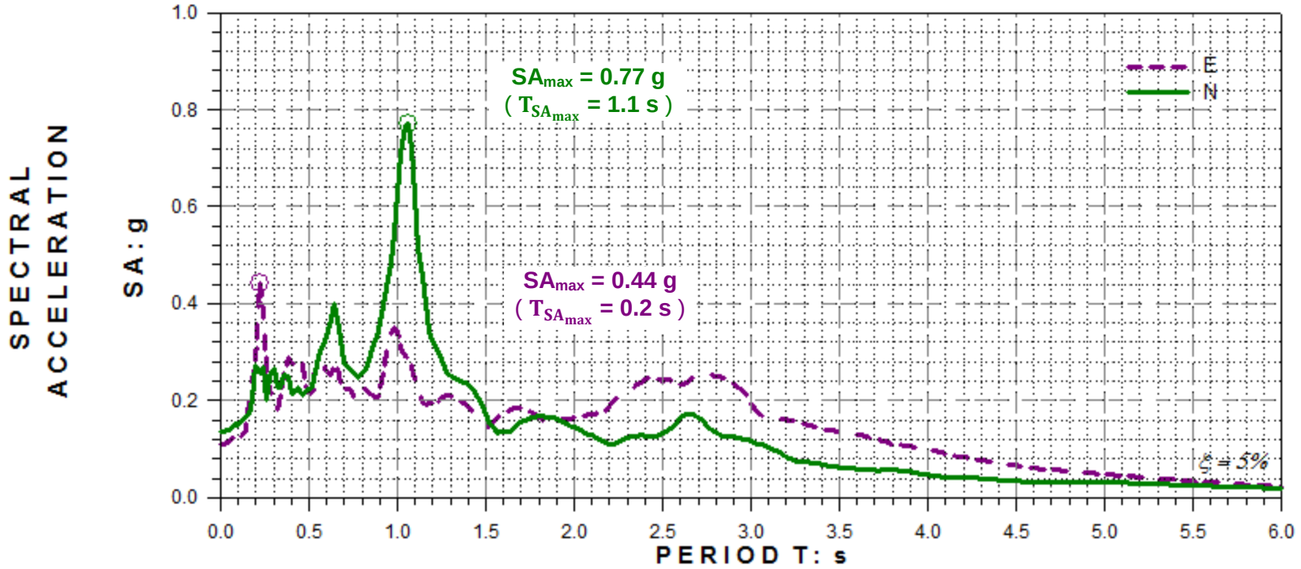
CIRES GROUND MOTIONS

CP28 STATION (19.439° N, 98.916° W) MEXICO CITY, MEXICO	STATION CP28

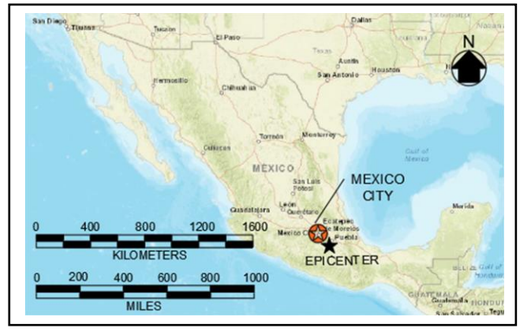
STATION: CS66







Parameter	E	N
PGA (g)	0.108	0.137
PGV (cm/s)	23.0	22.3
PGD (cm)	9.8	8.9
Period of Highest Spectral Peak (s)	0.2	1.1
Arias Intensity (m/s)	0.802	1.043
R_e (km)	115	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
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3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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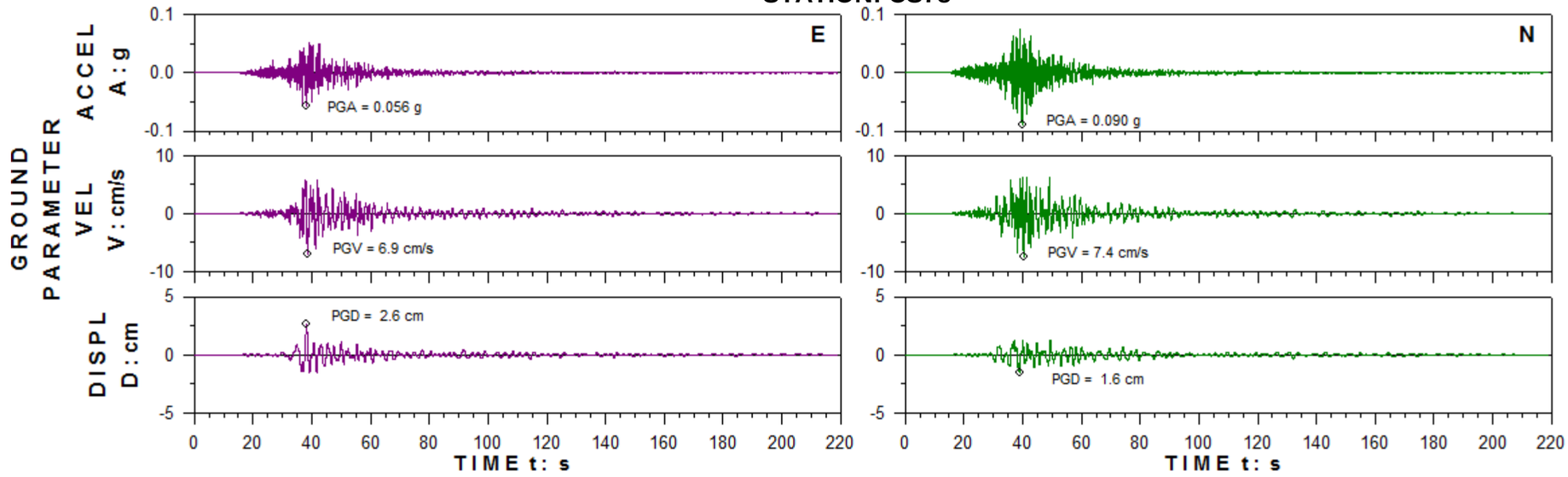
ATC-MEXICO RECONNAISSANCE

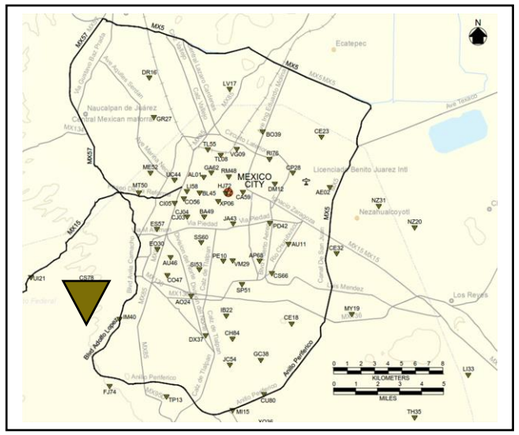
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

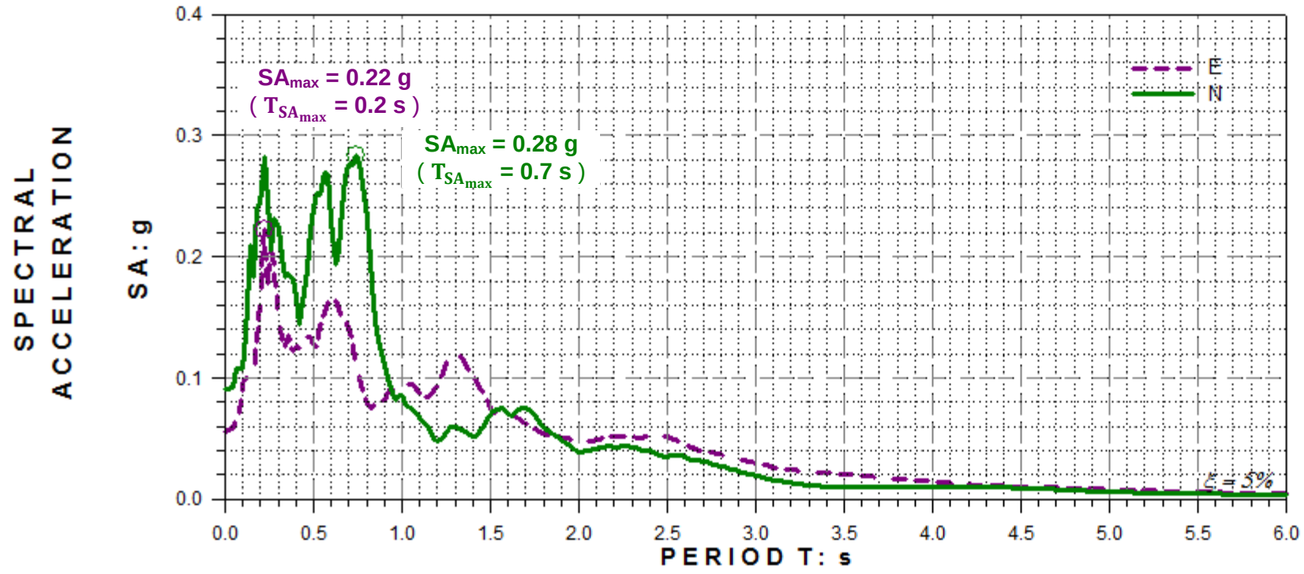
CIRES GROUND MOTIONS

CS66 STATION (19.373° N, 98.902° W) MEXICO CITY, MEXICO	STATION CS66

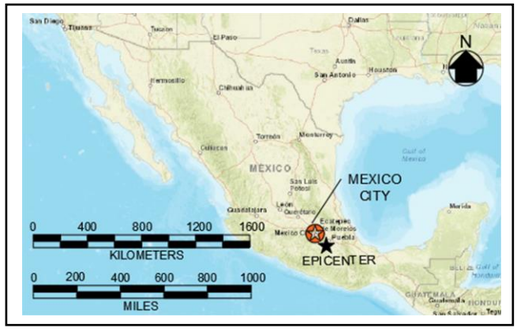
STATION: CS78







Parameter	E	N
PGA (g)	0.056	0.090
PGV (cm/s)	6.9	7.4
PGD (cm)	2.6	1.6
Period of Highest Spectral Peak (s)	0.2	0.7
Arias Intensity (m/s)	0.095	0.192
R_e (km)	120	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.21-32 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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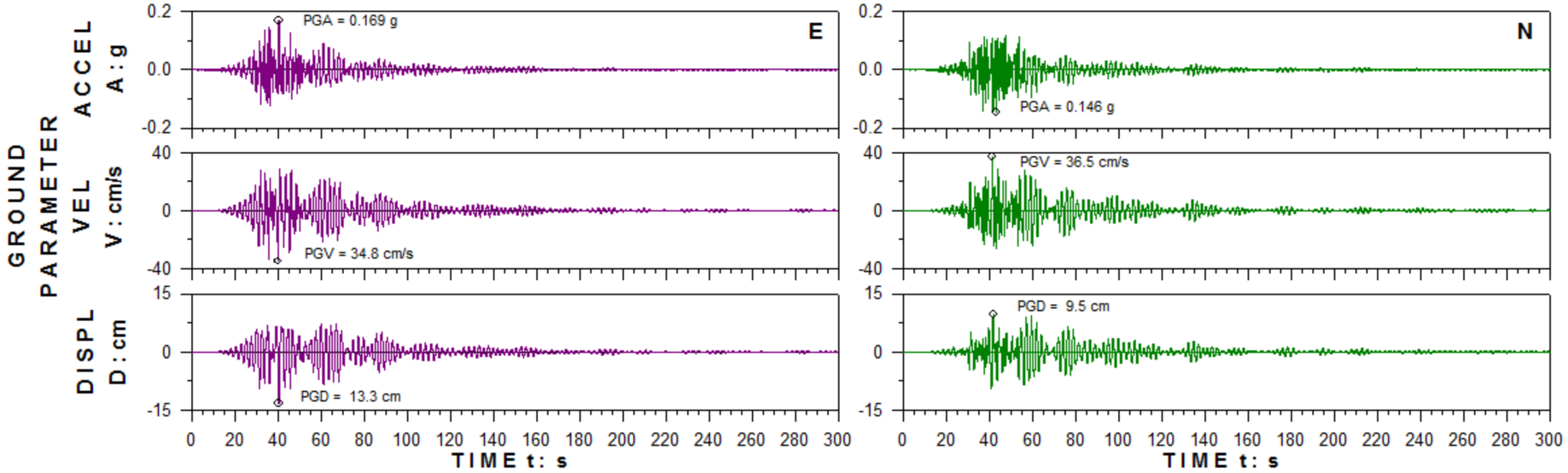
ATC-MEXICO RECONNAISSANCE

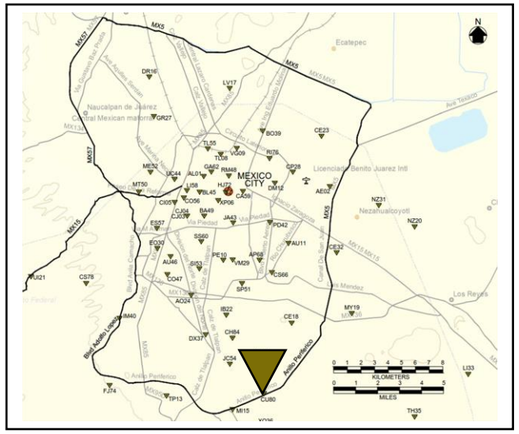
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

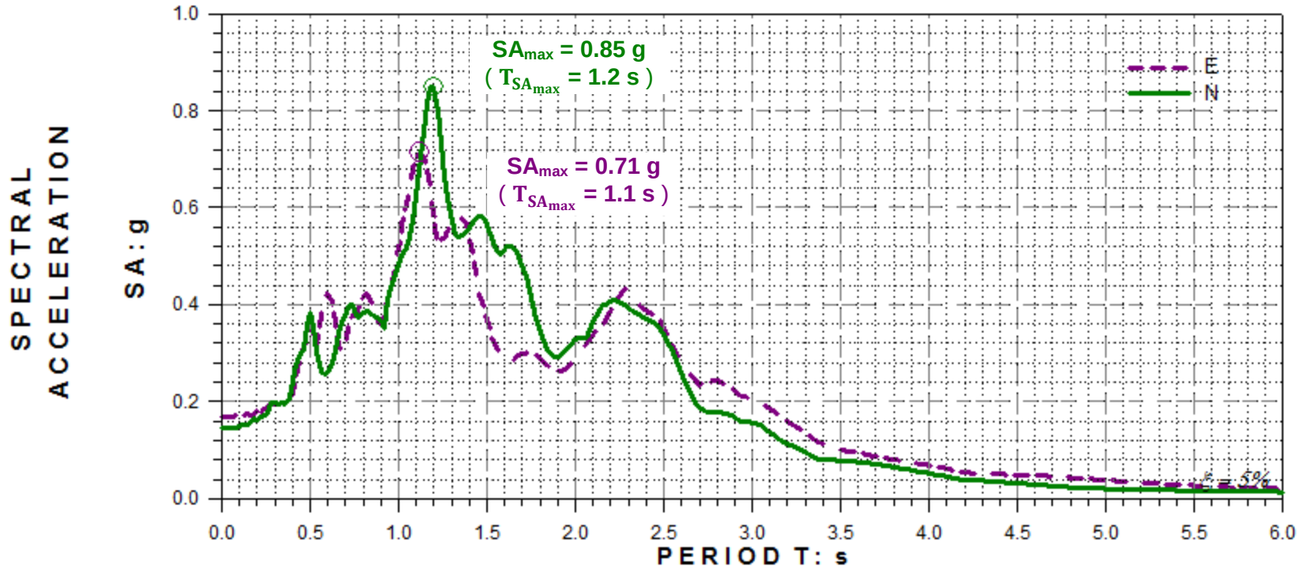
CIRES GROUND MOTIONS

CS78 STATION (19.366° N, 98.774° W) MEXICO CITY, MEXICO	STATION CS78

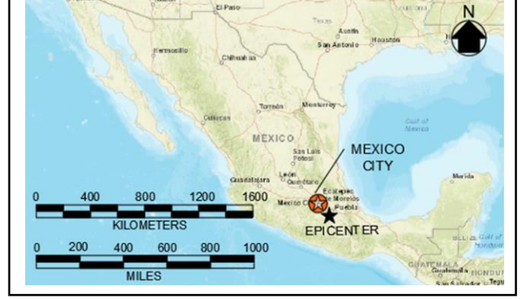
STATION: CU80







Parameter	E	N
PGA (g)	0.169	0.146
PGV (cm/s)	34.8	36.5
PGD (cm)	13.3	9.5
Period of Highest Spectral Peak (s)	1.1	1.2
Arias Intensity (m/s)	1.701	1.948
R_e (km)	107	



NOTES

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2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.25-10 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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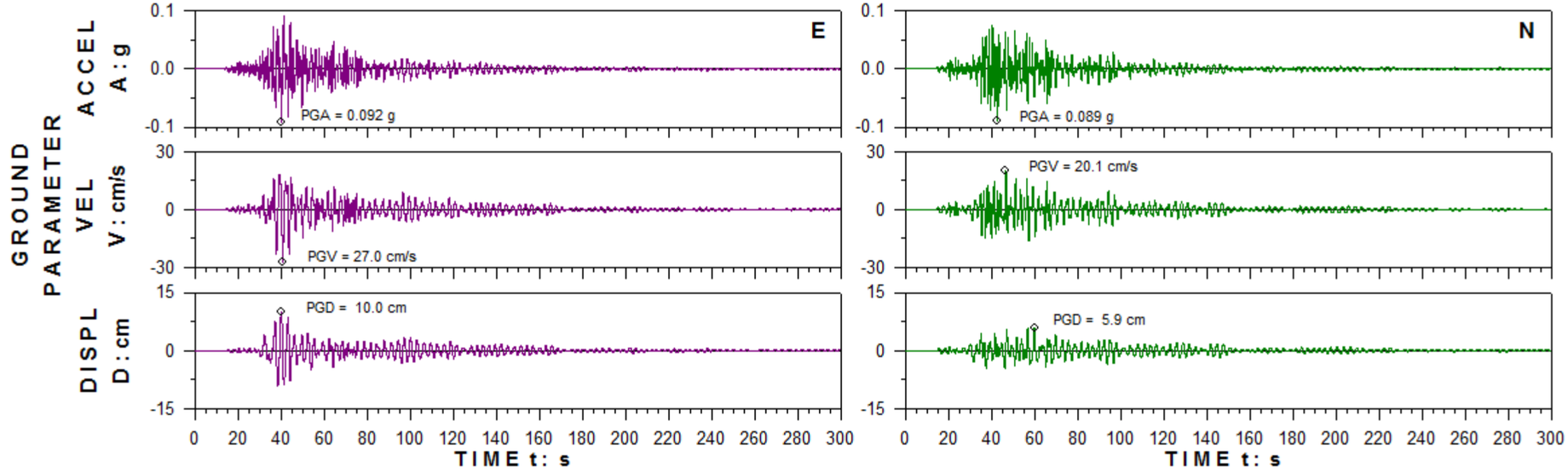
ATC-MEXICO RECONNAISSANCE

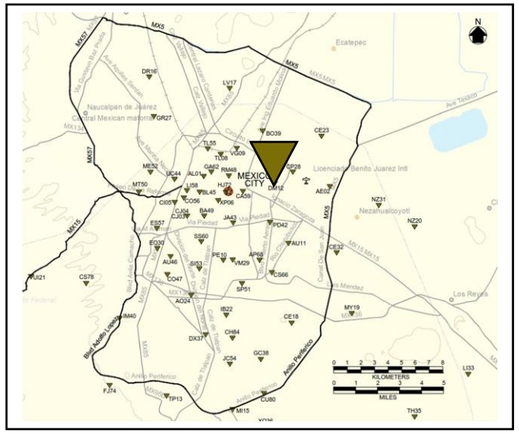
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

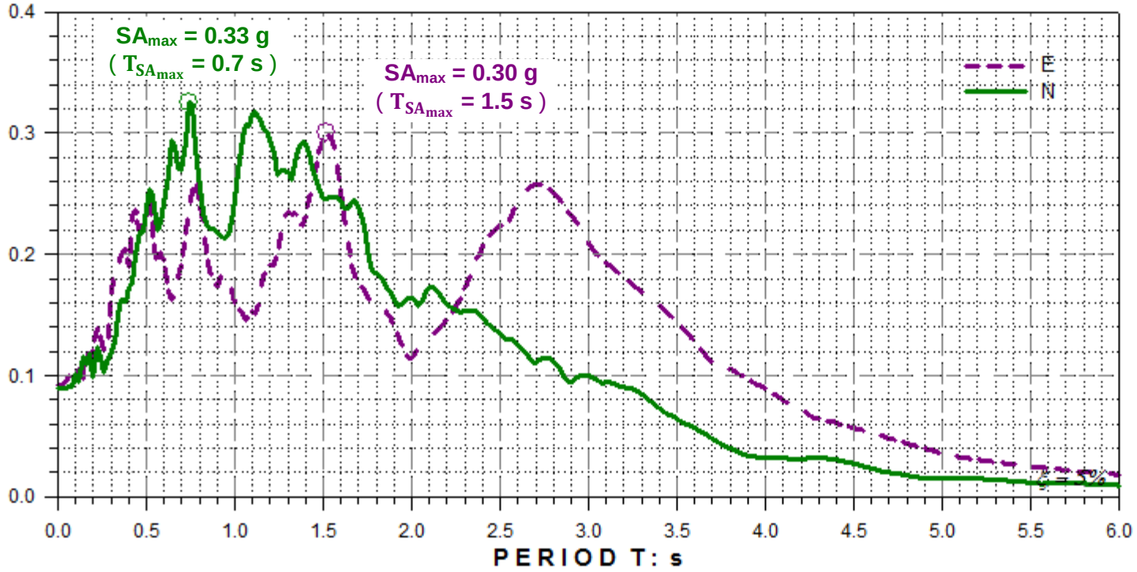
CIRES GROUND MOTIONS

CU80 STATION (19.294° N, 98.896° W) MEXICO CITY, MEXICO	STATION CU80

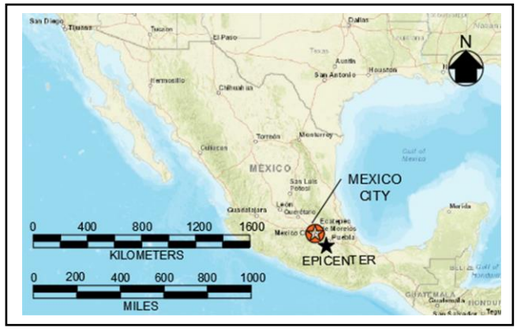
STATION: DM12







Parameter	E	N
PGA (g)	0.092	0.089
PGV (cm/s)	27.0	20.1
PGD (cm)	10.0	5.9
Period of Highest Spectral Peak (s)	1.5	0.7
Arias Intensity (m/s)	0.512	0.587
R_e (km)	121	



NOTES

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2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-28 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

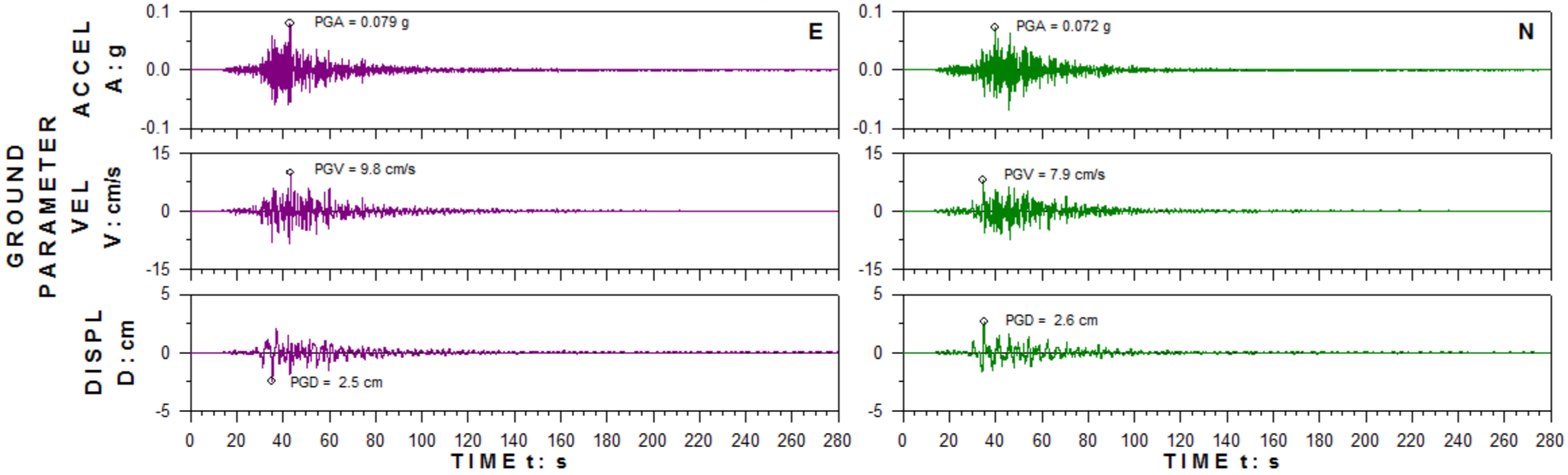
ATC-MEXICO RECONNAISSANCE

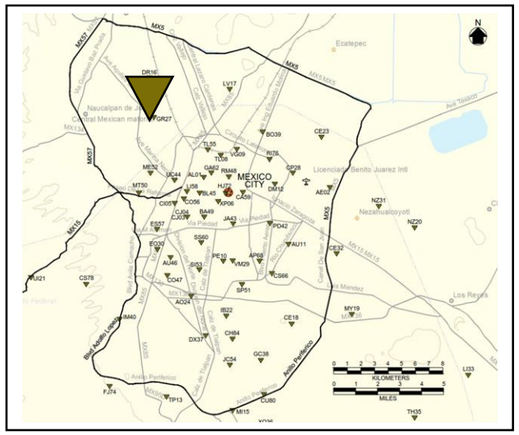
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

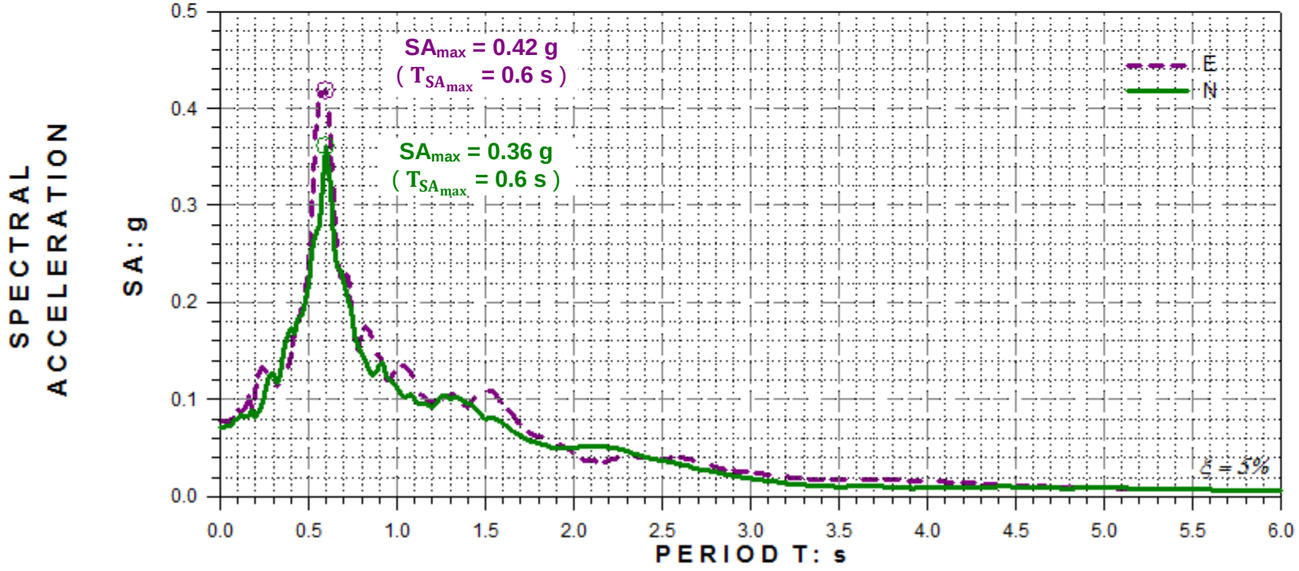
CIRES GROUND MOTIONS

DM12 STATION (19.431° N, 98.904° W) MEXICO CITY, MEXICO	STATION DM12

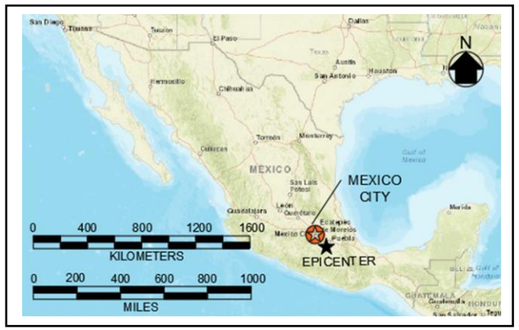
STATION: DR16







Parameter	E	N
PGA (g)	0.079	0.072
PGV (cm/s)	9.8	7.9
PGD (cm)	2.5	2.6
Period of Highest Spectral Peak (s)	0.6	0.6
Arias Intensity (m/s)	0.213	0.203
R_e (km)	131	



NOTES

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ATC-MEXICO RECONNAISSANCE

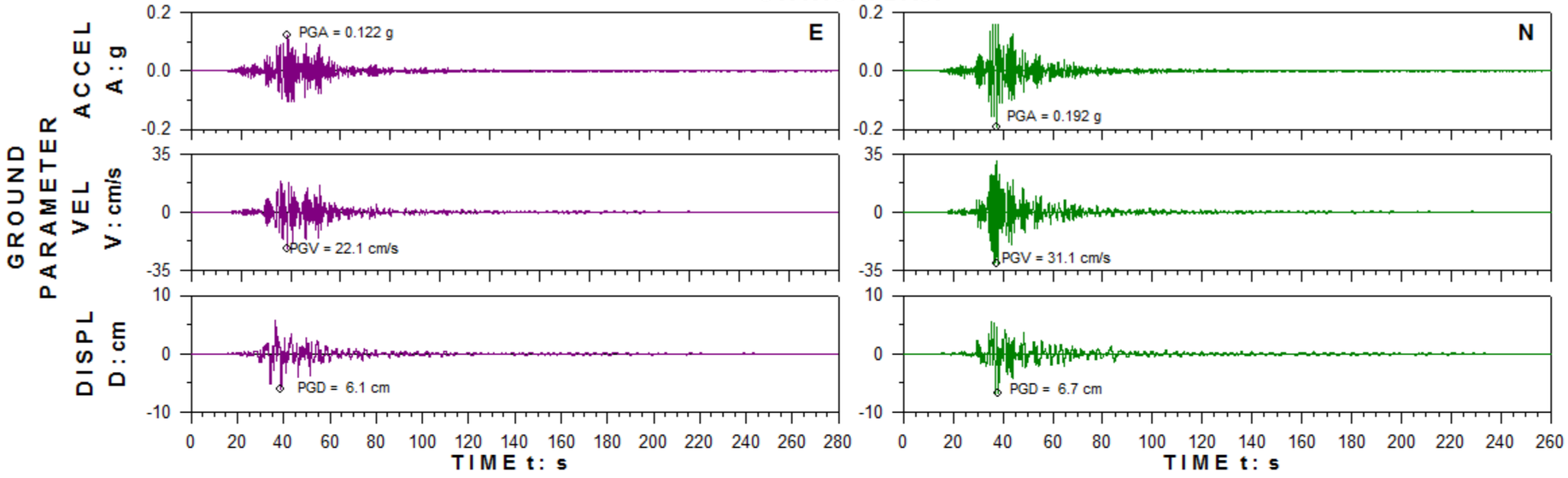
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

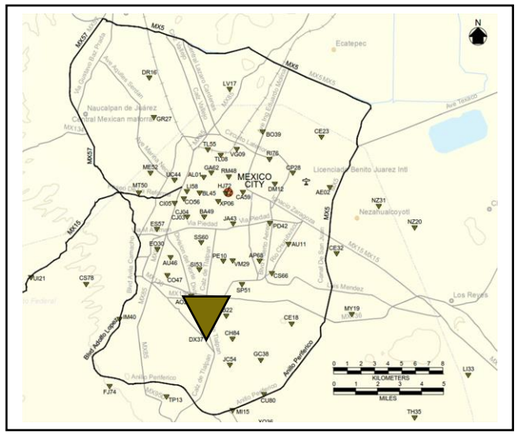
CIRES GROUND MOTIONS

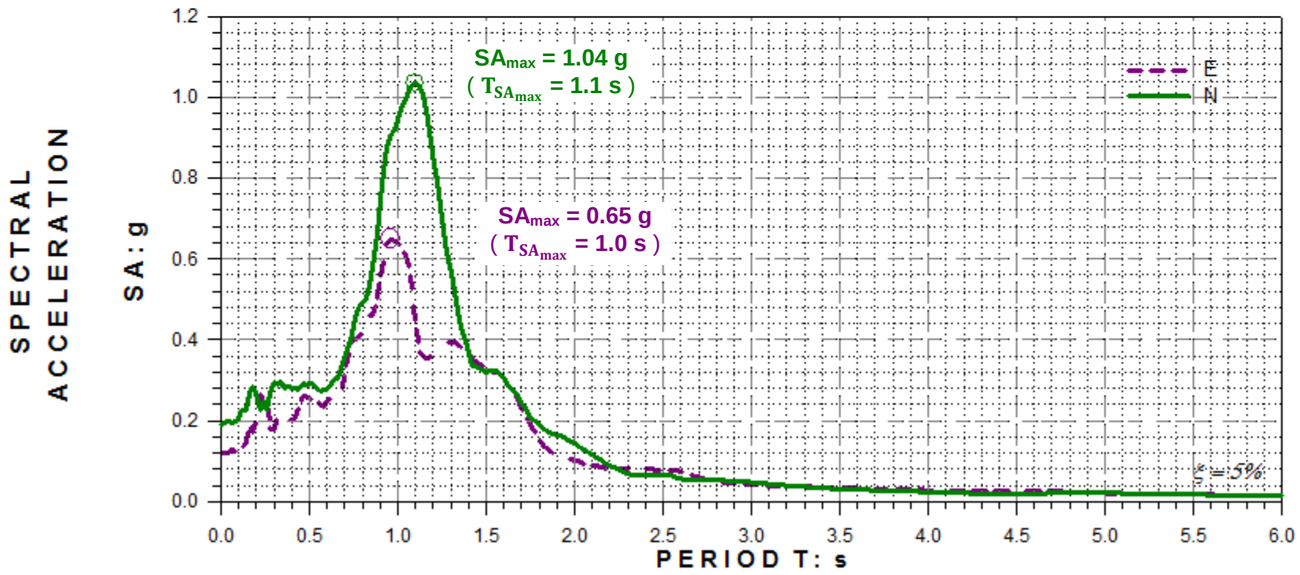
DR16 STATION (19.501° N, 98.817° W)
MEXICO CITY, MEXICO

STATION DR16

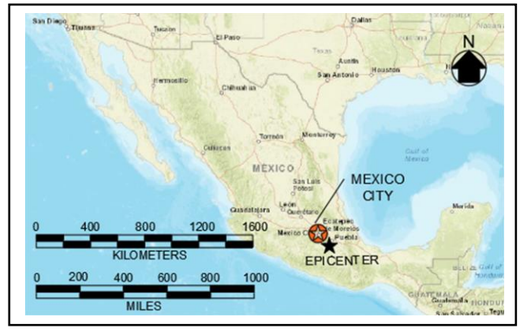
STATION: DX37







Parameter	E	N
PGA (g)	0.122	0.192
PGV (cm/s)	22.1	31.1
PGD (cm)	6.1	6.7
Period of Highest Spectral Peak (s)	1.0	1.9
Arias Intensity (m/s)	0.818	1.435
R_e (km)	113	



NOTES

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ATC-MEXICO RECONNAISSANCE

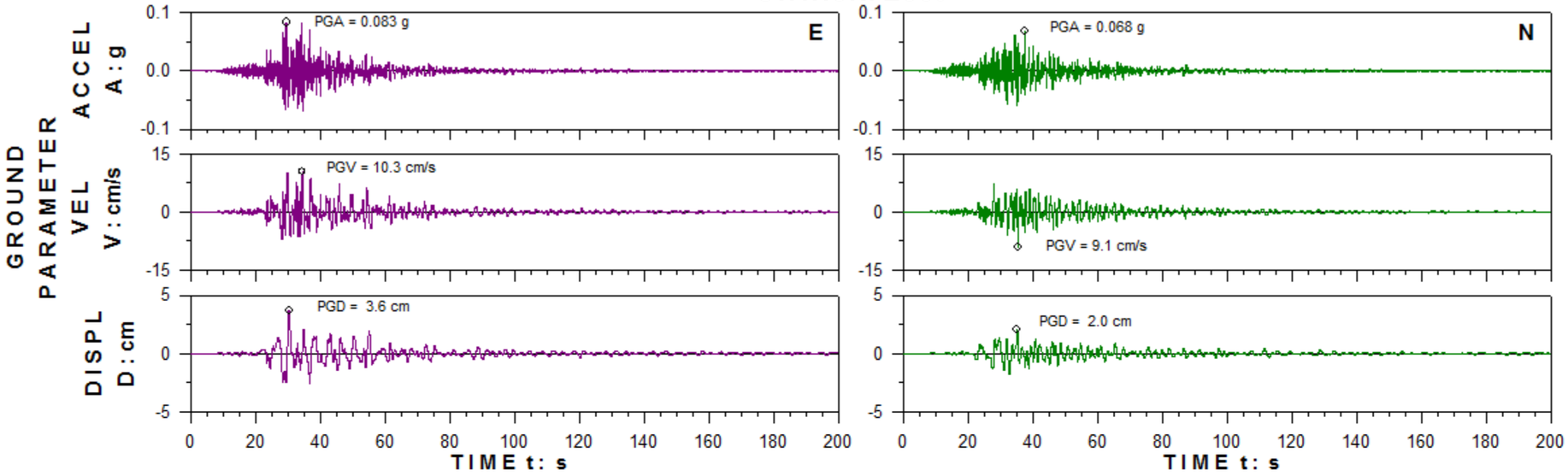
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

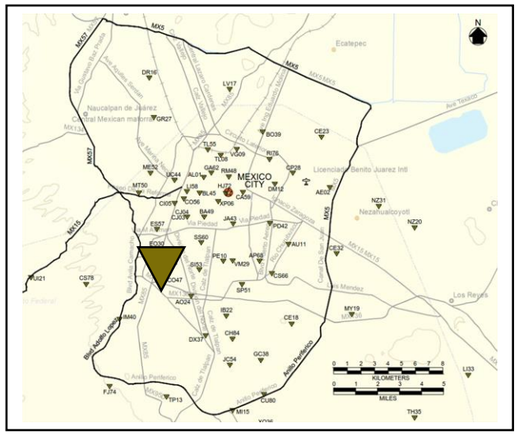
CIRES GROUND MOTIONS

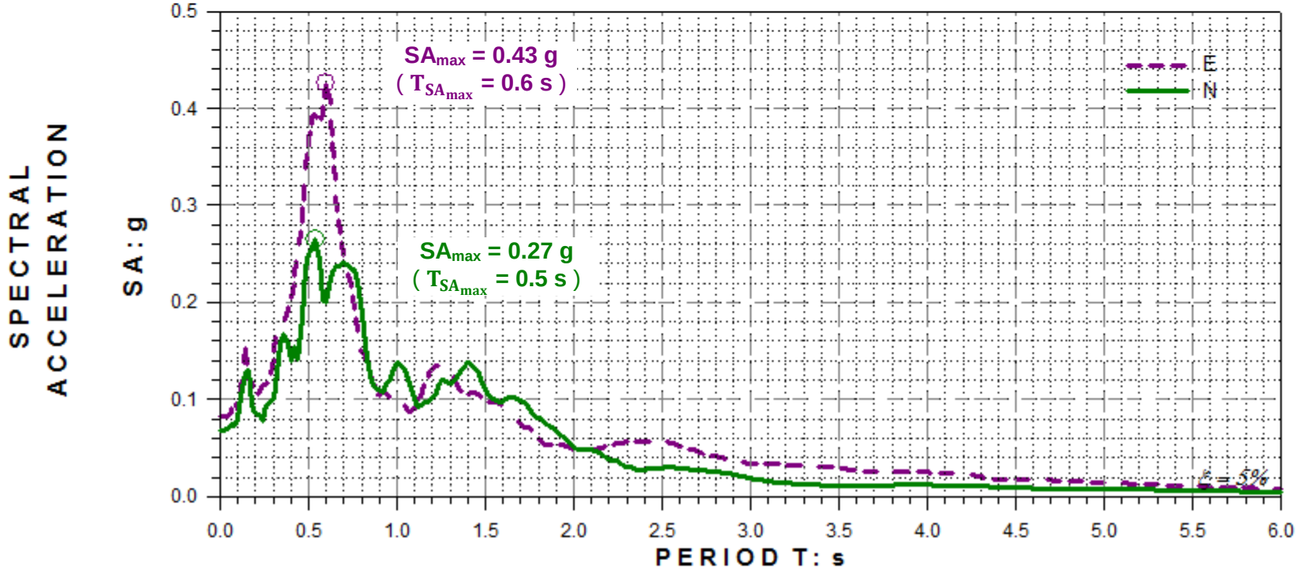
DX37 STATION (19.332° N, 98.856° W)
MEXICO CITY, MEXICO

STATION DX37

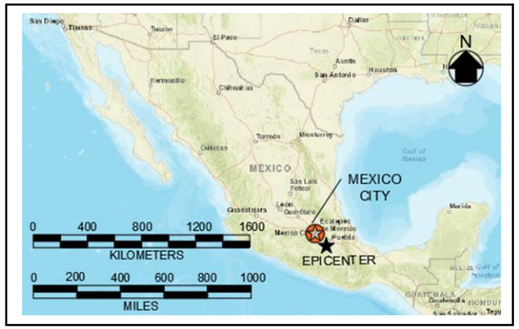
STATION: EO30







Parameter	E	N
PGA (g)	0.083	0.068
PGV (cm/s)	10.3	9.1
PGD (cm)	3.6	2.0
Period of Highest Spectral Peak (s)	0.6	0.5
Arias Intensity (m/s)	0.245	0.164
R_e (km)	120	



NOTES

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3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

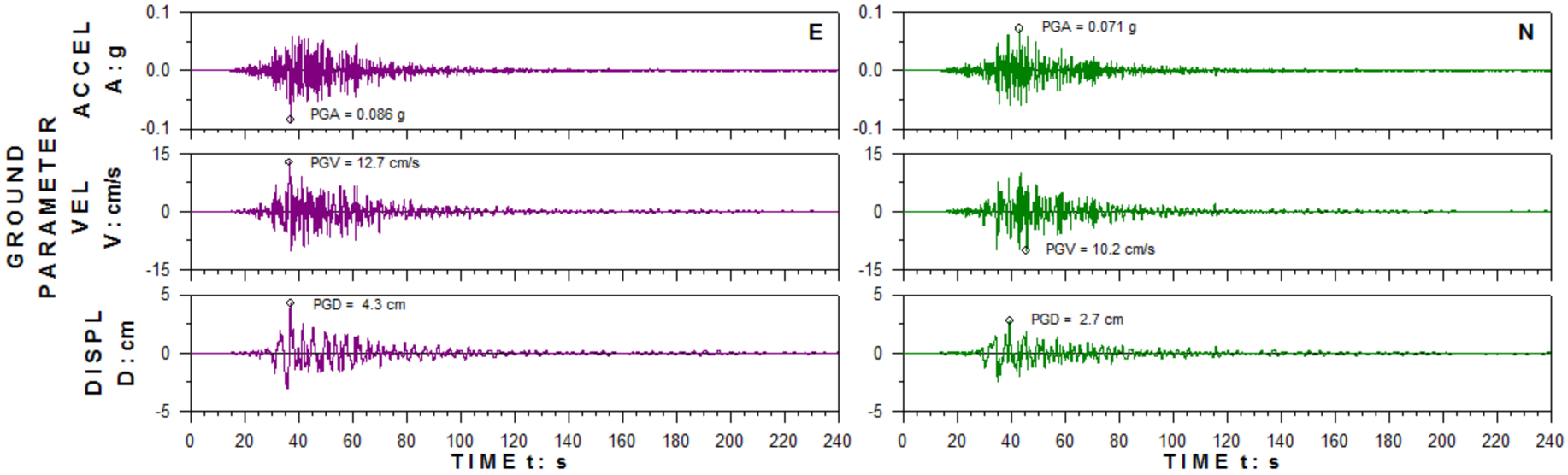
ATC-MEXICO RECONNAISSANCE

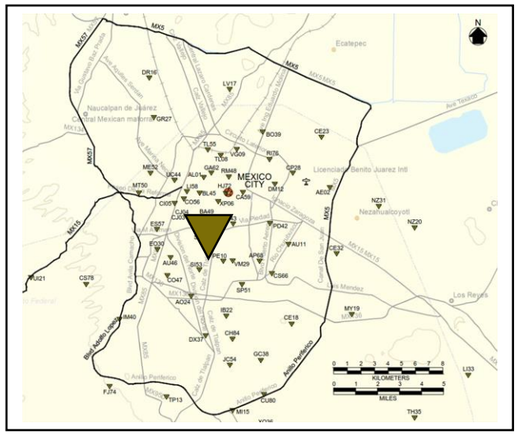
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

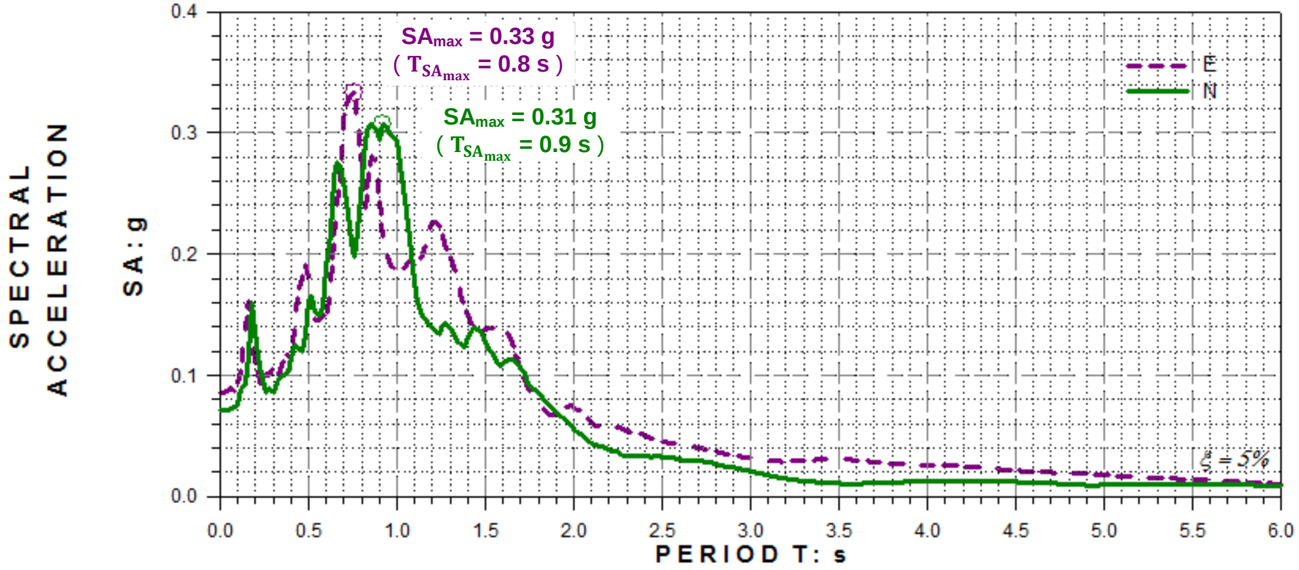
CIRES GROUND MOTIONS

EO30 STATION (19.389° N, 98.823° W) MEXICO CITY, MEXICO	STATION EO30

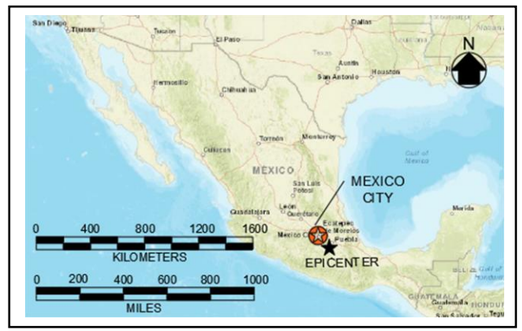
STATION: ES57







Parameter	E	N
PGA (g)	0.086	0.071
PGV (cm/s)	12.7	10.2
PGD (cm)	4.3	2.7
Period of Highest Spectral Peak (s)	0.8	0.9
Arias Intensity (m/s)	0.319	0.242
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-23 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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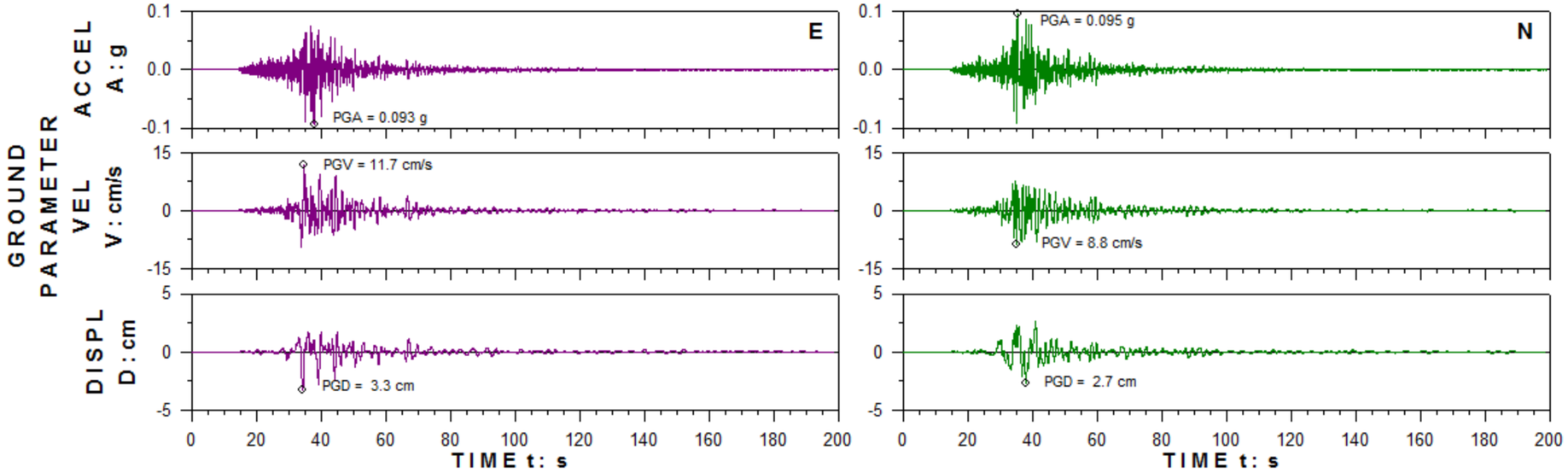
ATC-MEXICO RECONNAISSANCE

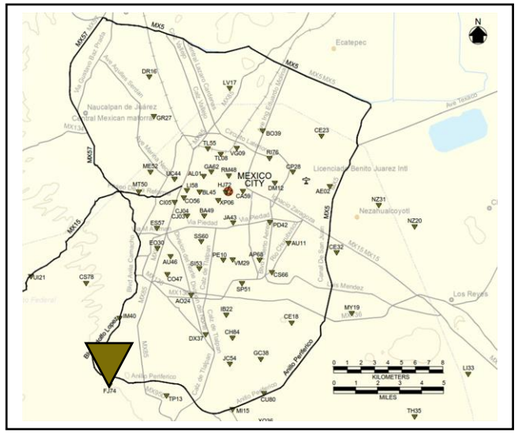
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

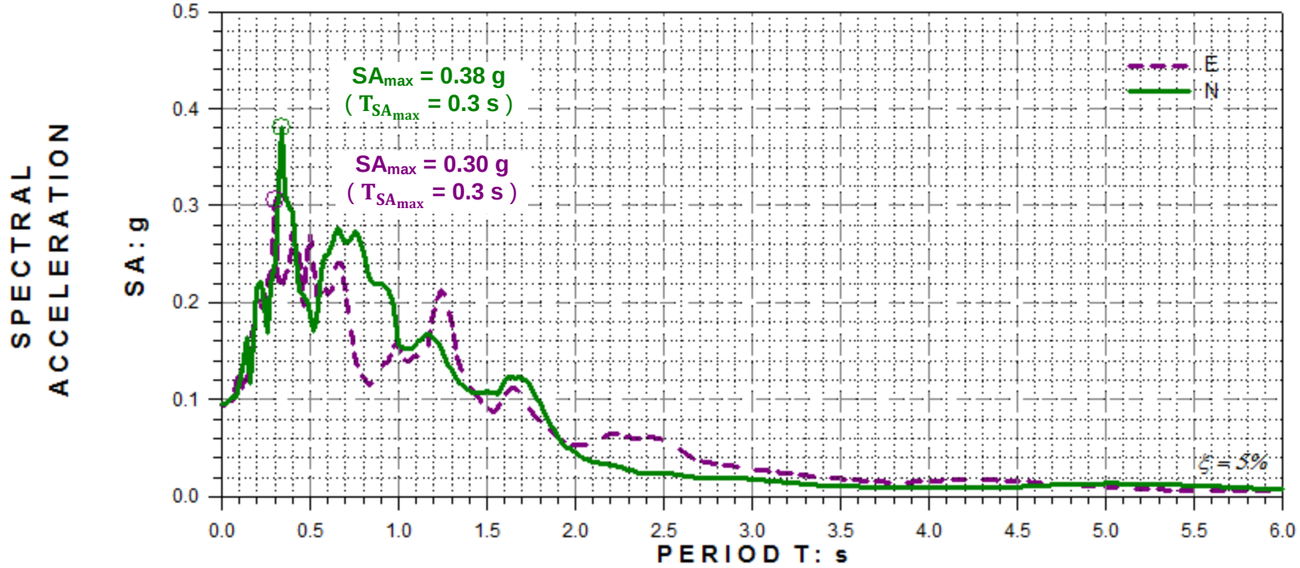
CIRES GROUND MOTIONS

ES57 STATION (19.402° N, 98.823° W) MEXICO CITY, MEXICO	STATION ES57

STATION: FJ74







Parameter	E	N
PGA (g)	0.093	0.095
PGV (cm/s)	11.7	8.8
PGD (cm)	3.3	2.7
Period of Highest Spectral Peak (s)	0.3	0.3
Arias Intensity (m/s)	0.222	0.216
R_e (km)	112	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
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4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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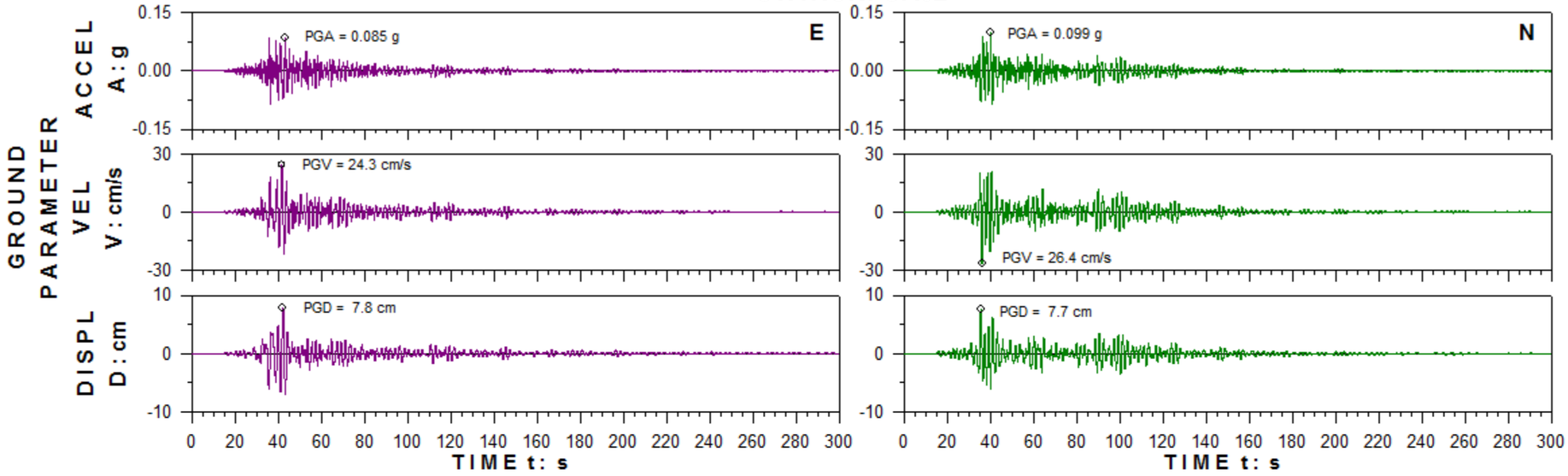
ATC-MEXICO RECONNAISSANCE

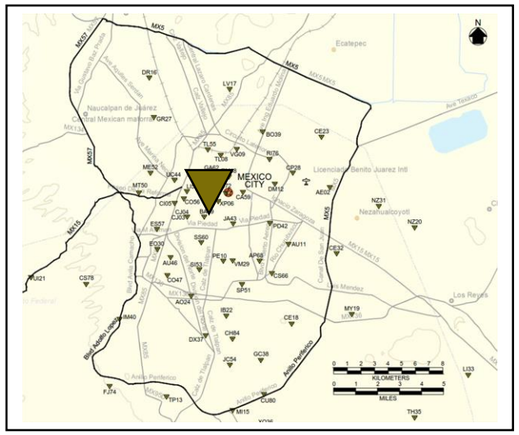
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

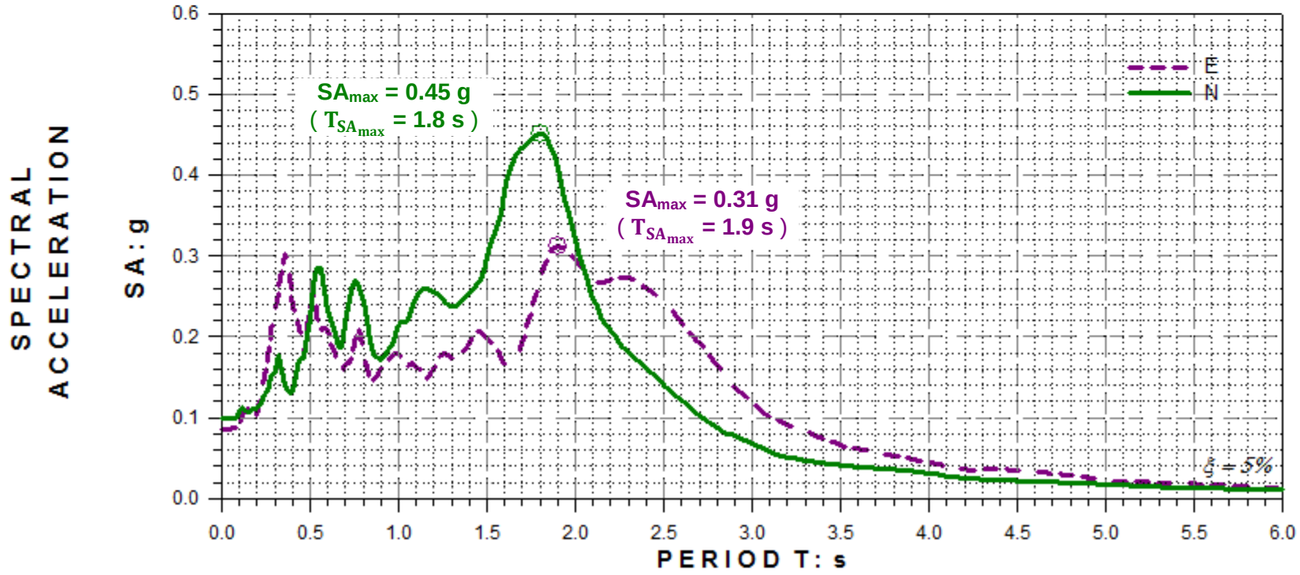
CIRES GROUND MOTIONS

FJ74 STATION (19.299° N, 98.790° W) MEXICO CITY, MEXICO	STATION FJ74

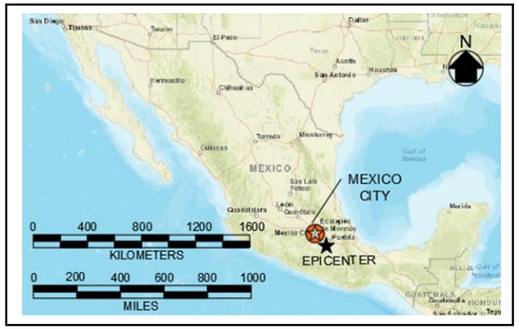
STATION: GA62







Parameter	E	N
PGA (g)	0.085	0.099
PGV (cm/s)	24.3	26.4
PGD (cm)	7.8	7.7
Period of Highest Spectral Peak (s)	1.9	1.8
Arias Intensity (m/s)	0.453	0.601
R_e (km)	123	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.16-23 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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ATC-MEXICO RECONNAISSANCE

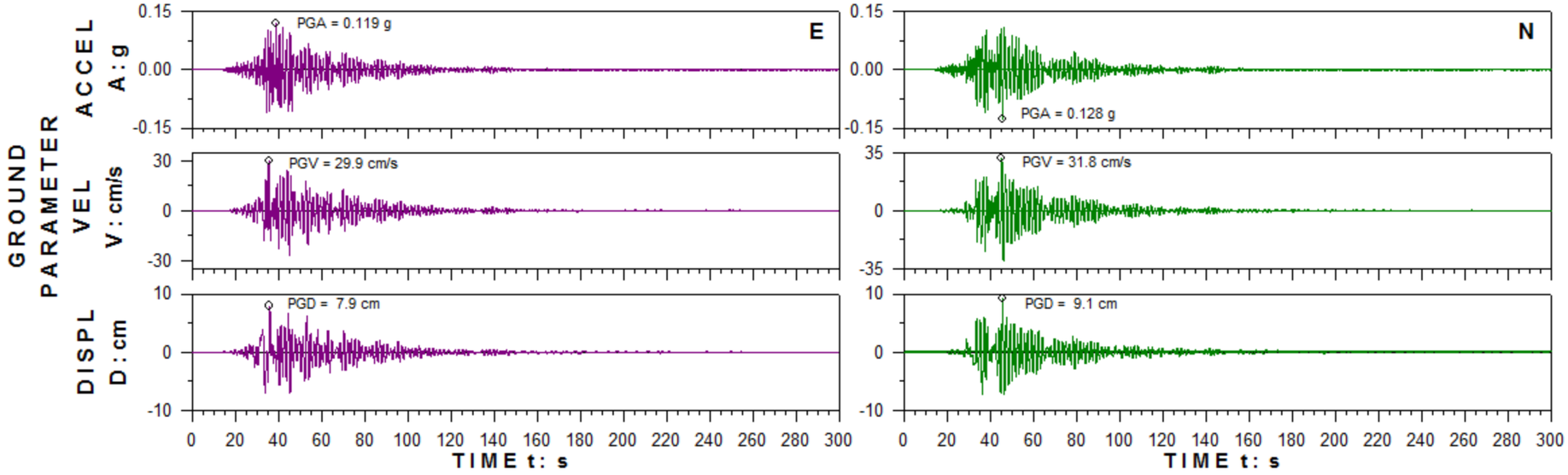
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

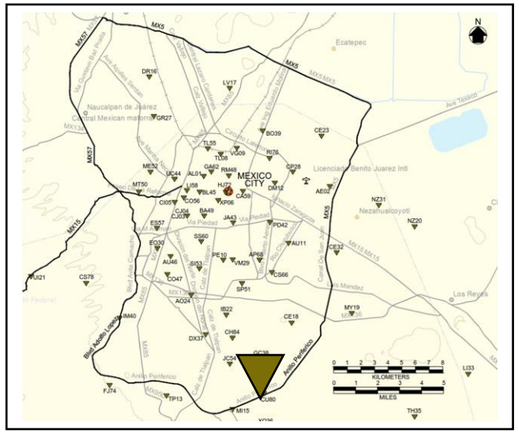
CIRES GROUND MOTIONS

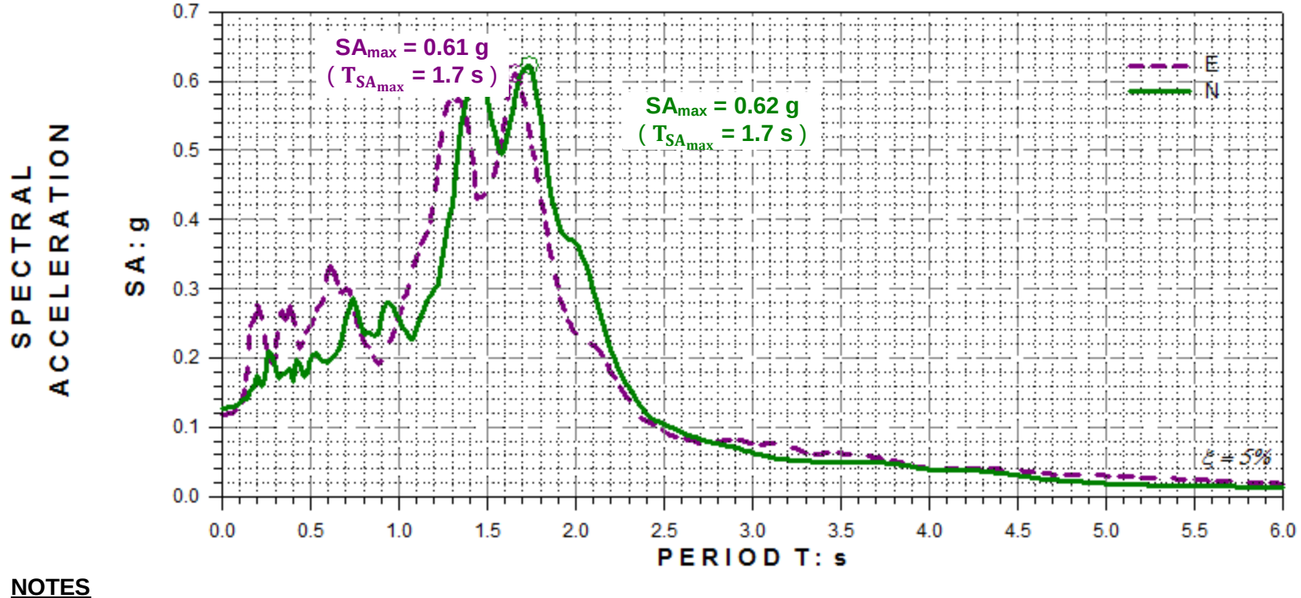
GA62 STATION (19.439° N, 98.860° W)
MEXICO CITY, MEXICO

STATION GA62

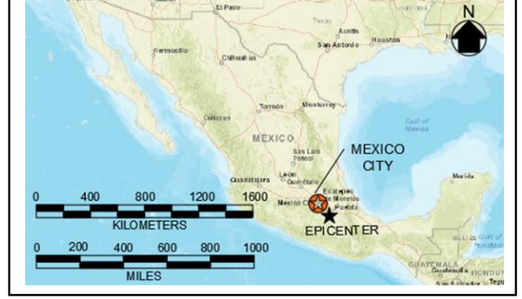
STATION: GC38







Parameter	E	N
PGA (g)	0.119	0.128
PGV (cm/s)	29.9	31.8
PGD (cm)	7.9	9.1
Period of Highest Spectral Peak (s)	1.7	1.7
Arias Intensity (m/s)	1.144	1.268
R_e (km)	109	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.18-25 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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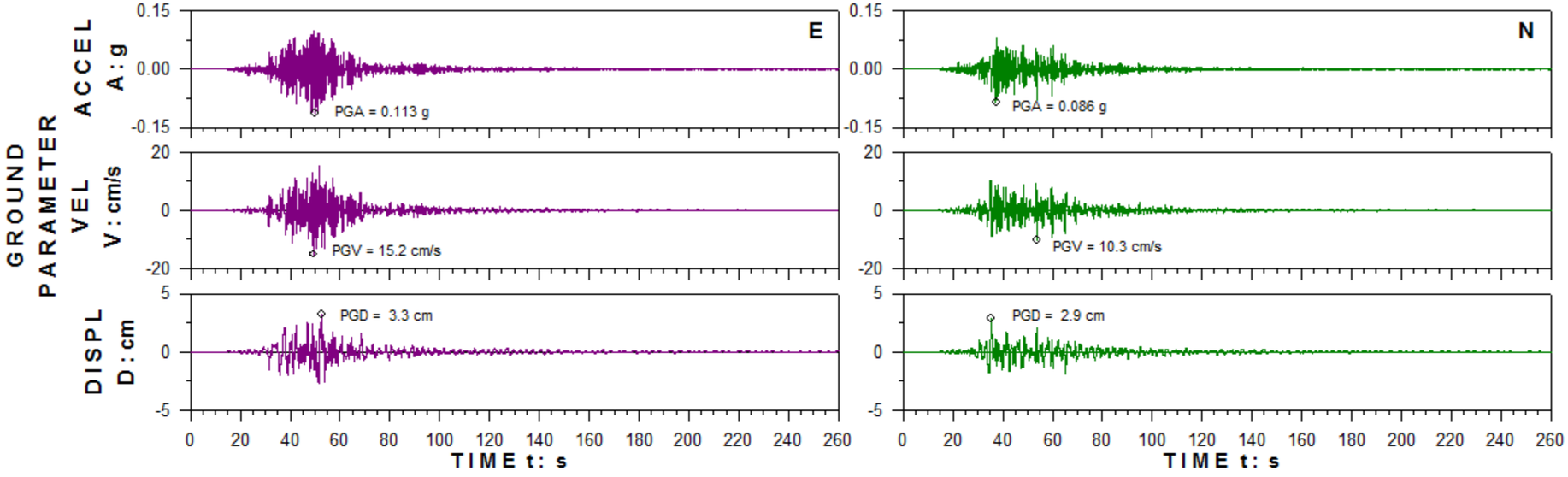
ATC-MEXICO RECONNAISSANCE

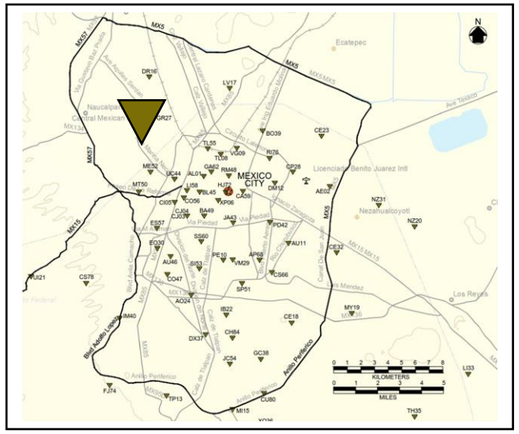
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

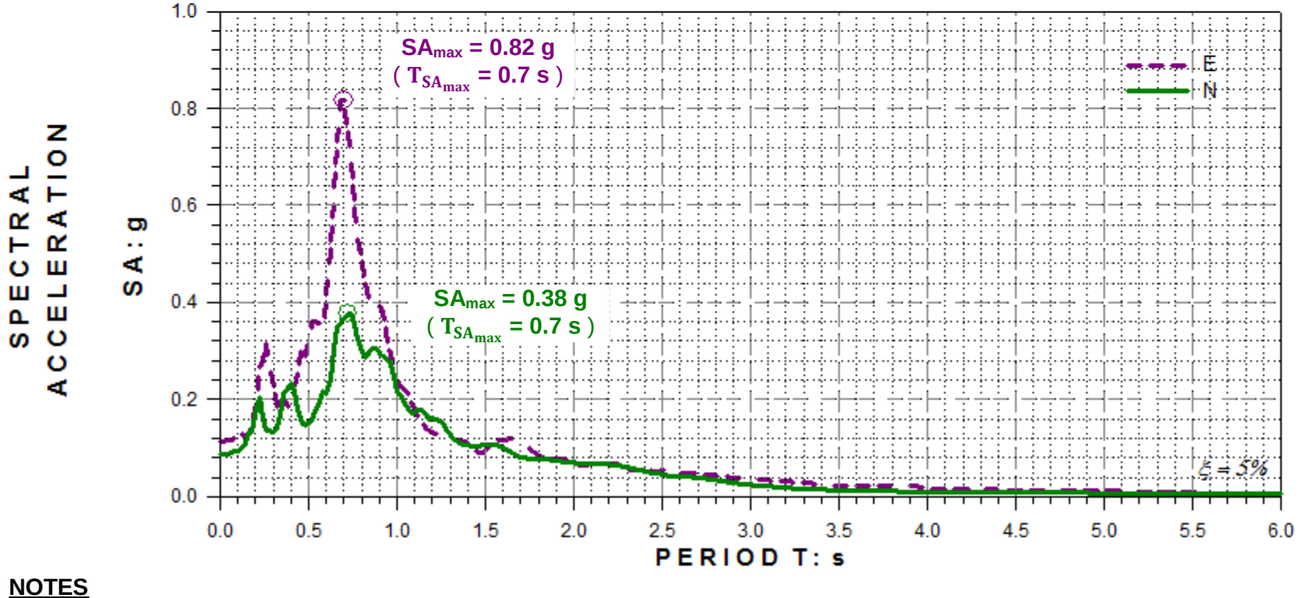
CIRES GROUND MOTIONS

GC38 STATION (19.316° N, 98.894° W) MEXICO CITY, MEXICO	STATION GC38

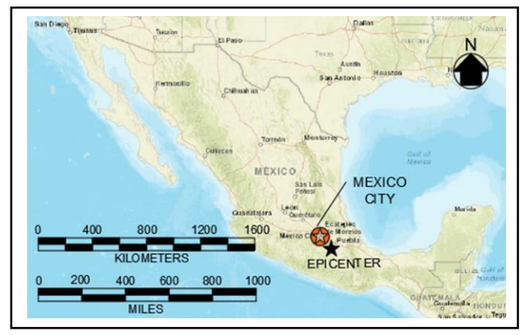
STATION: GR27







Parameter	E	N
PGA (g)	0.113	0.086
PGV (cm/s)	15.2	10.3
PGD (cm)	3.3	2.9
Period of Highest Spectral Peak (s)	0.7	0.7
Arias Intensity (m/s)	0.895	0.399
R_e (km)	129	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.21-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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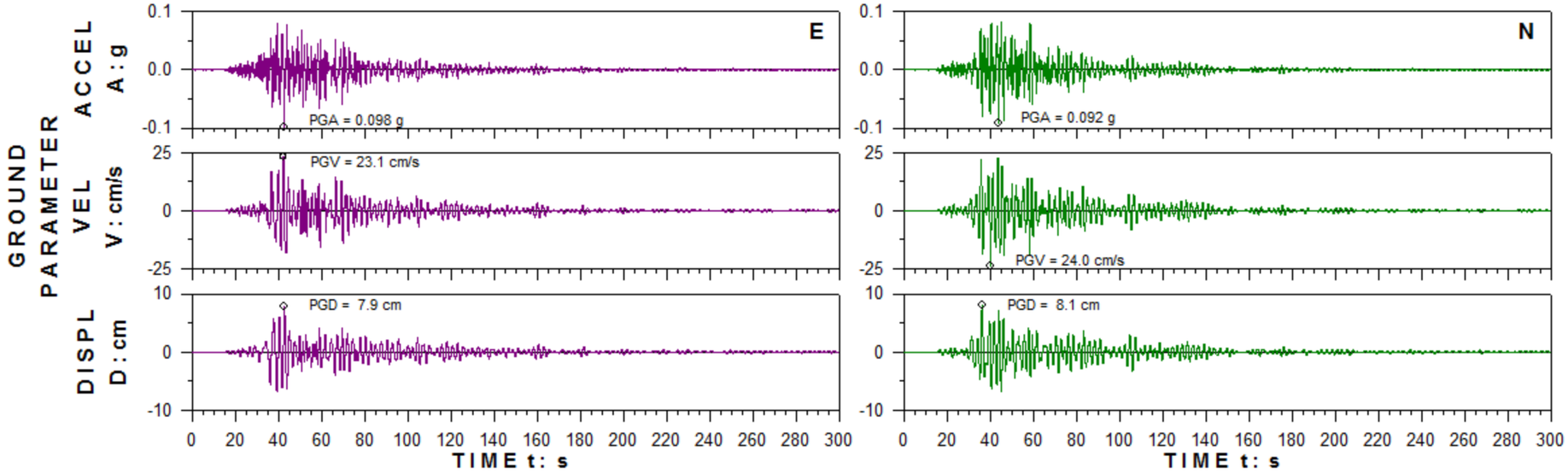
ATC-MEXICO RECONNAISSANCE

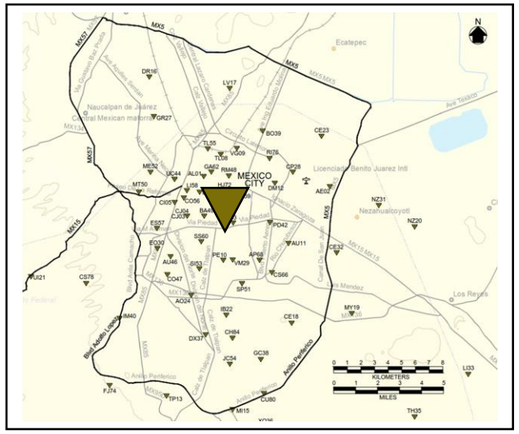
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

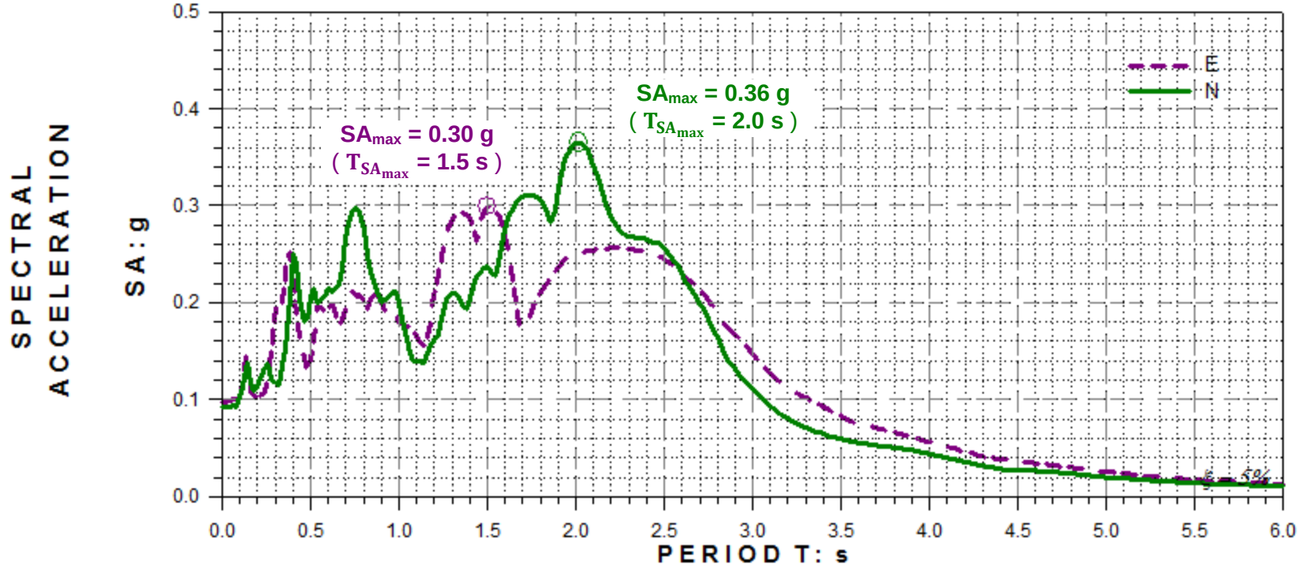
CIRES GROUND MOTIONS

GR27 STATION (19.475° N, 98.820° W) MEXICO CITY, MEXICO	STATION GR27

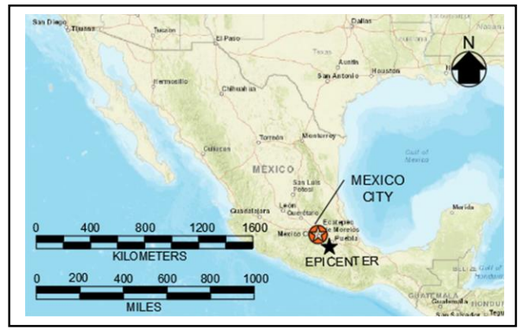
STATION: HJ72







Parameter	E	N
PGA (g)	0.098	0.092
PGV (cm/s)	23.1	24.0
PGD (cm)	7.9	8.1
Period of Highest Spectral Peak (s)	1.5	2.0
Arias Intensity (m/s)	0.563	0.651
R_e (km)	122	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.17-27 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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ATC-MEXICO RECONNAISSANCE

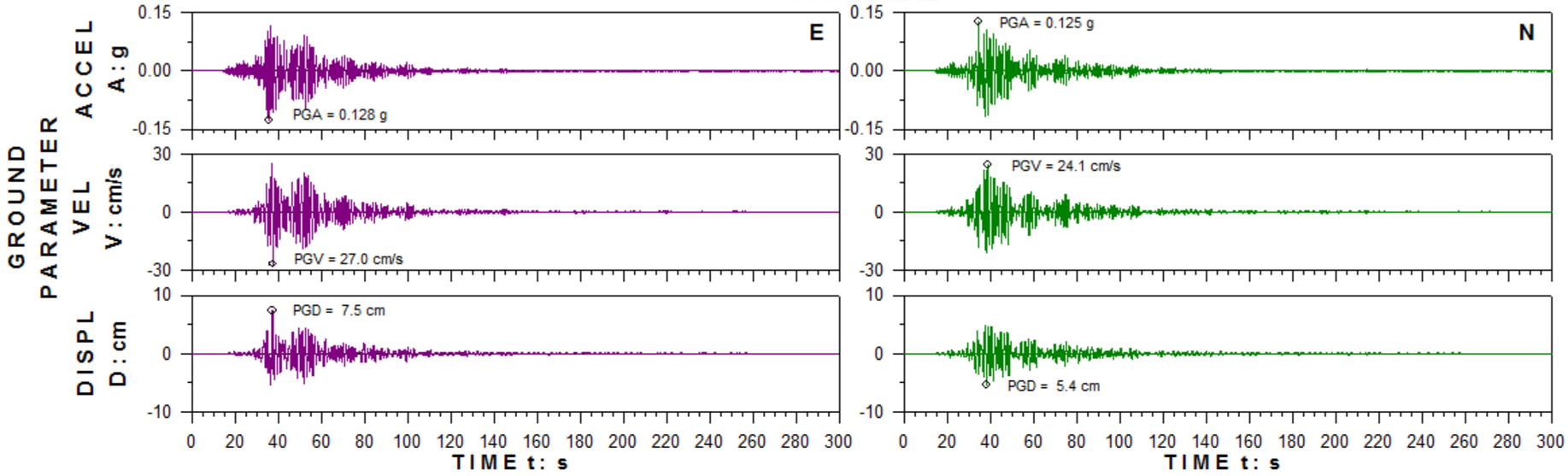
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

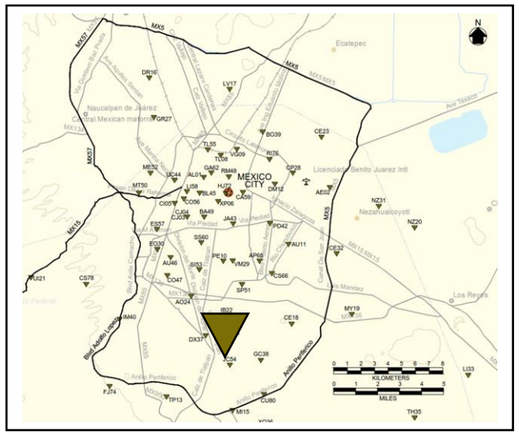
CIRES GROUND MOTIONS

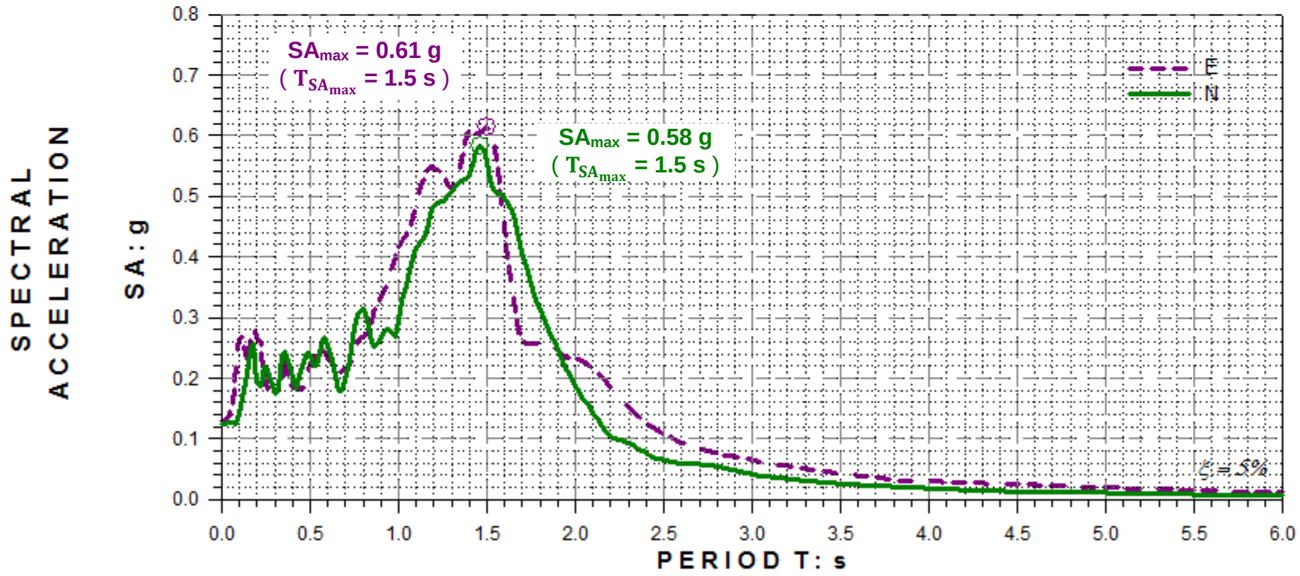
HJ72 STATION (19.425° N, 98.870° W)
MEXICO CITY, MEXICO

STATION HJ72

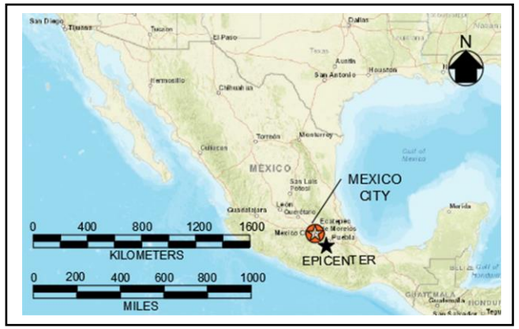
STATION: IB22







Parameter	E	N
PGA (g)	0.128	0.125
PGV (cm/s)	27.0	24.1
PGD (cm)	7.5	5.4
Period of Highest Spectral Peak (s)	1.5	1.5
Arias Intensity (m/s)	1.086	0.869
R_e (km)	113	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.25-28 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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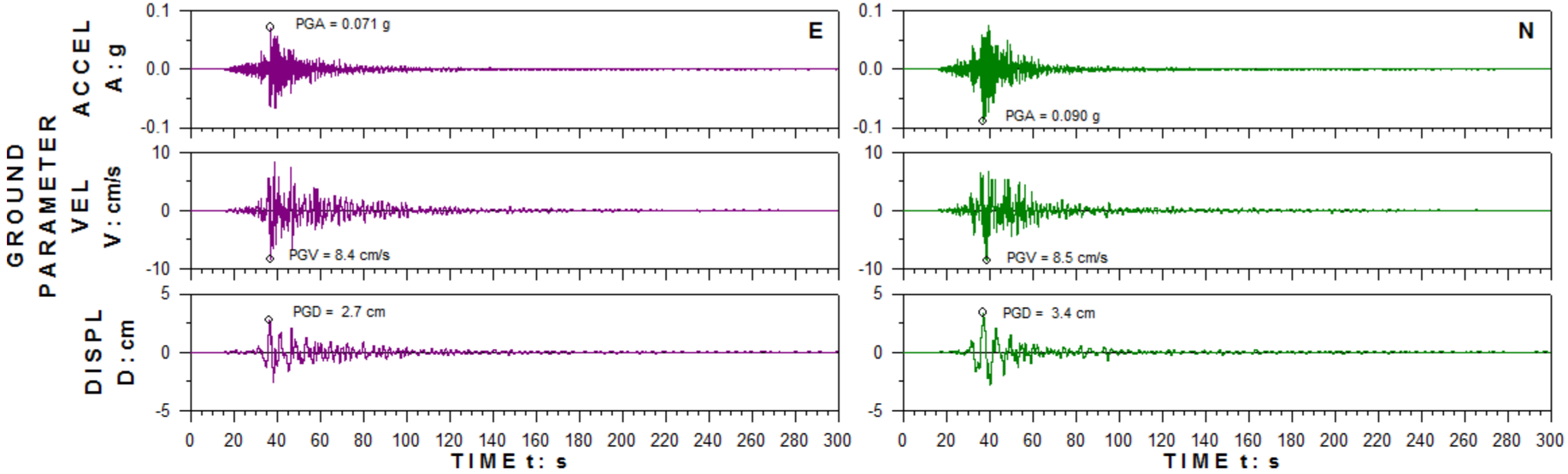
ATC-MEXICO RECONNAISSANCE

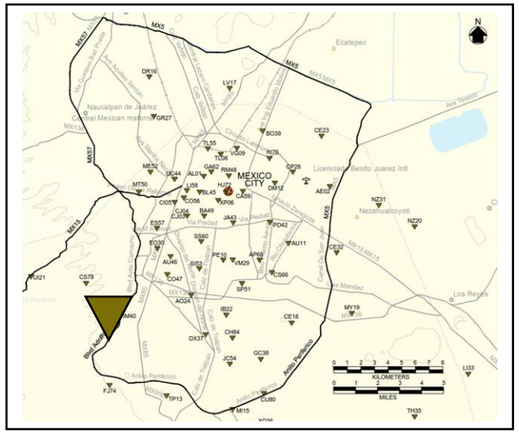
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

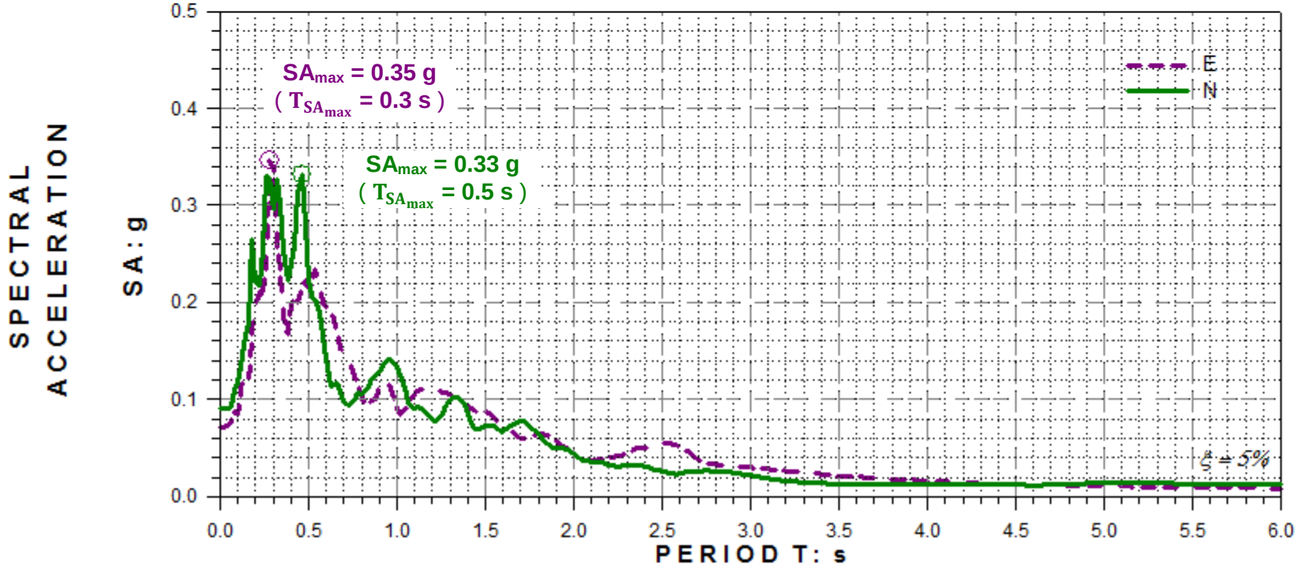
CIRES GROUND MOTIONS

IB22 STATION (19.345° N, 98.870° W) MEXICO CITY, MEXICO	STATION IB22

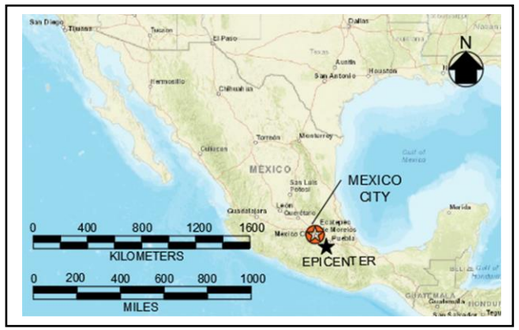
STATION: IM40







Parameter	E	N
PGA (g)	0.071	0.090
PGV (cm/s)	8.4	8.5
PGD (cm)	2.7	3.4
Period of Highest Spectral Peak (s)	0.3	0.5
Arias Intensity (m/s)	0.143	0.186
R_e (km)	116	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-40 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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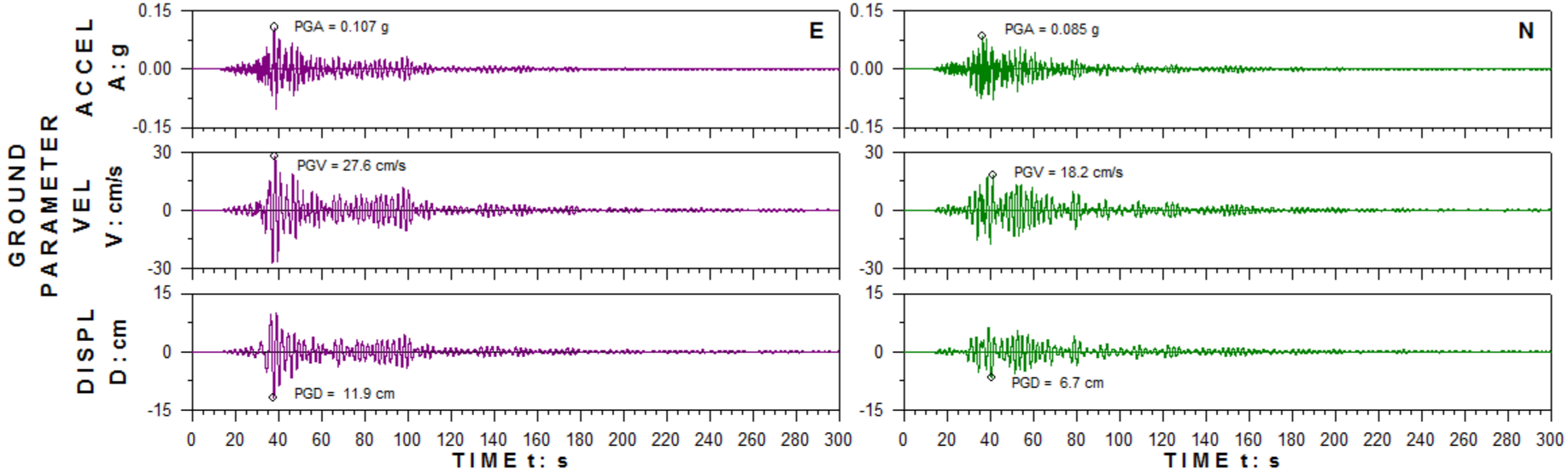
ATC-MEXICO RECONNAISSANCE

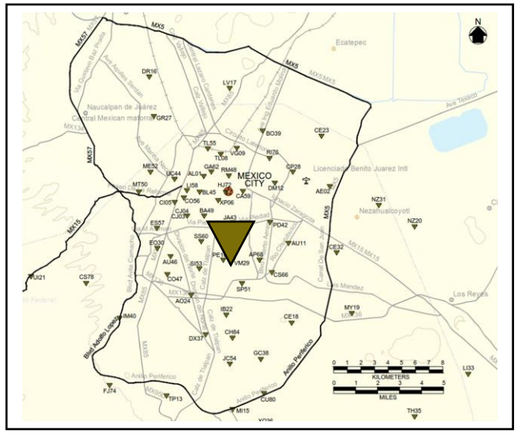
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

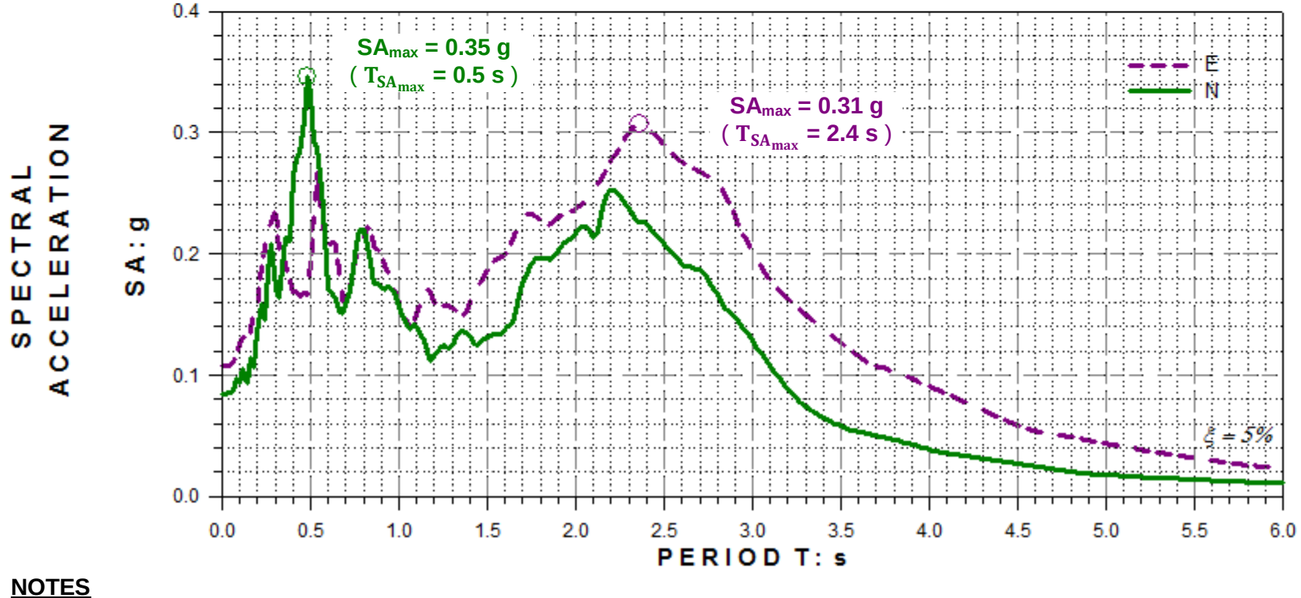
CIRES GROUND MOTIONS

IM40 STATION (19.343° N, 98.797° W) MEXICO CITY, MEXICO	STATION IM40

STATION: JA43







Parameter	E	N
PGA (g)	0.107	0.085
PGV (cm/s)	27.6	18.2
PGD (cm)	11.9	6.7
Period of Highest Spectral Peak (s)	0.5	2.4
Arias Intensity (m/s)	0.539	0.424
R_e (km)	119	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.14-27 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
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4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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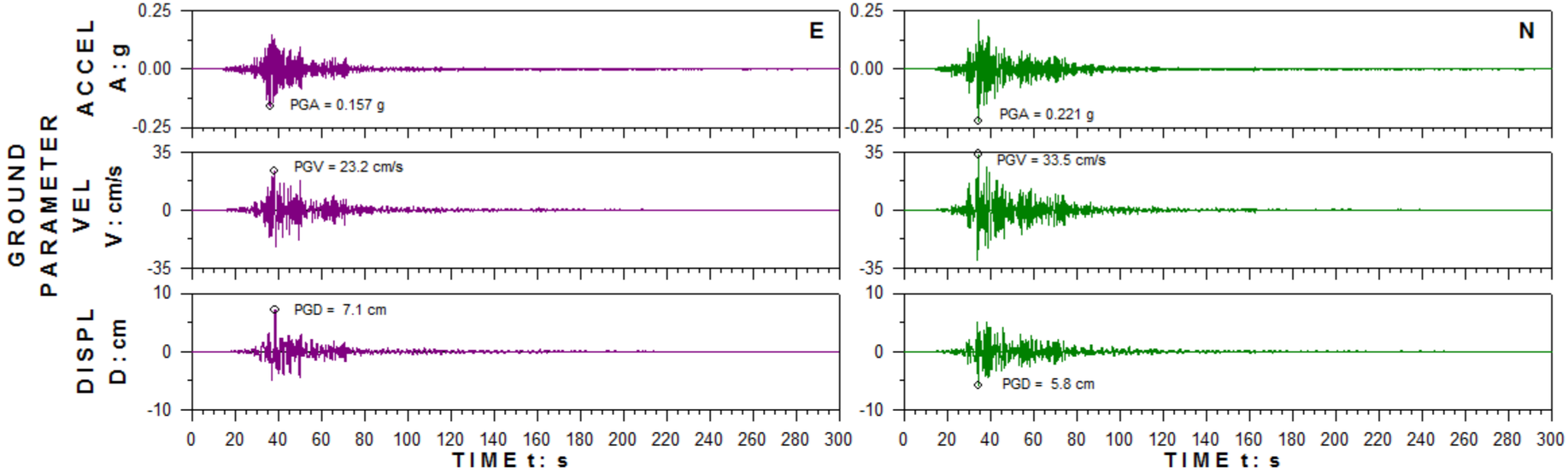
ATC-MEXICO RECONNAISSANCE

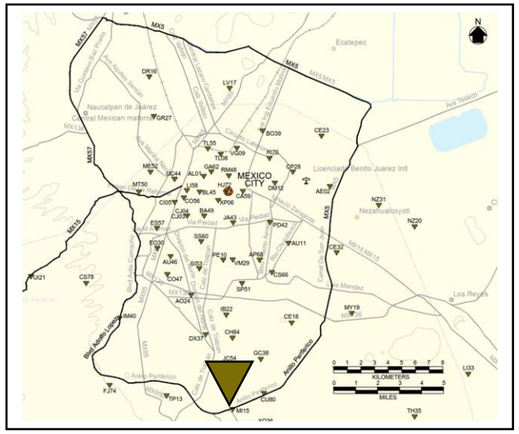
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

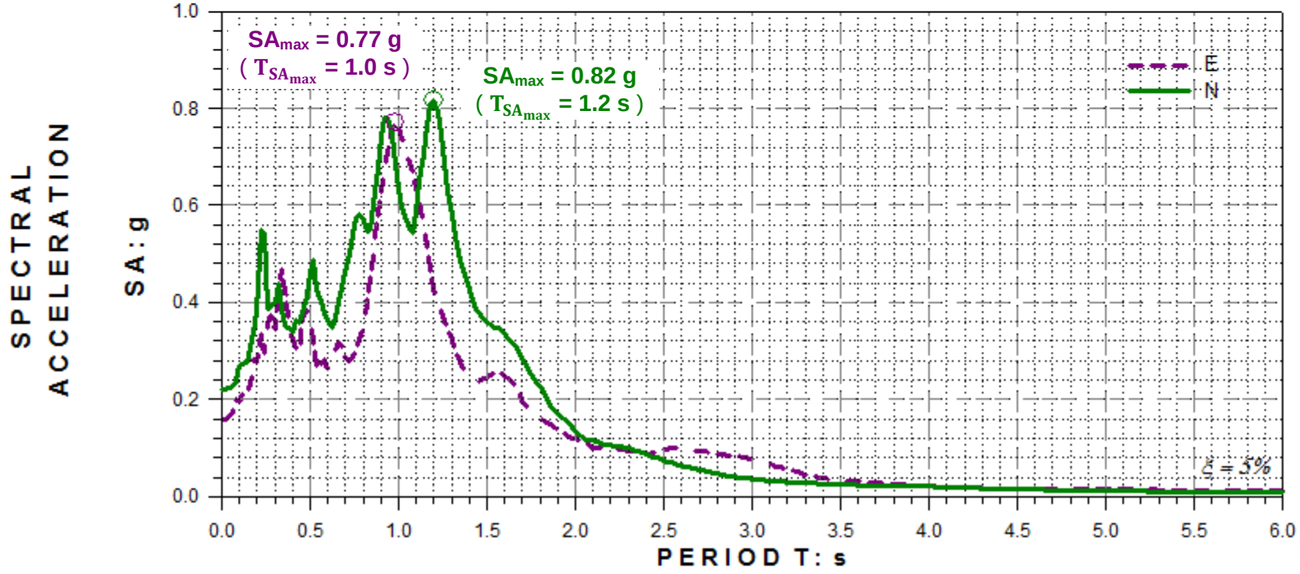
CIRES GROUND MOTIONS

JA43 STATION (19.405° N, 98.875° W) MEXICO CITY, MEXICO	STATION JA43

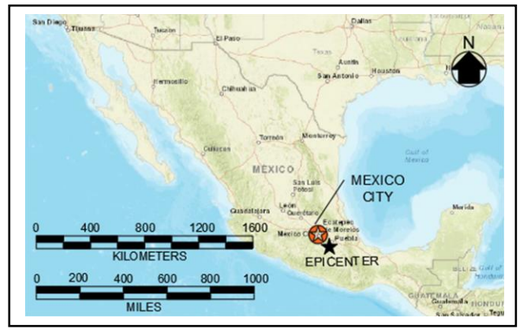
STATION: JC54







Parameter	E	N
PGA (g)	0.157	0.221
PGV (cm/s)	23.2	33.5
PGD (cm)	7.1	5.8
Period of Highest Spectral Peak (s)	1.0	1.2
Arias Intensity (m/s)	1.072	1.632
R_e (km)	110	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.25-22 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
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Applied Technology Council

ATC-MEXICO RECONNAISSANCE

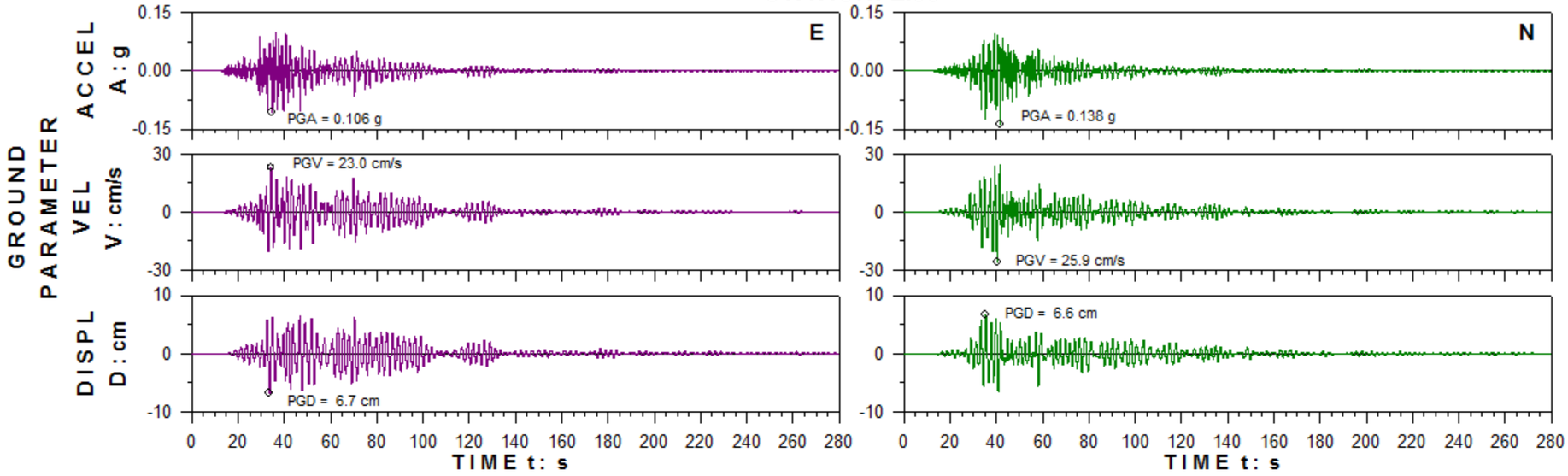
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

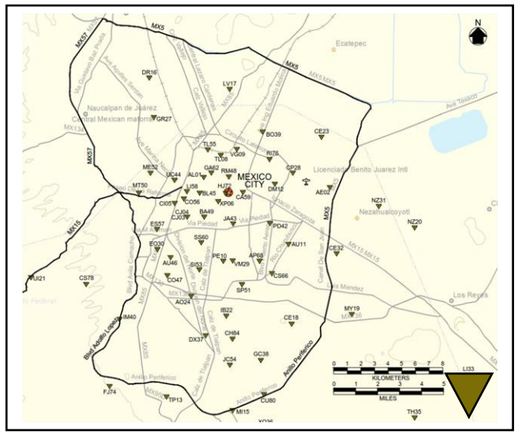
CIRES GROUND MOTIONS

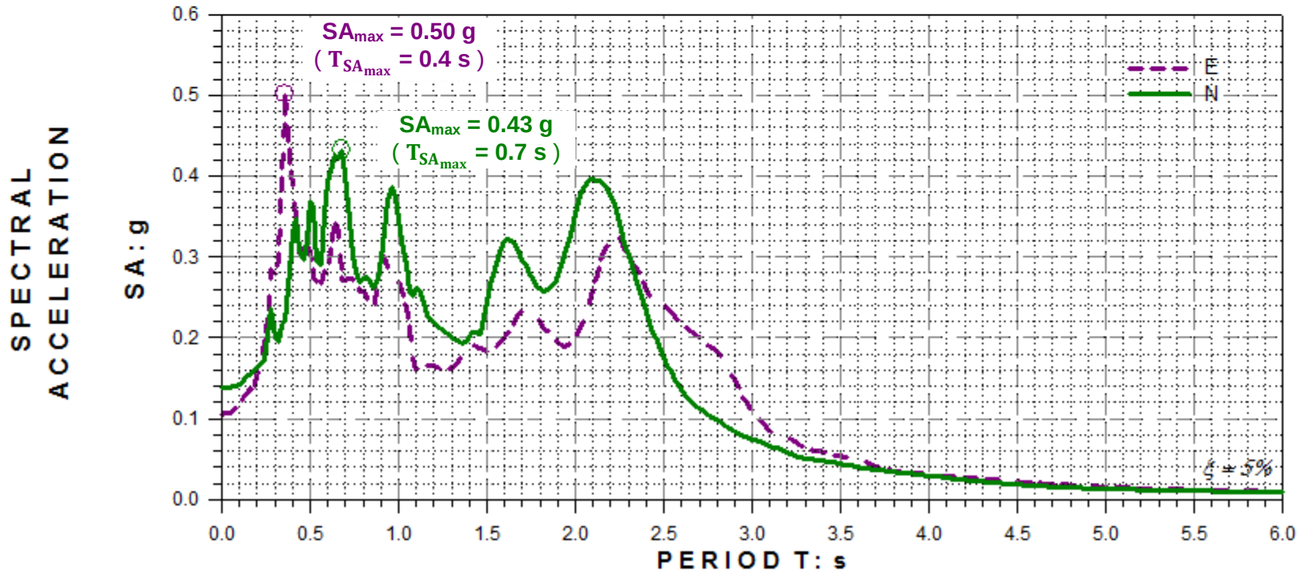
JC54 STATION (19.313° N, 98.873° W) MEXICO CITY, MEXICO

STATION JC54

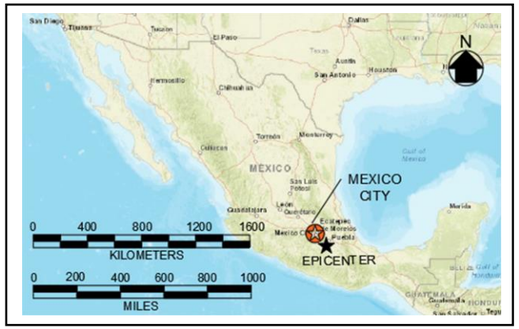
STATION: LI33







Parameter	E	N
PGA (g)	0.106	0.138
PGV (cm/s)	23.0	25.9
PGD (cm)	6.7	6.6
Period of Highest Spectral Peak (s)	0.4	0.7
Arias Intensity (m/s)	0.851	0.802
R_e (km)	104	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.27-30 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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ATC-MEXICO RECONNAISSANCE

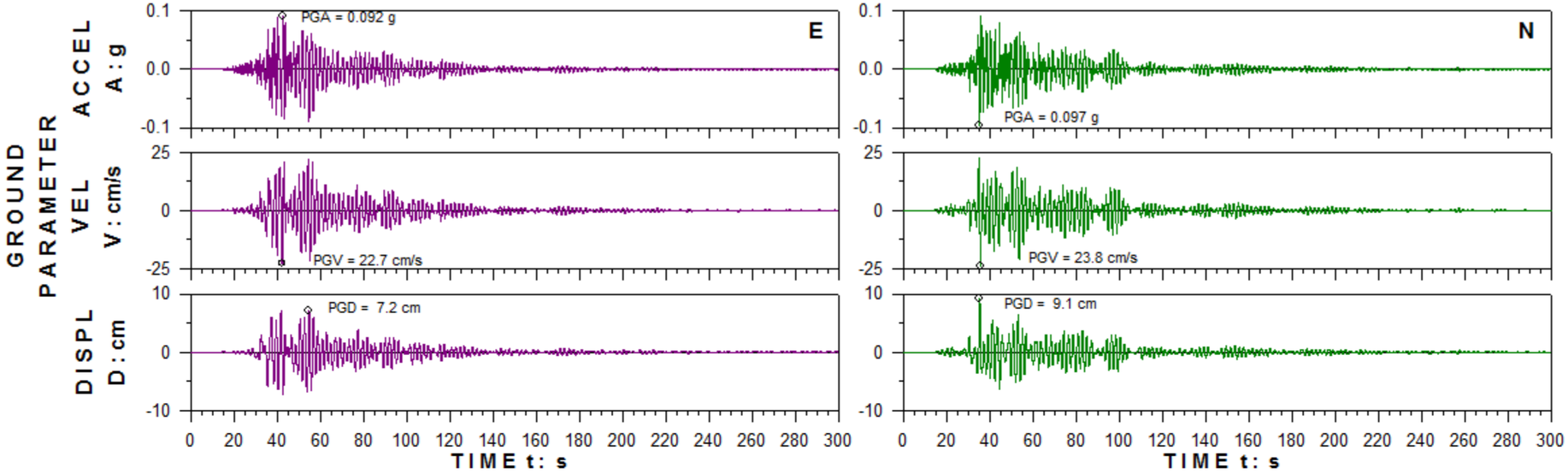
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

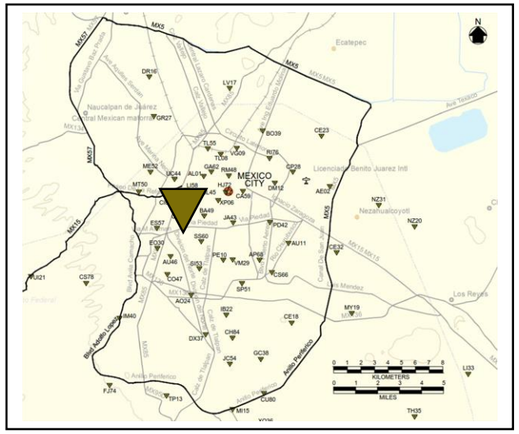
CIRES GROUND MOTIONS

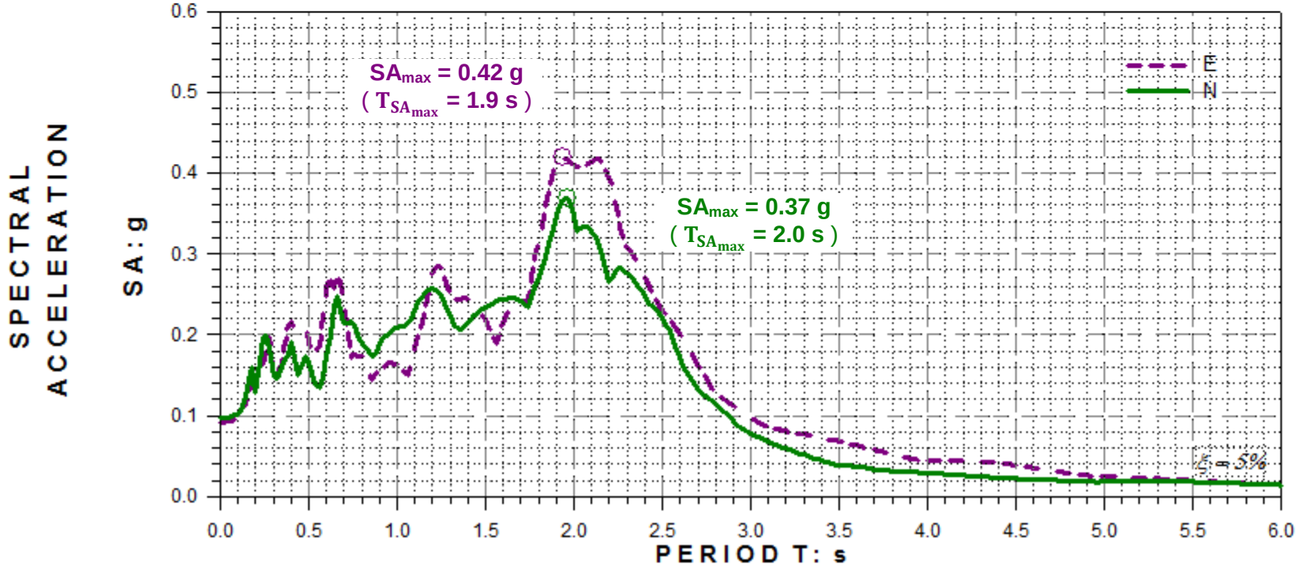
LI33 STATION (19.306° N, 97.037° W)
MEXICO CITY, MEXICO

STATION LI33

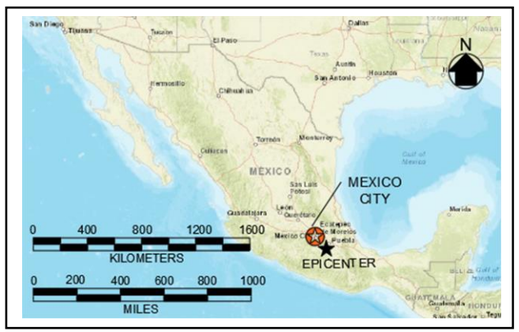
STATION: LI58







Parameter	E	N
PGA (g)	0.092	0.097
PGV (cm/s)	22.7	23.8
PGD (cm)	7.2	9.1
Period of Highest Spectral Peak (s)	1.9	2.0
Arias Intensity (m/s)	0.729	0.700
R_e (km)	123	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.13-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

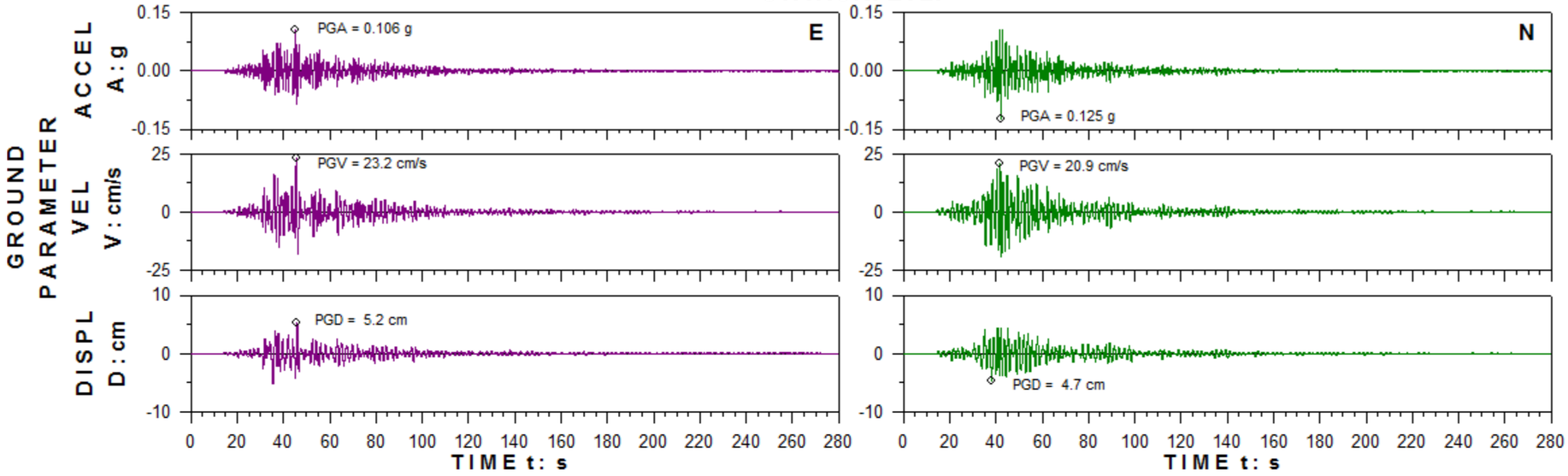
ATC-MEXICO RECONNAISSANCE

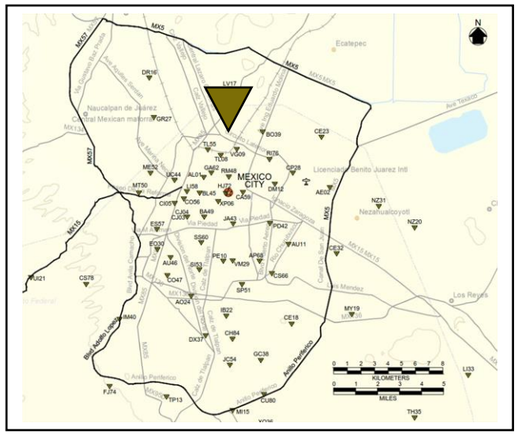
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

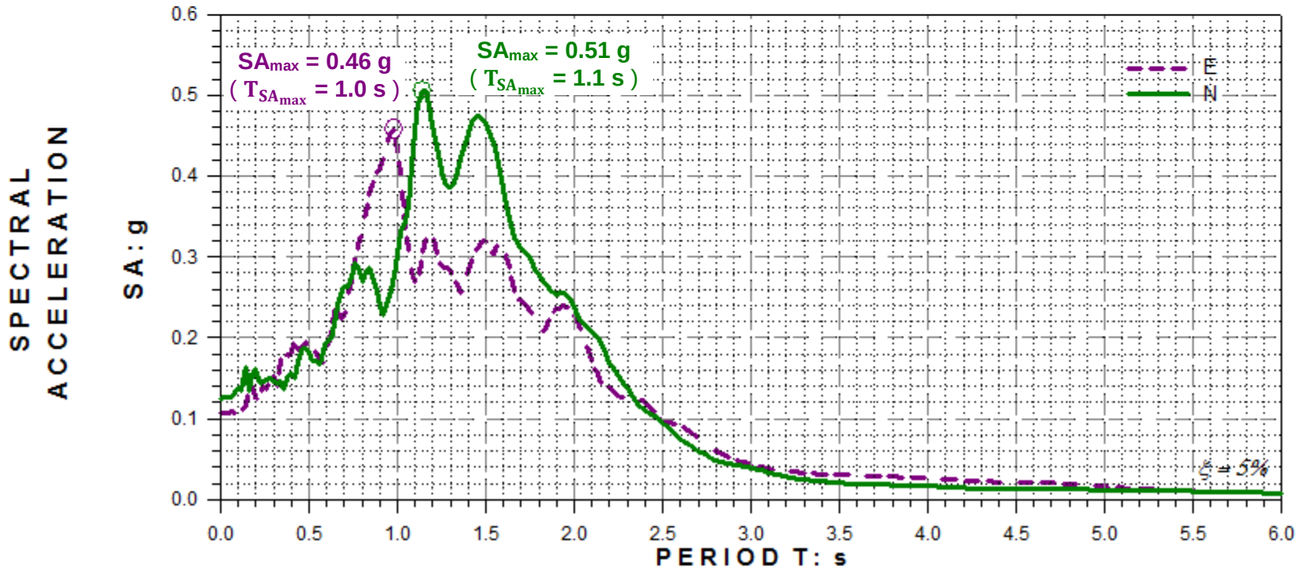
CIRES GROUND MOTIONS

LI58 STATION (19.426° N, 98.843° W) MEXICO CITY, MEXICO	STATION LI58

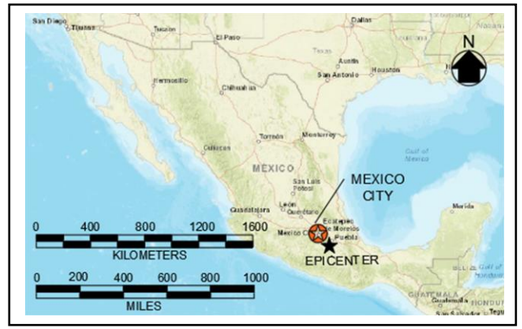
STATION: LV17







Parameter	E	N
PGA (g)	0.106	0.125
PGV (cm/s)	23.2	20.9
PGD (cm)	5.2	4.7
Period of Highest Spectral Peak (s)	1.0	1.1
Arias Intensity (m/s)	0.548	0.692
R_e (km)	129	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.16-21 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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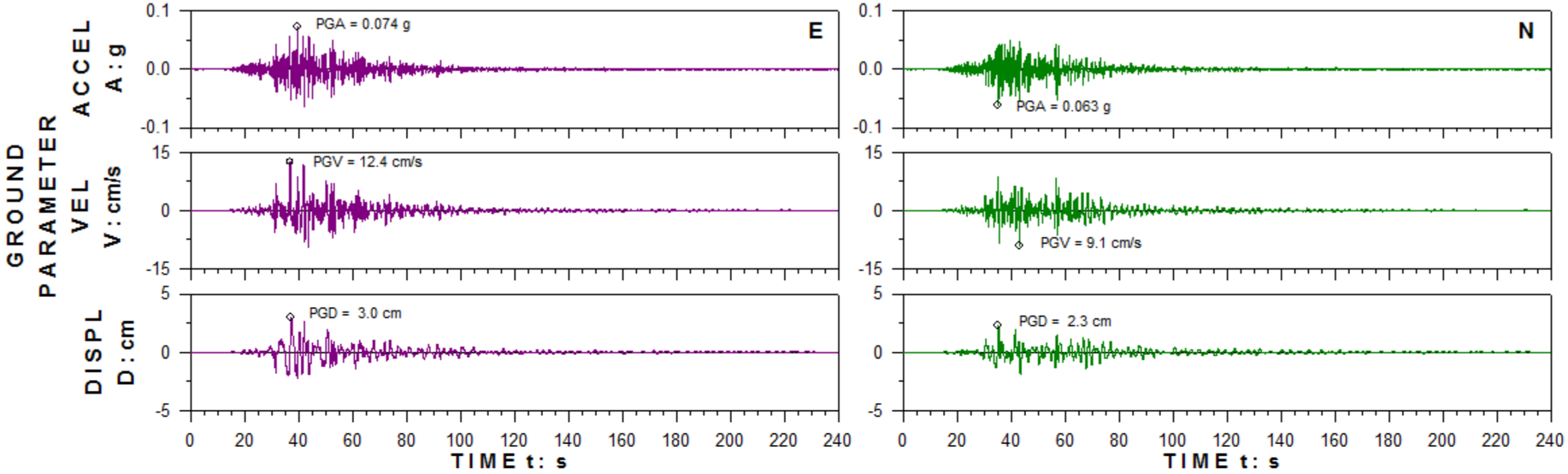
ATC-MEXICO RECONNAISSANCE

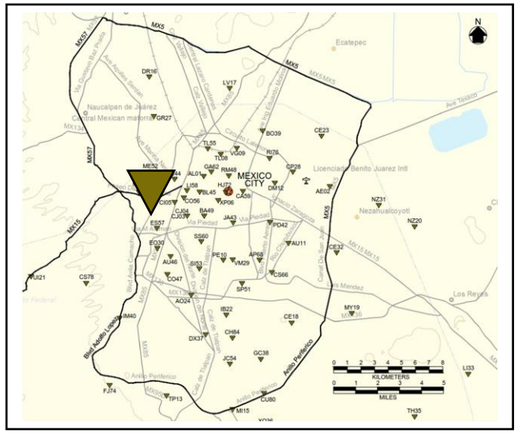
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

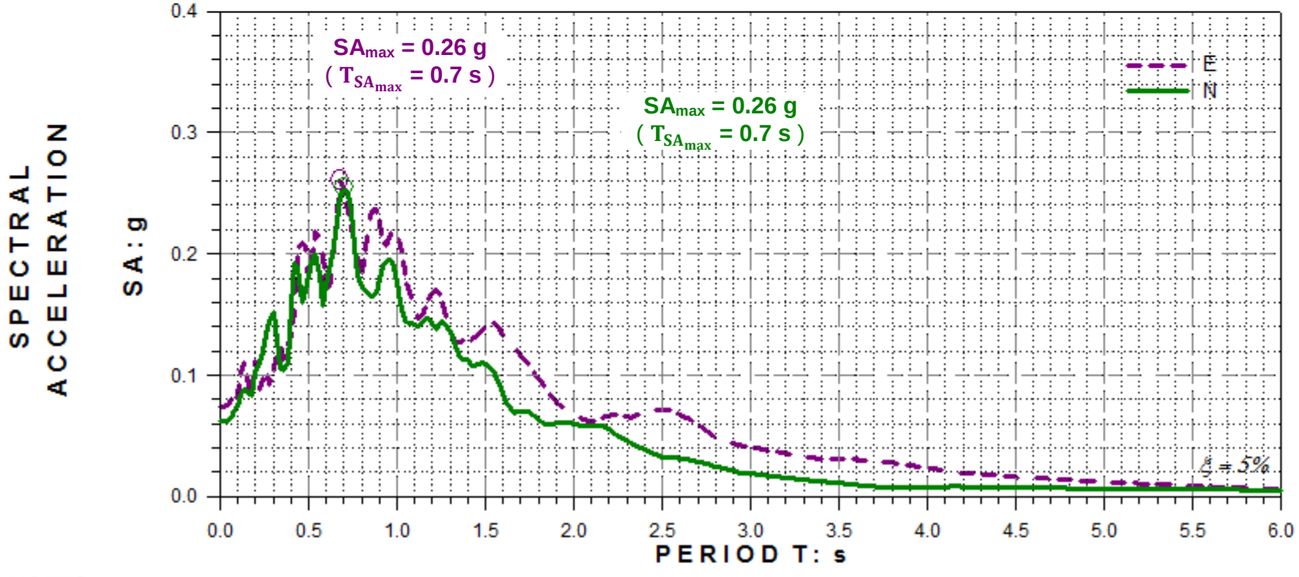
CIRES GROUND MOTIONS

LV17 STATION (19.493° N, 98.873° W) MEXICO CITY, MEXICO	STATION LV17

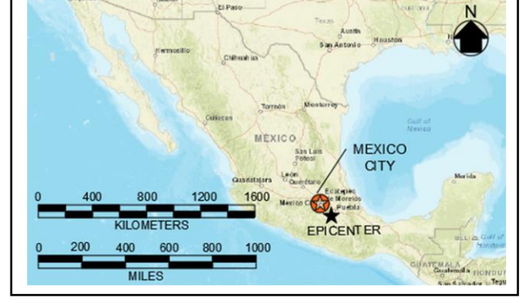
STATION: ME52







Parameter	E	N
PGA (g)	0.074	0.063
PGV (cm/s)	12.4	9.1
PGD (cm)	3.0	2.3
Period of Highest Spectral Peak (s)	0.7	0.7
Arias Intensity (m/s)	0.238	0.188
R_e (km)	125	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.19-21 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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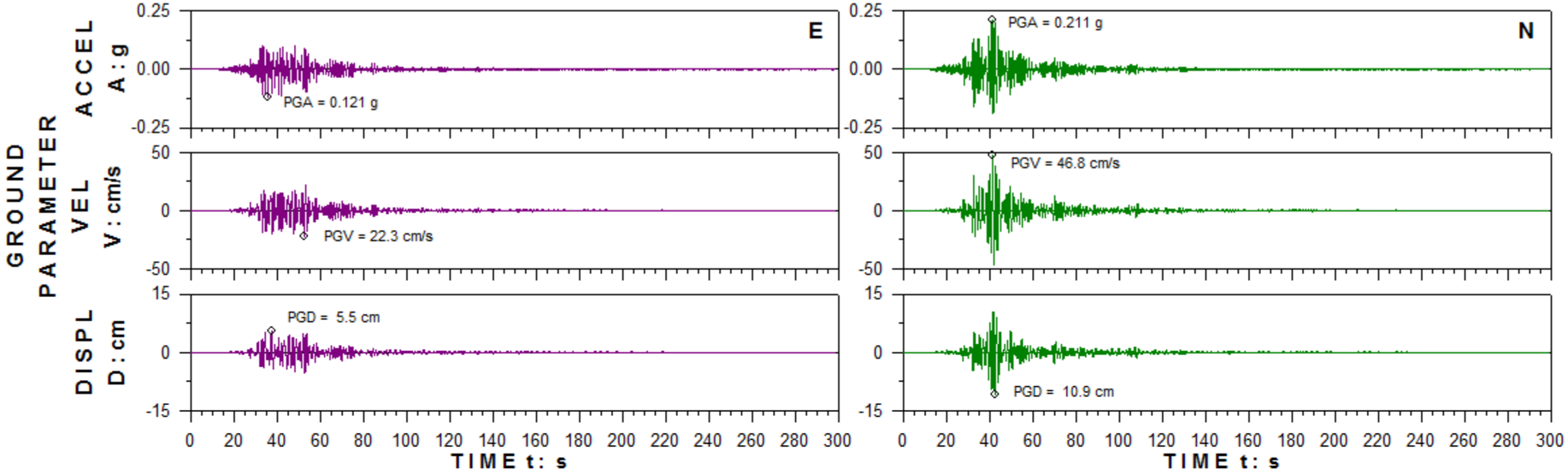
ATC-MEXICO RECONNAISSANCE

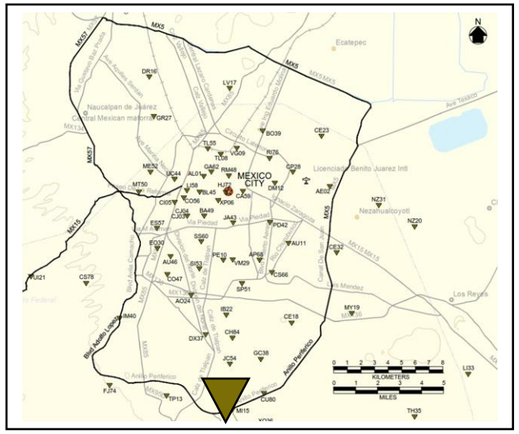
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

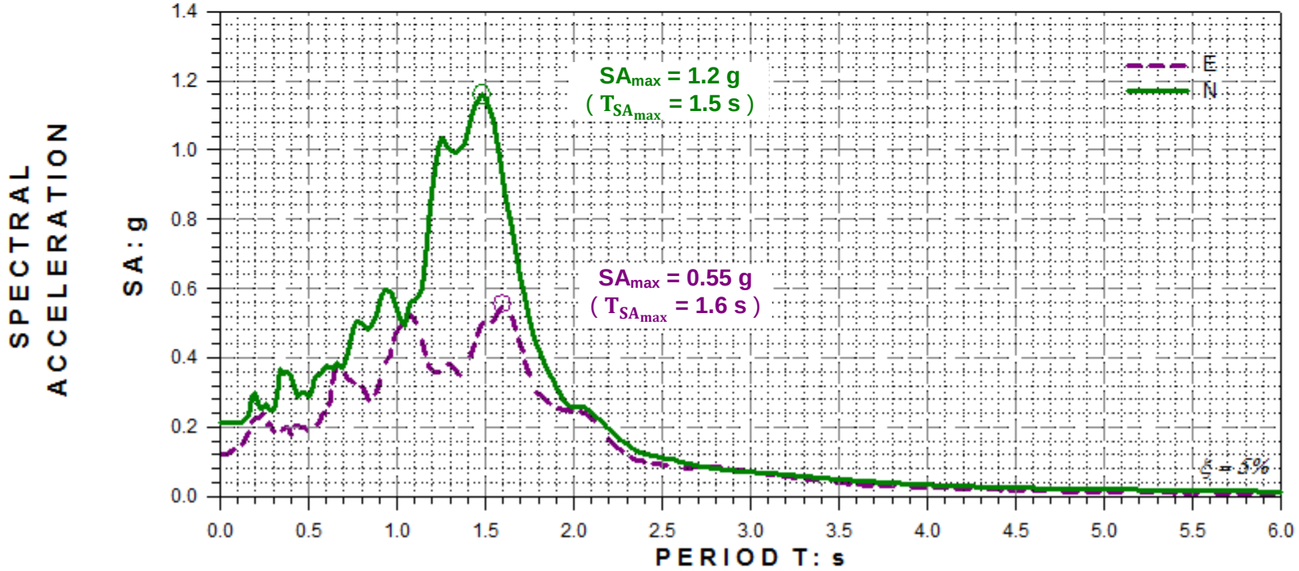
CIRES GROUND MOTIONS

ME52 STATION (19.438° N, 98.818° W) MEXICO CITY, MEXICO	STATION ME52

STATION: MI15







Parameter	E	N
PGA (g)	0.121	0.211
PGV (cm/s)	22.3	46.8
PGD (cm)	5.5	10.9
Period of Highest Spectral Peak (s)	1.6	1.5
Arias Intensity (m/s)	1.016	2.230
R_e (km)	107	



NOTES

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2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.30-16 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
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4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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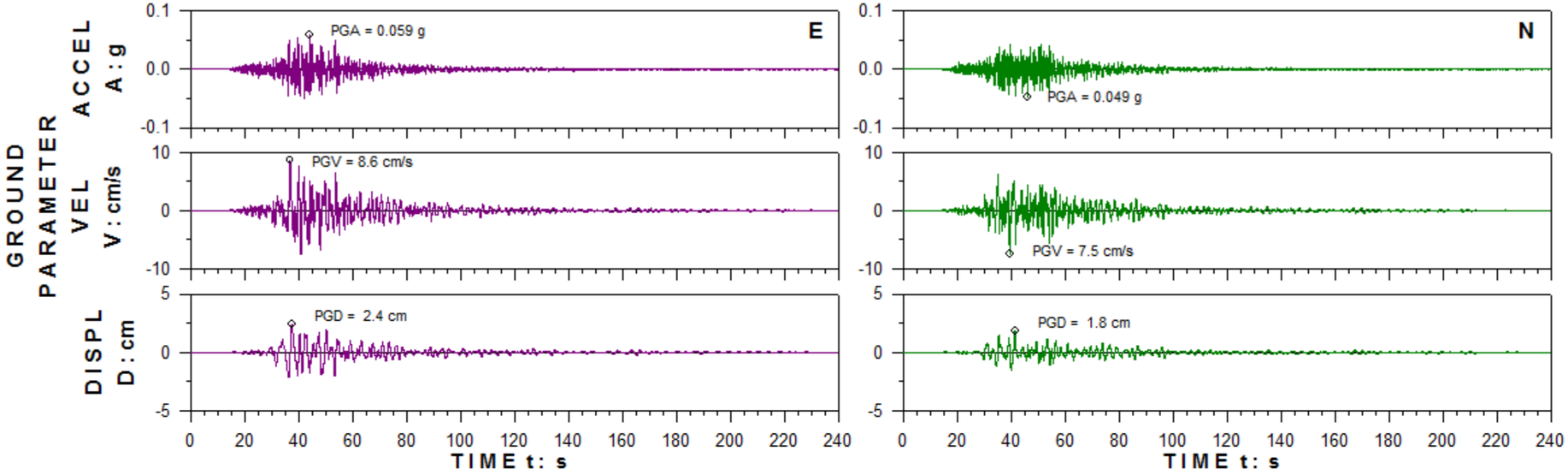
ATC-MEXICO RECONNAISSANCE

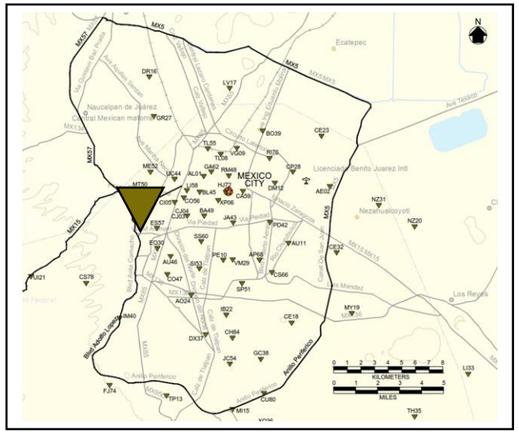
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

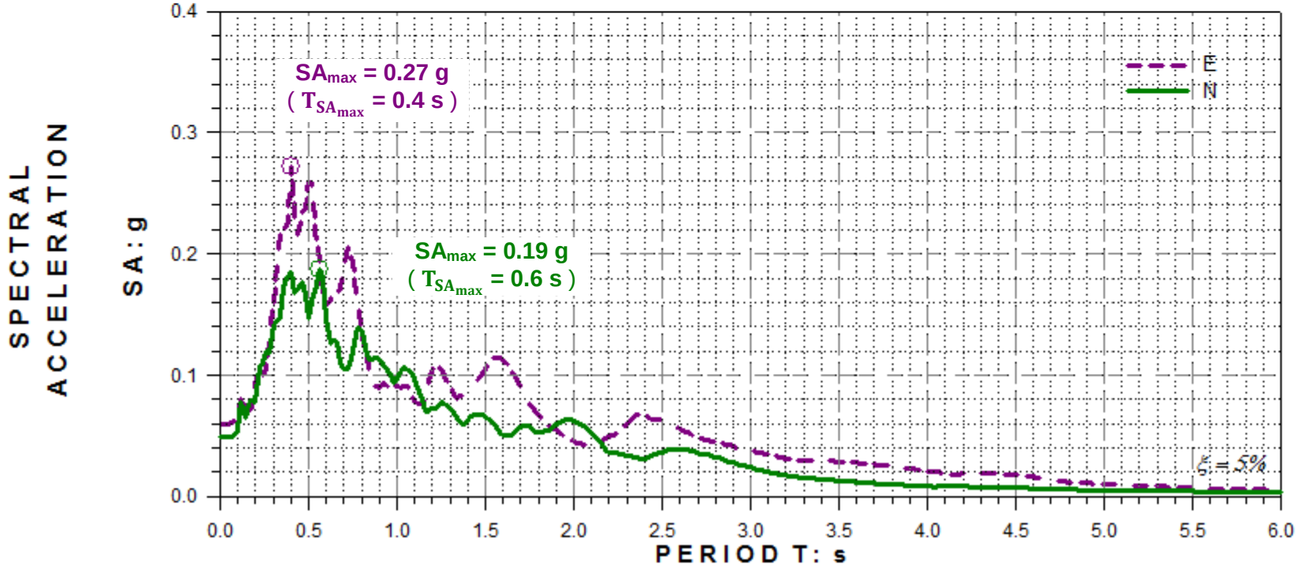
CIRES GROUND MOTIONS

MI15 STATION (19.283° N, 98.875° W) MEXICO CITY, MEXICO	STATION MI15

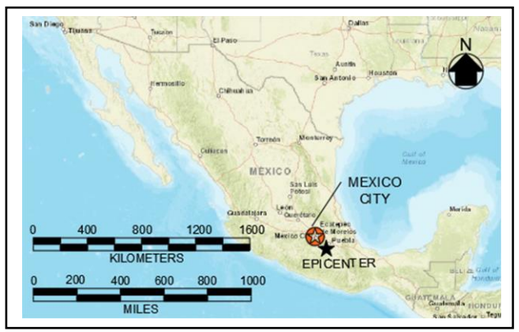
STATION: MT50







Parameter	E	N
PGA (g)	0.059	0.049
PGV (cm/s)	8.6	7.5
PGD (cm)	2.4	1.8
Period of Highest Spectral Peak (s)	0.4	0.6
Arias Intensity (m/s)	0.160	0.142
R_e (km)	124	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.20-19 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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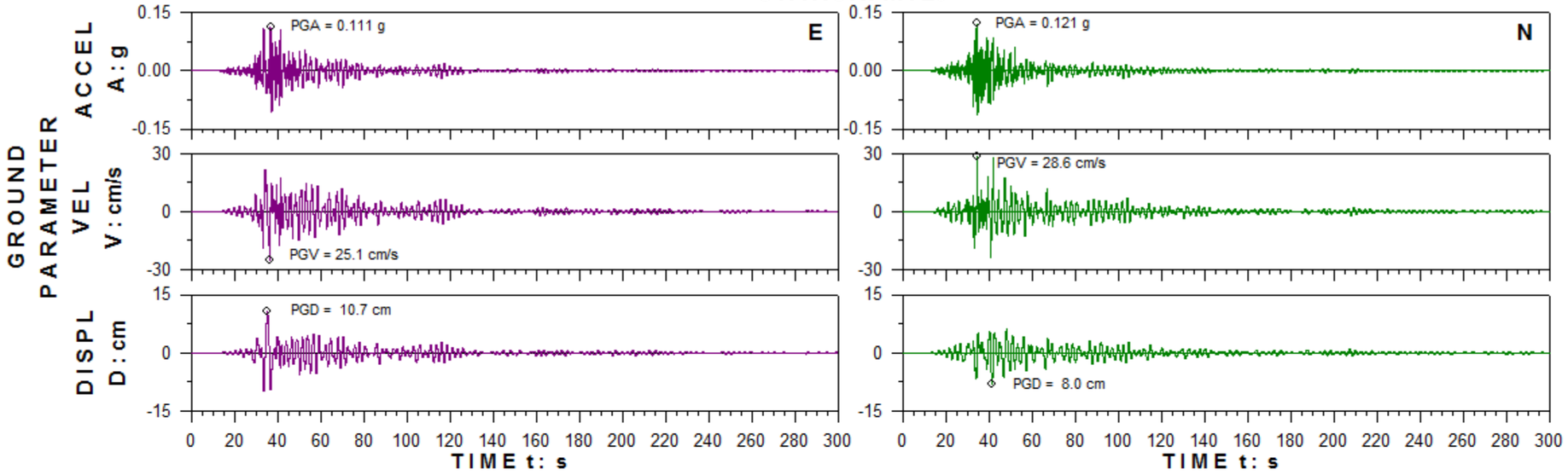
ATC-MEXICO RECONNAISSANCE

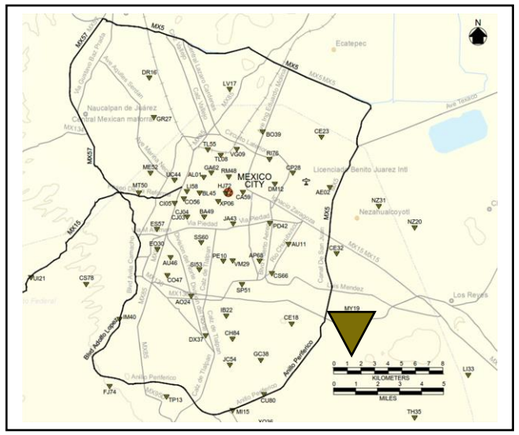
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

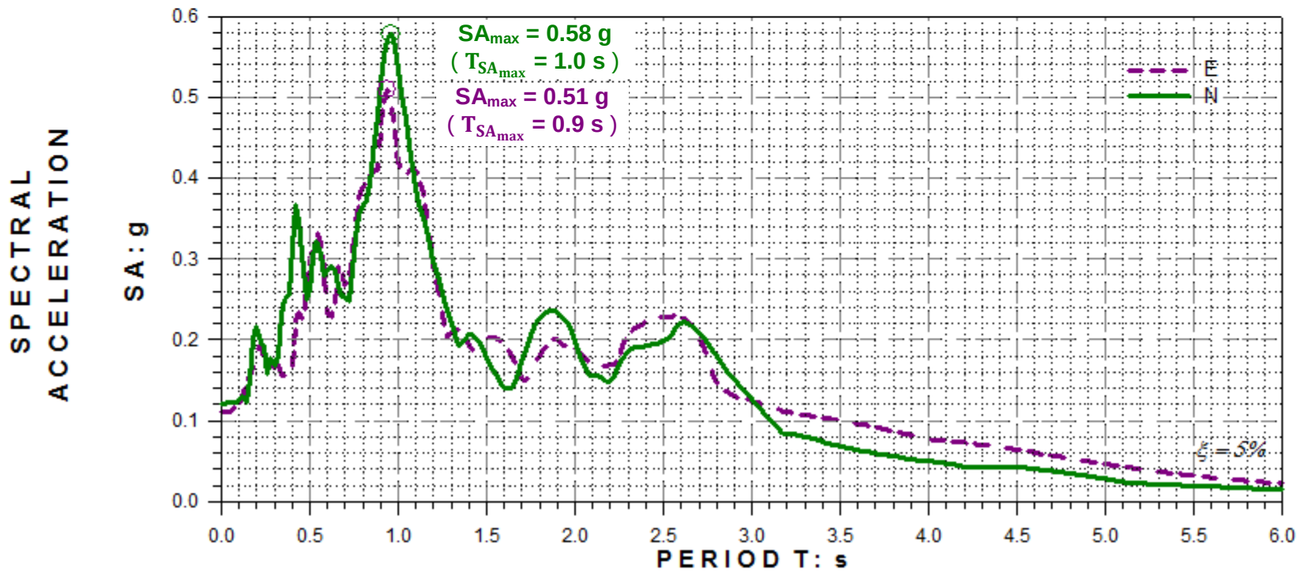
CIRES GROUND MOTIONS

MT50 STATION (19.425° N, 98.810° W) MEXICO CITY, MEXICO	STATION MT50

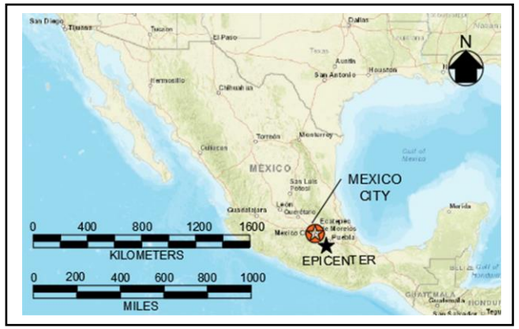
STATION: MY19







Parameter	E	N
PGA (g)	0.111	0.121
PGV (cm/s)	25.1	28.6
PGD (cm)	10.7	8.0
Period of Highest Spectral Peak (s)	0.9	1.0
Arias Intensity (m/s)	0.628	0.668
R_e (km)	110	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-35 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

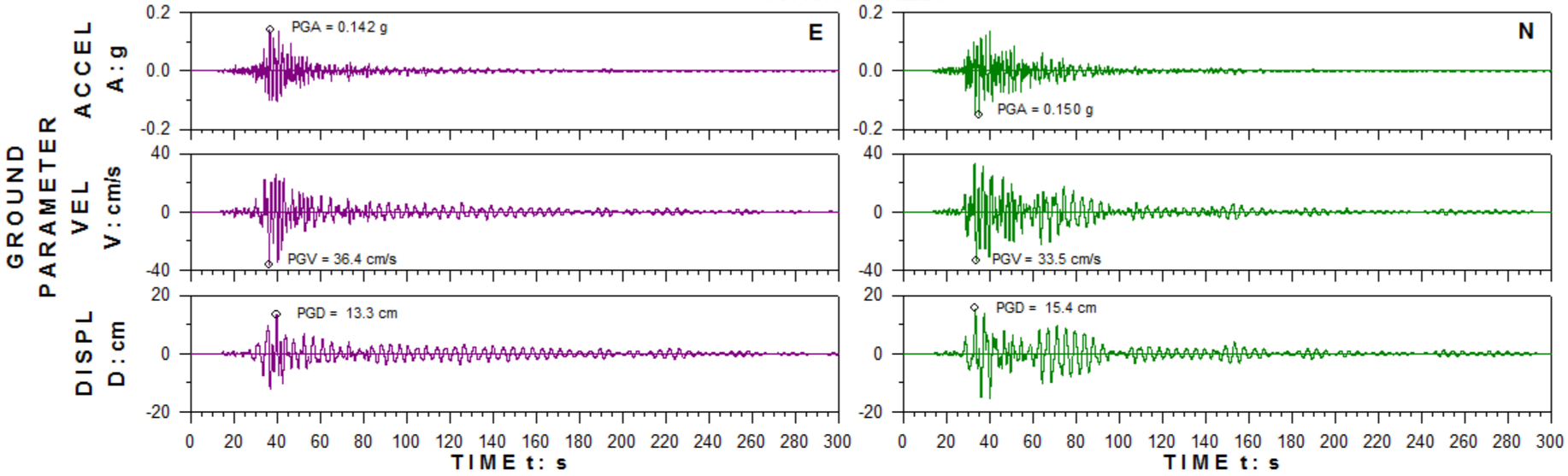
ATC-MEXICO RECONNAISSANCE

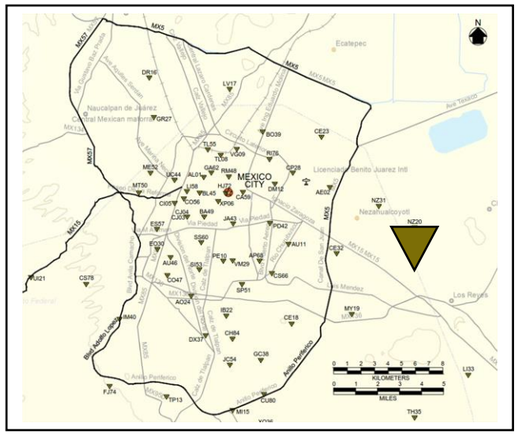
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

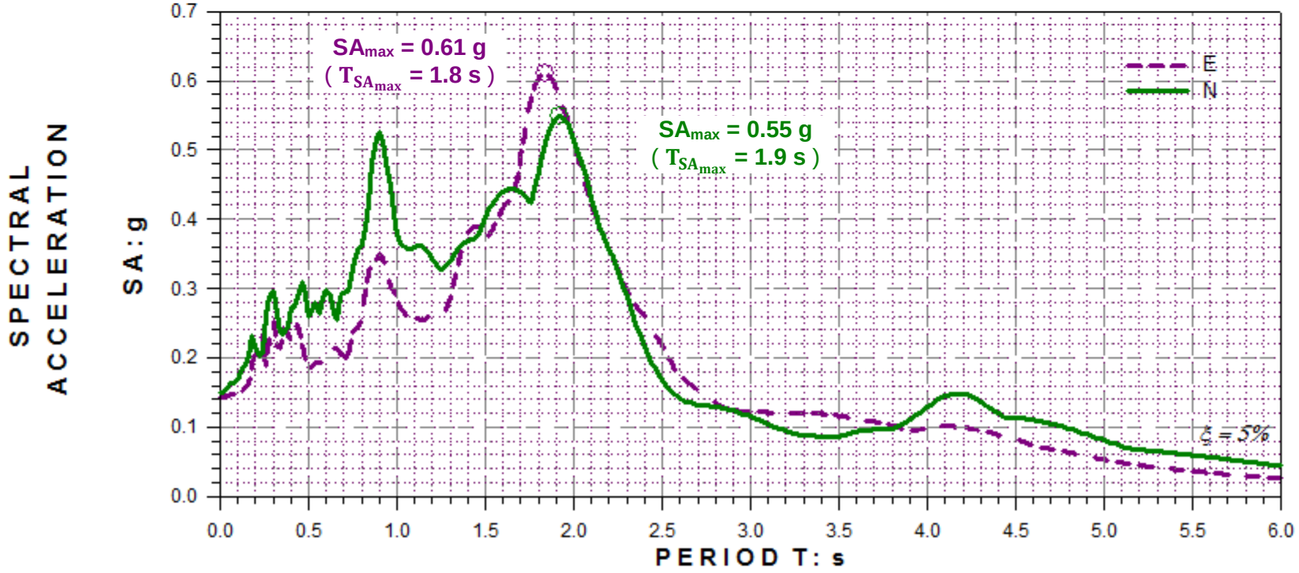
CIRES GROUND MOTIONS

MY19 STATION (19.346° N, 98.957° W) MEXICO CITY, MEXICO	STATION MY19

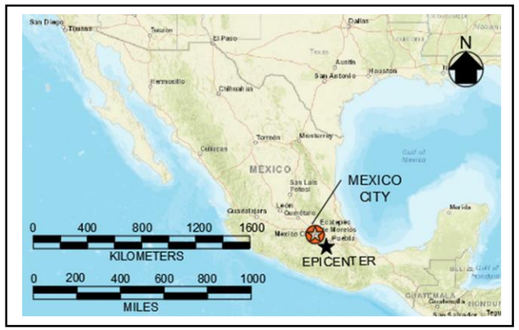
STATION: NZ20







Parameter	E	N
PGA (g)	0.142	0.150
PGV (cm/s)	36.4	33.5
PGD (cm)	13.3	15.4
Period of Highest Spectral Peak (s)	1.8	1.9
Arias Intensity (m/s)	0.803	1.234
R_e (km)	115	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
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4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

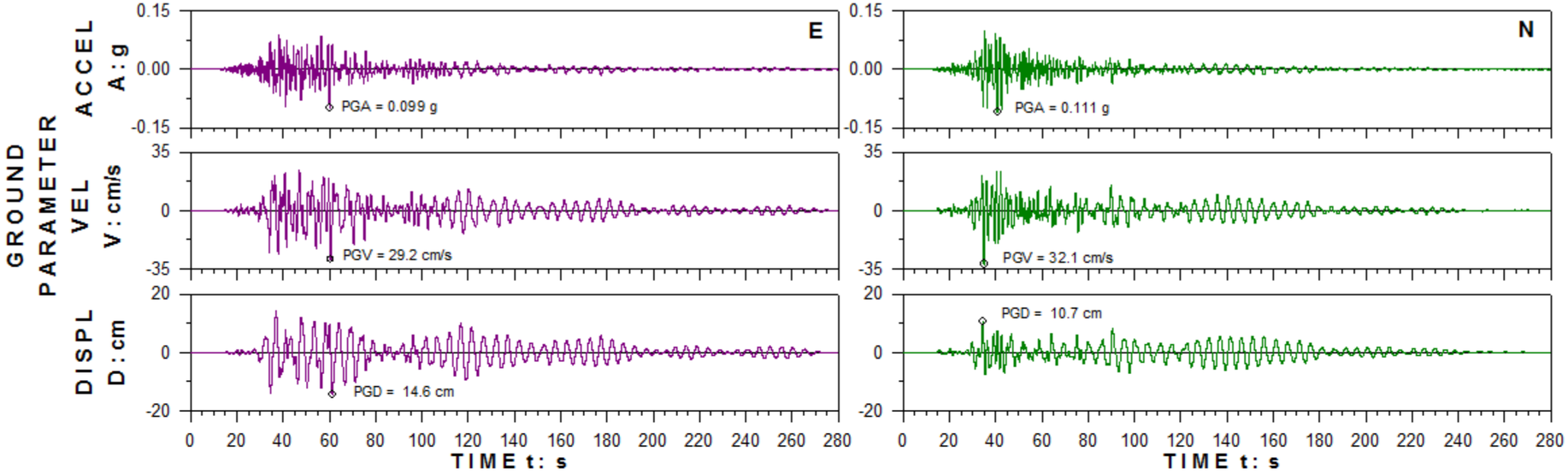
ATC-MEXICO RECONNAISSANCE

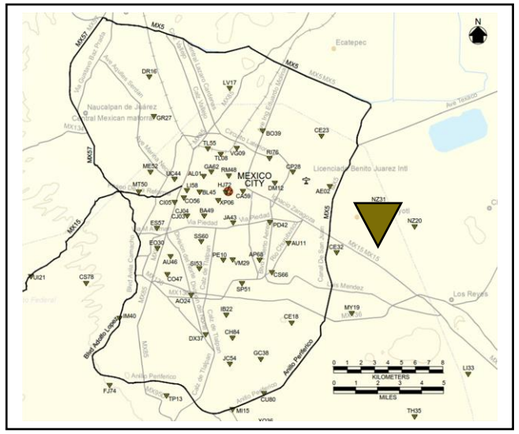
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

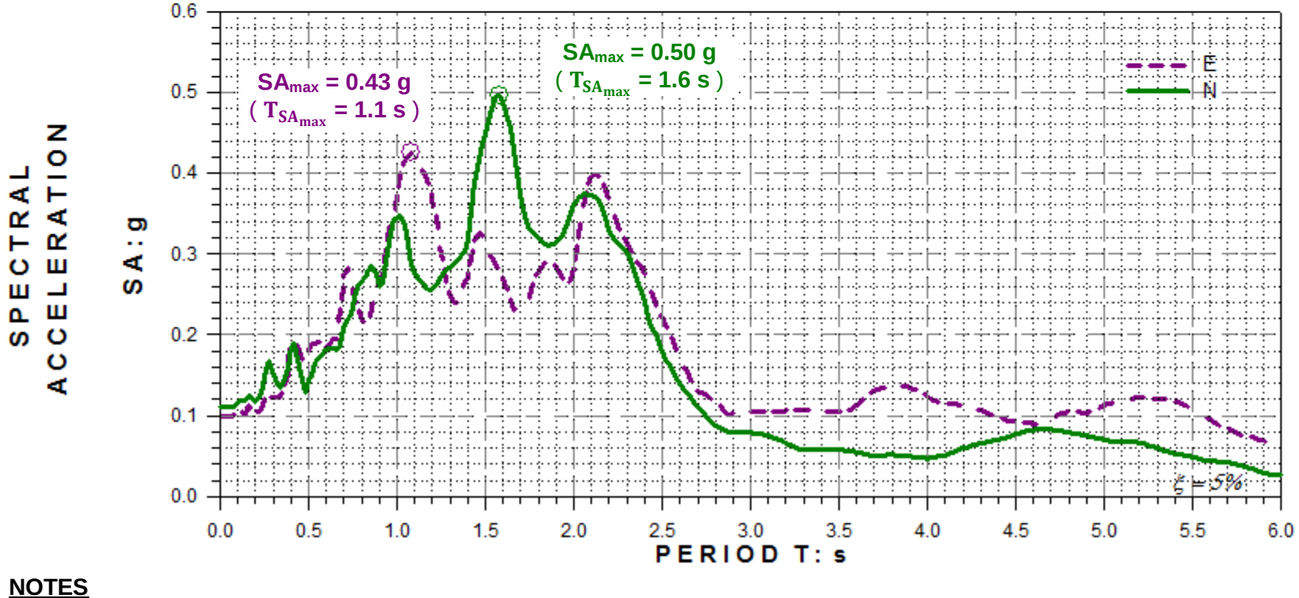
CIRES GROUND MOTIONS

NZ20 STATION (19.403° N, 98.000° W) MEXICO CITY, MEXICO	STATION NZ20

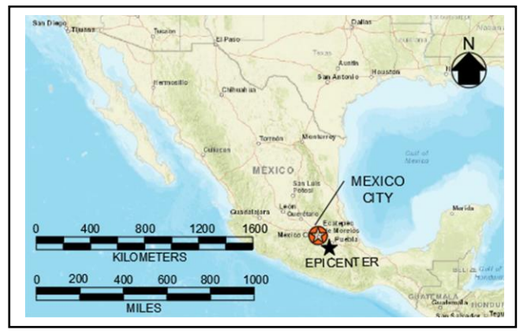
STATION: NZ31







Parameter	E	N
PGA (g)	0.099	0.111
PGV (cm/s)	29.2	32.1
PGD (cm)	14.6	10.7
Period of Highest Spectral Peak (s)	1.1	1.6
Arias Intensity (m/s)	0.912	0.779
R_e (km)	117	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-40 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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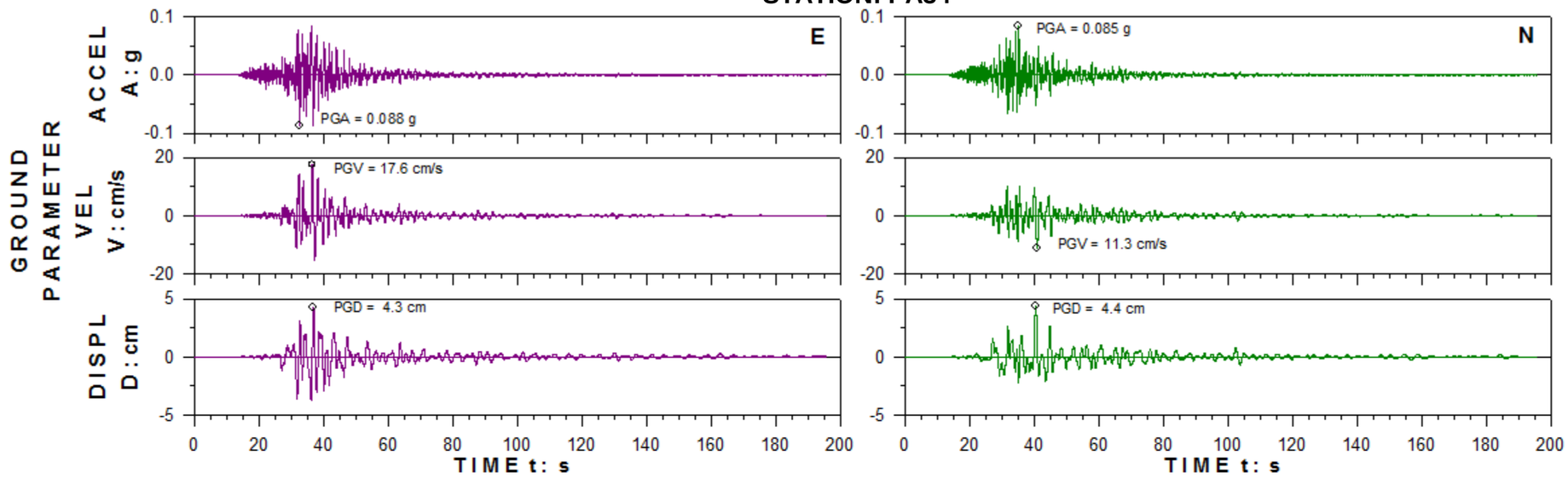
ATC-MEXICO RECONNAISSANCE

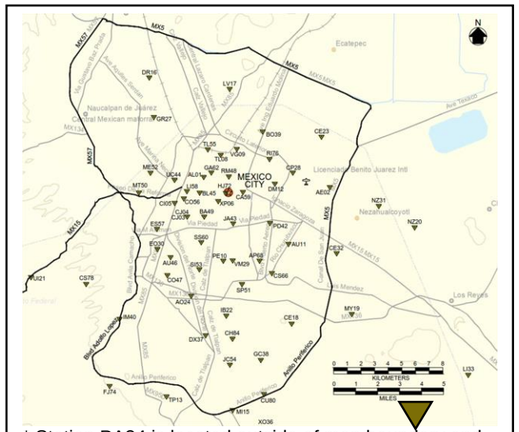
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

CIRES GROUND MOTIONS

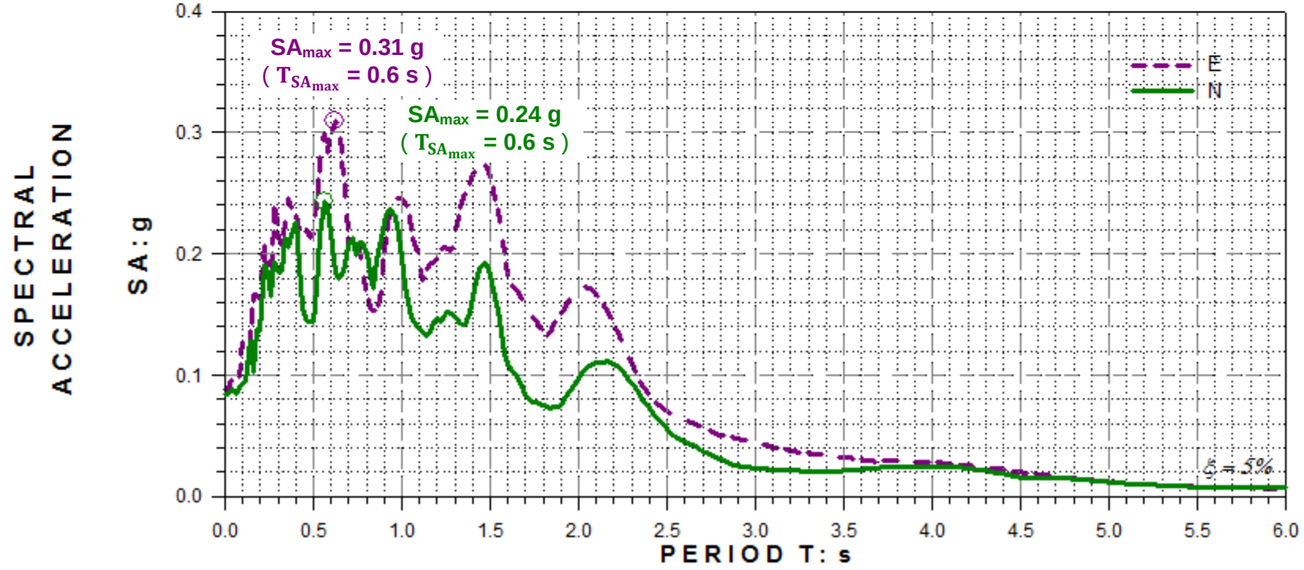
NZ31 STATION (19.417° N, 98.975° W) MEXICO CITY, MEXICO	STATION NZ31

STATION: PA34

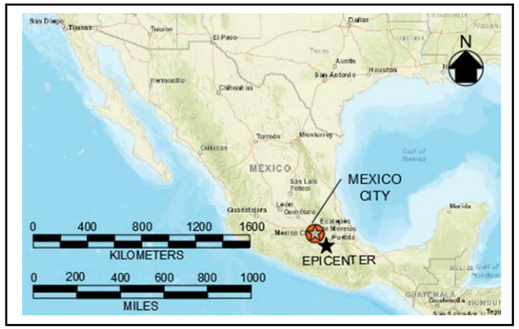




* Station PA34 is located outside of map boundary and 7.4 km south of the symbol as indicated above.



Parameter	E	N
PGA (g)	0.088	0.085
PGV (cm/s)	17.6	11.3
PGD (cm)	4.3	4.4
Period of Highest Spectral Peak (s)	0.6	0.6
Arias Intensity (m/s)	0.277	0.180
R_e (km)	95	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-21 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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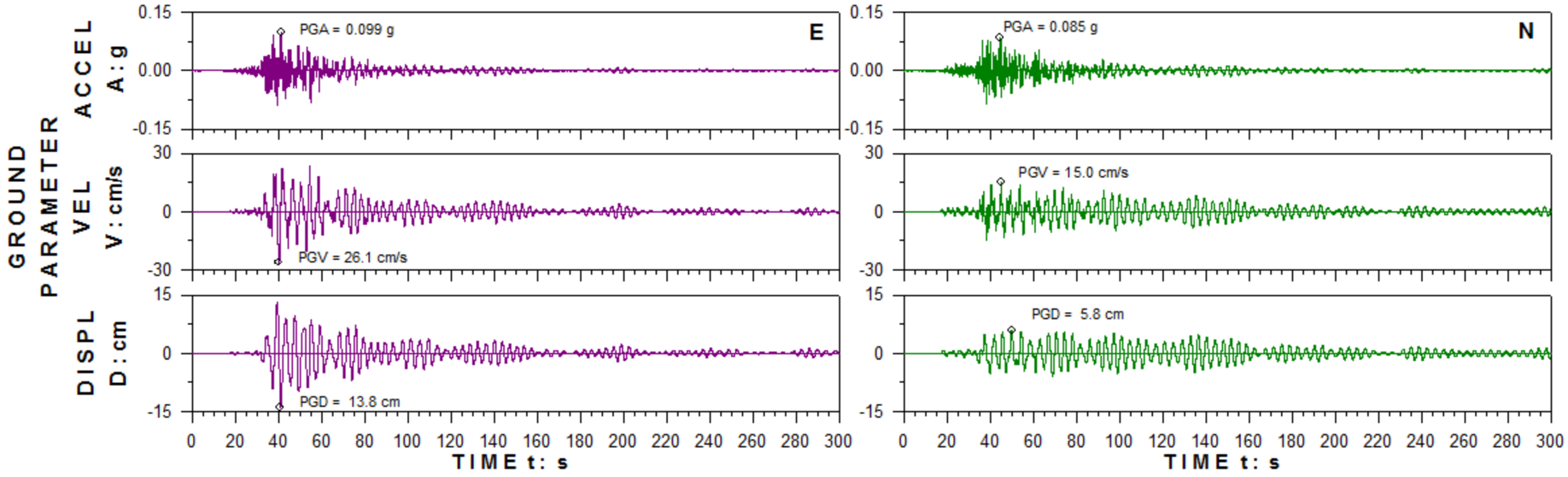
ATC-MEXICO RECONNAISSANCE

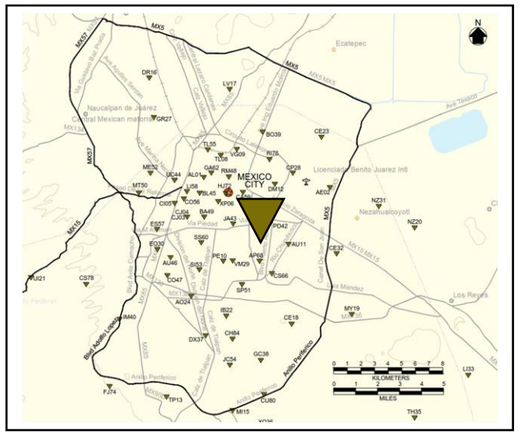
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

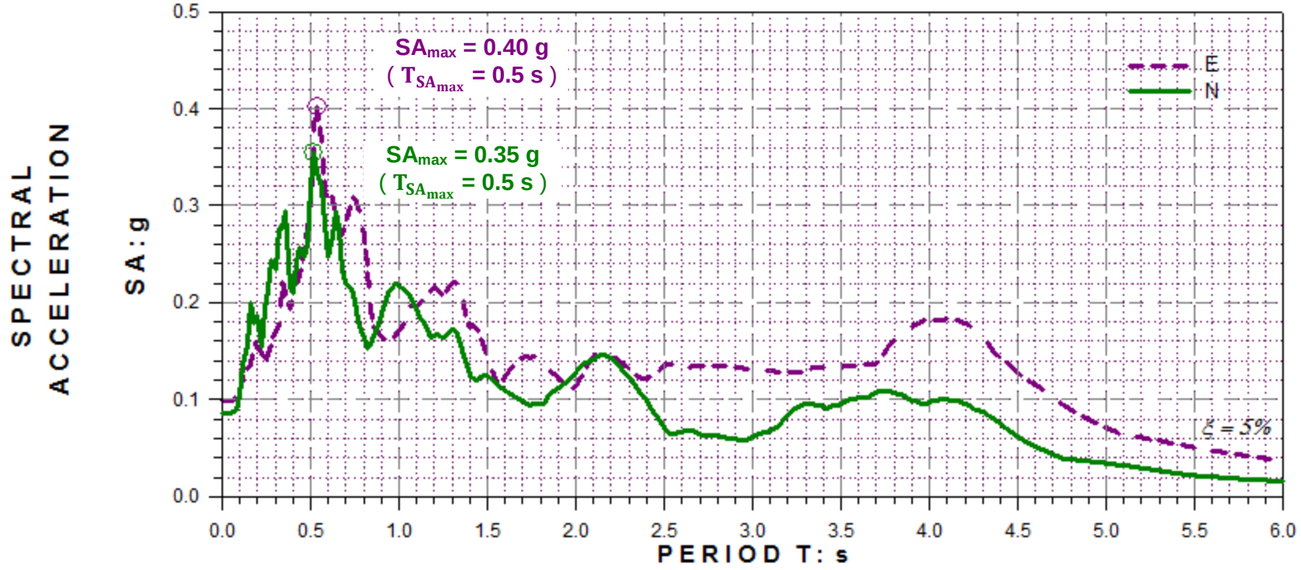
CIRES GROUND MOTIONS

PA34 STATION (19.202° N, 98.951° W) MEXICO CITY, MEXICO	STATION PA34

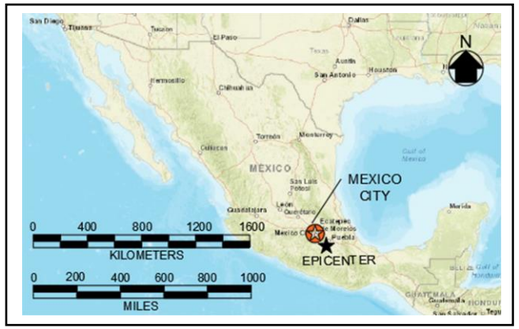
STATION: PD42







Parameter	E	N
PGA (g)	0.099	0.085
PGV (cm/s)	26.1	15.0
PGD (cm)	13.8	5.8
Period of Highest Spectral Peak (s)	0.5	0.5
Arias Intensity (m/s)	0.710	0.962
R_e (km)	119	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.12-11 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

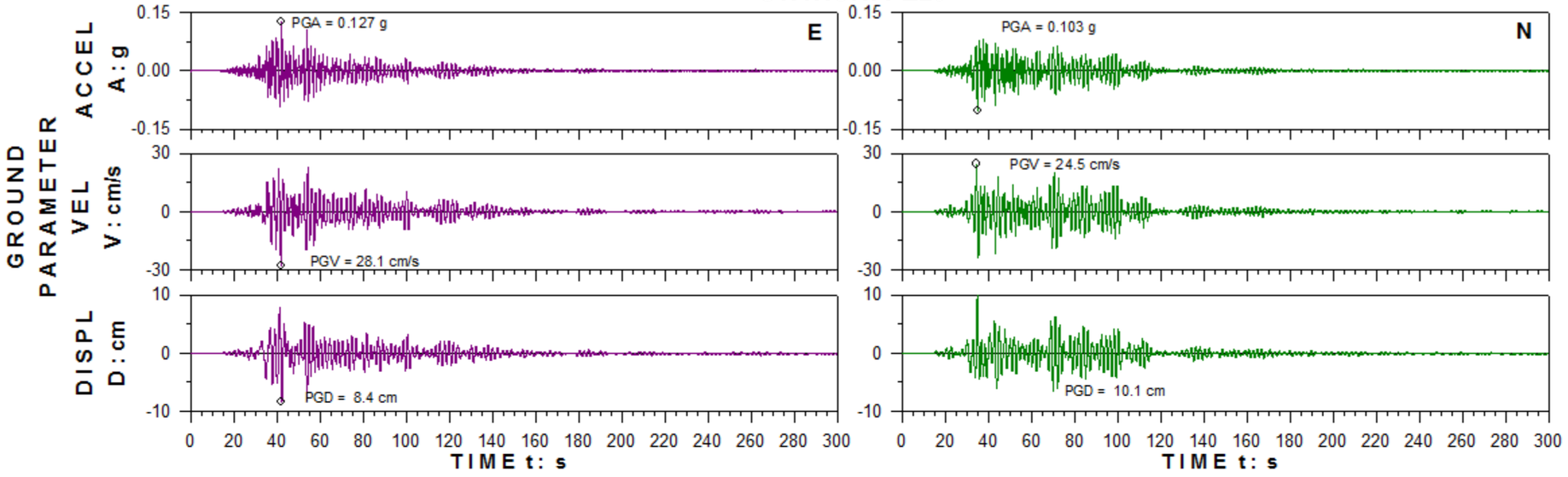
ATC-MEXICO RECONNAISSANCE

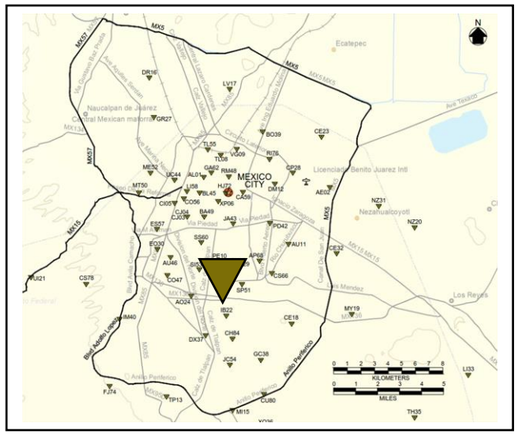
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

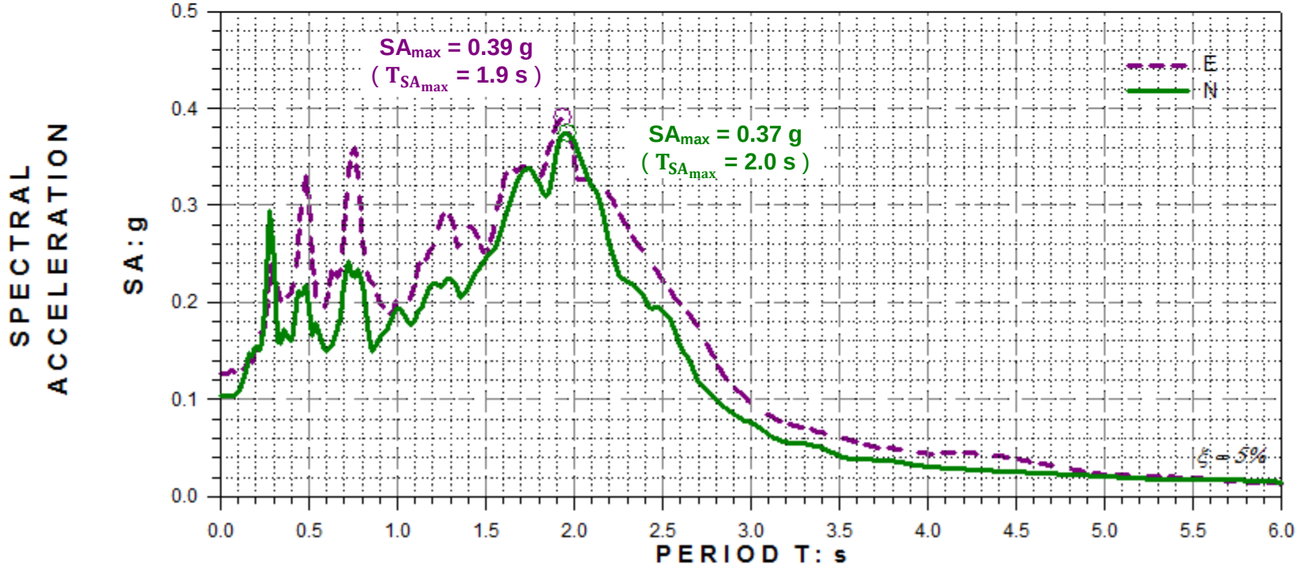
CIRES GROUND MOTIONS

PD42 STATION (19.406° N, 98.900° W) MEXICO CITY, MEXICO	STATION PD42

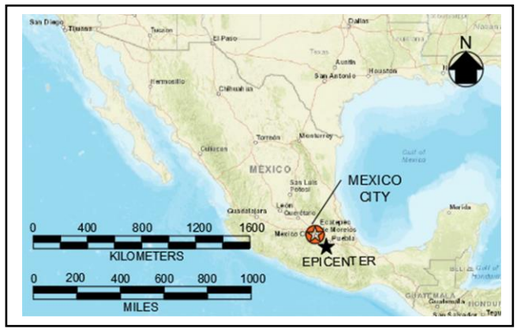
STATION: PE10







Parameter	E	N
PGA (g)	0.127	0.103
PGV (cm/s)	28.1	24.5
PGD (cm)	8.4	10.1
Period of Highest Spectral Peak (s)	1.9	2.0
Arias Intensity (m/s)	0.823	0.890
R_e (km)	117	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.10-31 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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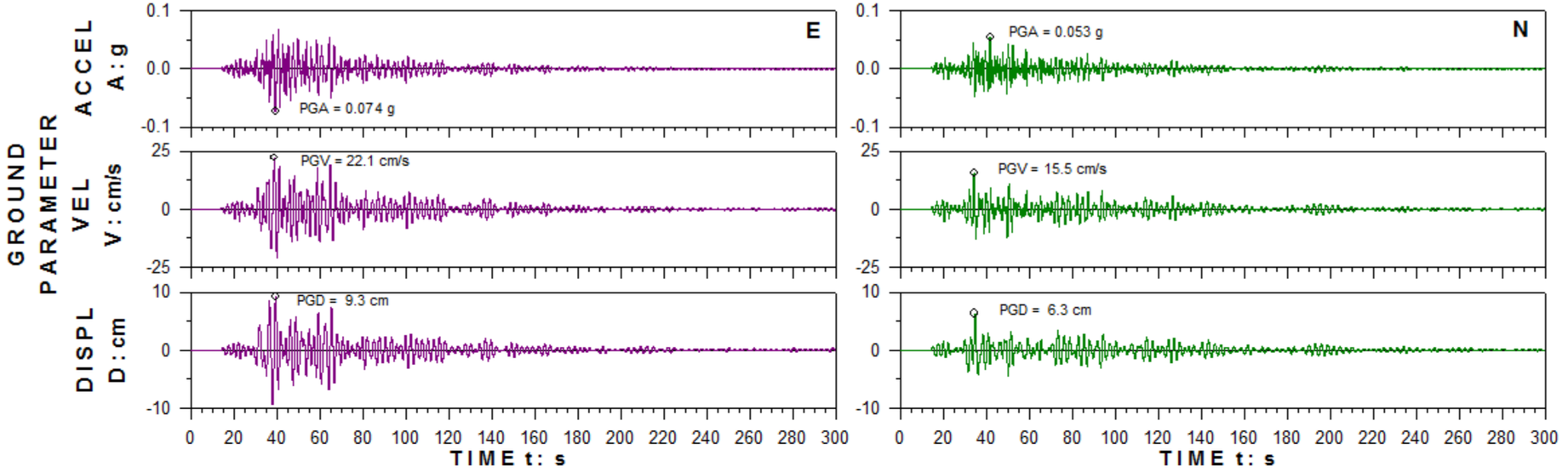
ATC-MEXICO RECONNAISSANCE

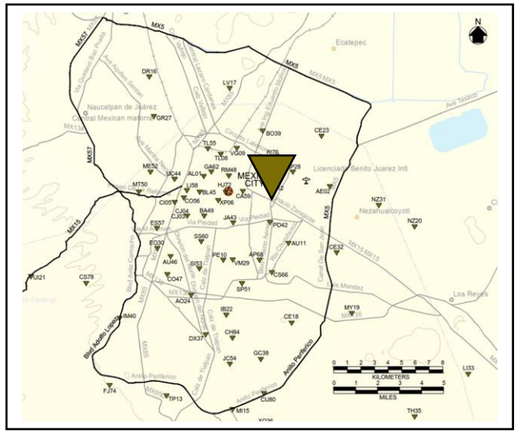
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

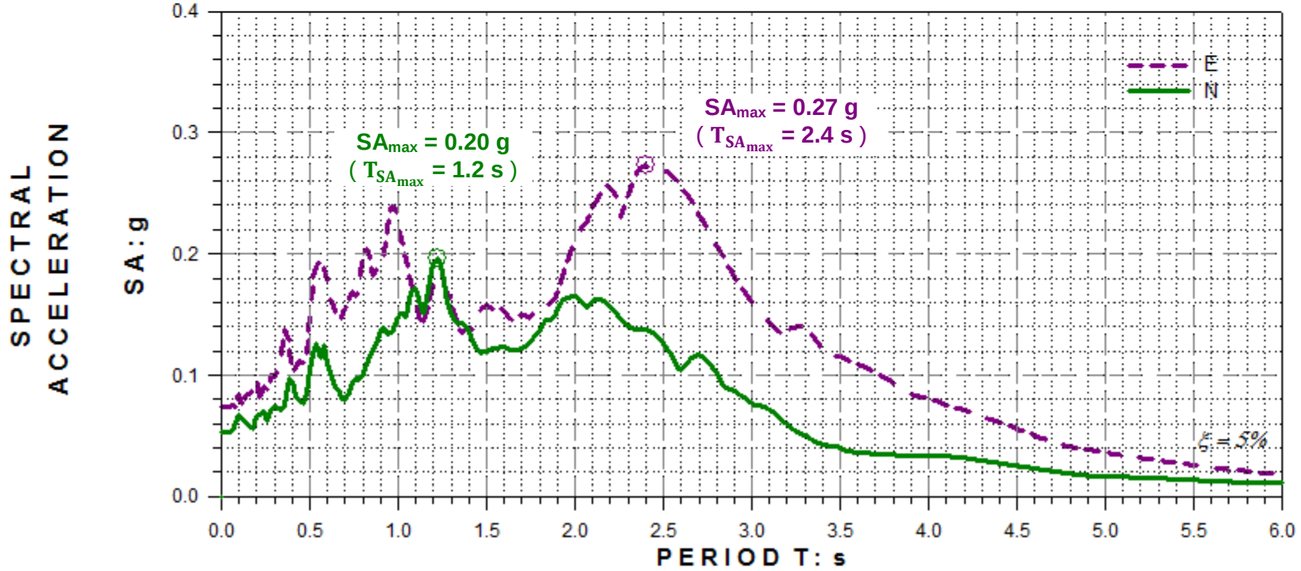
CIRES GROUND MOTIONS

PE10 STATION (19.381° N, 98.868° W) MEXICO CITY, MEXICO	STATION PE10

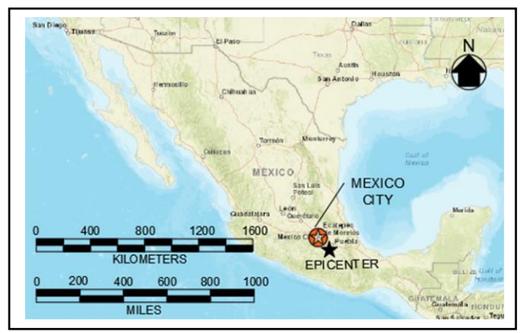
STATION: RI76







Parameter	E	N
PGA (g)	0.074	0.053
PGV (cm/s)	22.1	15.5
PGD (cm)	9.3	6.3
Period of Highest Spectral Peak (s)	2.4	1.2
Arias Intensity (m/s)	0.480	0.242
R_e (km)	123	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.11-38 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

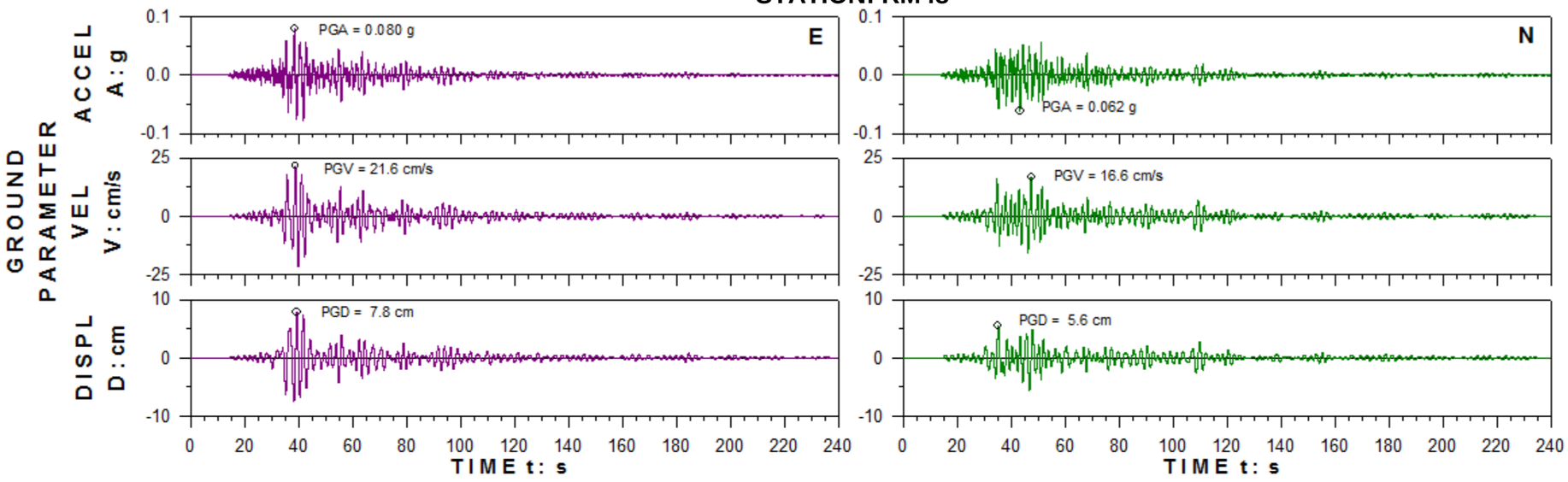
ATC-MEXICO RECONNAISSANCE

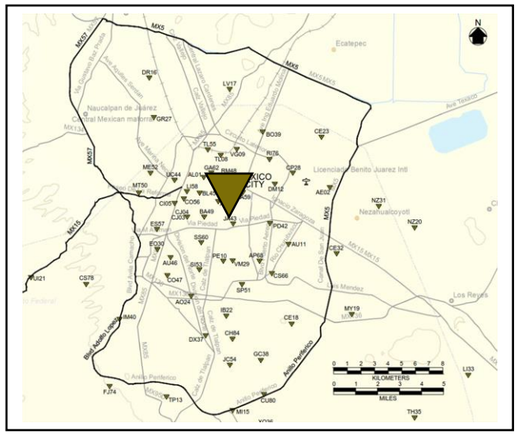
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

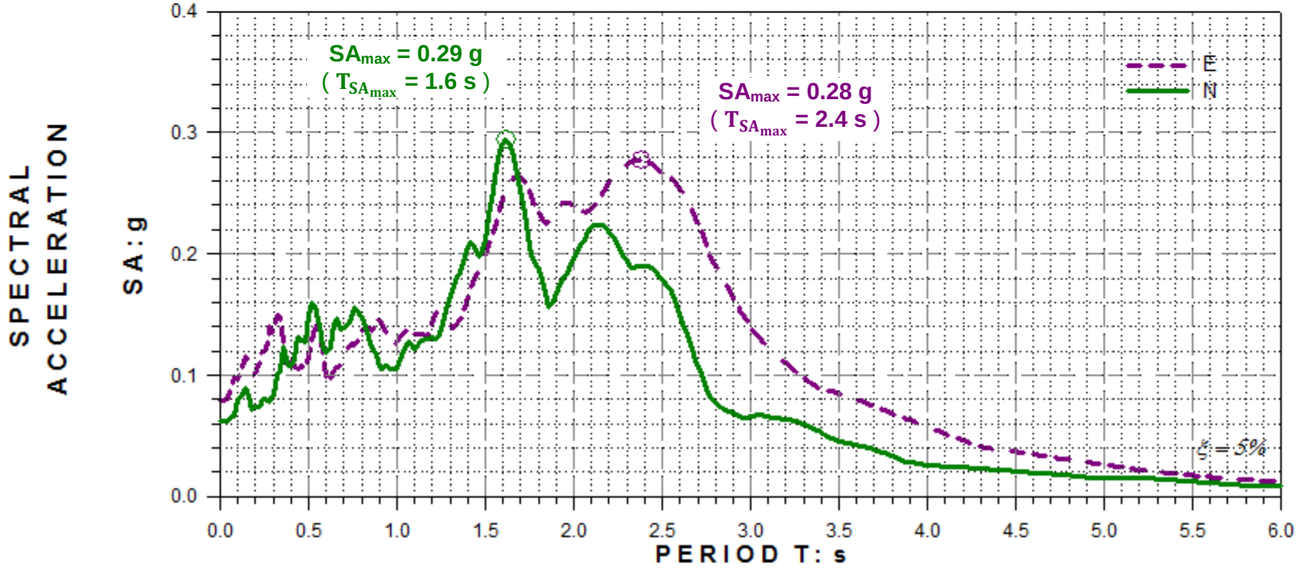
CIRES GROUND MOTIONS

RI76 STATION (19.447° N, 98.900° W) MEXICO CITY, MEXICO	STATION RI76

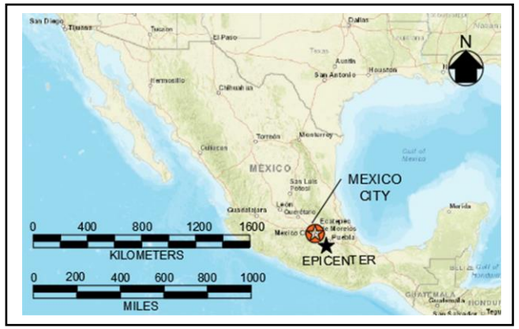
STATION: RM48







Parameter	E	N
PGA (g)	0.080	0.062
PGV (cm/s)	21.6	16.6
PGD (cm)	7.8	5.6
Period of Highest Spectral Peak (s)	2.4	1.6
Arias Intensity (m/s)	0.331	0.305
R_e (km)	123	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.17-29 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

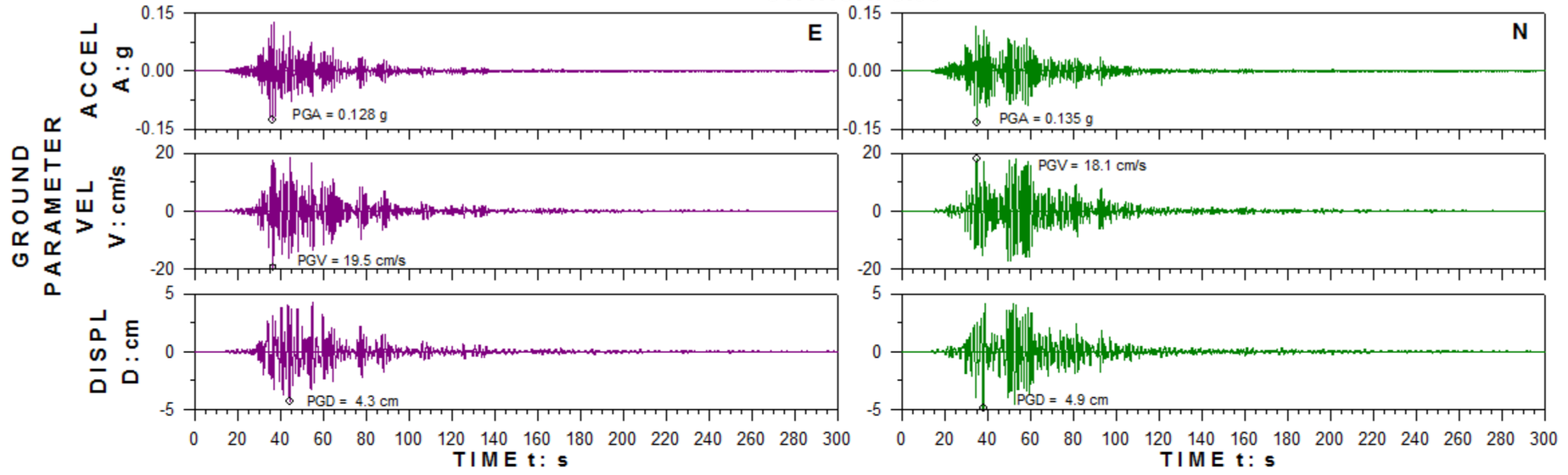
ATC-MEXICO RECONNAISSANCE

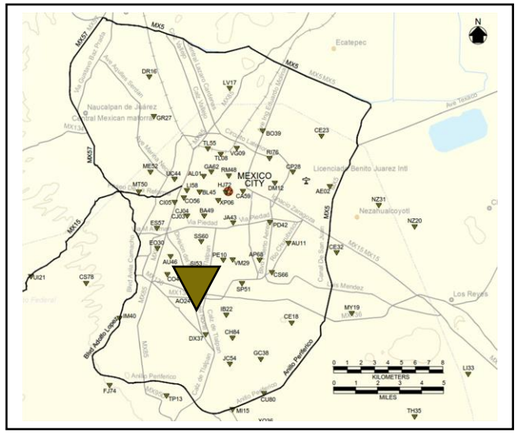
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

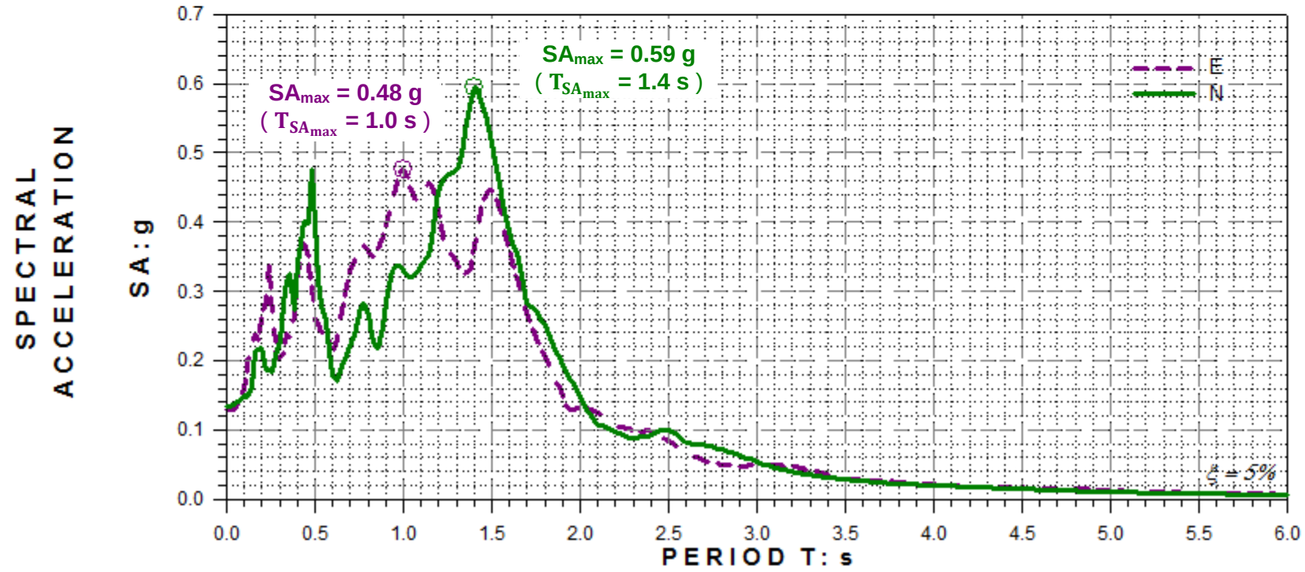
CIRES GROUND MOTIONS

RM48 STATION (19.436° N, 98.872° W) MEXICO CITY, MEXICO	STATION RM48

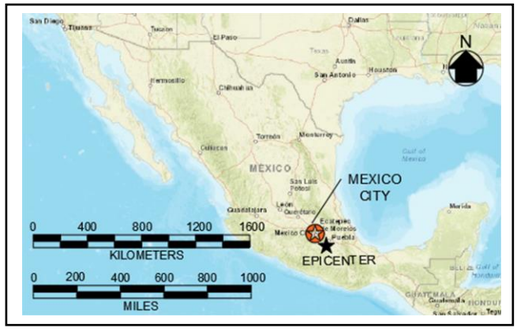
STATION: SI53







Parameter	E	N
PGA (g)	0.128	0.135
PGV (cm/s)	19.5	18.1
PGD (cm)	4.3	4.9
Period of Highest Spectral Peak (s)	1.0	1.4
Arias Intensity (m/s)	0.817	1.045
R_e (km)	117	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.25-40 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

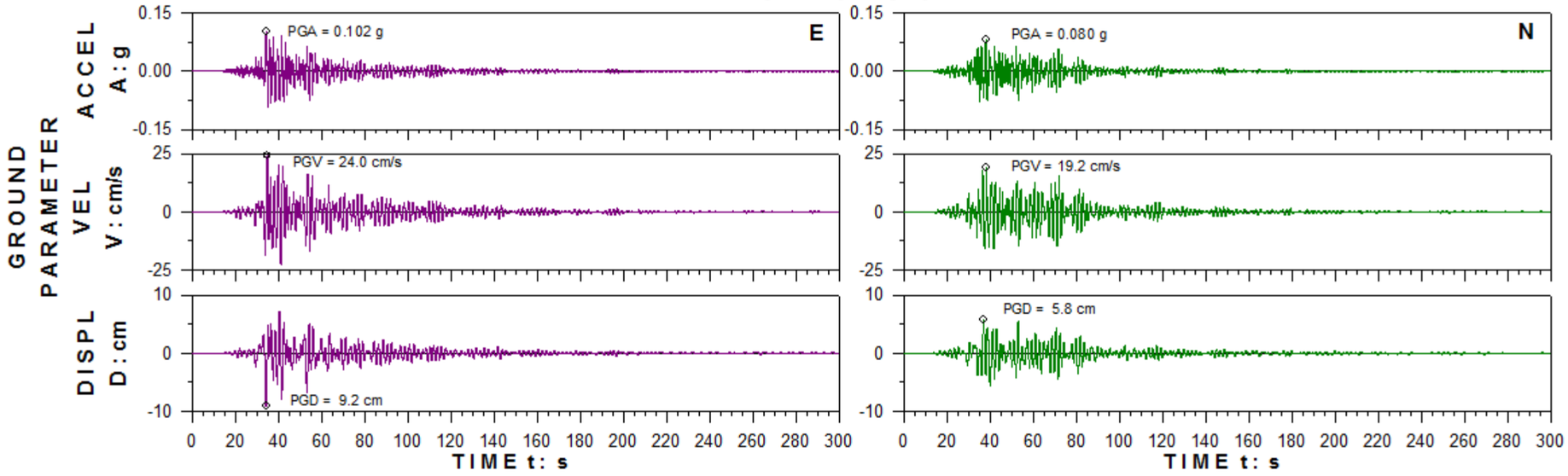
ATC-MEXICO RECONNAISSANCE

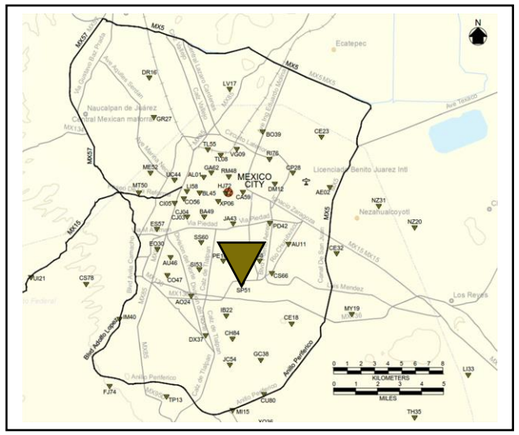
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

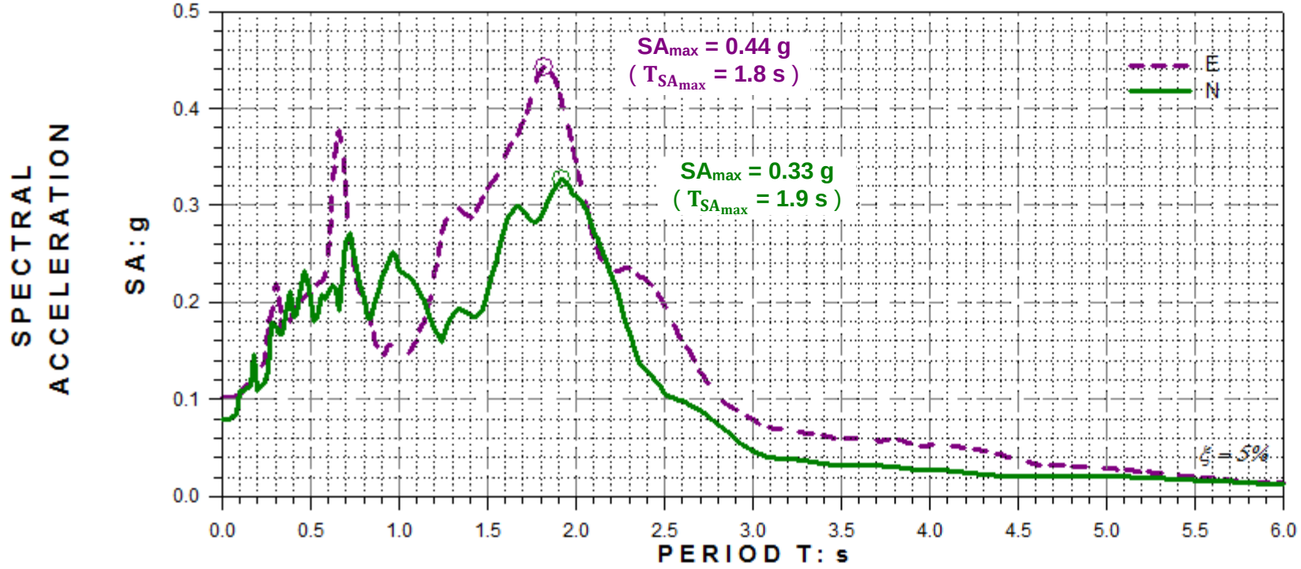
CIRES GROUND MOTIONS

SI53 STATION (19.375° N, 98.852° W) MEXICO CITY, MEXICO	STATION SI53

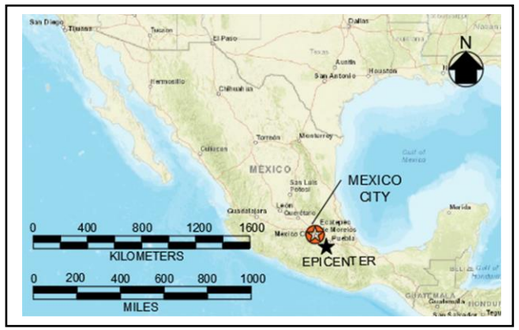
STATION: SP51







Parameter	E	N
PGA (g)	0.102	0.080
PGV (cm/s)	24.0	19.2
PGD (cm)	9.2	5.8
Period of Highest Spectral Peak (s)	1.8	1.9
Arias Intensity (m/s)	0.679	0.622
R_e (km)	115	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.14-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

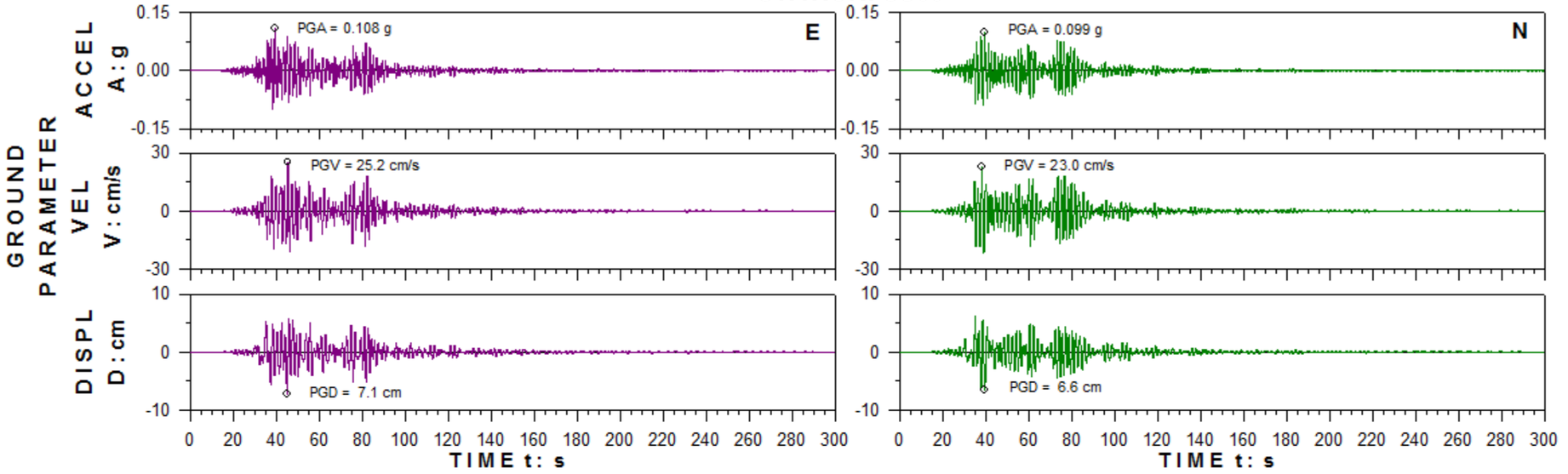
ATC-MEXICO RECONNAISSANCE

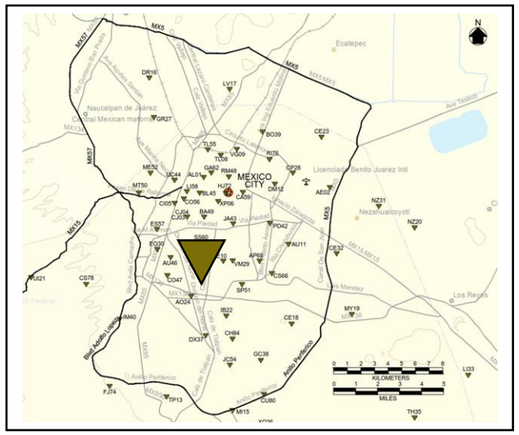
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

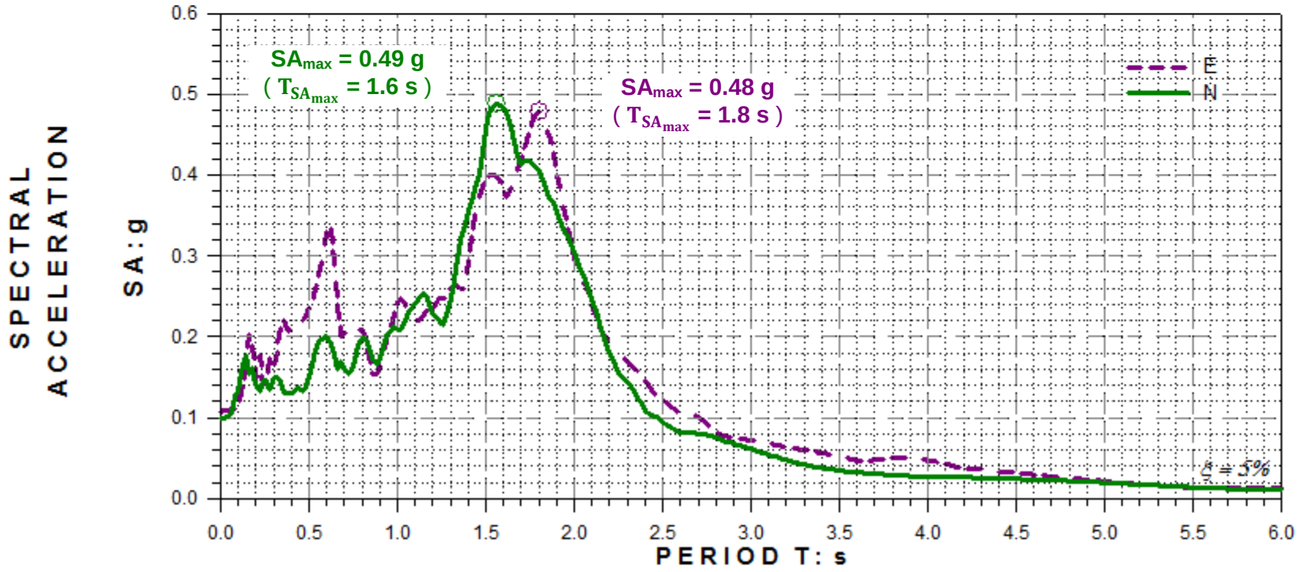
CIRES GROUND MOTIONS

SP51 STATION (19.366° N, 98.881° W) MEXICO CITY, MEXICO	STATION SP51

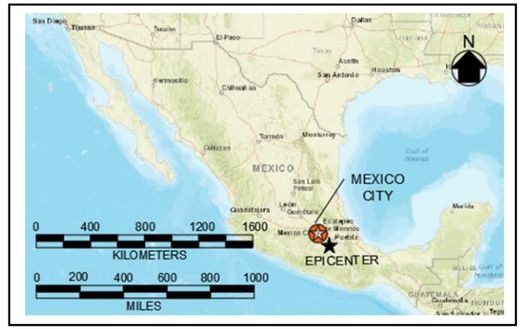
STATION: SS60







Parameter	E	N
PGA (g)	0.108	0.099
PGV (cm/s)	25.2	23.0
PGD (cm)	7.1	6.6
Period of Highest Spectral Peak (s)	1.8	1.6
Arias Intensity (m/s)	0.900	0.916
R_e (km)	119	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.13-50 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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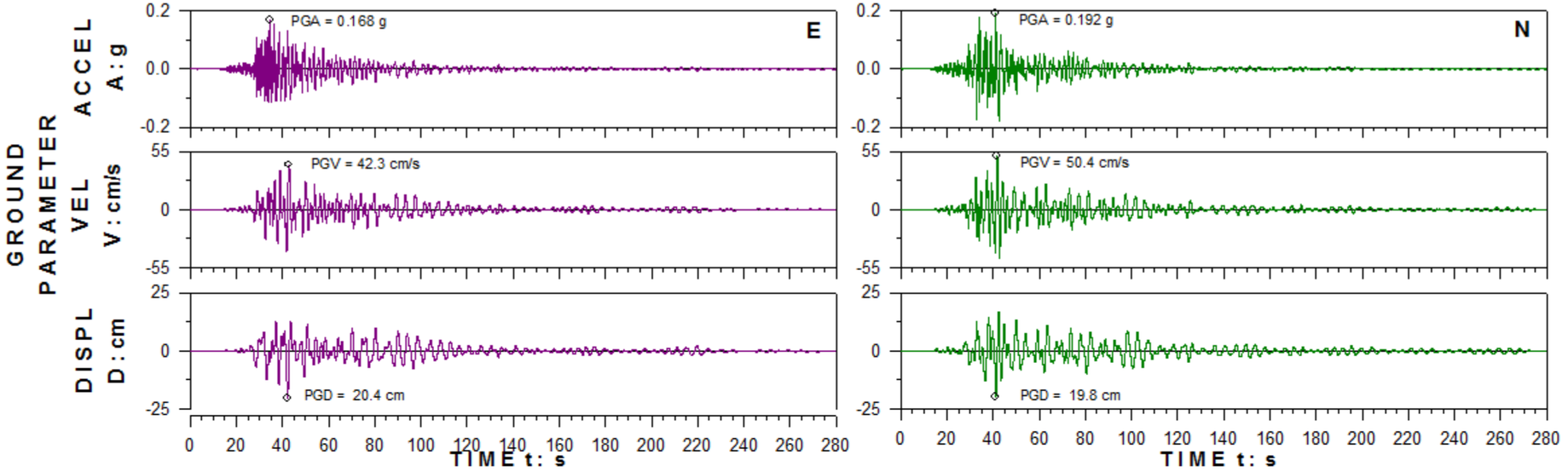
ATC-MEXICO RECONNAISSANCE

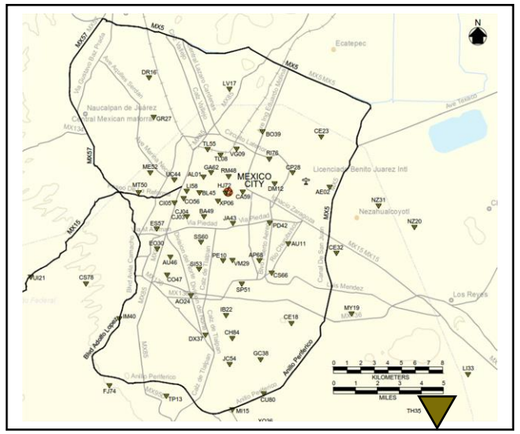
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

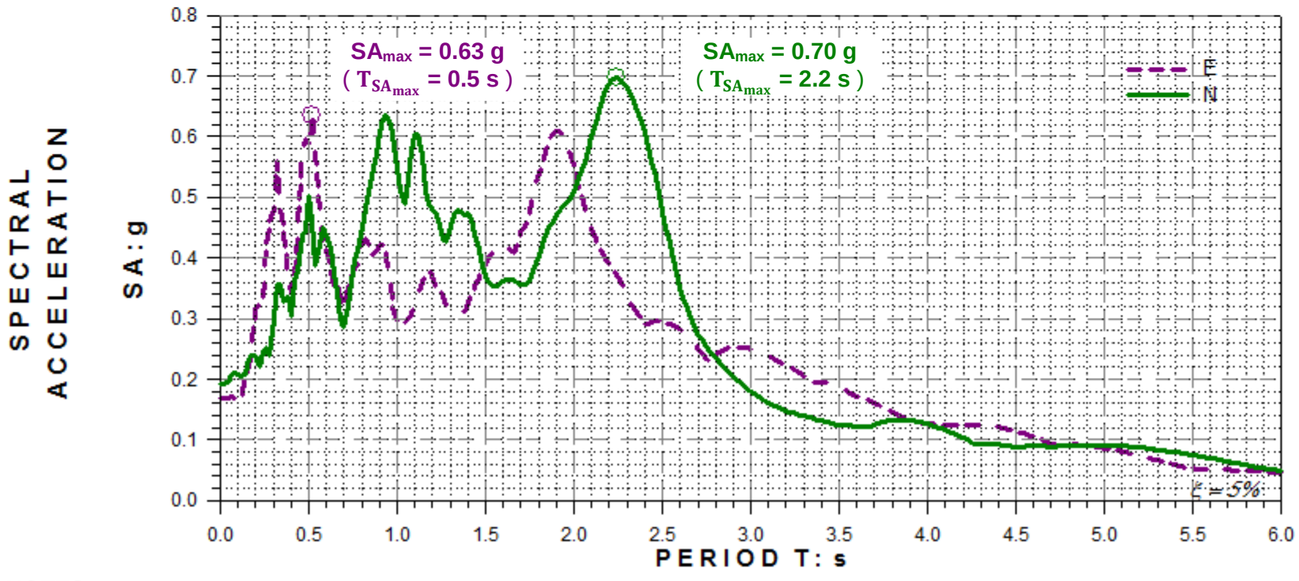
CIRES GROUND MOTIONS

SS60 STATION (19.393° N, 98.853° W) MEXICO CITY, MEXICO	STATION SS60

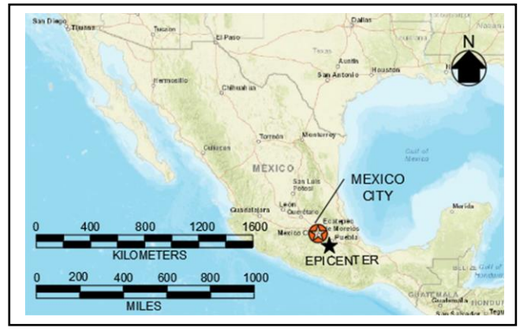
STATION: TH35







Parameter	E	N
PGA (g)	0.168	0.192
PGV (cm/s)	42.3	50.4
PGD (cm)	20.4	19.8
Period of Highest Spectral Peak (s)	0.5	2.2
Arias Intensity (m/s)	1.658	1.834
R_e (km)	102	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-38 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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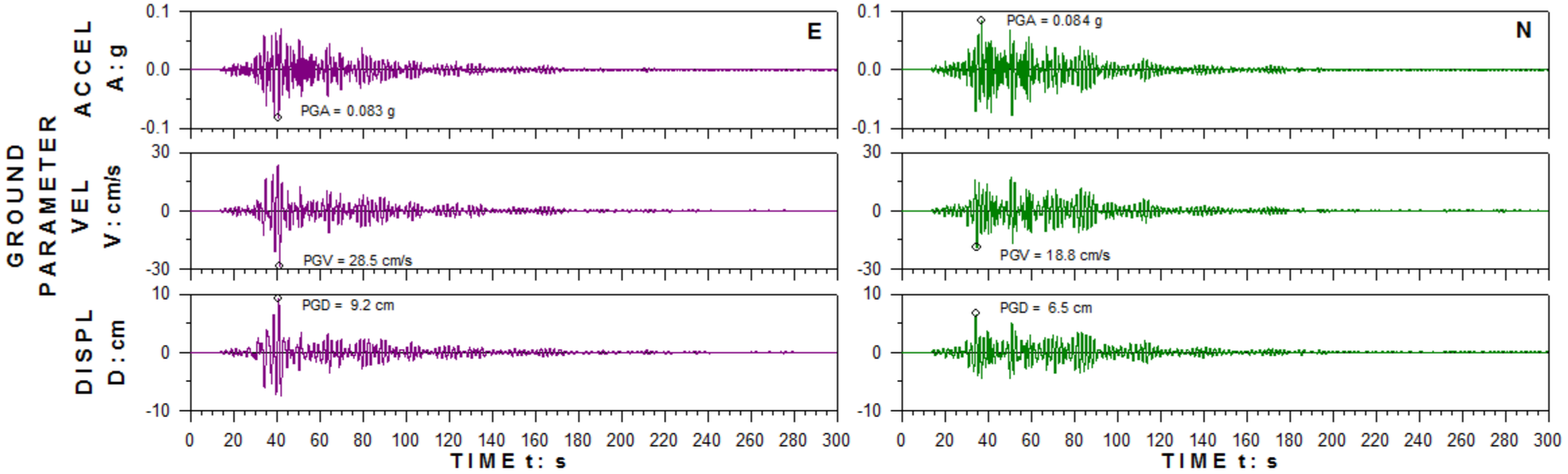
ATC-MEXICO RECONNAISSANCE

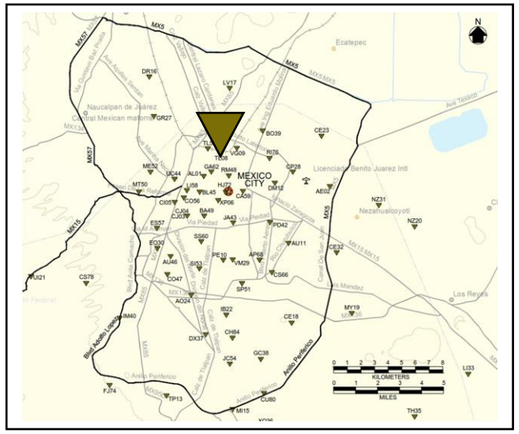
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

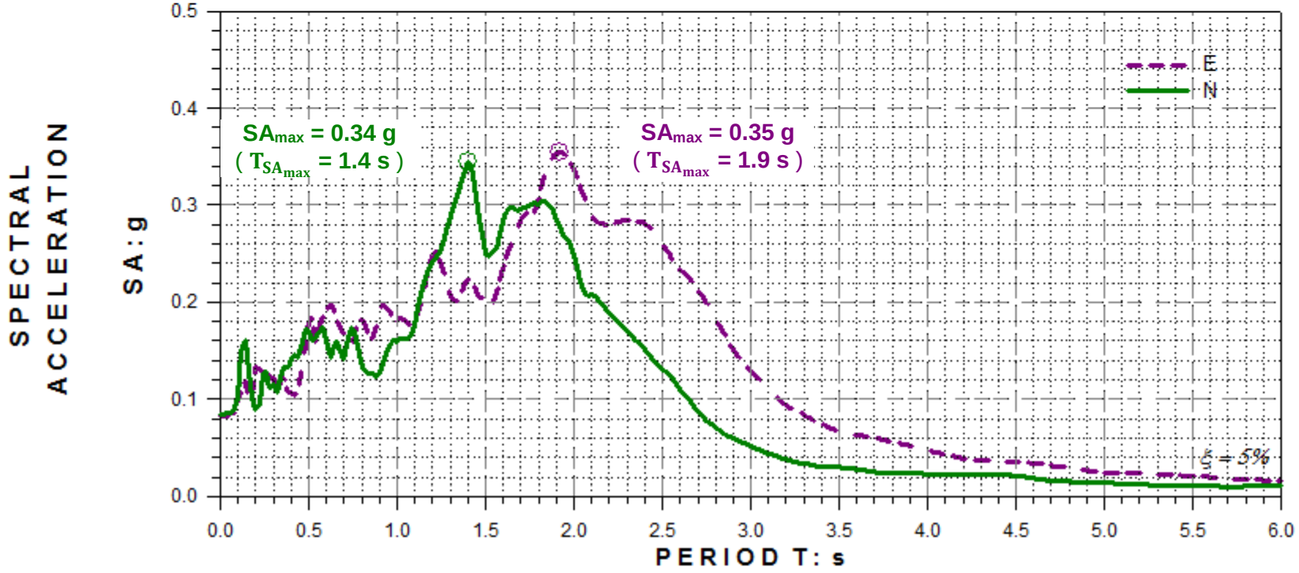
CIRES GROUND MOTIONS

TH35 STATION (19.279° N, 99.000° W) MEXICO CITY, MEXICO	STATION TH35

STATION: TL08







Parameter	E	N
PGA (g)	0.083	0.084
PGV (cm/s)	28.5	18.8
PGD (cm)	9.2	6.5
Period of Highest Spectral Peak (s)	1.9	1.4
Arias Intensity (m/s)	0.481	0.603
R_e (km)	124	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-35 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

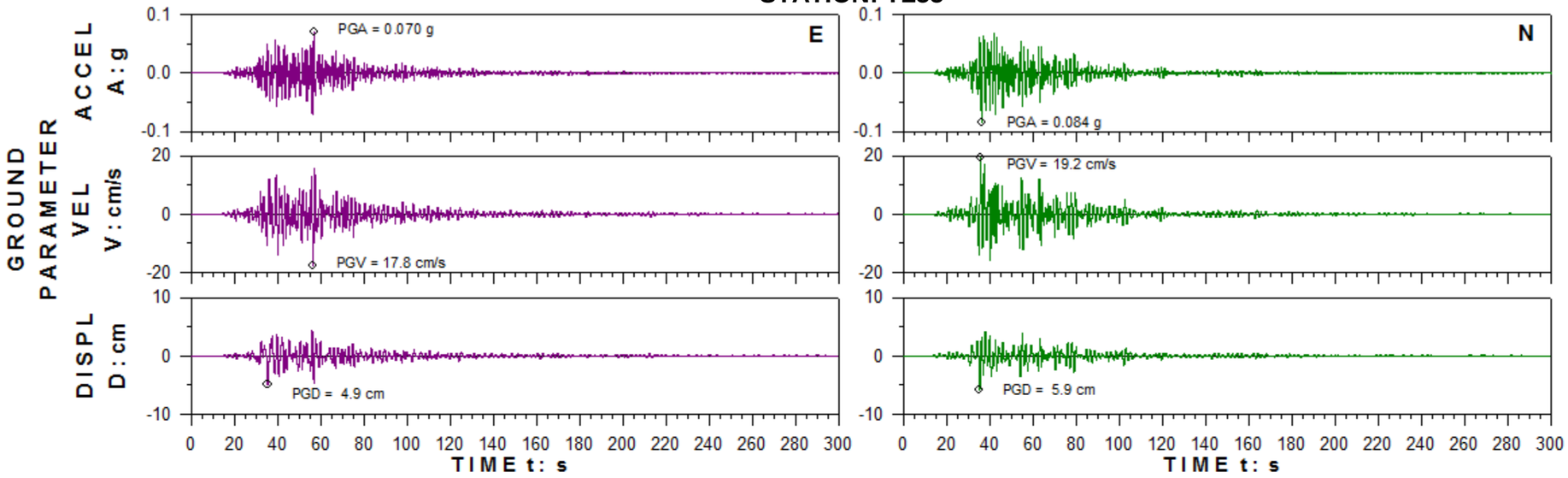
ATC-MEXICO RECONNAISSANCE

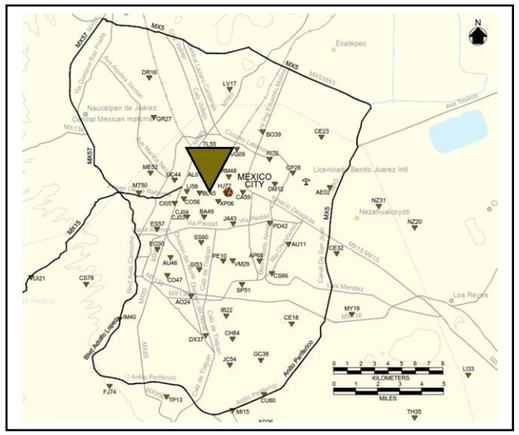
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

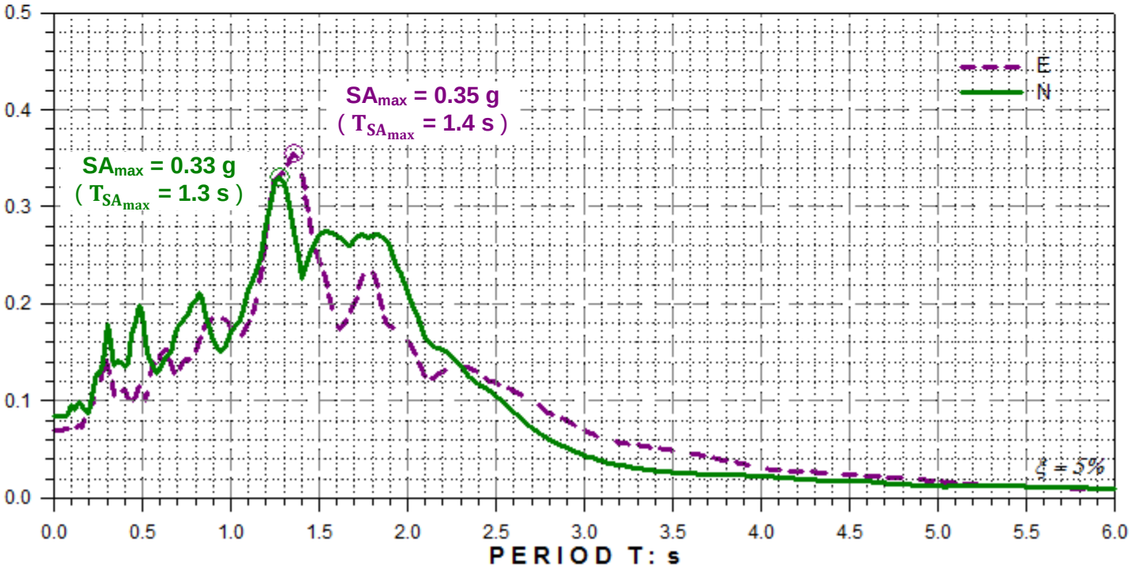
CIRES GROUND MOTIONS

TL08 STATION (19.450° N, 98.866° W) MEXICO CITY, MEXICO	STATION TL08

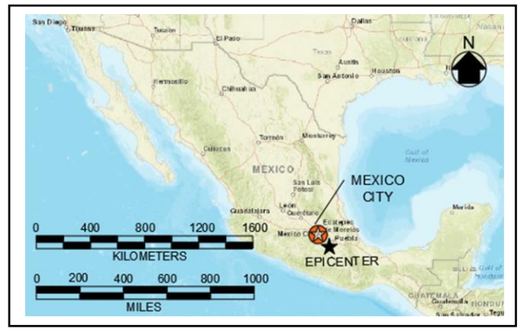
STATION: TL55







Parameter	E	N
PGA (g)	0.070	0.084
PGV (cm/s)	17.8	19.2
PGD (cm)	4.9	5.9
Period of Highest Spectral Peak (s)	1.4	1.3
Arias Intensity (m/s)	0.388	0.453
R_e (km)	125	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.13-20 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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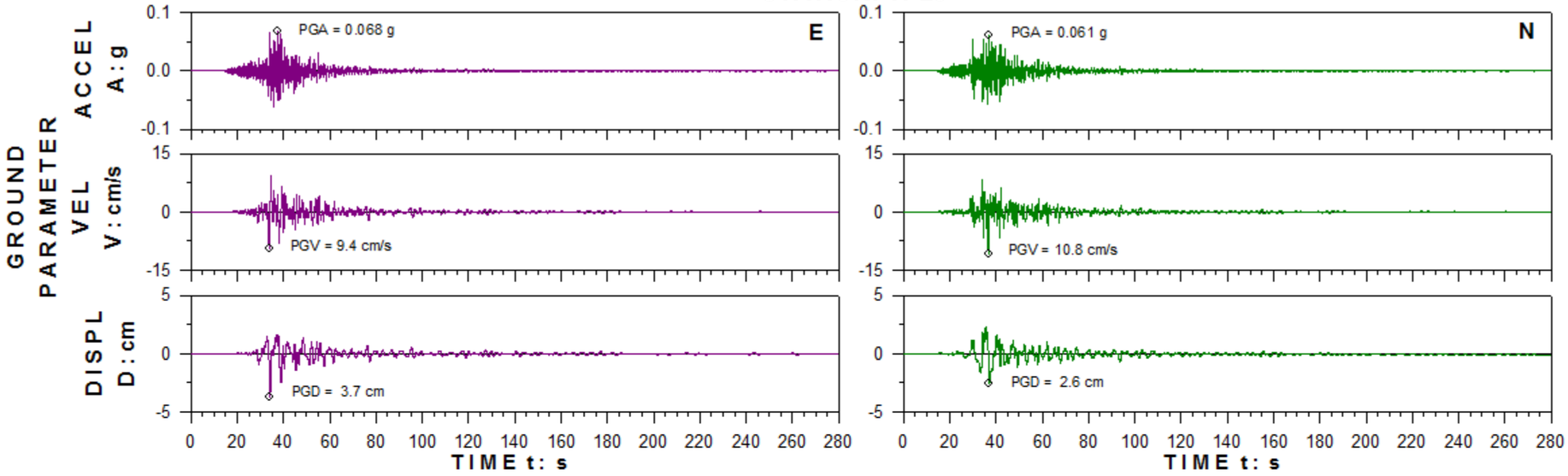
ATC-MEXICO RECONNAISSANCE

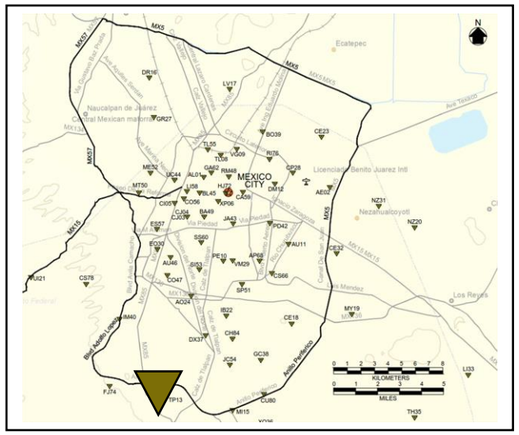
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

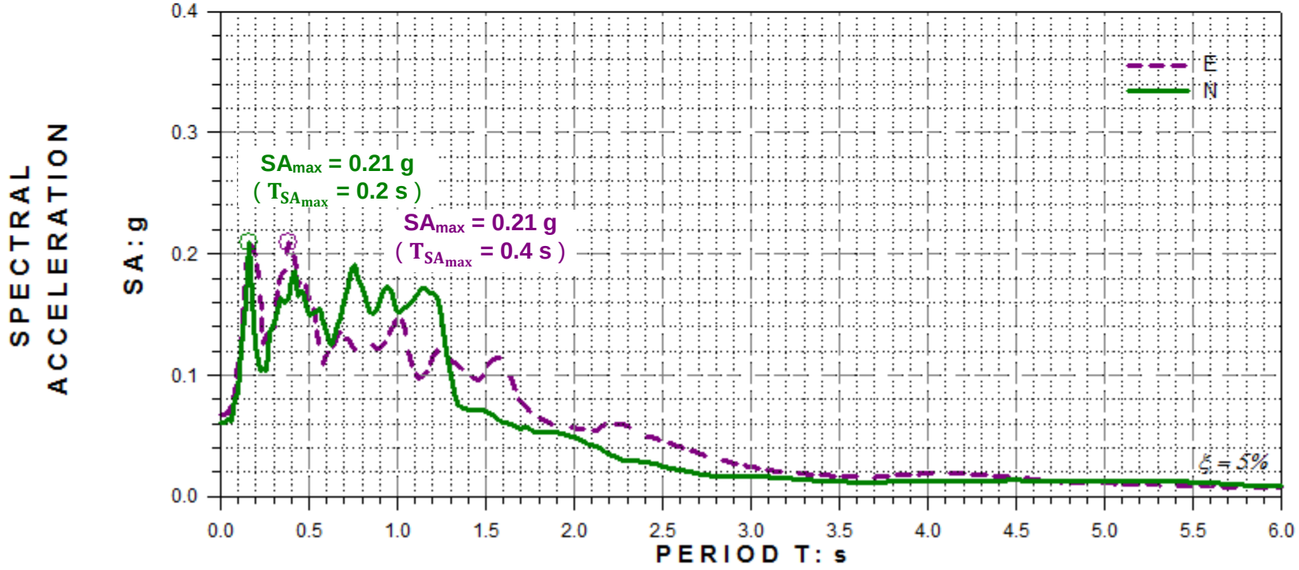
CIRES GROUND MOTIONS

TL55 STATION (19.454° N, 98.858° W) MEXICO CITY, MEXICO	STATION TL55

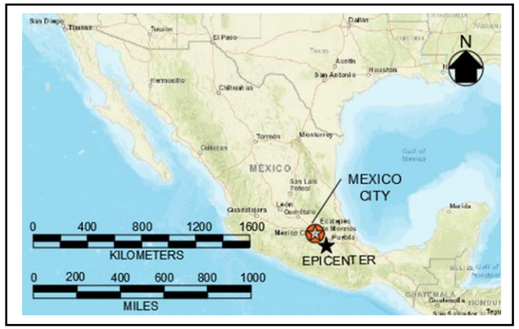
STATION: TP13







Parameter	E	N
PGA (g)	0.068	0.061
PGV (cm/s)	9.4	10.8
PGD (cm)	3.7	2.6
Period of Highest Spectral Peak (s)	0.4	0.2
Arias Intensity (m/s)	0.122	0.134
R_e (km)	110	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-32 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

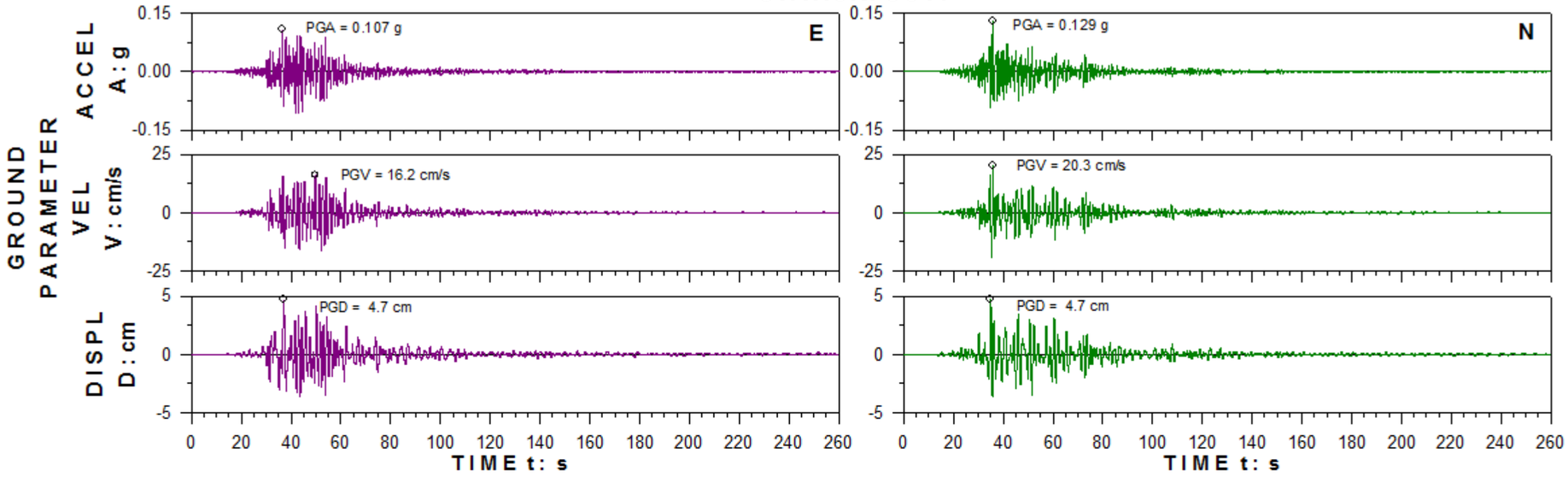
ATC-MEXICO RECONNAISSANCE

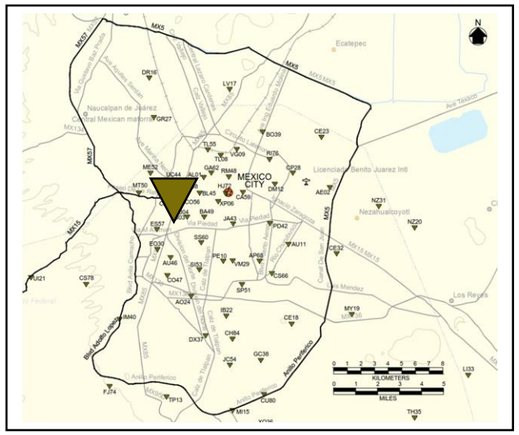
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

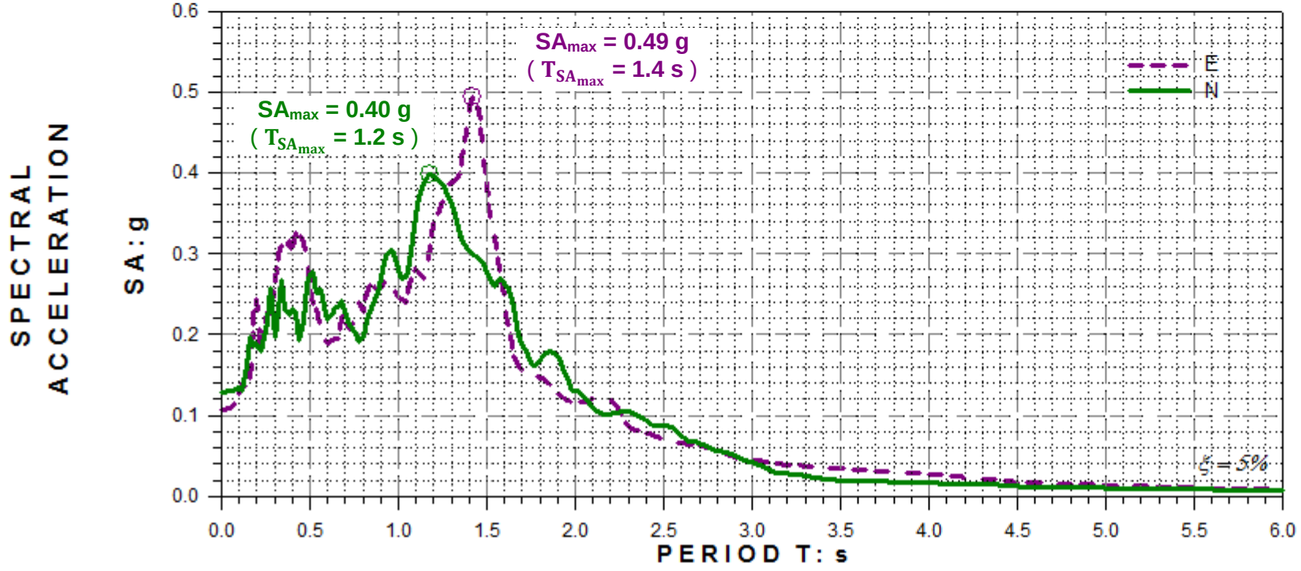
CIRES GROUND MOTIONS

TP13 STATION (19.292° N, 98.829° W) MEXICO CITY, MEXICO	STATION TP13

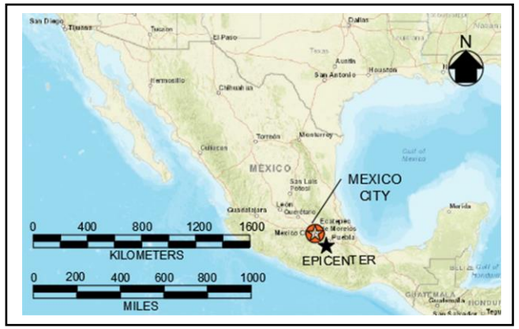
STATION: UC44







Parameter	E	N
PGA (g)	0.107	0.129
PGV (cm/s)	16.2	20.3
PGD (cm)	4.7	4.7
Period of Highest Spectral Peak (s)	1.4	1.2
Arias Intensity (m/s)	0.675	0.513
R_e (km)	124	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.20-17 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

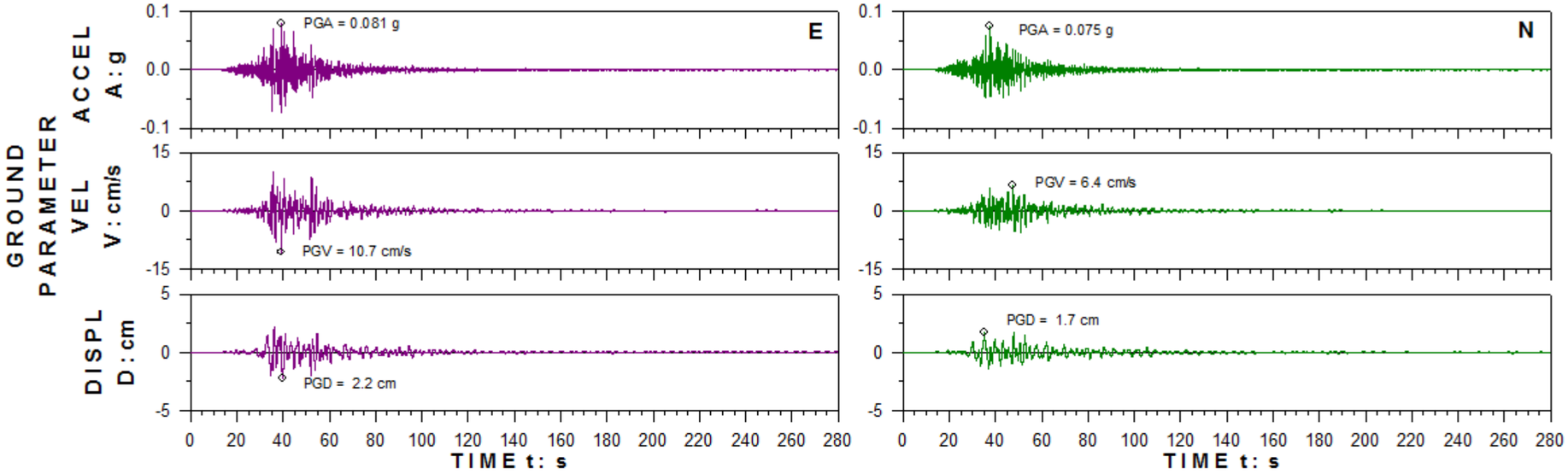
ATC-MEXICO RECONNAISSANCE

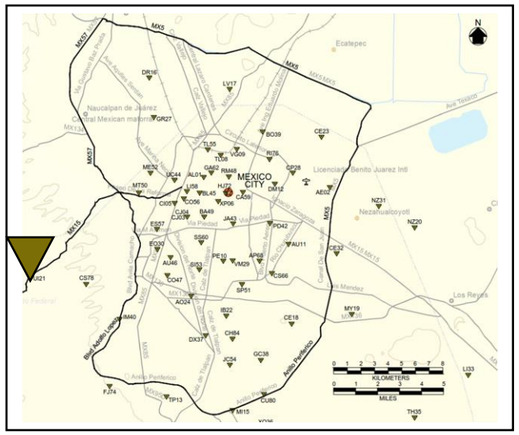
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

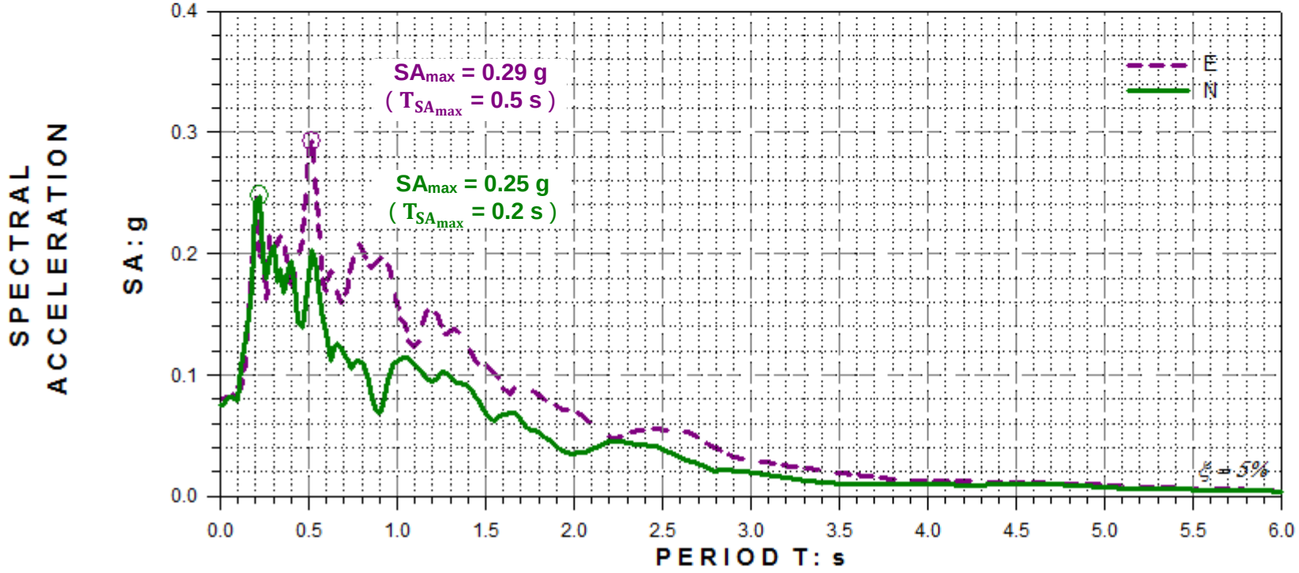
CIRES GROUND MOTIONS

UC44 STATION (19.434° N, 98.835° W) MEXICO CITY, MEXICO	STATION UC44

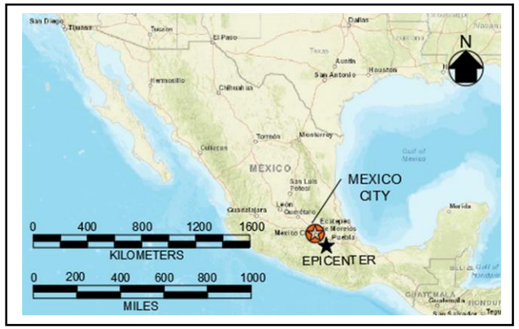
STATION: UI21







Parameter	E	N
PGA (g)	0.081	0.075
PGV (cm/s)	10.7	6.4
PGD (cm)	2.2	1.7
Period of Highest Spectral Peak (s)	0.5	0.2
Arias Intensity (m/s)	0.192	0.130
R_e (km)	122	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.18-40 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

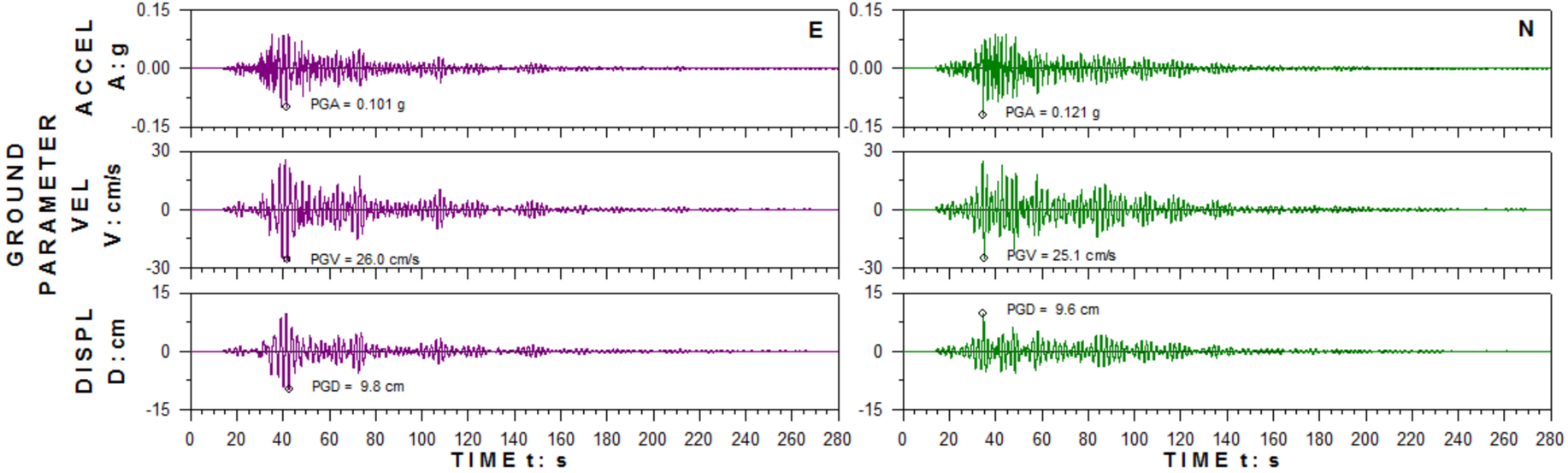
ATC-MEXICO RECONNAISSANCE

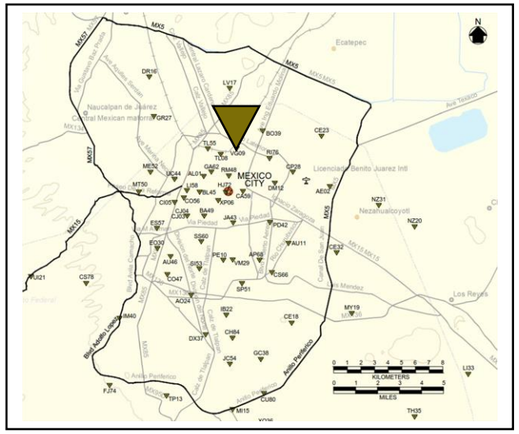
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

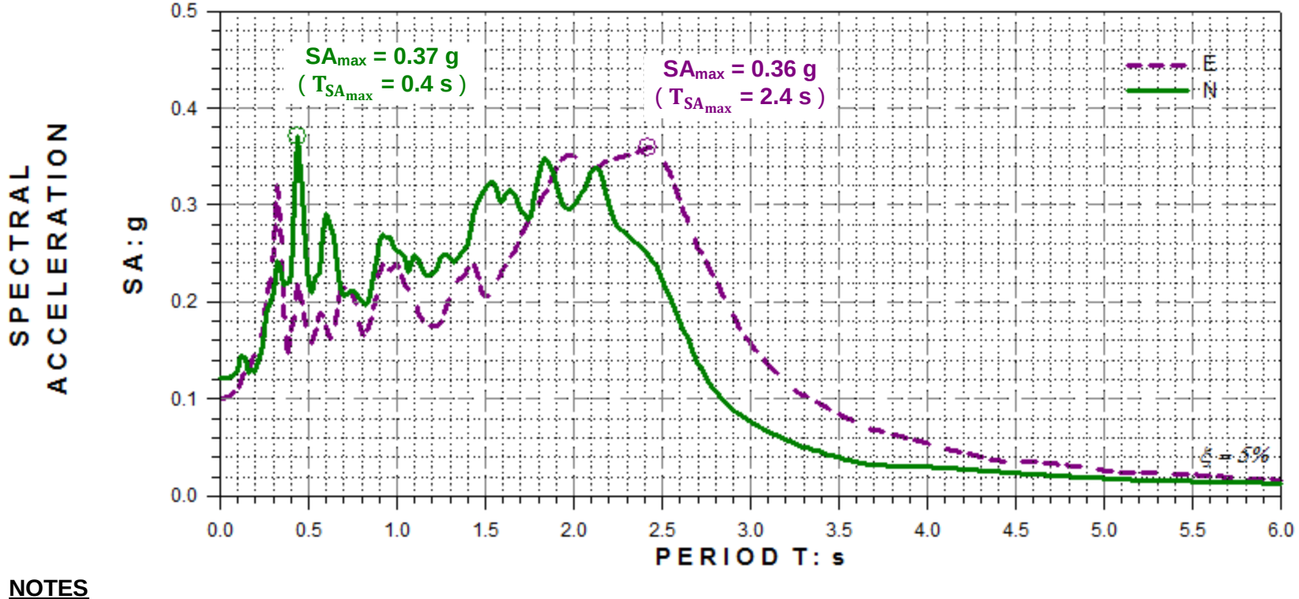
CIRES GROUND MOTIONS

UI21 STATION (19.370° N, 98.736° W) MEXICO CITY, MEXICO	STATION UI21

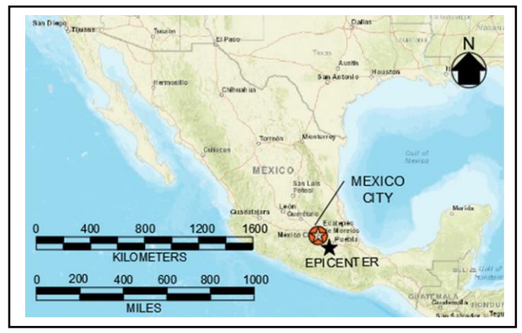
STATION: VG09







Parameter	E	N
PGA (g)	0.101	0.121
PGV (cm/s)	26.0	25.1
PGD (cm)	9.8	9.6
Period of Highest Spectral Peak (s)	2.4	0.4
Arias Intensity (m/s)	0.711	0.871
R_e (km)	124	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.14-25 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

Applied Technology Council

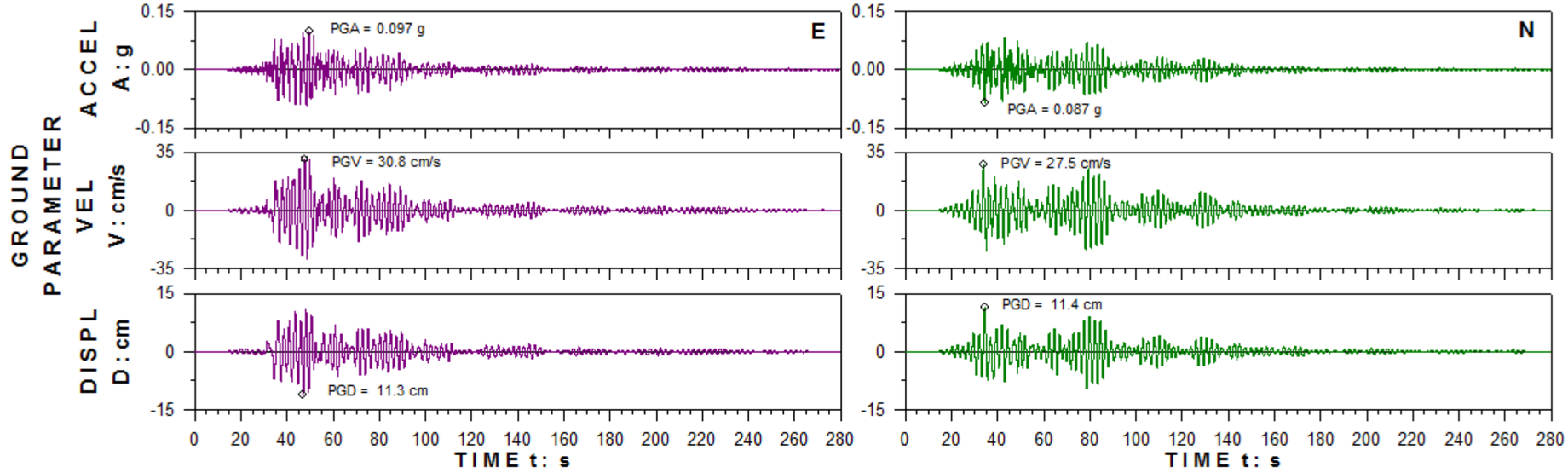
ATC-MEXICO RECONNAISSANCE

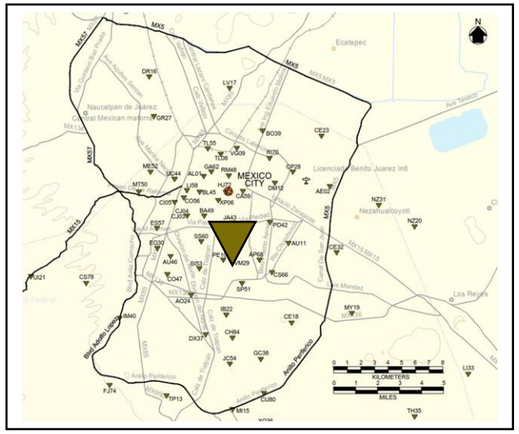
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

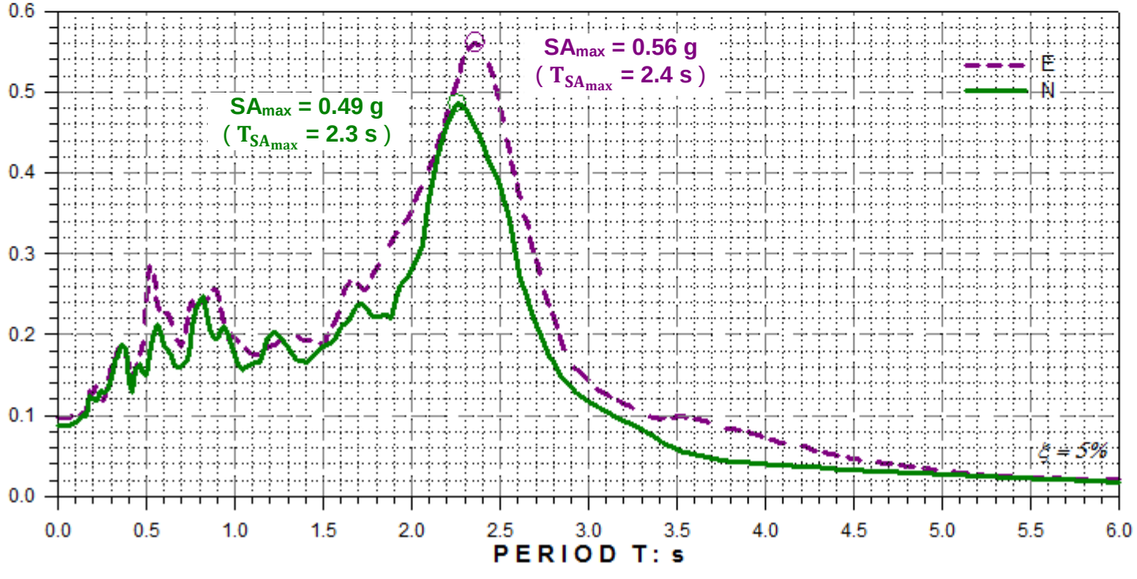
CIRES GROUND MOTIONS

VG09 STATION (19.454° N, 98.878° W) MEXICO CITY, MEXICO	STATION VG09

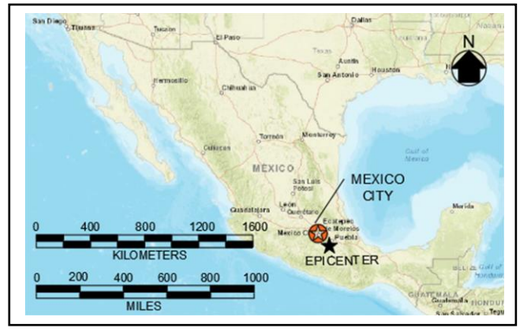
STATION: VM29







Parameter	E	N
PGA (g)	0.097	0.087
PGV (cm/s)	30.8	27.5
PGD (cm)	11.3	11.4
Period of Highest Spectral Peak (s)	2.4	2.3
Arias Intensity (m/s)	1.102	1.098
R_e (km)	117	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.09-29 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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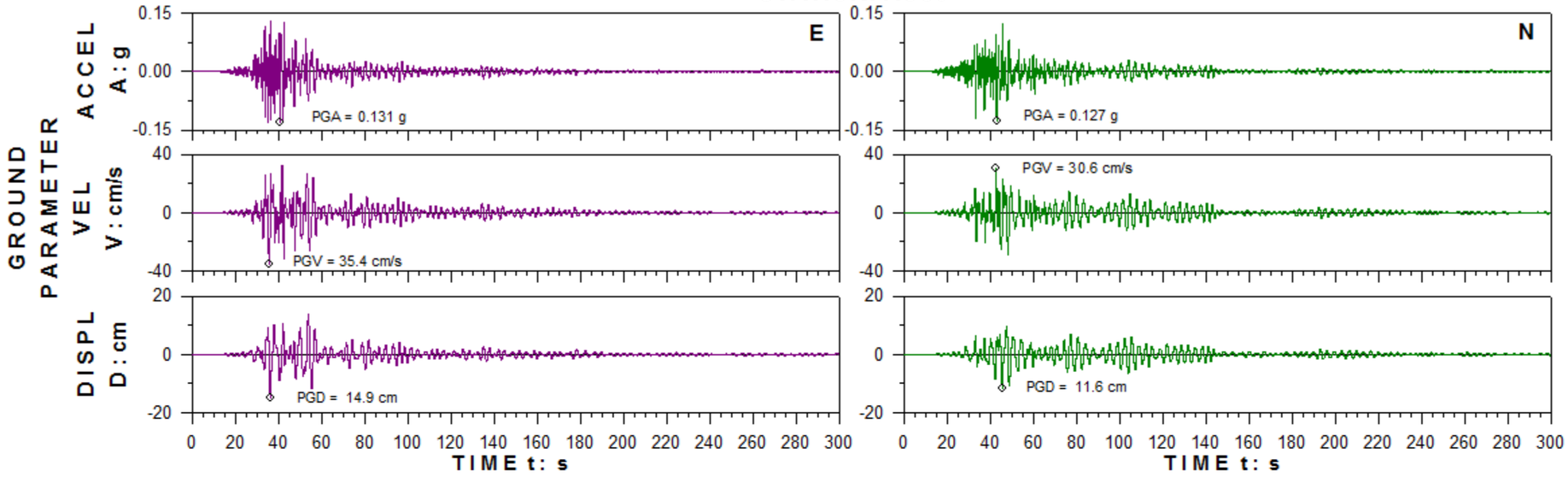
ATC-MEXICO RECONNAISSANCE

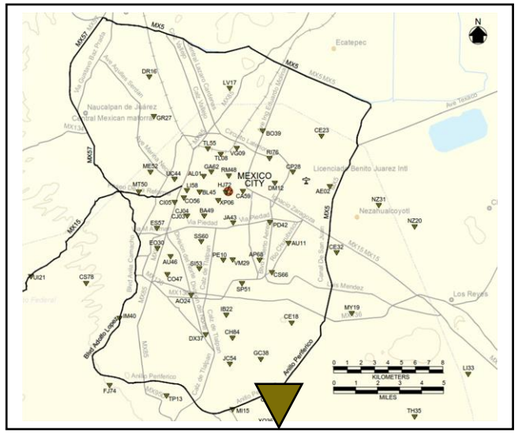
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

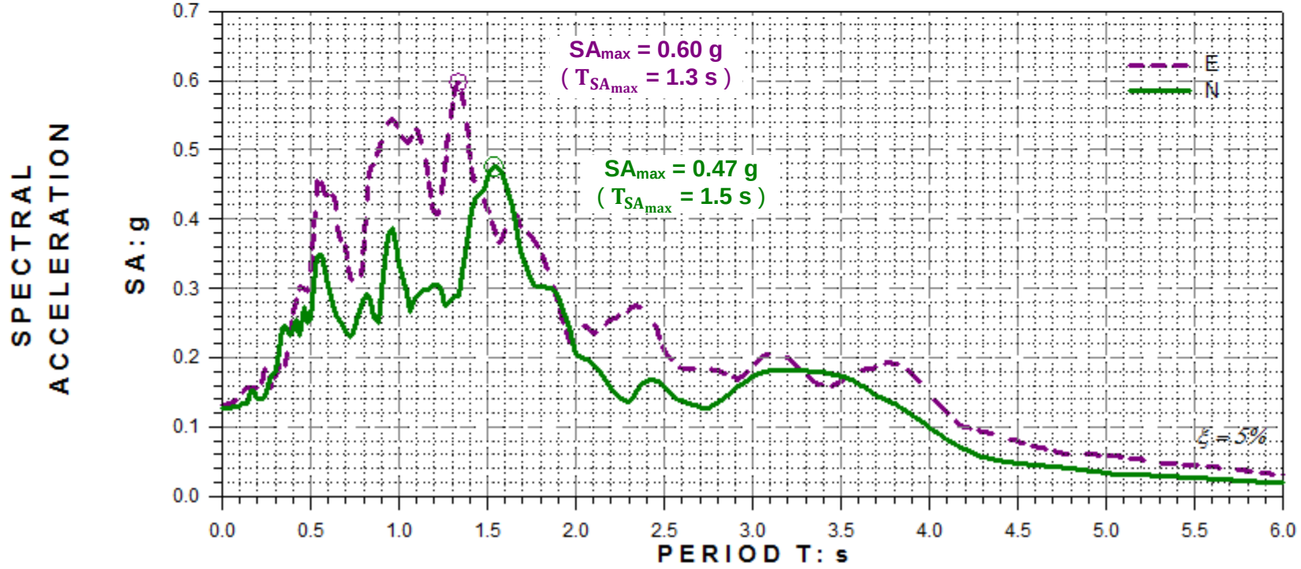
CIRES GROUND MOTIONS

VM29 STATION (19.381° N, 98.875° W) MEXICO CITY, MEXICO	STATION VM29

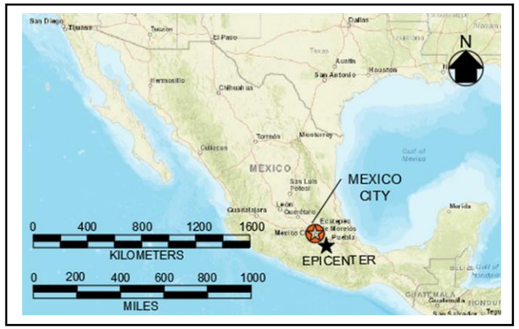
STATION: XO36







Parameter	E	N
PGA (g)	0.131	0.127
PGV (cm/s)	35.4	30.6
PGD (cm)	14.9	11.6
Period of Highest Spectral Peak (s)	1.3	1.5
Arias Intensity (m/s)	1.141	0.850
R_e (km)	105	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.21-37 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
4. The ATC-Mexico reconnaissance mission was sponsored by the Applied Technology Council Endowment Fund.

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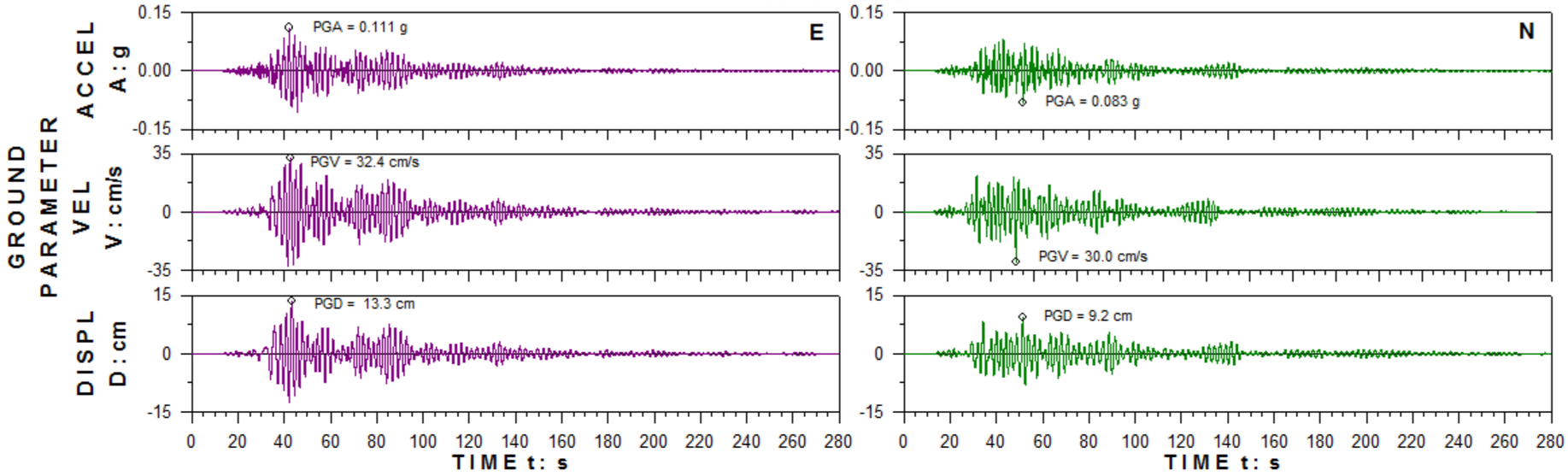
ATC-MEXICO RECONNAISSANCE

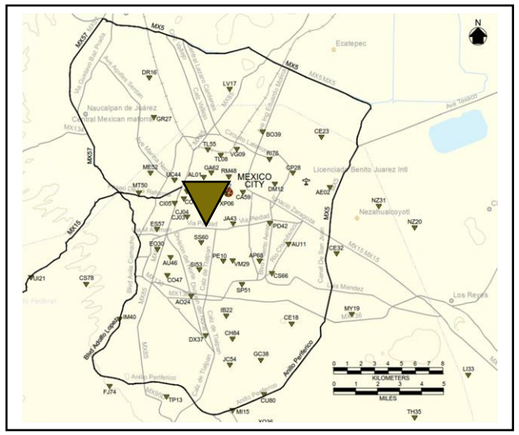
M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

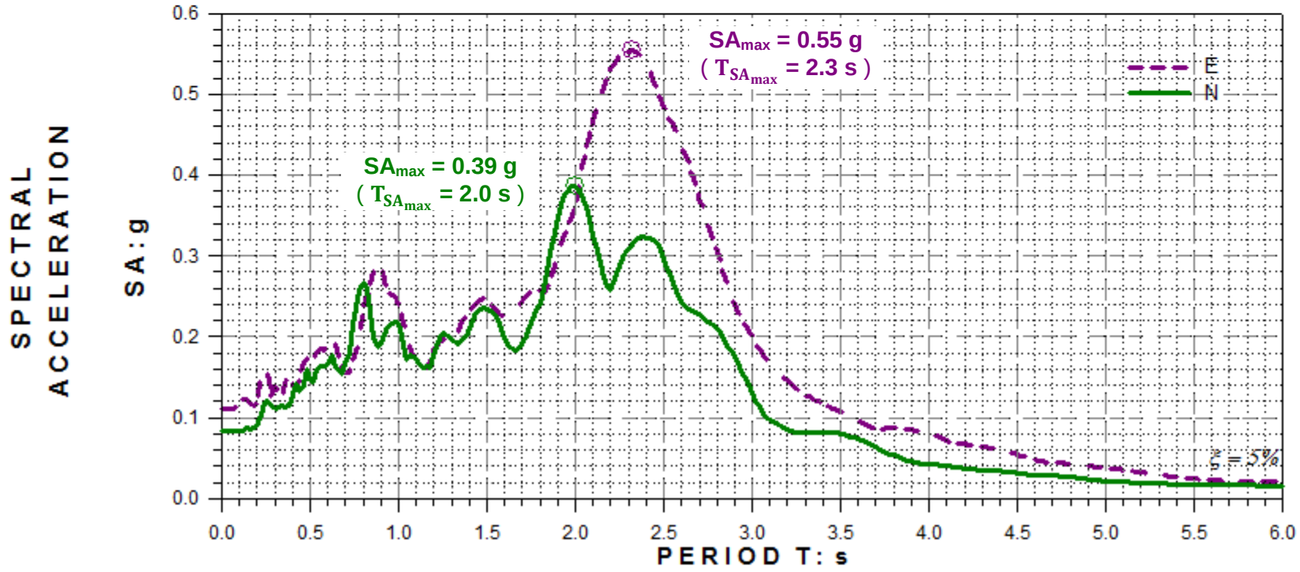
CIRES GROUND MOTIONS

XO36 STATION (19.271° N, 98.898° W) MEXICO CITY, MEXICO	STATION XO36

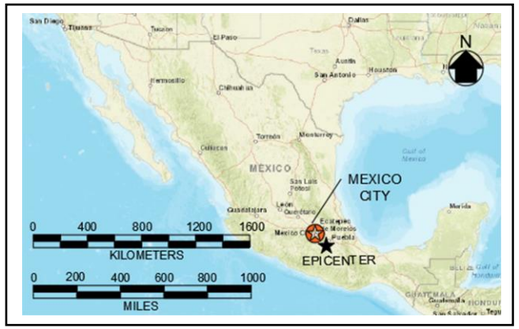
STATION: XP06







Parameter	E	N
PGA (g)	0.111	0.083
PGV (cm/s)	32.4	30.0
PGD (cm)	13.3	9.1
Period of Highest Spectral Peak (s)	2.3	2.0
Arias Intensity (m/s)	1.217	0.750
R_e (km)	121	



NOTES

1. Raw ground motions were provided to ATC Team Mexico Member Virgilio Domínguez by CIRES (the Center of Instrumentation and Seismic Records - Centro de Instrumentación y Registro Sismico), recorded by RACM (the Mexico City Accelerographic Network - Rdd Acelerográfica de la Ciudad de México), a technological resource funded by the Mexico City government through ISCDF (the Institute of Security in Constructions of Mexico City - Instituto para la Seguridad de las Construcciones en el Distrito Federal).
2. Processing of the time histories and derivation of response spectra were performed by ATC-Mexico team members, following the procedure described in the report. For both components of the recording shown here, a Butterworth filter (bandpass 0.15-12 Hz, 4 poles, 2 passes) was used. Structural damping ξ of 5% was assumed.
3. Details on the presented ground motions and additional records are included in the main body of the ATC-141 Report.
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ATC-MEXICO RECONNAISSANCE

M_w7.1 PUEBLA-MORELOS 9/19/17 EARTHQUAKE

CIRES GROUND MOTIONS

XP06 STATION (19.420° N, 98.865° W) MEXICO CITY, MEXICO	STATION XP06

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Applied Technology Council Projects and Report Information

One of the primary purposes of the Applied Technology Council is to develop engineering applications and resources that translate and summarize useful information for practicing building and bridge design professionals. This includes the development of guidelines and manuals, as well as the development of research recommendations for specific areas determined by the profession. ATC is not a code development organization, although ATC project reports often serve as resource documents for the development of codes, standards and specifications.

Applied Technology Council conducts projects that meet the following criteria:

1. The primary audience or benefactor is the design practitioner in structural engineering.
2. A cross section or consensus of engineering opinion is required to be obtained and presented by a neutral source.
3. The project fosters the advancement of structural engineering practice.

Funding for projects is obtained from government agencies and tax-deductible contributions from the private sector. Brief descriptions of completed ATC projects and reports are provided below.

ATC-1: This project resulted in five papers published as part of *Building Practices for Disaster Mitigation, Building Science Series 46*, proceedings of a workshop sponsored by the National Science Foundation (NSF) and the National Bureau of Standards (NBS). Available through the National Technical Information Service (NTIS), 5285 Port Royal Road, Springfield, VA 22151, as NTIS report No. COM-73-50188.

ATC-2: The report, *An Evaluation of a Response Spectrum Approach to Seismic Design of Buildings*, was funded by NSF and NBS and was conducted as part of the Cooperative Federal Program in Building Practices for Disaster Mitigation. Available through ATC. (Published 1974, 270 Pages)

ATC-3: The report, *Tentative Provisions for the Development of Seismic Regulations for Buildings* (ATC-3-06), was funded by NSF and NBS. The tentative provisions in this report served as the basis for the seismic provisions of the 1988 and subsequent issues of the *Uniform Building Code* and the *NEHRP Recommended Provisions for the Development of Seismic Regulation for New Building and Other Structures*. The second printing contains proposed amendments prepared by a joint committee of the Building Seismic Safety Council (BSSC) and the NBS. Available through ATC. (Published 1978, amended 1982, 505 pages plus proposed amendments)

ATC-3-2: The project, "Comparative Test Designs of Buildings Using ATC-3-06 Tentative Provisions", was funded by NSF. It consisted of a study to develop and plan a program for making comparative test designs of the ATC-3-06 Tentative Provisions. The project report was intended for use by the Building Seismic Safety Council in its refinement of the ATC-3-06 Tentative Provisions.

ATC-3-4: The report, *Redesign of Three Multistory Buildings: A Comparison Using ATC-3-06 and 1982 Uniform Building Code Design Provisions*, was published under a grant from NSF. Available through ATC. (Published 1984, 112 pages)

ATC-3-5: The project, "Assistance for First Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting

the first phase of its program to develop trial designs for buildings in Los Angeles, Seattle, Phoenix, and Memphis.

ATC-3-6: The project, "Assistance for Second Phase of ATC-3-06 Trial Design Program Being Conducted by the Building Seismic Safety Council," was funded by the Building Seismic Safety Council to obtain assistance in conducting the second phase of its program to develop trial designs for buildings in New York, Chicago, St. Louis, Charleston, and Fort Worth.

ATC-4: The report, *A Methodology for Seismic Design and Construction of Single-Family Dwellings*, was published under a contract with the Department of Housing and Urban Development (HUD). Available through ATC. (Published 1976, 576 pages)

ATC-4-1: The report, *The Home Builders Guide for Earthquake Design*, was published under a contract with HUD. Available through ATC. (Published 1980, 57 pages)

ATC-5: The report, *Guidelines for Seismic Design and Construction of Single-Story Masonry Dwellings in Seismic Zone 2*, was developed under a contract with HUD. Available through ATC. (Published 1986, 38 pages)

ATC-6: The report, *Seismic Design Guidelines for Highway Bridges*, was published under a contract with the Federal Highway Administration (FHWA). Available through ATC. (Published 1981, 210 pages)

ATC-6-1: The report, *Proceedings of a Workshop on Earthquake Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1979, 625 pages)

ATC-6-2: The report, *Seismic Retrofitting Guidelines for Highway Bridges*, was published under a contract with FHWA. Available through ATC. (Published 1983, 220 pages)

ATC-7: The report, *Guidelines for the Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1981, 190 pages)

ATC-7-1: The report, *Proceedings of a Workshop on Design of Horizontal Wood Diaphragms*, was published under a grant from NSF. Available through ATC. (Published 1980, 302 pages)

ATC-8: The report, *Proceedings of a Workshop on the Design of Prefabricated Concrete Buildings for Earthquake Loads*, was funded by NSF. Available through ATC. (Published 1981, 400 pages)

ATC-9: The report, *An Evaluation of the Imperial County Services Building Earthquake Response and Associated Damage*, was published under a grant from NSF. Available through ATC. (Published 1984, 231 pages)

ATC-10: The report, *An Investigation of the Correlation Between Earthquake Ground Motion and Building Performance*, was funded by the U.S. Geological Survey (USGS). Available through ATC. (Published 1982, 114 pages)

ATC-10-1: The report, *Critical Aspects of Earthquake Ground Motion and Building Damage Potential*, was co-funded by the USGS and the NSF. Available through ATC. (Published 1984, 259 pages)

ATC-11: The report, *Seismic Resistance of Reinforced Concrete Shear Walls and Frame Joints: Implications of Recent Research for Design Engineers*, was published under a grant from NSF. Available through ATC. (Published 1983, 184 pages)

ATC-12: The report, *Comparison of United States and New Zealand Seismic Design Practices for Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1982, 270 pages)

ATC-12-1: The report, *Proceedings of Second Joint U.S.-New Zealand Workshop on Seismic Resistance of Highway Bridges*, was published under a grant from NSF. Available through ATC. (Published 1986, 272 pages)

ATC-13: The report, *Earthquake Damage Evaluation Data for California*, was developed under a contract with the Federal Emergency Management Agency (FEMA). It presents expert-opinion earthquake damage and loss estimates for industrial, commercial, residential, utility and transportation facilities in California. Included are damage probability matrices for 78 classes of structures and estimates of time required to restore damaged facilities to pre-earthquake usability. Available through ATC. (Published 1985, 492 pages)

ATC-13-1: The report, *Commentary on the Use of ATC-13 Earthquake Damage Evaluation Data for Probable Maximum Loss Studies of California Buildings*, was developed with funding from the

ATC Endowment Fund. It provides guidance for using ATC-13 expert-opinion data for probable maximum loss (PML) studies of California buildings. Included are discussions of the limitations on the use of the ATC-13 expert-opinion data, and appendices containing information not included in the original ATC-13 report, such as model building type descriptions, beta damage distribution parameters for ATC-13 model building types, and PML values for ATC-13 model building types. Available through ATC. (Published 2002, 66 pages)

ATC-14: The report, *Evaluating the Seismic Resistance of Existing Buildings*, was developed under a grant from the NSF. It describes a methodology for performing preliminary and detailed seismic evaluations of buildings. A precursor to the eventual ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*, it contains useful background information including a state-of-practice review; seismic loading criteria; data collection procedures; a detailed description of the building classification system; preliminary and detailed analysis procedures; and example case studies, including nonstructural considerations. Available through ATC. (Published 1987, 370 pages)

ATC-15: The report, *Comparison of Seismic Design Practices in the United States and Japan*, was published under a grant from NSF. Available through ATC. (Published 1984, 317 pages)

ATC-15-1: The report, *Proceedings of Second U.S.-Japan Workshop on Improvement of Building Seismic Design and Construction Practices*, was published under a grant from NSF. It includes state-of-the-practice papers and case studies of actual building designs and information on regulatory, contractual, and licensing issues. Available through ATC. (Published 1987, 412 pages)

ATC-15-2: The report, *Proceedings of Third U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes state-of-the-practice papers on steel braced frame and reinforced concrete buildings, base isolation and passive energy dissipation devices, and comparisons between U.S. and Japanese design practice. Available through ATC. (Published 1989, 358 pages)

ATC-15-3: The report, *Proceedings of Fourth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on postearthquake building damage assessment; acceptable earthquake damage; repair and retrofit of earthquake-damaged buildings; base-isolated buildings, Architectural Institute of Japan recommendations for design; active damping systems; and wind-resistant design. Available through ATC. (Published 1992, 484 pages)

ATC-15-4: The report, *Proceedings of Fifth U.S.-Japan Workshop on Improvement of Building Structural Design and Construction Practices*, was published jointly by ATC and the Japan Structural Consultants Association. It includes papers on performance goals and acceptable damage; seismic design procedures and case studies; seismic evaluation, repair and upgrade; construction influences on design; isolation and passive energy dissipation; design of irregular structures; and quality control for design and construction. Available through ATC. (Published 1994, 360 pages)

ATC-15 Series: The purpose of this project series is to conduct workshops between the U.S., Japan, and New Zealand to develop policy recommendations for improved community resilience based on the current state-of-practice, innovative engineering solutions, and new and emerging technologies in all three countries.

ATC-16: The FEMA 90 report, *An Action Plan for Reducing Earthquake Hazards of Existing Buildings*, was funded by FEMA and was conducted by a joint venture of ATC, the Building Seismic Safety Council and the Earthquake Engineering Research Institute. Available through FEMA. (Published 1985, 75 pages)

ATC-17: The report, *Proceedings of a Seminar and Workshop on Base Isolation and Passive Energy Dissipation*, was published under a grant from NSF. It includes papers describing case studies in the United States, applications and developments worldwide, recent innovations in technology development, and structural and ground motion issues in base-isolation and passive energy-dissipation. Also included is a proposed 5-year research agenda. Available through ATC. (Published 1986, 478 pages)

ATC-17-1: The report, *Proceedings of a Seminar on Seismic Isolation, Passive Energy Dissipation and Active Control,* was published under a grant from NCEER and NSF. Available through ATC. (Published 1993, 841 pages in two volumes)

ATC-17-2: The project, "Seminar on Response Modification Technologies for Performance-Based Seismic Design", was funded by MCEER. The seminar was held on May 30-31, 2002, in Los Angeles, California.

ATC-18: The report, *Seismic Design Criteria for Bridges and Other Highway Structures: Current and Future***,** was developed under a grant from NCEER and FHWA. Available through ATC. (Published, 1997, 151 pages)

ATC-18-1: The report, *Impact Assessment of Selected MCEER Highway Project Research on the Seismic Design of Highway Structures***,** was developed under a contract with the Multidisciplinary Center for Earthquake Engineering Research (MCEER, formerly NCEER) and FHWA. Available through ATC. (Published, 1999, 136 pages)

ATC-19: The report, *Structural Response Modification Factors* was funded by NSF and NCEER. Available through ATC. (Published 1995, 70 pages)

ATC-20: The report, *Procedures for Postearthquake Safety Evaluation of Buildings*, was developed under a contract with the California Office of Emergency Services (OES), California Office of Statewide Health Planning and Development (OSHPD) and FEMA. It provides procedures and guidelines for inspecting buildings that have been damaged in an earthquake, and making decisions regarding their continued use and occupancy. Written for volunteer structural engineers and building inspectors, it includes rapid and detailed evaluation procedures for posting buildings as "inspected" (apparently safe, green placard), "limited entry" (yellow) or "unsafe" (red). Available through ATC (Published 1989, 152 pages)

ATC-20-1: The report, *Field Manual: Postearthquake Safety Evaluation of Buildings*, *Second Edition*, was funded by Applied Technology Council. A companion to the ATC-20 report, the *Field Manual* summarizes postearthquake safety evaluation procedures in a concise format designed for ease of use in the field. Available through ATC. (Published 2005, 143 pages)

ATC-20-1 Bhutan: The report, *Bhutan Field Manual: Postearthquake Safety Evaluation of Buildings,* was developed in partnership with GeoHazards International and the Royal Government of Bhutan's Department of Engineering Services and Department of Disaster Management with funding from the ATC Endowment Fund and the World Bank's Global Facility for Disaster Reduction in Recovery. The *Bhutan Field Manual* is an adaptation of the postearthquake safety evaluation procedures described in ATC-20 to account for Bhutan's vernacular buildings, as well as Bhutan's cultural and governmental context. Available through ATC. (Published 2014, 246 pages)

ATC-20-2: The report, *Addendum to the ATC-20 Postearthquake Building Safety Procedures* was published under a grant from the NSF and funded by the USGS. It provides updated assessment forms, placards, and evaluation procedures based on application and use in five earthquake events that occurred after the initial release of the ATC-20 report. Available through ATC. (Published 1995, 94 pages)

ATC-20-3: The report, *Case Studies in Rapid Postearthquake Safety Evaluation of Buildings,* was funded by ATC and R.P. Gallagher Associates. Containing over 50 case studies using the ATC-20 Rapid Evaluation procedure, the report is intended for use as a training and reference manual describing how buildings are inspected and evaluated. Illustrated with photos and completed safety assessment forms and placards. Available through ATC. (Published 1996, 295 pages)

ATC-20-T: The *Postearthquake Safety Evaluation of Buildings Training CD* was developed in cooperation with FEMA. The 4½-hour training seminar includes photographs, schematic drawings, and textual information. Available through ATC. (Published 2002, 230 PowerPoint slides with Speakers Notes)

ATC-21: The FEMA 154 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook*, *Second Edition*, was developed under a contract with FEMA. It describes a rapid visual screening procedure for identifying buildings that might pose serious risk of loss of life and injury in the event of a

damaging earthquake. Available through ATC and FEMA. (Published 2002, 161 pages)

ATC-21-1: The FEMA 155 report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation*, *Second Edition*, was developed under a contract with FEMA. It provides the technical basis for the updated rapid visual screening procedure. Available through ATC and FEMA. (Published 2002, 117 pages)

ATC-21-2: The report, *Earthquake Damaged Buildings: An Overview of Heavy Debris and Victim Extrication*, was developed under a contract with FEMA. (Published 1988, 95 pages)

ATC-21-T: The report, *Rapid Visual Screening of Buildings for Potential Seismic Hazards Training Manual, Second Edition,* was developed under a contract with FEMA. Training materials include120 slides in PowerPoint format and companion narrative coordinated with the presentation. Available through ATC. (Published 2004, 148 pages and PowerPoint presentation on companion USB)

ATC-22: The report, *A Handbook for Seismic Evaluation of Existing Buildings (Preliminary)*, was developed under a contract with FEMA in 1989. Based on the information originally developed in ATC-14, this report was revised by BSSC and published as the FEMA 178 report, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings* in 1992, revised by ASCE and published as the FEMA 310 report, *Handbook for the Seismic Evaluation of Buildings – a Prestandard* in 1998. Available through the American Society of Civil Engineers as the ASCE 31 Standard, *Seismic Evaluation of Existing Buildings*.

ATC-22-1: The report, *Seismic Evaluation of Existing Buildings: Supporting Documentation*, was developed under a contract with FEMA. (Published 1989, 160 pages)

ATC-23A: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part A: Survey Description, Summary of Results, Data Analysis and Interpretation*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 58 pages)

ATC-23B: The report, *General Acute Care Hospital Earthquake Survivability Inventory for California, Part B: Raw Data*, was developed under a contract with the Office of Statewide Health Planning and Development (OSHPD), State of California. Available through ATC. (Published 1991, 377 pages)

ATC-24: The report, *Guidelines for Seismic Testing of Components of Steel Structures*, was jointly funded by the American Iron and Steel Institute (AISI), American Institute of Steel Construction (AISC), National Center for Earthquake Engineering Research (NCEER), and NSF. Available through ATC. (Published 1992, 57 pages)

ATC-25: The report, *Seismic Vulnerability and Impact of Disruption of Lifelines in the Conterminous United State*s, was developed under a contract with FEMA. Available through ATC. (Published 1991, 440 pages)

ATC-25-1: The report, *A Model Methodology for Assessment of Seismic Vulnerability and Impact of Disruption of Water Supply Systems*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 147 pages)

ATC-26: This project, "U.S. Postal Service National Seismic Program," was funded under a contract with the U.S. Postal Service (USPS), and resulted in the following interim documents:

ATC-26, *Cost Projections for the U.S. Postal Service Seismic Program* (Completed 1990)

ATC-26-1, *United States Postal Service Procedures for Seismic Evaluation of Existing Buildings (Interim)* (Completed 1991)

ATC-26-2, *Procedures for Post-disaster Safety Evaluation of Postal Service Facilities (Interim)*. Available through ATC. (Published 1991, 221 pages)

ATC-26-3, *Field Manual: Post-earthquake Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 133 pages)

ATC-26-3A, *Field Manual: Post Flood and Wind Storm Safety Evaluation of Postal Buildings (Interim)*. Available through ATC. (Published 1992, 114 pages)

ATC-26-4, *United States Postal Service Procedures for Building Seismic Rehabilitation (Interim)* (Completed 1992)

ATC-26-5, *United States Postal Service Guidelines for Building and Site Selection in Seismic Areas (Interim)* (Completed 1992)

ATC-28: The report, *Development of Recommended Guidelines for Seismic Strengthening of Existing Buildings, Phase I: Issues Identification and Resolution*, was developed under a contract with FEMA. Available through ATC. (Published 1992, 150 pages)

ATC-29: The report, *Proceedings of a Seminar and Workshop on Seismic Design and Performance of Equipment and Nonstructural Elements in Buildings and Industrial Structures*, was developed under a grant from NCEER and NSF. It includes papers describing current practice, codes and regulations; earthquake performance; analytical and experimental investigations; development of new seismic qualification methods; and research, practice, and code development needs for nonstructural elements and systems. Available through ATC. (Published 1992, 470 pages)

ATC-29-1: The report, *Proceedings of a Seminar on Seismic Design, Retrofit, and Performance of Nonstructural Components*, was developed under a grant from NCEER and NSF. It includes papers on observed performance in recent earthquakes; seismic design codes, standards, and procedures for commercial and institutional buildings; design issues relating to industrial and hazardous material facilities; and seismic evaluation and rehabilitation of components in conventional and essential facilities. Available through ATC. (Published 1998, 518 pages)

ATC-29-2: The report, *Proceedings of Seminar on Seismic Design, Performance, and Retrofit of Nonstructural Components in Critical Facilities*, was developed under a grant from MCEER (formerly NCEER) and NSF. It includes papers on seismic design, performance, and retrofit of nonstructural components in critical facilities including current practices and emerging codes; seismic design and retrofit; risk and performance evaluation; system qualification and testing; and advanced technologies. Available through ATC. (Published 2003, 574 pages)

ATC-30: The report, *Proceedings of Workshop for Utilization of Research on Engineering and Socioeconomic Aspects of 1985 Chile and Mexico Earthquakes*, was developed under a grant from the NSF. Available through ATC. (Published 1991, 113 pages)

ATC-31: The report, *Evaluation of the Performance of Seismically Retrofitted Buildings*, was developed under a contract with the National Institute of Standards and Technology (NIST, formerly NBS) and funded by the USGS. Available through ATC. (Published 1992, 75 pages)

ATC-32: The report, *Improved Seismic Design Criteria for California Bridges: Provisional Recommendations,* was funded by the California Department of Transportation (Caltrans). Available through ATC. (Published 1996, 215 pages)

ATC-32-1: The report, *Improved Seismic Design Criteria for California Bridges: Resource Document,* was funded by Caltrans. Available through ATC. (Published 1996, 365 pages; also available in electronic format)

ATC-33: The project, funded under a contract with the Building Seismic Safety Council, was initiated by FEMA to develop nationally applicable, state-of-the-art guidance for performance-based seismic rehabilitation of buildings. Work resulted in the following publications:

FEMA 273, *NEHRP Guidelines for the Seismic Rehabilitation of Buildings* (Published 1997, 440 pages). Revised by ASCE and published as the FEMA 356 report, *Prestandard and Commentary for the Seismic Rehabilitation of Buildings* in 2000. Available through the American Society of Civil Engineers as the ASCE 41 Standard, *Seismic Rehabilitation of Existing Buildings*.

FEMA 274, *NEHRP Commentary on the Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 492 pages)

FEMA 276, *Example Applications of the NEHRP Guidelines for the Seismic Rehabilitation of Buildings*. Available through ATC and FEMA. (Published 1997, 295 pages)

ATC-34-1: The project "Development of Next-Generation Seismic Design Approach(es) for Buildings (continuation of on-going project entitled, "ATC/NCEER Joint Study of R Factors and Other Critical Code Issues")" was funded by NCEER to develop next-generation, nationally applicable, integrated seismic design approach(es) for buildings that consider reliability and probability, practical issues of concern to practitioners, and earthquake performance knowledge.

ATC-34: The report, *A Critical Review of Current Approaches to Earthquake Resistant Design***,** was developed under a grant from NCEER and NSF. Available through ATC. (Published, 1995, 94 pages)

ATC-35: The report, *Enhancing the Transfer of U.S. Geological Survey Research Results into Engineering Practice* was developed under a cooperative agreement with the USGS. Available through ATC. (Published 1994, 120 pages)

ATC-35-1: The report, *Proceedings of Seminar on New Developments in Earthquake Ground Motion Estimation and Implications for Engineering Design Practice*, was developed under a cooperative agreement with USGS. It includes papers describing state-of-the-art information on regional earthquake risk; new techniques for estimating strong ground motions as a function of earthquake source, travel path, and site parameters; and new developments applicable to geotechnical engineering. Available through ATC. (Published 1994, 478 pages)

ATC-35-2: The report, *Proceedings: National Earthquake Ground Motion Mapping Workshop*, was developed under a cooperative agreement with USGS. It includes papers on ground motion parameters; reference site conditions; probabilistic versus deterministic basis; and the treatment of uncertainty in seismic source characterization and ground motion attenuation. Available through ATC. (Published 1997, 154 pages)

ATC-35-3: The report, *Proceedings: Workshop on Improved Characterization of Strong Ground Shaking for Seismic Design,* was developed under a cooperative agreement with USGS. It includes papers on identifying needs and developing improved representations of earthquake ground motion for use in seismic design practice and building codes. Available through ATC. (Published 1999, 75 pages)

ATC-35-Series: The project, "Transfer U.S. Geological Survey Research Results into Engineering Design Practice", was funded by ATC and USGS, with co-sponsorships from ASCE, BSSC, FEMA, FHWA, International Code Council (ICC), Mid-America Earthquake Center, MCEER, National Fire Protection Association, Oregon Department of geology and mineral Industries, Pacific Earthquake Engineering Research Center, and the Structural Engineers Association of California (SEAOC).

ATC-36: The project, "Earthquake Loss Estimation Methodology and Databases for Utah," was funded by FEMA to translate and update the data and methodology developed under the ATC-13 project for use in the Salt Lake City area.

ATC-37: The report, *Review of Seismic Research Results on Existing Buildings***,** was developed in conjunction with SEAOC and California Universities for Research in Earthquake Engineering (CUREe) under a contract with the California Seismic Safety Commission (SSC). Available through the Seismic Safety Commission as Report SSC 94-03. (Published, 1994, 492 pages)

ATC-38: The report, *Database on the Performance of Structures near Strong-Motion Recordings: 1994 Northridge, California, Earthquake*, was developed with funding from the USGS, the Southern California Earthquake Center (SCEC), OES, and the Institute for Business and Home Safety (IBHS). Available through ATC. (Published 2000, 260 pages, with CD containing complete database).

ATC-39: The project, "Homeowner's Guide for Seismic Improvement of Unreinforced Masonry Dwellings," was a result of cooperation between FEMA and the State of Utah Division of Comprehensive Emergency Management (CEM).

ATC-40: The report, *Seismic Evaluation and Retrofit of Concrete Buildings***,** was developed under a contract with the California Seismic Safety Commission. It provides guidance on performance objectives, hazard characterization, identification of deficiencies, retrofit strategies, nonlinear static analysis procedures, modeling rules, foundation effects, and response limits for seismic evaluation and retrofit of concrete buildings. Available through ATC. (Published, 1996, 612 pages in two volumes)

ATC-41 (SAC Joint Venture, Phase 1): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 1," was funded by FEMA and OES and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 1 the following documents were prepared:

SAC-94-01, *Proceedings of the Invitational Workshop on Steel Seismic Issues, Los Angeles, September 1994*. Available through ATC. (Published 1994, 155 pages)

SAC-95-01, *Steel Moment-Frame Connection Advisory No. 3*. Available through ATC. (Published 1995, 310 pages)

SAC-95-02, *Interim Guidelines: Evaluation, Repair, Modification and Design of Welded Steel Moment-Frame Structures* (FEMA 267 report) (Published 1995, 215 pages; superseded by FEMA 350 to 353)

SAC-95-03, *Characterization of Ground Motions During the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 179 pages)

SAC-95-04, *Analytical and Field Investigations of Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 900 pages in two volumes)

SAC-95-05, *Parametric Analytical Investigations of Ground Motion and Structural Response, Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 274 pages)

SAC-95-06, *Surveys and Assessment of Damage to Buildings Affected by the Northridge Earthquake of January 17, 1994*. Available through ATC. (Published 1995, 315 pages)

SAC-95-07, *Case Studies of Steel Moment Frame Building Performance in the Northridge Earthquake of January 17, 1994* Available through ATC. (Published 1995, 260 pages)

SAC-95-08, *Experimental Investigations of Materials, Weldments and Nondestructive Examination Techniques*. Available through ATC. (Published 1995, 144 pages)

SAC-95-09, *Background Reports: Metallurgy, Fracture Mechanics, Welding, Moment Connections and Frame Systems Behavior* (FEMA 288 report). Available through ATC and FEMA. (Published 1995, 361 pages)

SAC-96-01, *Experimental Investigations of Beam-Column Subassemblages, Part 1 and 2*. Available through ATC. (Published 1996, 924 pages, in two volumes)

SAC-96-02, *Connection Test Summaries* (FEMA 289 report). Available through ATC. (Published 1996, 144 pages)

ATC-41-1 (SAC Joint Venture, Phase 2): The project, "Program to Reduce the Earthquake Hazards of Steel Moment-Resisting Frame Structures, Phase 2," was funded by FEMA and conducted by a Joint Venture partnership of SEAOC, ATC, and CUREe. Under Phase 2 the following documents were prepared:

SAC-96-03, *Interim Guidelines Advisory No. 1 Supplement to FEMA 267 Interim Guidelines* (FEMA 267A) (Published 1997, 100 pages; superseded by FEMA 350 to 353)

SAC-99-01, *Interim Guidelines Advisory No. 2 Supplement to FEMA 267 Interim Guidelines* (FEMA 267B, superseding FEMA 267A). (Published 1999, 150 pages; superseded by FEMA 350 to 353)

FEMA 350, *Recommended Seismic Design Criteria for New Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 190 pages)

FEMA 351, *Recommended Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 210 pages)

FEMA 352, *Recommended Postearthquake Evaluation and Repair Criteria for Welded Steel Moment-Frame Buildings*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 353, *Recommended Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications*. Available through ATC and FEMA. (Published 2000, 180 pages)

FEMA 354, *A Policy Guide to Steel Moment-Frame Construction*. Available through ATC and FEMA. (Published 2000, 27 pages)

FEMA 355A, *State of the Art Report on Base Materials and Fracture*. Available through ATC and FEMA. (Published 2000, 107 pages; in print and in electronic format).

FEMA 355B, *State of the Art Report on Welding and Inspection*. Available through ATC and FEMA. (Published 2000, 185 pages; in print and in electronic format).

FEMA 355C, *State of the Art Report on Systems Performance of Steel Moment Frames Subject to Earthquake Ground Shaking*. Available through ATC and FEMA. (Published 2000, 322 pages; in print and in electronic format).

FEMA 355D, *State of the Art Report on Connection Performance*. Available through ATC and FEMA. (Published 2000, 292 pages; in print and in electronic format).

FEMA 355E, *State of the Art Report on Past Performance of Steel Moment-Frame Buildings in Earthquakes*. Available through ATC and FEMA. (Published 2000, 190 pages; in print and in electronic format).

FEMA 355F, *State of the Art Report on Performance Prediction and Evaluation of Steel Moment-Frame Structures*. Available through ATC and FEMA. (Published 2000, 347 pages; in print and in electronic format).

ATC-42: The project, "Joint ATC/SEAOC/JSCA/ ASCE Structural Engineering Report on Hyogoken-Nanbu, Japan, Earthquake of January 17, 1995," was funded in partnership with SEAOC, JSCA, and ASCE to archive critically needed information on the performance of buildings and transportation, port, and industrial structures and assist design professionals in Japan and the U.S. to understand the reasons for the extensive structural damage.

ATC-43: The reports, *Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Basic Procedures Manual* (FEMA 306)*, Evaluation of Earthquake-Damaged Concrete and Masonry Wall Buildings, Technical Resources* (FEMA 307)*,* and *The Repair of Earthquake Damaged Concrete and Masonry Wall Buildings* (FEMA 308)**,** were developed for FEMA under a contract with the Partnership for Response and Recovery, a Joint Venture of Dewberry & Davis and Woodward-Clyde. Available through ATC and FEMA. (Published, 1998 in print and in electronic format; *Basic Procedures Manual*, 270 pages; *Technical Resources*, 271 pages; *Repair Manual*, 81 pages)

ATC-44: The report, *Hurricane Fran, North Carolina, September 5, 1996: Reconnaissance Report***,** was funded by the Applied Technology Council. Available through ATC. (Published 1997, 36 pages)

ATC-45: The report, *Field Manual*, *Safety Evaluation of Buildings After Windstorms and Floods*, was developed with funding from the ATC Endowment Fund and the Institute for Business and Home Safety (IBHS). It provides rapid and detailed evaluation procedures for inspecting buildings that have been damaged in windstorms and floods, and making decisions regarding their continued use and occupancy. Presented in a concise format designed for ease of use in the field, it is intended for use by volunteer structural engineers and building inspectors in posting buildings as "inspected" (apparently safe, green placard), "restricted use" (yellow) or "unsafe" (red). Available through ATC. (Published 2004, 132 pages)

ATC-46: The project, "1st U.S.-Japan Workshop on Performance-Based Engineering," facilitated a workshop organized by a Steering Committee consisting of representatives from Japan and the United States. The workshop was conducted in January 1997 by ATC and the Japan Building Research Institute.

ATC-46-1: The project, "2nd U.S.-Japan Workshop on Performance-Based Engineering," facilitated a workshop organized by a Steering Committee consisting of representatives from Japan and the United States. The workshop was conducted in July 1998 by ATC and the Japan Building Research Institute.

ATC-48 (ATC/SEAOC Joint Venture Training Curriculum): The training curriculum, *Built to Resist Earthquakes, The Path to Quality Seismic Design and Construction for Architects, Engineers, and Inspectors*, was developed under a contract with the California Seismic Safety Commission and prepared by a Joint Venture partnership between ATC and SEAOC. Available through ATC. (Published 1999, 314 pages)

ATC-49: The 2-volume report, *Recommended LRFD Guidelines for the Seismic Design of Highway Bridges; Part I: Specifications* and *Part II: Commentary and Appendices*, were developed

under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, *Part I*, 164 pages and *Part II*, 294 pages)

ATC-49-1: The document, *Liquefaction Study Report, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges,* was developed under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, 208 pages)

ATC-49-2: The report, *Design Examples, Recommended LRFD Guidelines for the Seismic Design of Highway Bridges*, was developed under the ATC/MCEER Joint Venture partnership with funding from the FHWA. Available through ATC. (Published 2003, 316 pages)

ATC-50: The project, funded by the City of Los Angeles Department of Building and Safety, with support from the California Office of Emergency Services and the U.S. Department of Housing and Urban Development, was initiated because of high economic losses resulting from damage to single-family wood-frame dwellings in the 1994 Northridge earthquake. Work resulted in the publication of:

ATC-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 135 pages). Revised by FEMA and published as the FEMA P-50 report, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings* (ATC-71-3 Project).

ATC-50-1, *Seismic Rehabilitation Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (Published 2002, revised 2007, 141 pages). Revised by FEMA and published as the FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings* (ATC-68-3 Project).

ATC-50-2, *Safer at Home in Earthquakes: A Proposed Earthquake Safety Program* (Published 2002, revised 2007, 79 pages).

ATC-51: The report, *U.S.-Italy Collaborative Recommendations for Improved Seismic Safety of Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey). Available through ATC. (Published 2000, 154 pages)

ATC-51-1: The report, *Recommended U.S.-Italy Collaborative Procedures for Earthquake Emergency Response Planning for Hospitals in Italy*, was developed under a contract with Servizio Sismico Nazionale of Italy (Italian National Seismic Survey, NSS). Available in English and Italian through ATC. (Published 2002, 129 pages in English; 120 pages in Italian)

ATC-51-2: The report, *Recommended U.S.-Italy Collaborative Guidelines for Bracing and Anchoring Nonstructural Components in Italian Hospitals*, was developed under a contract with the Department of Civil Protection, Italy. Available in English and Italian through ATC. (Published 2003, 164 pages)

ATC-52: The project, "Development of a Community Action Plan for Seismic Safety (CAPSS), City and County of San Francisco", was conducted under a contract with the San Francisco Department of Building Inspection. The following reports were prepared:

ATC-52-1, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts*. Available through ATC. (Published 2010, 78 pages)

ATC-52-1A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Potential Earthquake Impacts Technical Documentation*. Available through ATC. (Published 2010, 160 pages)

ATC-52-2, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: A Community Action Plan for Seismic Safety*. Available through ATC. (Published 2010, 92 pages)

ATC-52-3, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings*. Available through ATC. (Published 2009, 60 pages)

ATC-52-3A, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Earthquake Safety for Soft-Story Buildings Documentation Appendices*. Available through ATC. (Published 2009, 206 pages)

ATC-52-4, *Here Today—Here Tomorrow: The Road to Earthquake Resilience in San Francisco: Post-Earthquake Repair and*

Retrofit Requirements. Available through ATC. (Published 2010, 130 pages)

ATC-53: The report, *Assessment of the NIST 12-Million-Pound (53 MN) Large-Scale Testing Facility*, was developed under a contract with NIST. Available through ATC. (Published 2000, 44 pages)

ATC-54: The report, *Guidelines for Using Strong-Motion Data and ShakeMaps in Postearthquake Response*, was developed under a contract with the California Geological Survey. Available through ATC. (Published 2005, 222 pages)

ATC-55: The report, FEMA 440, *Improvement of Nonlinear Static Seismic Analysis Procedures*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2005, 152 pages)

ATC-56: The report, FEMA 389, *Primer for Design Professionals: Communicating with Owners and Managers of New Buildings on Earthquake Risk*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2004, 194 pages)

ATC-56-1: The report, FEMA 427, *Primer for Design of Commercial Buildings to Mitigate Terrorist Attacks – Providing Protection to People and Buildings*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2003, 106 pages)

ATC-57: The report, *The Missing Piece: Improving Seismic Design and Construction Practices*, was developed under a contract with NIST. It provides a framework for eliminating the technology transfer gap that has emerged within the National Earthquake Hazards Reduction Program (NEHRP) that limits the adaptation of basic research knowledge into practice. Available through ATC. (Published 2003, 102 pages)

ATC-58/58-1/58-1: This series of projects, titled "Development of Next-Generation Performance-Based Seismic Design Guidelines for New and Existing Buildings," was a multi-year, multi-phase effort funded by FEMA that resulted in the publication of the following publications:

ATC-58-1, *Proceedings of a FEMA-Sponsored Workshop on Communicating Earthquake Risk*. Available through ATC and FEMA. (Published 2002, 87 pages).

ATC-58-2, *Preliminary Evaluation of Methods for Defining Performance*. Available through ATC and FEMA. (Published 2003, 99 pages).

ATC-58-3, *Proceedings of a FEMA-Sponsored Workshop on Performance-Based Design*. Available through ATC and FEMA. (Published 2003, 146 pages).

ATC-58-4, *Proceedings of a FEMA-Sponsored Workshop on Communicating Seismic Performance Metrics in Design Decision-Making*. Available through ATC and FEMA. (Published 2014, 73 pages).

ATC-58-5, *Proceedings of FEMA-Sponsored Workshop on Design Guidelines and Tools to Implement Next-Generation Performance-Based Seismic Design*. Available through ATC and FEMA. (Published 2014, 85 pages)

ATC-58-6, Recommendations for Communicating Seismic Performance Considerations in Design Decision-Making. Available through ATC and FEMA. (Published 2016, 217 pages)

FEMA 445, *Next-Generation Performance-Based Seismic Design Guidelines, Program Plan for New and Existing Buildings*. Available through ATC and FEMA. (Published 2006, 131 pages).

FEMA 461, *Interim Testing Protocols for Determining the Seismic Performance Characteristics of Structural and Nonstructural Components*. Available through ATC and FEMA. (Published 2007, 113 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology*. (Published 2012, 319 pages).

FEMA P-58-1, *Seismic Performance Assessment of Buildings, Volume 1 – Methodology, Second Edition*. Available through ATC and FEMA. (Published 2018, 340 pages)

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide*. (Published 2012, 365 pages).

FEMA P-58-2, *Seismic Performance Assessment of Buildings, Volume 2 – Implementation Guide, Second Edition*.

Available through ATC and FEMA. (Published 2018, 378 pages).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. (Published 2012, in electronic format).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation, Second Edition*. (Published 2016, in electronic format).

FEMA P-58-3, *Seismic Performance Assessment of Buildings, Volume 3 – Supporting Electronic Materials and Background Documentation*. Available through ATC and FEMA. (Published 2018, in electronic format).

FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*. Available through ATC and FEMA. (Published 2018, 122 pages)

FEMA P-58-5, *Seismic Performance Assessment of Buildings, Volume 5 – Expected Seismic Performance of Code Conforming Buildings*. Available through ATC and FEMA. (Published 2018, 196 pages)

FEMA P-58-6, *Guidelines for Performance-Based Seismic Design of Buildings*. Available through ATC and FEMA. (Published 2018, 92 pages)

FEMA P-58-7, *Building the Performance You Need, A Guide to State-of-the-Art Tools for Seismic Design and Assessment*. Available through ATC and FEMA. (Published 2019, 28 pages)

ATC-59: The report, *Seismic Safety Inventory of California Public Schools—A Report to the Governor of California and the California State Legislature*, was prepared by for the Department of General Services mandated by California Assembly Bill 300, which requires the Department to inventory schools of concrete tilt-up construction and those with non-wood frame walls that do not meet the minimum requirements of the 1976 Uniform Building Code. (Published 2002, 43 pages)

ATC-60: The 2-volume report, *SEAW Commentary on Wind Code Provisions, Volume 1* and *Volume 2 - Example Problems,* was developed by the Structural Engineers Association of Washington (SEAW) in cooperation with ATC. Available through ATC. (Published 2004; *Volume 1*, 238 pages; *Volume 2*, 245 pages)

ATC-61: The 2-volume report, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities, Volume 1 – Findings, Conclusions, and Recommendations*, and *Volume 2 – Study Documentation,* was prepared for the Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences, with funding provided by FEMA. Available through ATC and the MMC. (Published 2005; *Volume 1*, 11 pages; *Volume 2*, 366 pages)

ATC-62: The report, FEMA P-440A, *Effects of Strength and Stiffness Degradation on Seismic Response*, was developed under a contract with FEMA. Developed as a supplement to the FEMA 440 report, it provides additional guidance on modeling of nonlinear degrading response. Available through ATC and FEMA. (Published 2009, 310 pages)

ATC-63: The report, FEMA P-695, *Quantification of Building Seismic Performance Factors*, was developed under a contract with FEMA. It describes a methodology for establishing seismic performance factors (R , Ω_0, and C_d) that involves the development of detailed system design information and probabilistic assessment of collapse risk. Available through ATC and FEMA. (Published 2009, 420 pages)

ATC-63-1: The report, FEMA P-795, *Quantification of Building Seismic Performance Factors: Component Equivalency Methodology*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 264 pages)

ATC-64: The reports, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis* (FEMA P-646), and *Vertical Evacuation from Tsunamis: A Guide for Community Officials* (FEMA P-646A), were developed under a contract with FEMA. Available through ATC and FEMA. (*Design Guidelines*, Published 2008, 174 pages; *Guide for Community Officials*, Published 2009, 62 pages)

ATC-65: The FEMA P-455 report, *Handbook for Rapid Visual Screening of Buildings to Evaluate Terrorism Risks*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 174 pages)

ATC-66: The FEMA P-774 report, *Unreinforced Masonry Buildings and Earthquakes, Developing Successful Risk Reduction Programs*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 194 pages)

ATC-66-Series: The project, "National Earthquake Technical Assistance Program (NETAP)," was funded by the Federal Emergency Management Agency and provides support for course development, logistical coordination, training delivery, technical assistance, performance tracking, and development of tools necessary to support the effective implementation of the National Earthquake Hazards Reduction Program.

ATC-67: The *Rapid Observation of Vulnerability and Estimation of Risk* (ROVER) smartphone application was developed in collaboration with specialists from SPA Risk LLC, and Instrumental Software Technologies Inc. under a contract with FEMA. It is intended for use by building professionals (engineers, architects, firefighters, building officials, and others) to do pre-earthquake screening and post-earthquake safety evaluation of buildings in an electronic format. Available through ATC and FEMA. (Published 2014, online and in electronic format)

ATC-68: The FEMA P-420 report, *Engineering Guideline for Incremental Seismic Rehabilitation*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2009, 94 pages)

ATC-68-3: The FEMA P-50-1 report, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 168 pages)

ATC-69: The report, *Reducing the Risks of Nonstructural Earthquake Damage, State-of-the-Art and Practice*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2008, 144 pages)

ATC-69-1: The electronic document, *Reducing the Risks of Nonstructural Earthquake Damage, A Practical Guide* (FEMA E-74), was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2011, 750 pages)

ATC-70: The report, NIST Technical Note 1476, *Performance of Physical Structures in Hurricane Katrina and Hurricane Rita: A Reconnaissance Report*, was developed under a contract with NIST. Available through NIST. (Published 2006, 222 pages)

ATC-71: The reports, *Workshop on Meeting the Challenges of Existing Buildings, Part 1 Workshop Proceedings; Part 2: Status Report on Seismic Evaluation and Rehabilitation of Existing Buildings;* and *Part 3: Action Plan for the FEMA Existing Buildings Program*, were developed under a contract with FEMA. Available through ATC and FEMA. (*Part 1*, Published 2008, 142 pages; *Part 2*, Published 2009, 140 pages; *Part 3*, Published 2009, 118 pages)

ATC-71-1: The report, FEMA P-807, *Seismic Evaluation and Retrofit of Multi-Unit Wood-Frame Buildings with Weak First Stories*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2012, 230 pages, including the *Weak Story Tool* in electronic format)

ATC-71-2: The report, *Proceedings: Workshop on a Rating System for the Earthquake Performance of Buildings*, was developed under a contract with FEMA. Available through ATC. (Published 2011, 102 pages)

ATC-71-3: The report, FEMA P-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-50 Project. Available through ATC and FEMA. (Published 2012, 190 pages)

ATC-71-4/ATC-71-5/ATC-71-6: The report, FEMA P-154, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: A Handbook, Third Edition*, and the report FEMA P-155, *Rapid Visual Screening of Buildings for Potential Seismic Hazards: Supporting Documentation, Third Edition*, were developed under a series of contracts with FEMA. Available through ATC and FEMA. (Published, 2014; *Handbook*, 388 pages; *Supporting Documentation*, 206 pages)

ATC-72: The report, *Proceedings of Workshop on Tall Building Seismic Design and Analysis Issues*, was prepared for the Building Seismic Safety Council of the National Institute of Building Sciences, with funding provided by FEMA. The report, *Modeling and Acceptance Criteria for Seismic Design and Analysis of Tall Buildings* (PEER/ATC-72-1) was prepared for the Pacific Earthquake Engineering Research Center. Available through ATC and PEER. (*Proceedings*, Published 2007, 84 pages; *Modeling and Acceptance Criteria*, Published 2010, 242 pages)

ATC-73: The report, *NEHRP Workshop on Meeting the Challenges of Existing Buildings, Prioritized Research for Reducing the Seismic Hazards of Existing Buildings,* was developed under a grant from NSF. Available through ATC. (Published 2007, 22 pages)

ATC-74: The report, *Collaborative Recommended Requirements for Automatic Natural Gas Shutoff Valves in Italy,* was funded by the Department of Civil Protection, Italy. Available through ATC. (Published 2007, 76 pages)

ATC-75: The report, *Improvements to BIM Structural Software Interoperability*, was developed under a contract with the Charles Pankow Foundation (CPF). Available through ATC and CPF. (Published 2013, 155 pages)

ATC-76-1/ATC-76-4: The report, *Evaluation of the FEMA P-695 Methodology for the Quantification of Building Seismic Performance Factors,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-8. (Published 2010, 240 pages)

ATC-76-2: The report, *Program Plan for the Development of Seismic Design Guidelines for Port Container, Wharf, and Cargo Systems,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-19. (Published 2012, 134 pages)

ATC-76-3: The reports, *NEHRP Technical Brief No. 1, Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers* and *NEHRP Technical Brief No. 2, Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers,* were developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST (*Technical Brief No. 1*, Report GCR 08-917-1. Published 2008, 32 pages; *Technical Brief No. 2*, Report GCR 09-917-3, Published 2009, 38 pages)

ATC-76-5: The report, *Program Plan for the Development of Collapse Assessment and Mitigation Strategies for Existing Reinforced Concrete Buildings,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-7. (Published 2010, 80 pages)

ATC-76-6: The report, *Applicability of Nonlinear Multiple-Degree-of-Freedom Modeling for Design,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-9. (Published 2010, 196 pages plus CD)

ATC-76-7: The report, *NEHRP Technical Brief No. 3, Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers,* was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-4. (Published 2010, 30 pages)

ATC-76-8: The report, *NEHRP Technical Brief No. 4, Nonlinear Structural Analysis for Seismic Design: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 10-917-5. (Published 2010, 32 pages)

ATC-76-9: The project, "Performance of Two Full Scale Reinforced Concrete Subassemblage Tests," was funded by NIST to perform tests in support of an internal research program to develop computer models for predicting the collapse potential of reinforced concrete structures. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-77: The project, "Hurricane Hugo 20th Anniversary Symposium on Building Safer Communities – Improving Disaster," was funded by ATC. The purpose of the Symposium was to convene wind engineering researchers, practitioners and other stakeholders in a forum to

discuss what has happened in the practice of hurricane mitigation since Hurricane Hugo struck the South Carolina coast in September 1989, and to identify what still needs to happen to reduce losses from these deadly storms. (Published 2009, 319 pages)

ATC-78: The report, *Identification and Mitigation of Seismically Hazardous Older Concrete Buildings: Interim Methodology Evaluation* (ATC-78), was developed under a contract with FEMA. Available through ATC. (Published 2011, 137 pages)

ATC-78-1: The report, *Evaluation of the Methodology to Select and Prioritize Collapse Indicators in Older Concrete Buildings* (ATC-78-1), was developed under a contract with FEMA. Available through ATC. (Published 2012, 153 pages)

ATC-78-2: The report, *Seismic Evaluation for Collapse Potential of older Concrete Frame Buildings (Interim Report)*, was developed under a contract with FEMA. Available through ATC. (Published 2014, 179 pages)

ATC-78-3: The report, *Seismic Evaluation of Older Concrete Frame Buildings for Collapse Potential*, was developed under a contract with FEMA and is available through ATC. (Published 2015, 201 pages)

ATC-78-4 (LADBS): The project, "Identification and Mitigation of Non-Ductile Concrete Buildings," was funded by the Federal Emergency Management Agency and the purpose is to begin developing an assessment guideline document for older or non-ductile concrete buildings to allow identification of those buildings that present an earthquake collapse hazard so that they may be evaluated and retrofitted, in order to mitigate the risks presented by this class of buildings,

ATC-78-5/78-6/78-7: The report FEMA P-2018, *Seismic Evaluation of Older Concrete Buildings for Collapse Potential*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2019, 352 pages)

ATC-79: The report FEMA P-646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Second Edition*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-64 Project. Available through ATC and FEMA. (Published 2012, 194 pages)

ATC-80: The project "U.S.-Netherlands Workshop on Risk and Reliability for MultiHazard Engineering," was jointly organized by ATC and the Civil Engineering Department at the Technical University of Delft. The Workshop was conducted in Delft on July 10, 2009, with the purpose to (a) explore state-of-the-art/state-of-the-practice methods and policies in multihazard risk and reliability; (b) open a binational dialogue on multihazard engineering research and practice; and (c) identify potential technologies and partners for future risk assessment and hazard mitigation technology transfer projects.

ATC-81: The project, "Development of Industry Foundation Classes (IFCs) for Structural Concrete Components - Strategic Plan" was funded under a grant from The Charles Pankow Foundation and the Ready-Mixed Concrete Research and Education Foundation. ATC worked with the ACI Foundation of the American Concrete Institute and the Strategic Development Council (SDC) to develop a strategic plan for the development of Industry Foundation Classes (IFCs) for Structural Concrete Components to foster interoperability between disparate Building Information Modeling (BIM) software platforms. This project produced the following three documents available online through ATC:

Strategic Plan to Develop BIM Interoperability in Structural Concrete, White Paper by the ATC-81 Project Management Committee (Published 2010, 5 pages)

ATC-81, *Development of IFCs for Structural Concrete Strategic Planning Session Report* (Published 2010, 140 pages)

ATC-81, *Development of IFCs for Structural Concrete, Strategic Plan* (Published 2010, 72 pages)

ATC-82: The report, *Selecting and Scaling Earthquake Ground Motions for Performing Response-History Analyses*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-5. (Published 2011, 234 pages)

ATC-83: The report, *Soil-Structure Interaction for Building Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-21. (Published 2012, 292 pages)

ATC-84: The report, *Tentative Framework for Development of Advanced Seismic Design Criteria for New Buildings*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-20. (Published 2012, 302 pages)

ATC-85: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions: Phases I-III," was funded by NIST to obtain technical assistance on the initiation of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-86: The report, FEMA P-58-4, *Seismic Performance Assessment of Buildings, Volume 4 – Methodology for Assessing Environmental Impacts*, was developed under a contract with FEMA in support of the ATC-58 Project. This report was reprinted under the ATC-58-2 project with an updated publication date. Available through ATC and FEMA. (Published 2012, 120 pages)

ATC-86-1: The project, "Environmental Benefits of Retrofitting," was funded by FEMA to develop a draft methodology to measure the environmental benefit (i.e., carbon footprint) of seismic retrofitting using the Seismic Performance Assessment Methodology developed under the FEMA/ATC-58 Performance Based Seismic Design Project.

ATC-87: The report, *NEHRP Technical Brief No. 5, Seismic Design of Composite Steel Deck and Concrete-filled Diaphragms: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-4. (Published 2011, 34 pages)

ATC-88: The report, *NEHRP Technical Brief No. 6, Seismic Design of Cast-in-Place Concrete Special Structural Walls and Coupling Beams: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-11. (Published 2011, 38 pages)

ATC-89: The report, *Cost Analyses and Benefit Studies for Earthquake-Resistant Construction in Memphis, Tennessee*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-26. (Published 2014, 227 pages)

ATC-90: The report, *Research Plan for the Study of Seismic Behavior and Design of Deep, Slender Wide Flange Structural Steel Beam-Column Members*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 11-917-13. (Published 2011, 148 pages)

ATC-91: The project, "Assessment of Nonlinear Seismic Analysis of Structures Based on Modal Superposition," was funded by NIST to obtain technical support for an internal research program investigating the use of a new approach to nonlinear analysis. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-92: The report, *Comparison of U.S. and Chilean Building Code Requirements and Seismic Design Practice 1985–2010*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-18. (Published 2012, 110 pages)

ATC-93: The project, "Ground Motion and Building Performance Data From the 2010 Chile Earthquake," was funded by NIST to develop a prototypical web-based repository for post-event data in support of the NIST Disaster and Failure Events Database initiative. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-94: The report, *Recommendations for Seismic Design of Reinforced Concrete Wall Buildings Based on Studies of the 2010 Maule, Chile Earthquake*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-25. (Published 2014, 321 pages)

ATC-95: The report, *Review of Past Performance and Further Development of Modeling Techniques for Collapse Assessment of Existing Reinforced Concrete Buildings*, was developed under a contract with NIST and prepared by a Joint

Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-28. (Published 2014, 201 pages)

ATC-96: The report, *Nonlinear Analysis Research and Development Program for Performance-Based Seismic Engineering*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-27. (Published 2014, 147 pages)

ATC-97: The report, *NEHRP Technical Brief No. 7, Seismic Design of Reinforced Concrete Mat Foundations: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 12-917-22. (Published 2012, 34 pages)

ATC-98: The report, *Use of High-Strength Reinforcement in Earthquake-Resistant Concrete Structures*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-30. (Published 2014, 231 pages)

ATC-99-Series: The project, "Methodology to Assess and Verify the Seismic Capacity of Low-Rise Buildings," was funded by FEMA to study an alternative seismic design approach for low-rise construction in the United States.

ATC-100: The report, *Measurement Science R&D Roadmap for Windstorm and Coastal Inundation Impact Reduction*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-973-13. (Published 2014, 130 pages)

ATC-101: The report, *A Framework to Update the Plan to Coordinate NEHRP Post-Earthquake Investigations*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-29. (Published 2014, 103 pages)

ATC-102: The report, *Earthquake-Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 14-917-33. (Published 2014, 163 pages)

ATC-103: The report, *NEHRP Technical Brief No. 8, Seismic Design of Steel Special Concentrically Braced Frame Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST and prepared by a Joint Venture partnership between ATC and CUREE. Available through ATC and NIST as GCR 13-917-24. (Published 2013, 36 pages)

ATC-104: The project, "Assessment of the Performance of Slender Reinforced Concrete Walls under Significant Lateral Loads," was funded by NIST to obtain technical support for an internal research project investigating the behavior of reinforced concrete shear walls. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-105: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2012," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2013. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-106: The project, "Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Steel Beam-Column Members**:** Phase 2 Experimental Evaluation," was funded by NIST to perform testing in support of an internal research program investigating the behavior of steel beam-column members. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-106-1: The project, "Seismic Behavior and Design of Deep, Slender Wide-Flange Structural Steel Beam-Column Members: Phase 2 Experimental Evaluation," was funded by NIST and aimed to develop and implement a testing program to study the behavior of plastic hinges in idealized deep, slender wide-flange structural steel beam-columns undergoing significant cyclic loading.

ATC-107: The project, "Wind Speed Mapping," was funded by NIST to obtain technical assistance in the development of revised wind speed maps incorporating NIST non-tropical wind analysis at different return periods. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-108: The project, "Assessment of ASCE 41 First Generation Performance-Based Seismic Design Methods for new Buildings in High-Seismic Regions" was funded by NIST to obtain technical assistance on the completion of an internal research project benchmarking ASCE 41 performance-based seismic design procedures as applied to new buildings designed in accordance with ASCE 7. Work was conducted under a Joint Venture partnership between ATC and CUREE.

ATC-109: The report, *Building Safety Evaluation after the February 22, 2011 Christchurch, New Zealand Earthquake: Observations by the ATC Reconnaissance Team*, was funded by the Applied Technology Council and the ATC Endowment Fund. Available from ATC. (Published 2014, 99 pages)

ATC-110: The report, *Plan for Development of a Prestandard for Evaluation and Retrofit of Wood Light-Frame Dwellings*, was developed under a contract with the California Earthquake Authority (CEA) in collaboration with FEMA. Available through ATC and CEA. (Published 2014, 85 pages)

ATC-110 (CEA 2): The project, "Development of a Prestandard for the Evaluation and Retrofit of One- and Two-Family Light Frame Residential Buildings," was jointly funded by CEA and FEMA, this work is intended to develop an eventual prestandard for the evaluation and retrofit of one- and two-family wood light frame residential buildings, building on available technical resource documents, but extending beyond their current reach to develop a single, stand-alone engineering resource document addressing structural and nonstructural evaluation and retrofit issues specific to this class of construction. This project produced the following reports:

FEMA P-1100, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings*. Available through ATC and FEMA. (Published 2019, 290 pages)

FEMA P-1100-2A, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2A – Plan Set for Crawlspace Dwellings*. Available through ATC and FEMA. (Published 2019, 34 pages)

FEMA P-1100-2B, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2B – Plan Set for Living-Space-Over-Garage Dwellings*. Available through ATC and FEMA. (Published 2019, 44 pages)

FEMA P-1100-2C, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 2C – Plan Set for Masonry Chimneys*. Available through ATC and FEMA. (Published 2019, 16 pages)

FEMA P-1100-3, *Vulnerability-Based Seismic Assessment and Retrofit of One- and Two-Family Dwellings, Volume 3 – Background Documentation*. Available online through ATC and FEMA. (Published 2019, 422 pages)

ATC-110 (CEA 3/CEA 4/CEA 5/CEA 6): The project, "Delivery of FEMA P-50/P-50-1 Training for the California Earthquake Authority" was funded by CEA and to conduct on-demand training for FEMA P-50, *Simplified Seismic Assessment of Detached, Single-Family, Wood-Frame Dwellings*, and FEMA P-50-1, *Seismic Retrofit Guidelines for Detached, Single-Family, Wood-Frame Dwellings*, at locations selected by CEA.

ATC-111: The report, *NEHRP Technical Brief No. 9, Seismic Design of Special Reinforced Masonry Shear Walls: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-31. (Published 2014, 42 pages)

ATC-112: The report, *NEHRP Technical Brief No. 10, Seismic Design of Wood Light-Frame Structural Diaphragm Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST, and prepared in collaboration with CUREE. Available through ATC and NIST as GCR 14-917-32. (Published 2014, 47 pages)

ATC-113: The project, "Development of Annual Report for National Earthquake Hazards Reduction Program Covering Fiscal Year 2013," was funded by NIST to obtain assistance in the development of the NEHRP Annual Report in 2014.

ATC-114: The project, "Analysis, Modeling, and Simulation for Performance-Based Seismic Engineering" was funded by NIST to close the gap between state-of-the-art academic research and state-of-practice engineering applications for nonlinear structural analysis, analytical structural

modeling, and computer simulation for performance-based seismic engineering. This project produced four reports:

NIST GCR 17-917-45, *Recommended Modeling Parameters and Acceptance Criteria for Nonlinear Analysis in Support of Seismic Evaluation, Retrofit, and Design*. (Published 2017, 597 pages)

NIST GCR 17-915-46v1, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part I – General.* (Published 2017, 137 pages)

NIST GCR 17-915-46v2, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part IIa – Steel Moment Frames.* (Published 2017, 145 pages)

NIST GCR 17-915-46v3, *Guidelines for Nonlinear Structural Analysis for Design of Buildings, Part IIb– Reinforced Concrete Moment Frames*. (Published 2017, 135 pages)

ATC-115: The report, *Roadmap for the Use of High-Strength Reinforcement in Reinforced Concrete Design*, was developed under a contract with the Charles Pankow Foundation (CPF). Available through ATC and CPF. (Published 2014, 197 pages)

ATC-116/116-1/116-2/116-3/116-4/116-5/116-6: The project, "Solutions to the Issue of Short-Period Building Performance," was funded by FEMA to advance the roadmap developed on the ATC-116 Project to: (1) identify key missing elements of current modeling practice related to short period buildings; (2) develop a methodology to improve analytical modeling of short period buildings; (3) calibrate the methodology with observed performance of short period buildings in recent earthquakes; and (4) simplify the methodology into practical solutions that can be implemented in codes and standards.

ATC-117: The project, "Next Generation Climate Change Adaptation Strategies To Create More Resilient Communities," was funded by FEMA to increase the nation's resilience against natural disasters, including floods, windstorms, earthquakes and tsunamis, by identifying strategies and approaches to encourage state and local adoption of current disaster-resistant building codes and standards, including related actions that could be undertaken by Federal agencies. The task order that authorized this effort required ATC to: (1) conduct two workshops to obtain input on the best means to encourage State and local adoption of disaster-resistant building codes and standards; and (2) develop an internal FEMA report describing the findings of the workshops by the end of March 2015.

ATC-118: The report, FEMA P-1019, *Emergency Power Systems for Critical Facilities: A Best Practices Approach to Improving Reliability*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2014, 170 pages)

ATC-119/119-1: The project, "Seismic Safety and Engineering Consulting Services for the Earthquake Safety Implementation Program (ESIP), City and County of San Francisco," was funded by CCSF to provide technical expertise in completing selected tasks from the Earthquake Safety Implementation Program (ESIP) work plan that was developed under the CAPSS project. The project produced multiple reports:

Recommendations for Mitigation of Chimney Hazards (Published 2015, 63 pages)

Study of Options to Reduce Post-Earthquake Fires in San Francisco (Published 2017, 70 pages)

Study of Earthquake Effects on Retail Businesses in San Francisco (Published 2017, 76 pages)

San Francisco Tall Buildings Study (Published 2019, 374 pages)

ATC-120: The project, "Scoping Study: Seismic Analysis and Design of Nonstructural Components and Systems," was funded by NIST to provide support for seismic analysis and design of nonstructural components and systems by bringing together relevant sources of information and formulating specific tasks to be addressed in subsequent studies. This project produced the following reports:

NIST GCR 17-917-44 report, *Seismic Analysis, Design, and Installation of Nonstructural Components and Systems – Background and Recommendations for Future Work* (Published 2017, 228 pages)

NIST GCR 18-917-43 report, *Recommendations for Improved Seismic Performance of Nonstructural Components* (Published 2018, 311 pages)

ATC-121: The report, *NEHRP Seismic Design Technical Brief No. 11, Seismic Design of Steel Buckling-Restrained Braced Frames*, was produced under a contract with NIST. Available through ATC and NIST. (Published 2015, 34 pages)

ATC-122/122-1: The report, FEMA P-1000, *Safer, Stronger, Smarter: A Guide to Improving School Natural Hazard Safety* was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2017, 282 pages)

ATC-123/123-1/123-2: The project, "Improving Seismic Design of Buildings with Configuration Irregularities," was funded by FEMA to conduct comprehensive quantitative studies of horizontal and vertical irregularity limits in current building seismic codes using the FEMA P-695 methodology.

ATC-123-3: The report, FEMA P-2012, *Assessing Seismic Performance of Buildings with Configuration Irregularities: Calibrating Current Standards and Practices*, was developed under a contract with FEMA. Available through ATC and FEMA. (Published 2018, 366 pages)

ATC-124/124-1/124-2: The project, "Update of Seismic Retrofitting Guidance," was funded by FEMA to develop a new FEMA support document that would provide design examples for seismic retrofit of specific buildings using the new ASCE/SEI 41-13 consensus standard. This new document would replace FEMA 276 Example Applications document.

ATC-125: The project, "Recovery Advisories for the South Napa Earthquake" was funded by FEMA and developed three reports following the 2014 South Napa earthquake, available through ATC and FEMA:

FEMA P-1024, *Performance of Buildings and Nonstructural Components in the 2014 South Napa Earthquake* (Published 2015, 359 pages)

FEMA Recovery Advisory DR-4193-RA1, *Repair of Earthquake-Damaged Masonry Fireplace Chimneys* (Published 2015, 11 pages)

FEMA Recovery Advisory DR-4193-RA2, *Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings* (Published 2015, 25 pages)

ATC-126: The report, *Critical Assessment of Lifeline System Performance: Understanding Societal Needs in Disaster Recovery*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2016, 392 pages)

ATC-127: The report, *Proceedings: ATC/USGS Seismic Hazard User-Needs Workshop*, was developed by ATC with funding from the USGS. (Published 2015, 89 pages)

ATC-128: The report, *Proceedings of Forum on Performance-Based Structural-Fire Engineering: Examples of Current Practice and Discussion on Future Directions*, was developed by ATC with funding from the ATC Endowment Fund. (Published 2015, 101 pages)

ATC-128-1: The project, "AISC-ATC Workshop on Performance-Based Structural-Fire Engineering," was intended to build on ATC's London Forum on performance-based structure-fire engineering to answer questions related to benefits and incentives for performance-based structural fire-engineering, cost savings, barriers to implementation in the United States, and strategies for implementation.

ATC-129: The project, "Development of Updated Standards of Seismic Safety for Existing Federally Owned and Leased Buildings," was funded by NIST to update ICSSC RP 8 (which was published in 2011) to harmonize with the latest reference standards and to address review comments from ICSSC Federal agencies during the development and approval phases of work.

ATC-130: The project, "Updates of NEHRP Seismic Design Technical Briefs 1-3," was developed under a contract with NIST and produced three reports, available through ATC and NIST:

NEHRP Seismic Design Technical Brief No. 1 (2nd Edition), Seismic Design of Reinforced Concrete Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 46 pages)

NEHRP Seismic Design Technical Brief No. 2 (2nd Edition), Seismic Design of Steel Special Moment Frames: A Guide for Practicing Engineers (Published 2016, 40 pages)

NEHRP Seismic Design Technical Brief No. 3 (2nd Edition), Seismic Design of Cast-in-Place Concrete Diaphragms, Chords, and Collectors: A Guide for Practicing Engineers (Published 2016, 43 pages)

ATC-131: The report, NEHRP Seismic Design Technical Brief No. 12, *Seismic Design of Cold-Formed Steel Lateral Force-Resisting Systems: A Guide for Practicing Engineers*, was developed under a contract with NIST. (Published 2016, 56 pages)

ATC-132: The report, *Guidelines for the Seismic Retrofit of Existing Schools and Design of New Schools in the Republic of Armenia*, was funded by the World Bank with the support of Global Facility for Disaster Reduction and Recovery's (GFDRR) Global Program for Safer Schools (GPSS). This report was printed in English and Armenian. (Published 2017, 158 pages in English; 176 pages in Armenian)

ATC-133: The report, NIST GCR 17-917-47, NEHRP Seismic Design Technical Brief No. 13, *Seismic Design of Precast Concrete Diaphragms: A Guide for Practicing Engineers*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2017, 45 pages)

ATC-134: The project, "Performance-Based Seismic Engineering: Benchmarking of Existing Building Evaluation Methodologies," was funded by NIST to conduct an objective comparison of the evaluation and assessment procedures contained in ASCE/SEI 41 in regards to other design and evaluation standards and to data recorded for reinforced concrete buildings. The project will consider both the current standard, ASCE/SEI 41-13, and the more recent version currently under development, ASCE/SEI 41-17.

ATC-134-1: The project, "Performance-Based Seismic Engineering: Benchmarking of Existing Building Evaluation Methodologies" was funded by NIST to expand the scope of the ATC-134 project to conduct an objective comparison of the evaluation and assessment procedures contained in ASCE/SEI 41 with regard to other design and evaluation standards and to data recorded for reinforced concrete buildings. The project also considered both the current standard, ASCE/SEI 41-13, and the more recent version currently under development, ASCE/SEI 41-17.

ATC-135: The project, "Studies for Improving Seismic Design Procedures and Requirements for New Buildings," was funded by FEMA to develop design procedures and requirements including, but not limited to: (1) an alternate design procedure for one-story, flexible diaphragm buildings with stiff vertical elements; (2) design procedure with requirements for rocking seismic force-resisting systems; (3) the inclusion of soil structure interaction effects on the design of inelastic seismic force-resisting systems; and (4) consolidation and simplification of design requirements based upon the Seismic Design Category (SDC) assigned to a building.

ATC-136/136-1/136-2/136-3: The report, FEMA P-1091, *Recommended Simplified Provisions for Seismic Design Category B Buildings*, was developed under a contract with FEMA. (Published 2017, 80 pages)

ATC-137/137-1: The project, "National Earthquake Technical Assistance Program (NETAP) Seismic Technical Guidance Development and Support Contract," was funded by FEMA to deliver direct assistance to the public to: (1) increase local earthquake knowledge and awareness; and (2) support the effective implementation of risk reduction activities from earthquakes or related hazards.

ATC-137-2/137-3: The project, "Technical Training and Product Development" was funded by FEMA to develop and maintain educational courses, related training materials, technical and non-technical guidance materials for earthquake mitigation, and conduct those training courses/webinars on behalf of FEMA. This project also supported the update of FEMA technical design guidance products, as needed, with a focus on course development, special projects, and national webinars. The project also had funding to deliver NETAP (ATC-66-10) trainings requested by states that exceed the ATC-66-10 budget, and the project supported the planning and delivery of a summit in Salt Lake City focused on unreinforced masonry. This project produced documents available through ATC and FEMA, including the following reports:

FEMA Recovery Advisory DR-4193-RA2, *Earthquake Strengthening of Cripple Walls in Wood-Frame Dwellings*. The original version of the report was developed under the ATC-125 Project. (Published 2019, 26 pages)

FEMA P-646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Third Edition*, was developed under a contract with FEMA. The original version of the report was developed under the ATC-64 Project and first updated under the ATC-79 Project.. (Published 2019, 202 pages)

FEMA P-2055, *Post-disaster Building Safety Evaluation Guidance –Report on the Current State of Practice, including Recommendations Related to Structural and Nonstructural Safety and Habitability*. (Published 2019, 228 pages)

ATC-137-2, *Proceedings of FEMA-Sponsored Summit on Unreinforced Masonry Buildings in Utah*. Available through ATC. (Published 2020, 125 pages)

FEMA P-530, *Earthquake Safety at Home*. (Published 2020, 110 pages)

ATC-138/138-1/138-2: The project, "Support of Performance-Based Seismic Design of Buildings," was funded by FEMA and aimed to develop materials necessary to encourage and assist in the use of performance-based seismic design products and tools developed under previous phases of ATC-58.

ATC-139: The purpose of this project was to support the FEMA-funded Project 17 effort that is examining the basis for the national seismic design value maps and the design procedures that reference them, in preparation for the 2020 Provisions update cycle. This work investigated the effects of duration on building response and collapse behavior, which is a topic that is not currently funded within the Project 17 scope of work.

ATC-140/140-1/140-2: The project, "Update of Seismic Evaluation and Retrofit of Existing Buildings Guidance" was funded by FEMA and aimed to investigate and address technical issues regarding the evaluation and retrofit of existing buildings and develop material for the expanded FEMA design applications document that will replace the current FEMA 275 Design Examples document.

ATC-141: The report*, September 19, 2017 Puebla-Morelos, Mexico Earthquake: Seismological and Structural Observations*, was funded by the ATC Endowment Fund in support of ongoing ATC projects funded by FEMA (ATC-78-7) and NIST (ATC-134). Available through ATC. (Published 2020, 499 pages)

ATC-142: The report, *Safety Prioritization of School Buildings for Seismic Retrofit Using Performance-Based Risk Assessment in the Kyrgyz Republic*, was developed under a contract with the World Bank Group. (Published 2019, 286 pages)

ATC-143: The project, "Update of CUREE Guidelines for Assessment and Repair of Earthquake Damage in Residential Woodframe Buildings" was funded by the CEA to update CUREE EDA-02 and CUREE EDA-06 and develop training materials on the resulting documents:

CEA-EDA-01, *Earthquake Damage Assessment and Repair Guidelines for Residential Wood-Frame Buildings, Volume 1 – General Guidelines* (Published 2020, 326 pages)

CEA-EDA-01, *Earthquake Damage Assessment and Repair Guidelines for Residential Wood-Frame Buildings, Volume 2 – Engineering Guidelines* (Published 2020, 342 pages)

ATC-144: The project, "Soil Structure Interaction Design Guide" was funded by FEMA to review available soil-structure interaction information and develop soil structure interaction design guidance.

ATC-145/145-1: The project, "Guide for Repair of Earthquake Damaged Buildings to Achieve Future Resilience" was funded by FEMA to review available information on repair of earthquake damage and develop and/or update repair design guidance.

ATC-146: The project, "Steel Buildings in the Central and Eastern United States Designed for Controlling Wind Loads to Evaluate their Seismic Performance" was funded by NIST and aimed to evaluate the seismic performance of two suites of archetype steel buildings designed in accordance with older building codes (circa 1980) and current building codes for specific locations within the Central and Eastern United States.

ATC-147: The report, *Large Outdoor Fire Modeling (LOFM) Workshop Summary Report*, was developed under a contract with NIST. Available through ATC and NIST. (Published 2019, 118 pages)

ATC-148: The project, "Building Technical Capacity in Central Asia to Design Risk-Informed Public Infrastructure Investments at Scale" was funded by the World Bank Group to provide technical support to World Bank's safer school initiatives in Central Asia.

ATC-149: The project, "Coastal Inundation Events in Developed Regions" was funded by the University of Notre Dame and NIST to develop

and test methodologies to improve predictions of inundation hydrodynamics and loading in developed (urban) regions for both storm wave and tsunami inundation, as aligned with the National Windstorm Impact Reduction Program and the Structural Performance under Multi-Hazard Program.

ATC-150: The project, "Improving the Nation's Lifelines Infrastructure to Achieve Seismic Resilience" was funded by FEMA to review NIST CGR 14-917-33, *Earthquake Resilient Lifelines: NEHRP Research, Development and Implementation Roadmap*, and initiate activities of Program Element I.

ATC-R-1: The report, *Cyclic Testing of Narrow Plywood Shear Walls*, was developed with funding from the ATC Endowment Fund. Available through ATC (Published 1995, 64 pages)

ATC Design Guide 1: The report, *Minimizing Floor Vibration*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 1999, 64 pages)

ATC Design Guide 2: The report, *Basic Wind Engineering for Low-Rise Buildings*, was developed with funding from the ATC Endowment Fund. Available through ATC. (Published, 2009, 114 pages)

ATC TechBrief 1: The ATC TechBrief 1, *Liquefaction Maps*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

ATC TechBrief 2: The ATC TechBrief 2, *Earthquake Aftershocks − Entering Damaged Buildings*, was developed under a contract with the United States Geological Survey. Available through ATC. (Published 1996, 12 pages)

FEMA Support for Earthquake Subject Matter Experts (SMEs): Seismic Technical Guidance Development and Support is funded by FEMA to provide overarching management of the task orders authorized under the existing FEMA Task Order Contract for Seismic Technical Guidance Development and Support, and to provide support for Earthquake Subject Matter Experts (SMEs) who report independently to FEMA. This project produced documents available through ATC and FEMA, including the following report:

> FEMA P-646, *Guidelines for Design of Structures for Vertical Evacuation from Tsunamis, Third Edition*. The original version of the report was developed under the ATC-64 Project. (Published 2019, 202 pages)

Northeastern RSB: Northeastern University Multi-Hazard Resilient and Sustainable Buildings aimed to provide technical advice and assistance to Northeastern University on their NSF- funded project to develop a decision framework that accounts for both resilience and sustainability across multiple hazards with different levels of severity, while optimizing lifecycle costs throughout the design process.

STARR II JV: Strategic Alliance for Risk Reduction (STARR) II Joint Venture, Production and Technical Services (PTS) for Architect and Engineering Services Nationwide Contract aimed to provide technical assistance and support services to FEMA on Hazard Mitigation Technical Assistance Projects (HMTAP) and Technical Assistance and Research Contract (TARC) projects on an as-needed, on-demand basis.

Website for Geographic Based Design Load Parameters: This project aimed to maintain and enhance the ATC windspeed website, and to add additional functionality related to other design loads, including ground snow loads and possible future earthquake ground accelerations. This site developed into the ATC Hazards by Location website which provides users with site-specific hazard information that can be used to determine design loads for buildings and other structures.

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