

ATC-165 Project Report:

# REDUCING THE SEISMIC RISK OF RESIDENTIAL BUILDINGS IN ISTANBUL

## RECOMMENDATIONS FOR IMMEDIATE ACTION

October 2024

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# Reducing the Seismic Risk of Residential Buildings in Istanbul: Recommendations for Immediate Action

## ATC-165 Project Report

**Prepared by**  
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October 2024

# KEY TAKEAWAYS

Following the devastating losses in Türkiye due to the February 2023 earthquake events, Esas Holding of Istanbul, Türkiye, convened the ATC-165 Technical Advisory Committee (ATC-165 Committee) facilitated by the Applied Technology Council (ATC), a structural engineering non-profit organization in California, U.S.A.

Existing studies estimate that when a magnitude 7 or greater earthquake occurs on the Main Marmara Fault (termed herein the Marmara Earthquake), an event that has about a 45% mean probability of occurrence in the next 30 years (Murru et al, 2016) about 200,000 buildings in Istanbul are expected to be damaged beyond repair, resulting in tens of thousands of casualties (IBB, 2019). Informed by these stark findings, the ATC-165 Committee identified seismic risk reduction in Istanbul, specifically for existing residential buildings, as its main priority.

The ATC-165 Committee reviewed the state-of-practice of seismic design, building construction, and code enforcement in Türkiye as well as existing political, social and financial mechanisms for reducing seismic risk in Istanbul and across the nation. Based upon this review, as well as discussions at a workshop held in Istanbul on March 12-13, 2024, the ATC-165 Committee presents the following recommendation for urgent action:

**To prevent significant loss of life from heavy building damages in the event of a magnitude 7 or greater Marmara Earthquake, there is an urgent need to expand existing efforts under the Urban Transformation Law at scale to enable seismic retrofit of existing residential buildings with the highest risk of collapse in such an earthquake. The ATC-165 Committee recommends the establishment of an Istanbul Seismic Retrofit Program directed at buildings with the highest seismic risk that can be retrofitted with targeted (limited invasiveness) risk reduction measures that are cost-effective and feasible to implement. Such a program will also allow accelerated response and recovery in smaller, more likely events.**

To support this principal recommendation, the ATC-165 Committee has outlined in this report three supporting pathways with recommended actions to enhance leadership and coordination of a seismic retrofit program (Pathway A), public understanding and demand for seismic retrofits (Pathway B), and public and private sector capacity to implement such a program (Pathway C). With improved leadership and coordination, an informed and engaged public demanding action, and a capable and responsible building industry, Istanbul will be able to launch a sustained seismic retrofit campaign and programs that can, over a number of years, make a significant contribution to reducing the city's seismic risk. Key takeaways from these pathways are as follows:

- At the outset of the Istanbul Seismic Retrofit Program, buildings with the highest seismic risk should be identified by **deploying the existing rapid assessment technique to all residential buildings in Istanbul, beginning from neighborhoods previously identified to have the highest seismic risk** to collect the necessary data to prioritize and implement a seismic retrofit program. The existing technique, PERA methodology for seismic performance rating, has been used on a limited basis by the Istanbul Metropolitan Municipality for the past several years, has the support of leading Turkish earthquake experts, and is well-placed to be expanded in use in Istanbul for assessing the seismic risk of the city's building stock.
- Regulatory and policy changes must be put in place to better incentivize seismic retrofits. One key technical recommendation is **the acceptance of a lower seismic performance objective for existing building retrofits under the effect of the Marmara Earthquake scenario for high-risk buildings**. Current regulations have proven to be impractical for the retrofit of

such buildings at scale, leading to unviable design solutions, excessive construction costs, and long-term displacement of residents. Many other countries, including Mexico, the United States, and Italy, have highly successful programs that permit the retrofit of existing buildings to a lower performance objective, termed “collapse prevention.”

- **Simplified, prescriptive seismic retrofit standards that target major life-safety deficiencies of high-risk buildings must be developed. Identifying a subset of high-risk building typologies that can be feasibly retrofitted with simple, low-invasive approaches is recommended.** These types of approaches will not only be more cost effective but will also minimize disruption and displacement of residents.
- Financial incentives, such as subsidies and loans, are needed to enable residential building owners to retrofit their buildings. **It is possible that existing government funding mechanisms under the Urban Transformation Law would be sufficient to cover most, if not all, retrofit costs if performance objectives for retrofits are reduced and more targeted design approaches are permitted.** There may also be opportunities to fund seismic retrofits through other innovative approaches such as Transfer of Development Rights (TDR) or drawing on climate finance for integrated energy efficiency and seismic retrofits.
- **Training and capacity building of both public sector and private sector building professionals, as well as more formalized approaches for professional certification and quality control,** are needed to support the successful implementation of a seismic retrofit program in Istanbul.
- **Finally, a Seismic Advisory Council should be established to support and advise the public sector** in regulatory and policy changes; risk assessment and retrofit prioritization; the development of consensus-based retrofit standards; advocacy for seismic risk reduction; and professional certification procedures for retrofits. The Council should be comprised of Türkiye’s leading seismic experts as well as experts on related policy, legal, economic, urban planning, and community engagement aspects.

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# 1 INTRODUCTION

## 1.1 Background

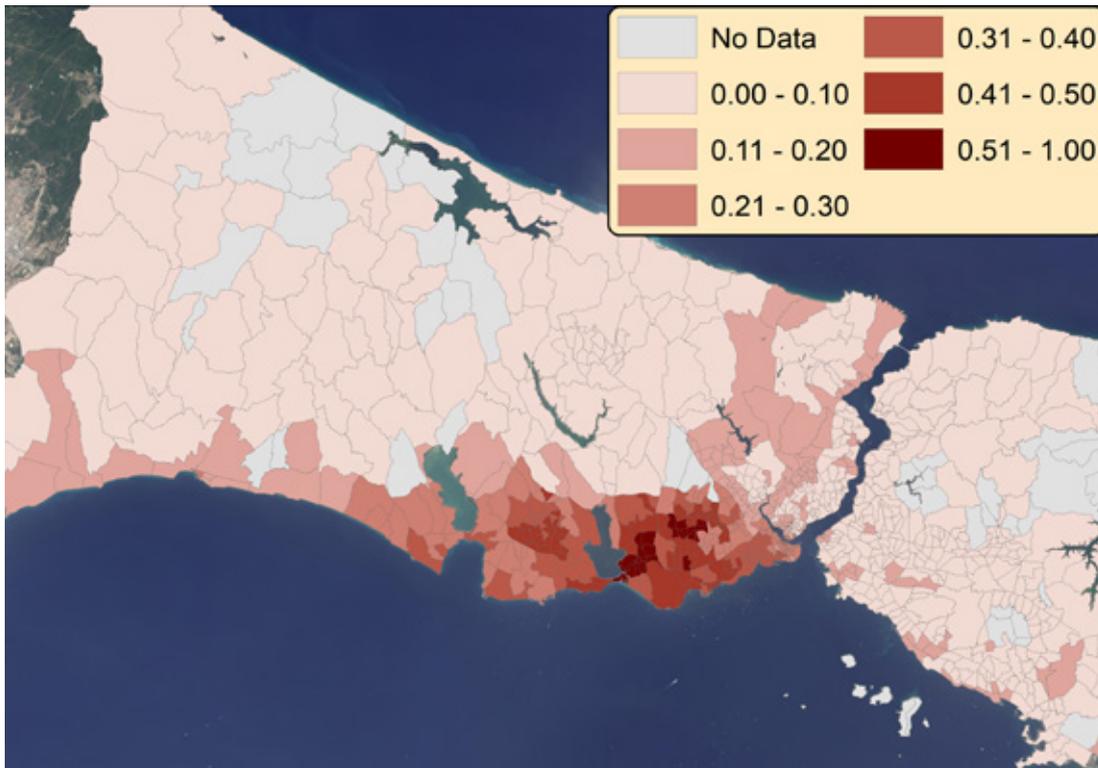
The M7.7 and M7.8 earthquakes that occurred in Türkiye on 06 February 2023 were the largest in the country in almost a century and served as a sobering reminder of the country's exposure to seismic risk. The earthquakes resulted in over 50,000 deaths due to about 300,000 heavily damaged and collapsed buildings, leaving over 3 million people homeless (Ministry of Strategy Budget, 2023). It should be noted that the bulk of the life losses were associated with the collapse of residential buildings. In May 2024, over one year after the earthquake events, nearly 700,000 people were still reported living in temporary disaster shelters (Al Jazeera, 2024).



**Figure 1:** Photographs from Kahramanmaraş prior to and following the February 2023 earthquakes showing complete collapse of multi-story residential and mixed-use buildings. (photo credits: top - Google Maps; bottom – Ayhan Irfanoglu)

The earthquakes have also re-drawn attention to the urgency of addressing the significant seismic risk of Istanbul, the country's largest city with approximately 16 million residents and the country's cultural and economic center of activity. More than half of the 1.2 million buildings in Istanbul were constructed prior to the existence of modern (post-1998) building codes, with inadequate attention not only to seismic resistance, but also to basic gravity loading and structural stability. In many cases, a lack of adequate maintenance or inappropriate building modifications exacerbate building vulnerabilities.

It is predicted that in a large earthquake event (greater than magnitude 7) – which has a median 30 year probability of about 45% (Murru et al, 2016) – with a 50% probability of exceedance, about 200,000 buildings in Istanbul will be heavily damaged and collapsed, tens of thousands of people will be at risk of losing their lives, and about 800,000 people will be left homeless (IBB, 2019). According to a recent study (Aydogdu, 2024), very high-risk buildings (i.e., buildings classified as E class by employing the PERA rapid seismic assessment methodology (Aydogdu et al., 2023) for a magnitude 7.5 scenario earthquake) constitute almost 20% of the building stock in Istanbul. The estimated ratios of buildings within each neighborhood with very high risk are shown in Figure 2, where the darkest color indicates neighborhoods where the ratio of buildings with very high risk is 50% or higher, i.e., more than half of the buildings in the neighborhood has very high risk. The economic impacts from such an event can be estimated to be close to USD 100 Billion (at a scale similar to the losses from the 2023 earthquake events, approximately 9% of the country's GDP), again with a 50% probability of exceedance. While new residential buildings are required to be designed and constructed to the current building code, which has seismic safety provisions that are consistent with international best practices generally aimed at minimizing life loss, facilitating recovery and reducing economic disruption, there is currently no plan with adequate coverage and coordination for improving the seismic safety of **existing** residential buildings in Istanbul.



**Figure 2:** The ratio of buildings in risk Class E (“very high risk”) to the total number of buildings in each neighborhood of Istanbul based on a magnitude 7.5 Marmara Earthquake scenario (Aydođdu, 2024)

Many cities around the world face the same challenge of addressing the seismic risk posed by existing buildings built prior to modern building codes. Some cities have made considerable progress in tackling this challenge through coordinated and sustained efforts to seismically retrofit existing buildings over decades, recognizing that the socio-economic costs of doing so before an earthquake are much less significant than the losses following one. Many of the approaches used by other countries relate to technical standards development, policy change, and financing to support seismic risk reduction; many of these are transferable to the challenges that Türkiye, including Istanbul, faces.

In late 2023, with generous funding from Esas Holding, a family-owned investment firm, the ATC-165 project was established, led by the Applied Technology Council (ATC), a United States-based not-for-profit organization. ATC was founded in 1973 to accelerate the transition of seismic research into practice and was instrumental in writing America's earthquake codes and supporting seismic risk reduction since the 1970's.

The goal of the ATC-165 project is to share relevant international practices for seismic risk reduction and determine how they might be applied or adapted in Türkiye to reduce the seismic risk of existing residential buildings in Istanbul. This report summarizes the findings of this effort.

## 1.2 Project Objectives

This project aims to support improving the seismic safety and resilience of Türkiye by initiating a new and effective plan for reducing earthquake risk to residential buildings in Istanbul. To this end, the Technical Advisory Committee focused their efforts on the following objectives:

- Identify key challenges and gaps towards improving the seismic safety of buildings in Istanbul, with a specific focus on residential buildings;
- Identify promising existing initiatives in Türkiye that can be built upon for further impact;
- Understanding this context, identify potential feasible solutions that have been successfully implemented in other countries, including technical approaches and policy and financing considerations;
- Begin to identify how to effectively adapt these solutions to the local context of Istanbul and link them to recommended pathways for further exploration.

Specifically, the effort is concentrated on **reducing the collapse risk of residential buildings** – and consequential life losses – in the Marmara Earthquake. This is referred to as a “collapse prevention” performance objective. Reducing the collapse risk of residential buildings should be the primary tool for the reduction of life losses.

The infrastructure damage, which can limit the re-occupancy of buildings following an earthquake, is also important for supporting community resilience and reducing the economic consequences of an earthquake. However, due to the severe seismic vulnerability of many existing buildings in Istanbul and the life safety risk posed to residents, the project focused on the fundamental objective of saving lives in the Marmara earthquake.

An important feature of the project is the managed participation and engagement of both local and international experts in a collaborative process, incorporating a broad spectrum of engineering opinion and experience. While the expert group consisted mainly of built environment experts and engineers, the range of topics covered in the project was deliberately broader, including policy, finance, and social considerations.

The intent for this initial phase of work is to catalyze a more sustained effort supporting seismic risk reduction in Istanbul with the recommendations from the ATC-165 TAC serving as an initial roadmap to engage stakeholders and develop a locally-led action plan.

### 1.3 Project Methodology

Technical work on the project was developed by the ATC-165 Technical Advisory Committee (referred to as the “ATC-165 TAC” in this report), comprised of Turkish and international practice and research experts engaged in seismic risk reduction efforts. International advisors were sourced from Chile, Mexico, the United States of America, Japan, and Italy, a diverse set of countries that have substantial seismic risk and have taken significant steps towards mitigation. Members of the ATC-165 TAC are listed in Appendix A.

The project commenced in the fall of 2023 with a series of presentations led by the Turkish members of the ATC-165 TAC providing background and context to the seismic risk challenges of Türkiye and Istanbul as well as past and current initiatives focused on risk assessment and mitigation. Topics covered in the framing presentations included:

- Istanbul’s earthquake risk and past earthquake risk assessment studies
- A review of the 2003 Istanbul Earthquake Masterplan
- Data on Istanbul’s building inventory and typical structural vulnerabilities of buildings built before 2000
- Other common building vulnerabilities, including construction, site deficiencies, and maintenance
- Overview of the PERA seismic risk rating methodology including guidance and results for seismic performance assessments of existing buildings in Istanbul
- Comparison of retrofit versus reconstruction approaches
- Overview of codes and regulations in Türkiye and comparison to international standards
- Community and civil society initiatives including post-disaster training and response

The framing presentations and subsequent discussions led the ATC-165 TAC to decide to focus a workshop in March 2024 on the development of **recommendations to support the seismic retrofit of existing high-risk residential buildings in Istanbul for collapse prevention to drastically reduce the life losses in the Marmara Earthquake**. Using content from the presentations, a problem tree framework was developed to summarize challenges and gaps and to identify solutions areas on which to focus case studies and discussions in the workshop. These findings are provided in Sections 2.3.

An in-person workshop was held in Istanbul on 12-13 March 2024 to convene the ATC-165 TAC and other technical experts on seismic risk in Türkiye to share international experiences and develop recommendations through collaborative group exercises (refer to Section 3 for more detail on the workshop).

This report presents the scope of outputs from the workshop, which have been organized into a set of recommended actions. The intent is for this report to be shared widely and used as a tool for further engagement to drive action on seismic risk reduction.

## 2 CHALLENGES AND OPPORTUNITIES

### 2.1 Overview

The problem tree framework presented in Figure 3 highlights and organizes the main challenges and gaps contributing to the seismic risk of residential buildings in Istanbul and was used as a means of focusing and organizing the development of recommendations. The content included in the problem tree was sourced from framing presentations provided by the Turkish members of the ATC-165 TAC.

### 2.2 Opportunities to Build Upon

In addition to identifying challenges, Turkish members of the ATC-165 TAC highlighted numerous areas of progress and opportunities to build upon existing efforts and successes. These “bright spots” include the following topics:

1. **Political will:** There is political will to address seismic safety in the current moment. **How can it be leveraged?**
2. **Seismic masterplan:** The 2003 earthquake masterplan for Istanbul (IBB, 2003) laid out good objectives as a starting point but needs examples on implementation. **What can be learned from this effort in terms of improvements to institutional coordination and addressing barriers to effective implementation of seismic risk reduction?**
3. **ISMEP:** The Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) is a globally recognized example of successful, sustained seismic risk reduction for public buildings, such as schools and hospitals, linking technical solutions, policy change and financing for public buildings. **How can learnings and impacts from the program regarding implementation structure, capacity building, public procurement approaches, and financing approaches be leveraged for the retrofit of private buildings?**
4. **Insurance:** There is widespread uptake of compulsory earthquake insurance. **How can it better incentivize mitigation through seismic retrofits? Would an earthquake performance rating system be supportive?**
5. **Urban Transformation Law:** There are examples of effective incentives for risk mitigation including developer-driven initiatives to replace existing “risky” buildings through the Urban Transformation Law 6306, as well as campaigns of the government, such as “Yarısı bizden” (half from us), or the Istanbul Metropolitan Municipality (IMM), such as “İstanbul’u yeniliyoruz, İstanbul’u güçlendiriyoruz” (we are renewing Istanbul, we are strengthening Istanbul). **What can we learn from these programs and how can they be improved and scaled up? How can similar mechanisms be used for retrofits?**
6. **Risk assessment and prioritization:** There is a well-developed guideline for the seismic risk evaluation of existing buildings (Provisions for Assessment of Risky Buildings, 2019). However, the methodology is costly and time-consuming and intended for individual buildings, not an entire building stock. An approved method for the rapid seismic risk evaluation of existing buildings (PERA) also exists. The PERA method (Aydogdu et al., 2023) aims to quantify the seismic risk level of a building by calculating the Seismic Safety Ratio

**PROBLEM STATEMENT:**  
A significant portion of residential buildings in Istanbul will not protect life safety in a large seismic event.

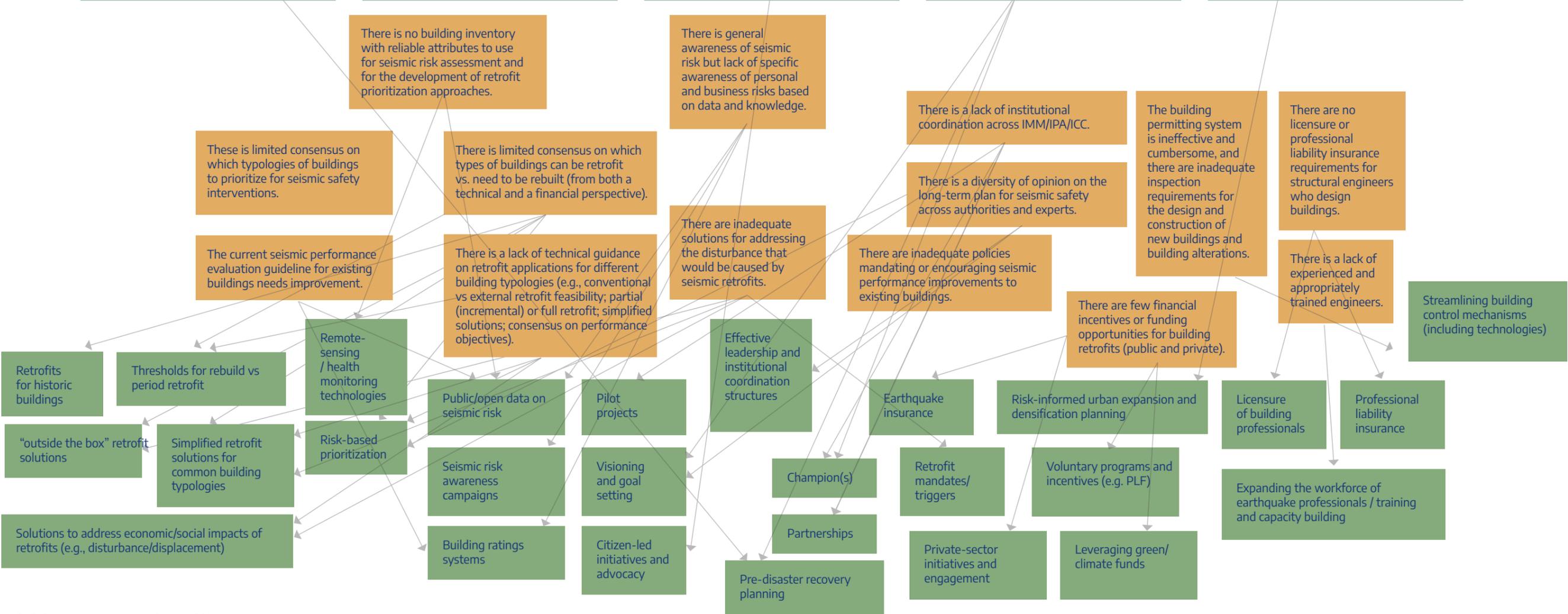


Figure 3: Solution topics mapped to problem tree components

(SSR) through a series of linear structural analyses, based upon a 2-3 hour field evaluation of the building. The SSR index is the ratio of the building's seismic capacity to seismic demand (i.e., code or scenario earthquake-based design earthquake ground motion). Depending on the SSR value, each assessed building is labeled with one of risk classes (A to E, where A corresponds to a low seismic risk and E indicates a very high seismic risk). Once the methodology is applied to the city's building inventory, it can be used for prioritization. **What are the limitations to rapidly scaling this methodology to assess all at-risk buildings in Istanbul, and how can they be addressed?**

7. **Seismic design code:** There is agreement that the 2018 Turkish Seismic Design Code (Government of Türkiye, 2018) has state-of-the-practice seismic provisions for construction of new buildings. **How can we focus on ensuring quality implementation and addressing barriers to cost-effective and feasible retrofits of existing buildings?**
8. **Proven life-safe building typologies:** Buildings with tunnel-form construction performed well in the 2023 earthquakes (Çetin et al, 2023), even with known shortcomings in building quality controls. A compact set of strict, simple, and prescriptive rules for the seismic design and construction of new buildings will also soon be published. These rules (e.g., use of shear walls, larger columns) will allow for straight forward plan checks and detection of deviations. **How can these types of simplified, conservative rules be leveraged for retrofits?**
9. **Citizen-led initiatives:** There are many examples of citizen-led preparedness and resilience-building initiatives. **How can they be strengthened and channeled towards more effective advocacy for seismic risk mitigation to encourage action?**

## 2.3 Solution Areas

From the problem tree shown in the top of Figure 3, solution topics were identified and linked to the problems, based on discussions among ATC-165 TAC members. The bottom half of Figure 3 shows the types of solution topics that were identified in advance of the workshop.

From this mapping, the following solution areas were identified as particularly relevant to the problem statement and used to organize workshop discussions and formulate recommendations:

- Driving demand for earthquake-safe housing
- Policy approaches for seismic retrofits and risk reduction (mandates and incentives)
- Seismic retrofit solutions that are technically and financially viable
- Improving building regulations to ensure newly constructed buildings are safe
- Vision, leadership, and institutional coordination for seismic risk reduction

## 3 WORKSHOP OVERVIEW AND OUTPUTS

### 3.1 Workshop Program and Attendees

The Workshop on Seismic Risk Reduction in Istanbul was held on 12-13 March 2024, with approximately 40 attendees, including members of the ATC-165 TAC and built environment experts from Türkiye representing the following organizations:

University and research institutions:

- Bosphorus University, Istanbul
- Institute of Innovative Research at the Tokyo Institute of Technology, Japan
- Istanbul Technical University
- Istanbul University
- IUSS Pavia, Italy
- Middle Eastern Technical University, Ankara
- National Autonomous University of Mexico, UNAM, Mexico City, Mexico
- TED University, Ankara
- University of Chile, Santiago, Chile

Building design practitioners:

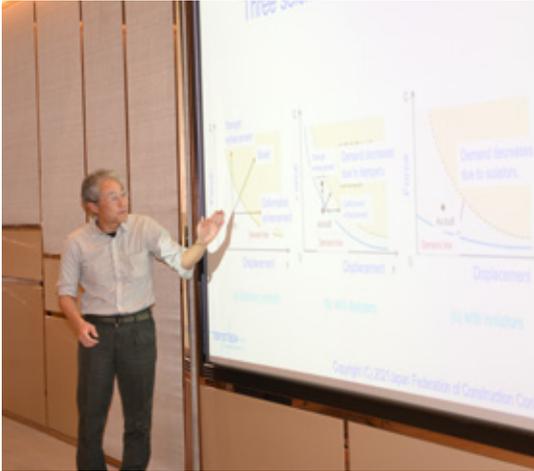
- Altensis
- Kentsel Yenileme Merkezi (KEYM), Istanbul
- Rutherford + Chekene, San Francisco, California, U.S.A.
- Tece Mimarlik, Istanbul
- T-rupt Teknoloji, Istanbul
- Ülker Engineering, Istanbul

Civic and governmental organizations:

- Istanbul Project Coordination Unit (IPKB), Istanbul
- Natural Hazards Insurance Cooperation (Dogal Afetler Sigorta Kurum, DASK), Istanbul
- Seismic Isolation Society (Deprem Izolasyon Dernegi, DID), Istanbul
- Seismic Strengthening Society (DEGÜDER), Istanbul
- U.S. Geological Survey, Menlo Park, California, U.S.A.
- World Bank, Ankara

International members of the ATC-165 TAC represented perspectives from Mexico, Italy, Chile, Japan, and the United States of America.





The main objectives of the workshop were to:

- Identify promising solutions for improving the seismic safety of residential buildings that have been implemented successfully in other countries based on the collective understanding of challenges and gaps related to seismic safety in Istanbul;
- Begin to explore how solutions from other countries could build upon existing efforts in Istanbul and Türkiye more broadly, be adapted to the context of Istanbul, and organized in a coordinated plan for implementation.



The workshop began with framing presentations highlighting the following ongoing initiatives in Türkiye as opportunities to learn from and to leverage in identifying new solutions:

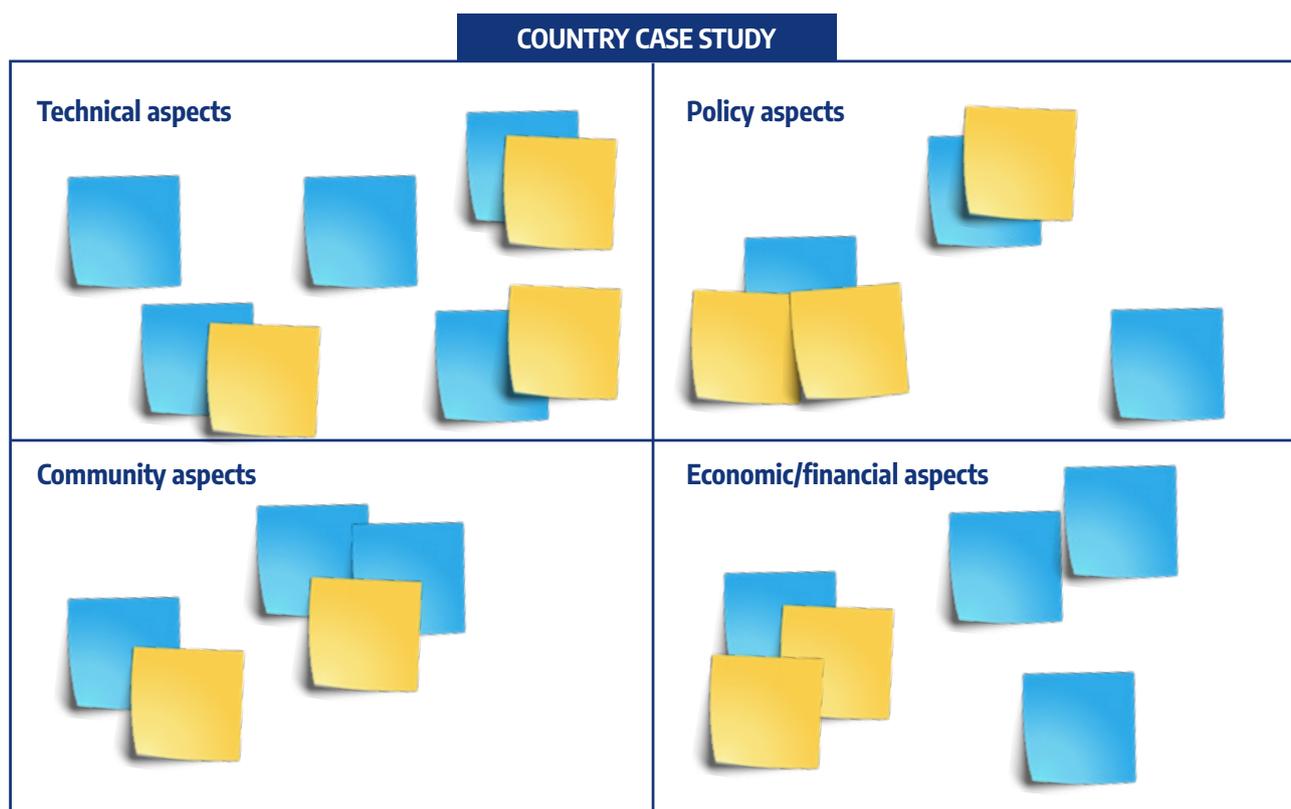
- Turkish Catastrophic Insurance Pool (TCIP) by Dogal Afet Sigortaları Kurumu (DASK)
- Examples of urban transformation projects by Kentsel Yenileme Merkezi (KEYM)
- The Istanbul Seismic Risk Mitigation and Emergency Preparedness Project (ISMEP) by the Istanbul Project Coordination Unit (IPKB)

The framing presentations are provided in the supporting documentation volume that can be obtained separately.

Next, the international experts gave presentations highlighting successful initiatives and existing challenges (case studies) related to seismic risk reduction from other countries, including the seismic evaluation of existing buildings, seismic retrofit program planning and implementation, engineering solutions and guidelines for retrofits, and building regulatory reform. These presentations are provided in the supporting documentation volume that can be obtained separately.



Following each case study presentation, workshop participants separated into small groups to discuss the solutions that were presented. First, attendees identified and mapped **promising elements** of each case study into four categories: **Technical Aspects, Policy Aspects, Community Aspects, and Economic/Financial Aspects** (see Figure 4). Next, attendees identified **constructive actions** that could be taken to move the idea forward in Istanbul and Türkiye.



**Figure 4:** An example of the small group exercise template. Blue Post-It notes were used to identify promising elements and yellow Post-It notes were used to identify constructive actions.



## 3.2 Selected International Case Studies

The international presentations highlighted numerous examples of successful seismic risk reduction initiatives that can serve as potential blueprints for action in Istanbul. This section highlights several case studies that have a direct connection to some of the recommendations that are presented in Section 4.

### 3.2.1. New Seismic Retrofit Standards for Existing Buildings in Mexico City following the 2017 Puebla Earthquake (Mexico, Dr. Sergio Alcocer)

On September 19, 2017, Mexico City suffered significant damage from a M7.1 earthquake including the collapse of 36 buildings and the tragic loss of 369 lives. This event prompted significant changes in the city's building policies and urban management strategies that are still under implementation (Mexico City functions autonomously in Mexico's federal system). Post-disaster analysis revealed that buildings compliant with more recent building codes predominantly withstood the earthquake, pointing to the effective performance of newer construction regulations. Thirty-five of the 36 buildings that collapsed were built prior to seismic reforms introduced following the magnitude 8.1 Mexico City earthquake in 1985. Buildings with an adequate structural layout (i.e., fewer irregularities), higher quality design and construction practices, and proper maintenance exhibited superior performance.

Following the 2017 earthquake, a new **Reconstruction and Resilience Commission (RRC)** was



formed in Mexico City. The RRC was tasked with developing robust seismic assessment and retrofit standards, coordinating the retrofitting of buildings, and developing public policies to enhance the city's seismic resilience. The RRC was supported by the **Structural Safety Advisory Committee** comprised of academics and seismic experts and established after the 1985 earthquake. The committee first prepared and published an ad hoc standard "Standard for the Rehabilitation of Concrete Buildings Damaged by the September 19, 2017 Earthquake" in December 2017. The committee then reviewed, revised and developed ten Complementary Technical Norms (CTNs) (i.e., design and construction standards) that went into effect in May 2024 and form an integral part of the Mexico City Building Code (MCBC).



One of the new CTNs covers the structural assessment and rehabilitation of existing buildings. It includes differentiated seismic performance requirements based on building vulnerability, depending on location, soil type, structural framing, and level of damage. This CTN allowed, for the first time, older versions of the MCBC to be used for the design of seismic retrofits based on a building's vulnerability and age. Setting a **more relaxed standard for existing building retrofits** compared to new structures was a direct response to the technical and financial constraints involved in upgrading existing buildings to the most up-to-date standard. The aim of this new CTN is to attain a collapse-prevention performance of retrofitted buildings.

Buildings are classified in three categories. Class A are those structures where retrofitting techniques demand highly specialized engineering (i.e., such as where energy dissipation devices are used). Class C are concrete and steel frames, with or without infills, upto 4 stories high, and masonry and timber-walled structures not taller than 2 stories, regular or irregular, that could be analyzed using linear static procedures. Class B are the remainder of the buildings.

Mexico City's repair and retrofit program introduced after the 2017 earthquake resulted in retrofit or reconstruction of approximately 400 multi-story buildings and 2,000 single-family dwellings in accordance with the ad hoc standard. The program provided government subsidies that covered the total retrofit costs including costs for design services and construction of the retrofit measures and new finishes for buildings damaged in the earthquake that were inspected by government authorities. In most cases, the retrofit cost was approximately 30% of the cost to replace the building. In situations where the cost to retrofit the building was more than 65% of the cost of replacement (including demolition), the building was rebuilt rather than retrofit. In these cases, the government also covered the total costs of design, construction, and finishes but was able to recover part of the expenses by increasing the floor area of each building by 35% (referred to as re-densification).

An inventory assessment of existing building retrofits made since 2017 found that 78% of the retrofitted buildings were irregular or highly irregular. The main retrofit techniques for reinforced concrete structures included **masonry wall jacketing (i.e., wall enlargement), column jacketing with reinforced concrete, and the addition of new concrete walls**. For **heritage structures**, retrofit efforts were carefully applied to balance structural integrity and historical preservation, including the possibility of reversing the intervention if necessary. The use of original structural systems with improved behavior, such as substituting or adding walls built with better materials and reinforcement, or the addition of anchors and ties were favored to maintain the original architectural aesthetics while providing the necessary reinforcement.

The 2017 Puebla Earthquake acted as a catalyst for Mexico City to reevaluate and enhance its approach to urban seismic resilience. Through strategic policy improvements, rigorous building standards, and supportive financial frameworks, the city is on the way to setting a robust model for disaster preparedness and mitigation, ensuring safer urban environments for future generations.

### 3.2.2. Government-backed Financial Incentives for Voluntary Seismic Retrofits of Private Homes (Italy, Dr. Michele Calvi)

In Italy, **seismic retrofits of private residential buildings are financially incentivized through a national law** that provides a multi-year tax reduction (applied to property or personal taxes) covering a large portion of the retrofit cost - in some cases up to 110% of the cost. Building owners are permitted to sell the tax reduction to others, including construction companies and banks. This policy allows homeowners who otherwise would not be able to finance a retrofit to immediately receive an up-front cash payment for the multi-year tax benefit, making the project financially feasible. Oftentimes, it is the construction company working on the retrofit. The program covers both single-family houses as well as multi-story apartment buildings. In the case of a building having multiple owners, at least half of the owners must approve the decision to apply to the program to compel all owners to participate.



Figure 5: Examples of seismic retrofit measures in Italy

The amount of governmental **financial support is based upon the estimated seismic risk reduction** of the retrofit measure (expressed as a reduction of the expected annual loss – EAL), or the “jump” in defined “class.” For example, improving by two classes provides greater financial support than improving by one class. This is justified based upon a benefit-cost analysis comparing avoided losses to the cost of intervention.

To facilitate the process, automatic **relationships were defined between the retrofit measures for different common typologies and the class jump**. For example, for an unreinforced masonry building typical of historic Italian towns, a “jump” of two classes was accepted without analytical demonstration if the following measures were implemented: a good connection between transverse walls; ties inserted between walls; ties added to vaulted ceilings; and a proper ring beam at the connection between the roof and walls.

The program has been well-received by private building owners and has led to over 425,000 retrofits to date at a cost of 85 billion Euros (ENEA, 2023), resulting in a notable reduction in seismic risk in Italy. Furthermore, **the simplification of the retrofit measures relative to seismic risk reduction and level of financial support allowed for a clear understanding of the program by non-technical stakeholders**. However, these simplifications have also made it more difficult to precisely evaluate the risk reduction resulting from the program. The sizeable financial incentives provided by the government have also led to many fraud attempts.

In Italy, there is no compulsory insurance against earthquake damage because it is viewed as an unfair tax. However, in the presence of a significant public contribution such as that being made in the retrofit program, a compulsory insurance policy is viewed as fair because it is the only measure that guarantees the government will not be asked to spend additional funds in case of an earthquake. As such, a **mandatory, parametric insurance policy for retrofit buildings is being considered as an addition to this existing program.** The cost of the insurance policy for each retrofit home could be based upon a single function correlating a local intensity parameter (e.g., PGA) to the expected level of loss, expressed as a fraction of the cost of reconstruction. An accelerometer could be located at each building basement, and the insurance payment could be based on the recorded parameter only, without requiring a damage inspection.

### 3.2.3. Building Regulations Mandating Highly Resistant, Low Damage Buildings for Frequent, Large Earthquakes (Chile, Dr. Ruben Boroschek)

Chile is located in one of the most active seismic zones in the world. A perceptible seismic event occurs every two days in Chile. Instrumental, historical, and paleoseismic records indicate that a magnitude 7.5 earthquake occurs approximately every five years, a magnitude 8.0 every ten years, a magnitude 8.5 every fifteen years, and above magnitude 9.0 every 250 to 350 years.

Chile's high seismic activity has shaped the public attitude towards earthquakes and the way the country designs, constructs, and maintains its infrastructure. The Valparaiso earthquake of 1906 magnitude 8.2 (Okal, 2005) showed that buildings with concrete shear walls suffered very limited or no damage, resulting in the extensive promotion of this structural system in the country (R. Boroschek and Retamales, 2016). **Today nearly all residential buildings more than five stories are built with reinforced concrete shear walls** (Bonelli et al., 2017; Lagos et al., 2020).

These structures have high structural wall densities (typically 4% wall area of the floor area) in each direction (R. L. Boroschek and Yáñez, 2000; Calderon, 2007).

**High shear wall density and the reduced use of nonstructural masonry partitions** in buildings higher than five stories have contributed to exceptionally low damage in structural components and low losses in general for residential buildings in large earthquake events in past decades. During the magnitude 8.8 earthquake in 2010, approximately 2,000 buildings taller than nine stories were exposed to the highest levels of ground shaking (Lagos et al., 2020; Wallace et al., 2012). Only one building suffered total collapse, and only approximately 2% of the 2000 buildings suffered damage that needed to be repaired (one was beyond repair and demolished). The structural shear wall system has shown excellent response and is fully accepted by users, designers, and contractors.



**Figure 6:** High rise building that suffered damaged during the magnitude 8.8 earthquake in 2010

Because of Chile’s high seismic activity, it has long been recognized that weak structural systems, such as unreinforced masonry and adobe, are highly susceptible to collapse. For example, the regulations from 1936 (General Law about Construction and Urbanization, 1936) already restricted adobe as the main structural system. The seismic base shear coefficient was also already high in these provisions, **limiting the use of weak lateral systems** (0.10 horizontal and 0.05 vertical, with an increase for poor soils).

The reduction in death tolls from strong earthquakes are indicators of the elimination (i.e., destruction with no replacement in kind) of weak structural systems such as adobe and unreinforced masonry (Table 1). After each earthquake, weak systems and deteriorated structures that suffered total or partial collapse were not rebuilt. As a result of the frequent seismic activity removing weak buildings and the prohibition on the construction of weak structural systems, **building retrofit programs or mandates have not been necessary** in Chile.

**Table 1:** Summary of death in strong earthquakes in Chile.

Year of Earthquake	Magnitude	Estimated Population (Millions)	Estimated Earthquake Death
1906	8.2	3.2	3,000
1922	8.3	3.7	100
1928	7.6	4.0	230
1960	9.5	7.6	1,700
1985	8.0	12.1	180
2010	8.8	17.1	550
2014	8.2	17.7	6
2015	8.3	17.9	13

**Building codes:** Building design and construction codes in Chile recognize the **economic benefits of highly resistant, low damage systems**, such as reinforced concrete shear wall systems, in a country with continual occurrences of strong ground shaking. Stiff and strong structural wall systems prevent recurring damage in non-structural elements sensitive to displacement, and for higher ground motions, the need to repair structural systems.

- For residential and office buildings, **interstory drift is limited to 0.2%. High minimum base shears are** also specified (12%W for houses and 6%W for buildings in the 1972 building code. Currently, the minimum base shear coefficient for buildings in high seismic zones is between 6-9%W, depending upon the soil type).
- The building code did not require ductile detailing for reinforced concrete shear walls until 2009. Much of the damage observed during the 2010 earthquake was attributed to a lack of ductile detailing rather than slender walls and wall irregularities, and **requirements on ductile detailing and minimum geometric conditions** were the main reforms made to the code in an emergency decree developed in 2011.
- The building code does not place any restrictions on irregularities as most are handled by limiting interstory drift.

- **Chilean seismic design codes are prescriptive.** While performance objectives are mentioned (NCh433 specifies life safety for buildings; NCh2369 specifies ease of recovery for industrial facilities), validation of these objectives through analytical procedures is not required.

**Building code enforcement:** In 2001, a law established the **mandatory review of certain types of new building designs** by a government-approved structural engineer. The review is mandatory for all buildings for public use; all housing built by the national housing and urbanization service; all buildings housing essential services that must be operational for emergencies; and all residential and commercial buildings above three stories. During the construction of a building for public use, a Construction Technical Inspector must supervise the process to confirm that the construction is carried out according to the approved codes.

**Responsibilities of professionals:** Finally, another contributor to the low seismic damage of buildings in Chile is the legal responsibility of the parties involved in their design and construction. Structural engineers are responsible for 10 years, and contractors are responsible for 5 years, following the construction of a building. The first investor or first seller of the building is also initially responsible, but the law does not specify responsibilities even though the intent was for the first seller to be fully responsible for their commercial part and for the work of professionals they hired. In practice, when a building issue arises, all parties involved are jointly sued. Despite the **strict liability requirements for building professionals** in Chile, it is not mandatory for engineers to be professionally licensed to design a building or for building professionals to carry insurance.

### 3.2.4. Non-invasive Seismic Retrofits (Japan, Dr. Susumu Kono)

Since the passage of Japan's Law for the Promotion of Seismic Retrofit in 1995, seismic retrofit measures have been applied to a wide variety of reinforced concrete buildings, including high-rise buildings as well as low- and mid-rise public buildings such as schools. In these applications, the following needs have arisen:

- Retrofit under continuous occupancy and use of the building
- Retrofit measures that do not change the design or function of the building
- Retrofit measures that can be completed in a short period of time

To address these needs, new construction methods and concepts for reinforcement continue to be developed, new materials are being applied, and improvements to existing technologies are being made. In addition to mitigating seismic risk, to be feasible, retrofits must:

- Mitigate impacts on building functions (e.g., lighting, circulation of users, serviceability)
- Minimize negative impacts during construction (e.g., sound, vibration, dust, smell)
- Minimize cost and construction time
- Consider the impact of the retrofit design on existing foundations

To respond to these needs, seismic experts in Japan have developed a variety of new seismic retrofit methods. The following are several examples that may be relevant to consider in other countries:

- **External frames or braces:** New precast concrete frames can be added to the exterior of existing buildings while the building is still in use by remodeling the building facade (Figure 7). Compared to brace systems, frame systems have less of an impact on the appearance of the building and do not block windows and natural light entering a building. The use of precast elements also improves construction speed and reduces noise, dust, and formwork. However,

it is also possible to reinforce an existing concrete frame with cast-in-place concrete entirely from the exterior of the building with steel plates and anchors. This has been done at the Atsuta Police Station in Japan. In cases where the additional weight of the new precast or cast-in-place concrete frame on foundations is problematic, lighter systems, such as external steel braces, can also be considered. External cable systems have also been used (Figure 8).



**Figure 7:** Three-story building before and after retrofit using precast concrete external frames  
(Photo credit: Prof. F. Watanabe, 2006)

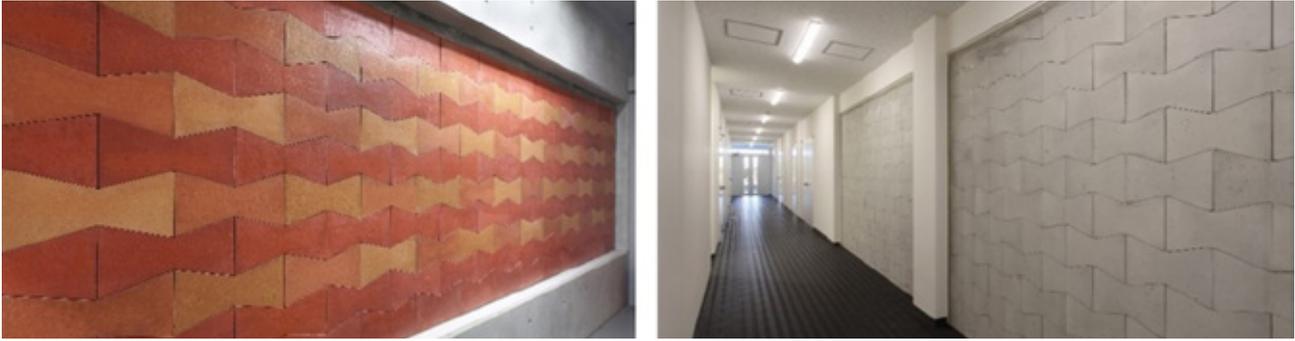


**Figure 8:** Retrofit of a four-story building with external cable system  
(Photo credit: Prof. F. Watanabe, 2006)

- **Seismic walls constructed by stacking GFRP bricks and interlocking blocks:** While not in widespread use, there are examples of building materials that can strengthen and stiffen an existing building's lateral system by creating new or improved infill walls with minimal disruption to building operation. For example, Obayashi Corp. developed a system of glass fiber reinforced plastic (GFRP) bricks that are as strong as steel and lighter than aluminum and can be stacked in a grid pattern as internal building walls while also transmitting light and air flow to the interior of the building (see Figure 9). Also, Takenaka Corp. developed a system of interlocking blocks. The butterfly shape of the concrete blocks allows the blocks to interlock with each other and efficiently transmit horizontal force without the need for reinforcing bars (see Figure 10). Therefore, only the minimum amount of vertical reinforcement is needed to prevent out-of-plane collapse, and anchoring work can be reduced to one-fifth of the ordinary retrofit construction.
- **Seismic isolation for intermediate floors:** Normally when seismic isolation systems are used in the seismic retrofit of intermediate floors, the floor cannot be used during construction. It is possible, however, to phase construction in different sections of a building to allow continuous occupancy of the floors above and below the isolation system. This approach was used in the 40-year-old Koto Ward Office Building where isolators were installed between a parking lot and office space while maintaining the functionality of both spaces.
- **Seismic response control braces:** High performance systems that include seismic damping braces with friction dampers can also be incorporated into external brace retrofit solutions. In a conventional retrofit method, it is necessary to remove the window frames and interior materials first and install the retrofit components next, making it impractical to continue using the building during the reinforcement work. With this quick and low-cost retrofit method, the retrofit work can be done while the building is still in use because the braces are simply attached to the exterior of the building, with minimal material and noise.



**Figure 9:** Retrofit with GFRP bricks at the Obayashi Technical Research Institute in Japan (photo credit: Obayashi Corp.)



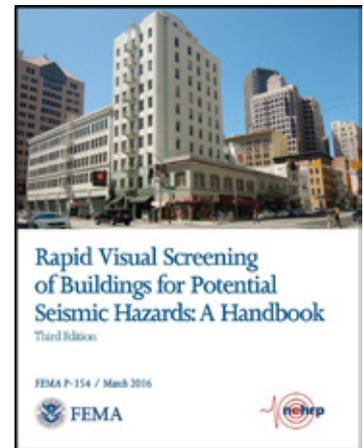
**Figure 10:** Retrofit with interlocking butterfly blocks at the Osaka Main Branch Mido Building (left) and Hyogo Univ. (right) in Japan (photo credit: Takenaka Corp.)

### 3.2.5. Seismic Risk Assessment of Building Portfolios in California (USA, Afshar Jalalian S.E.)

#### California Court Buildings Seismic Safety Program:

In 2019, the expected seismic performance of 200 existing California court buildings was evaluated for Judicial Council of California (JCC), using the FEMA P-154 Rapid Visual Screening (RVS) methodology. A seismic score was assigned to each building and used in conjunction with other scores for various building conditions (e.g., facility condition, fire safety, universal accessibility, environmental hazards, security, overcrowding, and public access to court services) to inform the prioritization of future actions for court building design and construction projects in California.

FEMA P-154 (**Handbook for Rapid Visual Screening of Buildings for Potential Seismic Hazards**) (FEMA, 2015) presents a methodology for **assessing the seismic vulnerability of a large inventory of buildings rapidly and visually** (approximately 1-4 hours per building in total, depending upon its size). The methodology identifies and screens buildings that are potentially seismically hazardous. FEMA P-154 has two levels of evaluation, Level 1 and Level 2. Level 2 is a more detailed evaluation than Level 1. The FEMA P-154 methodology calculates a score for each building based on its structural system, age, visually identifiable deficiencies, site seismicity, and soil type. Only those buildings identified as potentially seismically hazardous require further evaluation by an engineer experienced in seismic design to confirm the assessment. This screening methodology is utilized in many jurisdictions in the U.S. with free trainings expanding the capacity of available evaluators each year.



The advantage of using FEMA P-154 for JCC’s prioritization effort was to allow rapid assessment and scoring using a consistent methodology. Using FEMA P-154, each building was assigned a base score depending on the site seismicity level and building’s structural system. The base score was then modified by adding or deducting points, or modifiers, based on structural deficiencies, soil condition, and the age of the building.

The seismic scores resulting from application of the FEMA P-154 methodology must be calibrated against data from detailed assessments to establish a dividing line in scoring between acceptable and unacceptable risk. For this project, the scores were calibrated based on results of previous ASCE 41/ASCE 31 evaluations of 300 California state buildings that were ranked based on their probability of collapse into four risk categories: Very High Risk (VHR), High Risk (HR), Moderate Risk (MR) and Acceptable Risk (AR). The buildings were then placed into these four Risk Categories based on their FEMA P-154 seismic scores.

### **University of California Seismic Safety Program:**

The University of California (UC) maintains approximately 6,000 buildings across its ten campuses. University of California's first seismic safety policy was issued in January 1975 and has been updated over time to incorporate current knowledge in seismology, structural and geotechnical engineering. The current policy is dated March 2021.

During the 1990s, UC commissioned a seismic review of its buildings in response to significant advancements in structural engineering that followed several major seismic events in California. An action plan was launched for enhancement and renewal of facilities. Since then, UC has invested hundreds of millions of dollars in seismic improvements.

About 10 years ago, the UC, in collaboration with the California Department of General Services and the California State University System, developed a building rating system for seismic resiliency based on the existing California building code. The seismic performance ratings (SPRs) (University of California, 2020) for UC buildings are:

- SPR I - SPR IV: Seismic safety policy compliant
- SPR V: Will require further evaluation and, if confirmed, must be addressed
- SPR VI: Priority for improvement
- SPR VII: Unoccupied and access-restricted

In 2017, the University of California proactively launched a comprehensive, multi-year effort to update seismic safety policies systemwide. The primary goal of this current initiative is to provide an adequate level of safety and well-being for the UC community and the public at large. The updated UC policy requires that every UC building with significant seismic performance deficiencies be retrofitted, replaced, or vacated no later than the year 2030. Efforts to assess and rate every building on each of the ten campuses were launched in 2018.

### **3.2.6. Resilience Rating System for Buildings (USA, Evan Reis S.E.)**

The **US Resiliency Council (USRC) Building Performance Rating System** (USRC, 2019) was developed to take advantage of science and engineering research that had been developed for quantifying the performance of buildings subject to natural perils, such as earthquakes, wind, and flood. In order to bridge the gap between the public's expectations of how buildings were designed to withstand hazards, and those of engineers and building codes, the USRC Rating System was created to communicate complex research in terms that building stakeholders could use to make rational decisions about investing in resilience, and thereby better align expectations among those in the entire stakeholder community.

The USRC Rating System estimates building performance along three dimensions: Safety, Damage, and Recovery Time, for both newly constructed and older buildings. The system consists of one to five stars in each of these three dimensions, with three stars generally aligned with design to modern US building codes. Older buildings built to earlier codes are likely to achieve lower ratings, and buildings built to high performance standards, such as hospitals, are likely to achieve higher ratings.

The rating system is designed to have three key pillars:

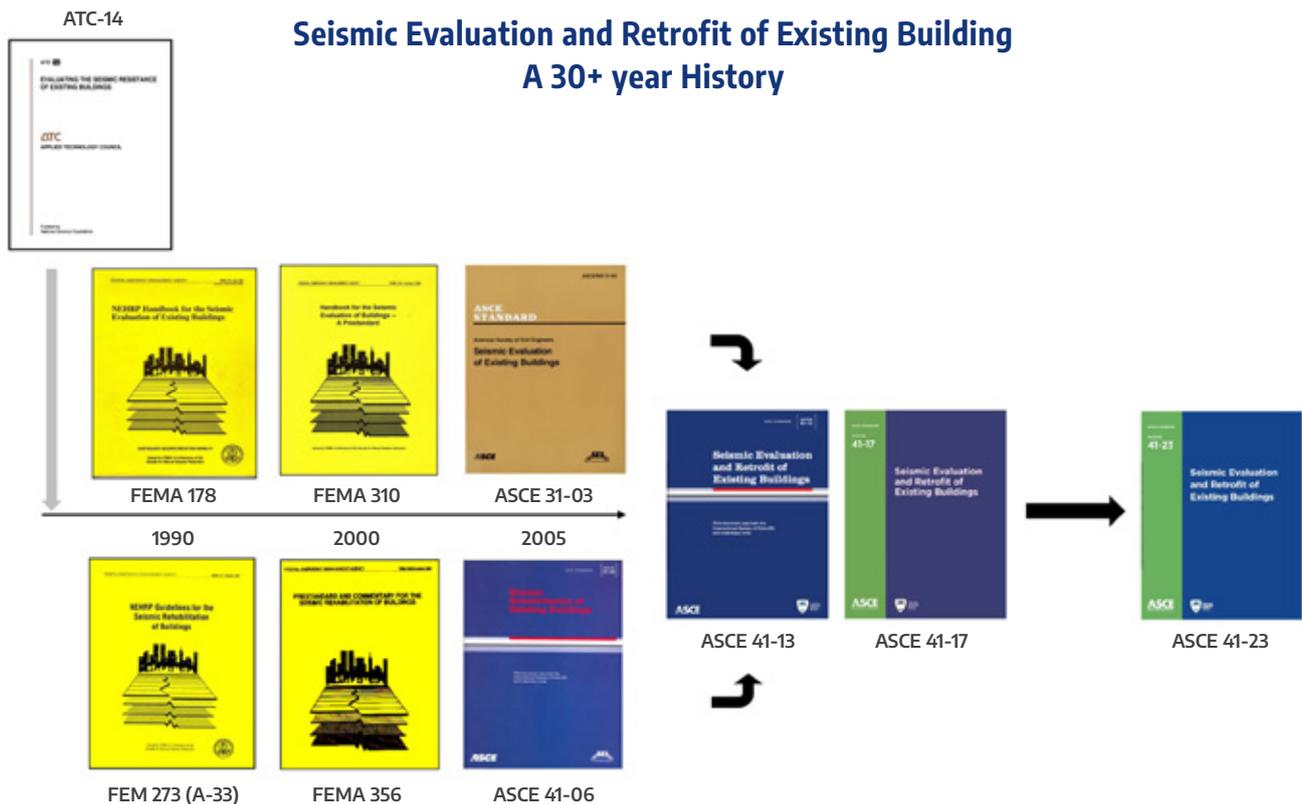
- **Credibility:** A team of highly respected engineers were assembled to evaluate existing research and translate it into a rating system that would be respected by both engineers and the financial sector (insurance and lending). The rating system builds on research that had been ongoing for more than a decade with funding by the U.S. Federal Government, giving it broad credibility.
- **Consistency:** A standardized process was developed for performing a USRC evaluation using expert, certified engineers, and for reviewing the ratings in an objective way to ensure as much as possible that buildings would be rated in a consistent manner, without bias or manipulation.
- **Value:** Unlike most rating systems in existence at the time, the ability to quantify performance was considered essential. To be the most useful for decision making, the **rating system expresses performance in financial, social, and economic terms** that can be used for benefit-cost (BCA) and return on investment (ROI) analyses.

The take-up of the USRC Rating System has been slower than hoped, largely because engineers, who were expected to be the primary drivers of integrating the system with building design, were uncomfortable leading the way and pushing clients to make resilience-based, rather than cost-only based decisions. Nevertheless, as natural disasters continue to impact the United States, lenders, insurers, governments at all levels, and thoughtful owners have been gravitating toward standards that would reduce their risk and increase the market value of their properties. Developers of data centers and laboratories have begun to specify USRC ratings in their design criteria, as have state governments for the construction of mission critical facilities. A tipping point seems to have been reached in the insurance and lending industries as underwriters begin to pull out of markets where building resilience standards are not in place, leaving lenders unable to effectively work in those markets. The USRC expects that in the future, the **financial sector will be the primary driver to raising demand for rating systems.**

In hindsight, and as guidance for others hoping to develop rating systems for other markets or countries, a concerted effort to engage leaders and decision makers among the broader stakeholder community is essential in the beginning of development, so that **awareness and demand for the value of rating systems will drive the design and construction community to respond with more resilient buildings.**

### 3.2.7. Lower Seismic Performance Objectives for Existing Buildings (USA, Chris Poland P.E. S.E.)

**ASCE/SEI 41: Seismic Evaluation and Retrofit of Existing Buildings** (ASCE, 2023) is the dominant seismic retrofit standard in the United States. Its multiple iterations and editions represent nearly 40 years of research and practice by thousands of engineers. As shown in Figure 11, it began as an evaluation guideline published by the Applied Technology Council in 1985 focused on key deficiencies observed in past earthquakes worldwide. With each evolution, committees of professional engineers and researchers crafted the provisions at each step using multi-year consensus processes into a complete evaluation and retrofit standard that is used worldwide on thousands of buildings annually. It fulfills the need for guidelines usable for a wide range of existing building types and formalizes a variety of performance-based evaluation and design techniques.



**Figure 11:** Evolution of Seismic Evaluation and Retrofit Standards in the US

ASCE 41 is organized as a three-tier procedure that begins by defining a series of model building types each with specific checklists that are used to identify potential deficiencies based on observed damage in past earthquakes. The second tier is a simplified deficiency-based procedure that is used to validate the potential deficiencies and direct their retrofit. The third tier provides a sophisticated and more accurate process to be used when appropriate. The underlying principle is to **only require the level of evaluation and retrofit necessary to meet the selected rehabilitation objective in a cost-effective manner.**

**For over 60 years, it has been a common practice in the high seismic regions of the United States to evaluate and retrofit existing buildings to lower performance objectives than used for new buildings.** This practice was commonly justified by the recognition that existing buildings had a shorter life than new buildings, the observation that the cost of achieving full compliance with a standard for new buildings can be disproportionate to the increased benefit, and the reality that newer buildings with minor deficiencies should not need to be retrofitted.

The 2013 edition of ASCE 41 and subsequent editions define this process with the introduction of Basic Performance Objectives for New Buildings (BPON) and for Existing Buildings (BPOE). Buildings evaluated and retrofitted to the BPON are judged to be capable of similar performance to new buildings. Buildings evaluated and retrofitted to the BPOE receive the benefit of a less stringent standard. Both the BPON and BPOE utilize the same structural performance levels but different hazard levels. **Existing buildings are evaluated and retrofitted for shorter return period events.** If the BPOE is selected for the project or a program, this shift in designating a reduction in hazard level is similar to the traditional U.S. practice while providing consistency across seismic zones and analysis procedures. When selected, the BPOE evaluation and retrofit can achieve the same structural performance level as a new building while accepting a higher risk of occurrence.

### 3.2.8. Developing and Implementing San Francisco’s Community Action Plan for Seismic Safety (USA, Ayse Hortacsu P.E.)

In 2013, the San Francisco mayor issued an Executive Directive that required the establishment of a **mandatory program to retrofit wood-frame buildings three-stories or taller** with five or more dwelling units, constructed prior to 1978 with no prior seismic strengthening. In 2023, the program reached 92% completion, meaning over 4,500 buildings (each with 5 or more units) were seismically strengthened.

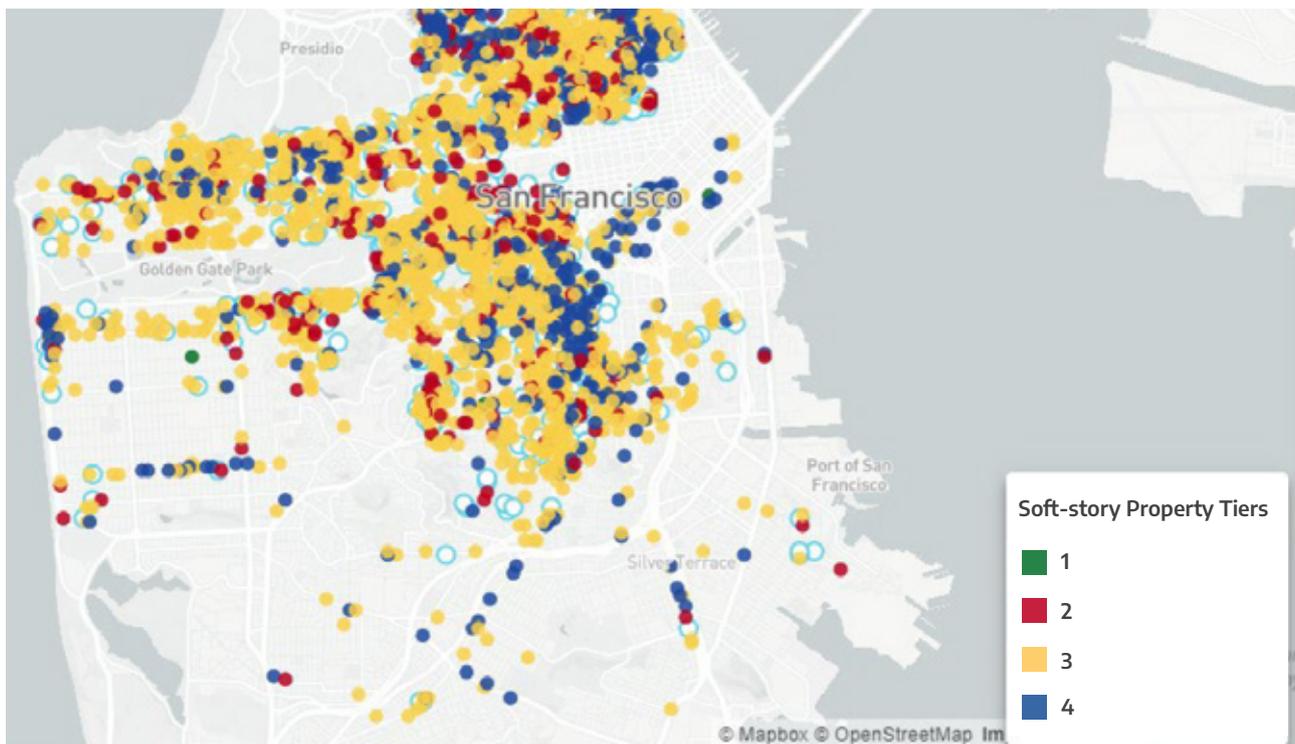


Figure 12: Completed soft story retrofits in San Francisco as of 2023

The mandatory program included technical requirements that established that the retrofit work needed to address the weak/soft or “target” story only (where the number of walls and the wall layout are significantly different from the typical stories above). The technical requirements included three different analysis and design methodologies, including an innovative performance-based approach developed specifically for this type of building vulnerability.

The selection of the specific building type was the result of a 10-year study that developed **San Francisco’s 30-year Earthquake Safety Implementation Plan** (City and County of San Francisco, 2011), including technical work conducted by engineers, as well as input from stakeholders as part of the development of a **Community Action Plan for Seismic Safety**. A parallel grassroots, stakeholder effort by the San Francisco Planning and Urban Research Institute (SPUR, 1990) provided a resilience framework for the plan. The selected building type was both known to be vulnerable (with many having collapsed in the 1989 Loma Prieta Earthquake) and to house a large number of residents, many of whom were considered economically vulnerable.

The Community Action Plan provides 17 recommendations and defines a 30-year implementation program. The recommendations are related to understanding the risk, informing the public, updating

codes and standards, retrofitting vulnerable structures, providing incentives, setting post-earthquake repair standards, and addressing fire following earthquakes.

The City of San Francisco is continuing implementation of the 30-year plan. They have completed evaluation of private school buildings, developed an ordinance for inspection of building facades, and are currently developing an **ordinance for seismic retrofit of older concrete buildings**, similar to those in Istanbul (1960's non-ductile construction, multi-story, residential buildings). Development of the concrete program has again included co-design opportunities with the affected population, e.g., building owners, tenants, and hotel owners.

### 3.2.9. Retrofitting Unreinforced Masonry Buildings in Seattle, Washington (USA, Amanda Hertzfeld<sup>1</sup>)

The City of Seattle in Washington State has over 1100 seismically vulnerable unreinforced masonry buildings at risk of collapse in a large earthquake. While moving in the direction of a mandatory, phased-in retrofit program for URM buildings, Seattle is currently implementing a voluntary URM retrofit program. To support the program, the city has developed a draft URM Retrofit Technical Standard (Seattle Department of Construction and Inspections, 2023) that allows the use of an Alternate Method to the code-based retrofit method for certain types of buildings. The method applies to residential and other non-essential function buildings that are six stories or less that meet certain qualifications (e.g., a lateral system verified through simple rule-of-thumb methodologies, no weak story irregularities, minimum strength requirements for masonry walls and mortar based on in situ testing). The Alternate Method, informed by California's Bolts+ Standard, allows for the use of reduced seismic hazard levels and more targeted improvements addressing critical components, such as wall anchorage, diaphragm shear transfer, out-of-plane wall bracing, and parapet bracing. While the retrofit does not achieve any specific performance level, **cost estimates demonstrate that the proposed Alternate Method of retrofit is 3 to 4 times less expensive than the code-based retrofit method** (NDC, 2019).

Many of the unreinforced masonry (URM) buildings in Seattle have historic preservation value. The seismic retrofit and hotel conversion of two historic URM buildings in the city demonstrates ways that financing and financial incentives can be creatively layered in a project to support cost-effective seismic retrofit and other building upgrades. These projects used a combination of Federal Low-Income housing tax credits, Federal and state historic preservation tax credits and loans, green building credits, solar power credits, and Transfer of Landmark Development Potential (e.g., Transfer of Development Rights, or TDR). Together, these incentives reduced the cost of the retrofits by almost 40%, most of which came from historic preservation tax credits and TDR. Transfer of Development Rights refers to policies that permit buildings with excess development capacity (i.e., zoned development capacity minus existing development) to sell the value of those unused development rights (NDC, 2019). While TDR is an effective approach for supporting seismic retrofits, the city has identified barriers to expanding the use of TDR to offset the cost of seismic retrofits, which it is currently working to address.

### 3.2.10. Certification of Engineers (Multiple Countries)

During the workshop, the international experts also shared information about the qualifications, certifications and licenses necessary for engineers in their respective countries to be authorized to design buildings or review building designs by others. The following summaries demonstrate a range of approaches across countries but with a consistent emphasis on regulatory approaches that ensure quality and safety in building design and construction.

## Mexico:

To become licensed in Mexico City (Mexico City, 2024), engineers must complete a college degree. In reality, anyone with a college degree could design a structure. However, such design must be checked by at least another engineer and architect, called Director Responsible of the Work (DRW). The DRW must pass a competency exam and earn their accreditation from their state's licensure board. Typically, licensure boards are administered by the local building or infrastructure department. DRWs must renew their accreditation every five years, showing proof that they completed the mandatory professional development hours. For large, complex or critical buildings (such as hospitals and schools) another professional must participate: the Co-Responsible of Structural Safety, CRSS. CRSSs are accredited by the same board as DRWs, although examinations are different in scope and depth. Two levels of CRSSs exist: Level 2 is for projects where complex configurations or large irregularities exist, with difficult soil conditions and/or deep excavations, for important (i.e., critical) structures, and/or where new materials or advanced hazard-estimation methodologies or analysis techniques are used. Mexico City requires the design engineer to sign and submit engineering plans and drawings to the DRW and CRSS, if necessary. DRW and CRSS are, in letter, responsible for reviewing compliance to the code. However, in practice, the judicial system has found them responsible for any material and human losses. All rehabilitation projects must be revised by a DRW and CRSS, regardless of their size and occupancy. At the time of this writing, a new Mexico City Construction Standard Law is under discussion. One objective of the new law is to define the attributions and responsibilities of the stakeholders involved in building and infrastructure projects. The new law distributes stakeholders' responsibilities based on their work, aiming at establishing high ethical standards of practice. Under the new law, a professional design licensure will be established, similar to the American practice.

## Chile:

In Chile (Chile, 2018), to sign structural drawings, one only needs to have a degree title as Civil Engineer. There is no requirement to be registered in any institution or to have a professional license or insurance. However, structural review is mandatory for structures higher than 4 stories and others depending on their use. There are three levels of structural reviewer. The highest standard reviewer requires demonstration of permanent design activities of complex structures (a minimum of 12 years of experience, 150,000 sq m of design in the last 10 years, and a minimum of five buildings of dimensions greater than 10,000 sq m in the last 8 years). The certification as reviewer must be renewed every six years.

## Japan:

In Japan (MLIT, 2024), there are three levels of qualifications for architects (note: in Japan, architecture covers any building-related profession, including structural engineering). The First-Class Architect is the highest level of qualification for architects in Japan. First-Class Architects have extensive knowledge, experience, and expertise in architectural design, construction, and project management. They are authorized to independently engage in all aspects of architectural practice, including designing large-scale and complex buildings, managing construction projects, and ensuring regulatory compliance. To obtain the qualifications, individuals must meet specific educational requirements, gain practical experience in the field, and pass a national examination administered by the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The exam covers a wide range of topics related to architecture, including design principles, building technology, structural engineering, architectural laws and regulations, environmental considerations, and project management. Additionally, continuing education and professional development are required to maintain and to renew architect qualifications in Japan, typically every ten years.

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<sup>1</sup> Amanda Hertzfeld was not a participant in the March 2024 workshop, but information provided by her was included in this report due to its relevance to workshop discussions.

## USA:

To become a licensed Professional Engineer (P.E.) in the U.S. (NSPE, 2024; CCR, 2023), one must obtain a Bachelor's Degree in Engineering from an accredited college, pass an 8-hour Fundamentals of Engineering (Engineer in Training) exam, work under a Professional Engineer for two years, and finally pass an 8-12 hour PE examination. To obtain a Structural Engineering (S.E.) license, after obtaining the P.E. one must have three additional years of work experience under the supervision of an S.E. and pass a 23+ hour exam. To be eligible to renew a P.E. or S.E. license, one "must" regularly complete continuing professional development courses, depending on the state in which one is licensed. Only licensed P.E. or S.E. engineers may prepare, sign, seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients. In California and some other states, a licensed S.E. is required to design certain essential facilities, such as schools and hospitals. In many federal, state, and municipal agencies, certain governmental engineering positions, particularly those considered higher level and responsible positions, must be filled by licensed professional engineers.

## 4 RECOMMENDATIONS

### 4.1 Overview of Recommendations Framework

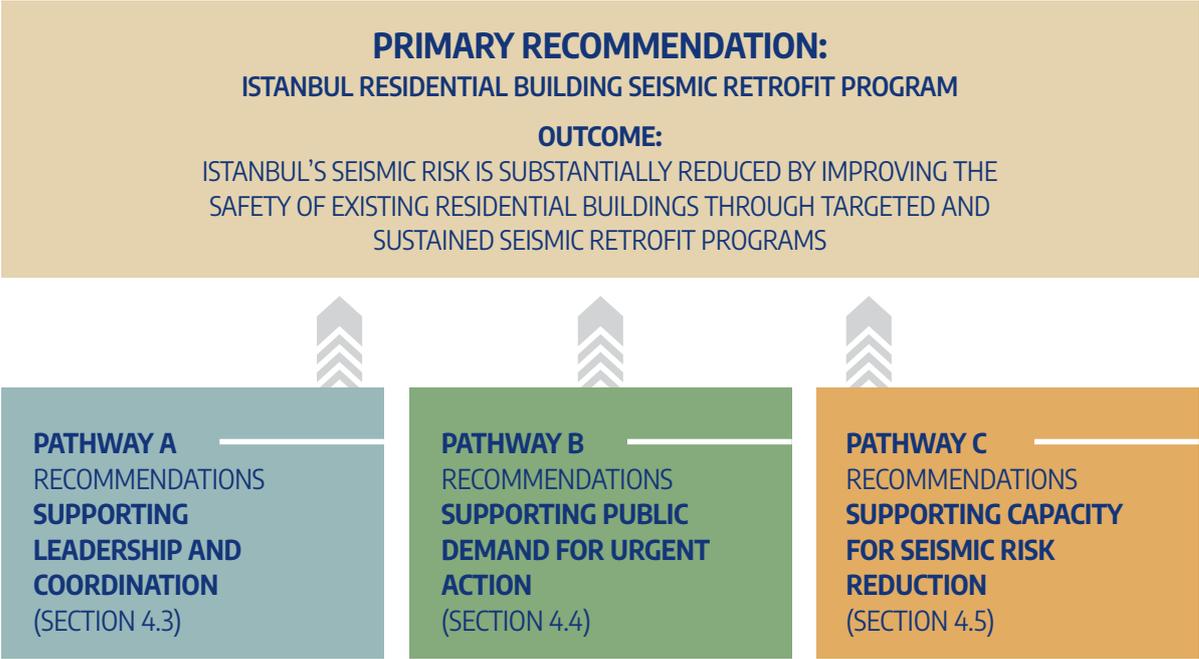
The collaborative discussions that followed the international case study presentations during the March 2024 workshop in Istanbul yielded a variety of recommendations – some quite broad, some very specific - for improving the seismic safety of residential buildings in Istanbul. These workshop outputs were analyzed by the ATC-165 TAC and organized into a recommendations framework shown.

The framework includes recommendations organized around three pathways (A, B, C) supporting the primary recommendation (see Section 4.2) of a **widespread mandatory residential building seismic retrofit program in Istanbul, especially for highest risk residential buildings, to prevent their collapse in the Marmara Earthquake.**

**The three pathways (A, B, C) support improvements to the broader enabling environment to facilitate the successful creation and implementation of a seismic retrofit program.** With improved leadership and coordination (Pathway A – see Section 4.3), an informed and engaged public demanding action (Pathway B – see Section 4.4), and a capable and responsible building industry (Pathway C – see Section 4.5), Istanbul can launch a sustained seismic retrofit campaign and programs that can, over time, make a significant contribution to reducing the city’s seismic risk.

While the actions are presented in different pathways for clarity, they are interrelated, and many actions can and should be pursued in parallel. For example, the further study of retrofit solutions should not delay the start of a seismic retrofit program because existing solutions are already available. **Urgency of action is of utmost importance.**

**Further development of these recommendations into a coordinated action plan is outside the scope of this project and would require deeper engagement with key public sector, private sector, and civil society stakeholders. It is our hope that this report will support this engagement, leading to further elaboration and implementation of these actions.**



## 4.2 Primary Recommendation: A Residential Building Seismic Retrofit Program in Istanbul

Istanbul must urgently implement a seismic retrofit program, focusing initially on mandatory retrofits for the highest risk residential buildings to achieve a “collapse prevention” performance objective. This program should prioritize retrofits not only for the highest risk buildings but for identified archetype buildings that can be feasibly retrofitted in a short timeframe with simplified retrofit solutions to prevent structural collapse in the event of the Marmara Earthquake. This program will also significantly improve the response and recovery time needed for smaller earthquakes.

The program can be implemented in parallel with the existing Urban Transformation Law applications or as a standalone campaign. To date, the Urban Transformation Law has primarily focused on the replacement of high-risk buildings as opposed to their retrofit, and in recent years, the pace of building replacement through the program has fallen short of the expectations. The existing public funding from the Urban Transformation Law could be leveraged to cover most, if not all, of the cost of retrofitting of highest risk residential buildings if seismic performance standards that are lower than current code requirements are permitted.

Simplified retrofit designs targeting the collapse prevention performance standard – including external and less invasive solutions that minimize disruption to residents – could be piloted in the near term by private companies, including construction firms and real estate firms, could also be encouraged to pilot new approaches themselves to build more public trust in the feasibility of retrofit solutions.

## 4.3 Pathway A: Recommendations supporting Leadership and Coordination

### PATHWAY A

#### SEISMIC RISK REDUCTION IS ENABLED THROUGH IMPROVED PUBLIC AND PRIVATE SECTOR LEADERSHIP AND COORDINATION

One of the underlying barriers to seismic risk reduction efforts in Istanbul identified by the ATC-165 TAC is the lack of adequately sustained and coordinated leadership for seismic safety, at both national and municipal levels. While numerous efforts are in progress, they are not well-coordinated, and many are rather limited in scale and impact by policy and regulatory barriers. Ad hoc efforts by members of academia and civil society also lack coordination and mechanisms for building consensus and unified messaging that can help to support advocacy, advise the government, and ultimately drive action. This pathway intends to address these barriers and enable improved seismic risk reduction through improved public and private sector leadership and coordination via two sets of actions:

### PATHWAY A1

#### OUTPUT:

Public sector, coordinated at national and municipal levels, enables and incentivizes residential seismic retrofits through policy and regulatory changes.

#### RECOMMENDED ACTIONS:

- 1 — Create a **seismic resilience plan** for Istanbul with short- and long-term goals, targeting retrofits with collapse prevention seismic performance objective of highest risk residential buildings in the short term, and incorporating longer-term community resilience and recovery goals (see USA (San Francisco) case study, Section 3.2.8). The plan should:
  - a. Prioritize interventions using building inventory and risk data (coordinated with actions under Pathway A.2 and B.1).
  - b. Use **cost-benefit analysis** to study alternate retrofit methods and to identify the “break even” point for retrofitting versus replacement for different building archetypes. (see USA (Seattle) case study in Section 3.2.9)
  - c. Include the **social costs** (e.g. time to implement and resulting resident displacement) in addition to physical costs in the cost-benefit evaluation of options.
  - d. **Identify funding needs** for implementation.
  - e. Identify needs for **temporary housing** (6-12 months) for the relocation of residents during retrofits, if necessary.

In addition to initially targeting the highest risk buildings that are feasible to retrofit, consider **prioritizing the retrofit of buildings and infrastructure that are critical to disaster resilience goals** (e.g., buildings that would block emergency road access in the event of collapse).

- 2 — **Establish and empower a Seismic Advisory Council** to lead the development of building seismic retrofit guidance, the oversight of retrofit campaigns and programs, including as part of the Urban Transformation Law, and to support public awareness and advocacy (see Mexico case study in Section 3.2.1).
- 3 — Enable modifications to national building regulations to allow an **adequate yet feasible performance standard for retrofits** of existing high-risk buildings (e.g., collapse prevention performance under exposure to earthquake ground motion levels based on the Marmara earthquake scenario) (see USA (ASCE-41 and Seattle) in Sections 3.2.7 and 3.2.9 and Mexico case studies in Section 3.2.1).

- 4 — Pass a **special law at city level** to enable retrofits including technical requirements, subsidies, and financial incentives, including adjustments to the existing Urban Transformation Law to address identified barriers to implementation of retrofits through the program (e.g., the percentage of agreement by homeowners approval is higher for retrofits than for replacements; also, policies related to architectural features of facades limit retrofit solutions) (see Mexico case study Section 3.2.1).
- 5 — Enable **improved building regulation enforcement** through policy change and budgeting decisions including plan review and onsite inspection (coordinated with actions under Pathway C.1. Also see Chile case study in Section 3.2.3).
- 6 — Identify potential **funding solutions**:
  - a. Provide **government grants, loans or other financial incentives** (e.g., subsidies, property or personal tax deductions) for retrofits, with funding linked to changes in PERA Seismic Safety Ratio (SSR). If retrofit solutions with relaxed performance standards are developed to fall within the existing grant amounts available to homeowners as part of the Urban Transformation Law, additional funding may not be necessary. (see case studies from Mexico in Section 3.2.1, Italy in Section 3.2.2 and USA (Seattle) in Section 3.2.9).
  - b. Justify the investment through **cost-benefit analysis** to show that the cost to the Turkish government to retrofit buildings in advance of an earthquake will be a fraction of the reconstruction costs they will need to bear (see Italy case study in Section 3.2.2). This work is already being advanced to estimate the costs and demonstrate the value of seismic retrofits (Aydoğdu, 2024).
  - c. Pair retrofits with **mandatory earthquake insurance** for homeowners (see case study from Italy in Section 3.2.2).
  - d. Consider other financial incentives for private sector retrofits including transfer of development rights (see USA (Seattle) case study in Section 3.2.9)
  - e. Identify **green building or climate funds** that can support integrated seismic + energy-efficiency retrofits, supporting risk reduction and climate mitigation (i.e., reduction of carbon footprint) simultaneously (see USA (Seattle) case study in Section 3.2.9).

## PATHWAY A

### SEISMIC RISK REDUCTION IS ENABLED THROUGH IMPROVED PUBLIC AND PRIVATE SECTOR LEADERSHIP AND COORDINATION

One of the underlying barriers to seismic risk reduction efforts in Istanbul identified by the ATC-165 TAC is the lack of adequately sustained and coordinated leadership for seismic safety, at both national and municipal levels. While numerous efforts are in progress, they are not well-coordinated, and many are rather limited in scale and impact by policy and regulatory barriers. Ad hoc efforts by members of academia and civil society also lack coordination and mechanisms for building consensus and unified messaging that can help to support advocacy, advise the government, and ultimately drive action. This pathway intends to address these barriers and enable improved seismic risk reduction through improved public and private sector leadership and coordination via two sets of actions:

## PATHWAY A2

### OUTPUT:

Civil Society and academia share information, develop practical, consensus-based retrofit solutions, and advocate for seismic risk reduction in a coordinated fashion.

### RECOMMENDED ACTIONS:

- 1 — Source members of the **Seismic Advisory Council** (see action under Pathway A.1) from the most respected engineering institutions in Türkiye, building on existing ad hoc academic and practitioner collaborations and creating a credible, unified message to guide the public sector on technical approaches for seismic retrofits (see case studies from Mexico (Section 3.2.1) and USA (Section 3.2.7)).
- 2 — Create a **clearinghouse of existing data** to support risk assessment and retrofit solution development, including data and learnings from past and current projects and research to feed into prioritization efforts of the seismic resilience plan in the actions under Output A.1.
- 3 — Develop **consensus-based technical standards**, led by the Seismic Advisory Council, for feasible (i.e., simple, efficient, low-invasiveness, and financially viable) seismic retrofit solutions for common archetypes of “very high risk” existing buildings targeting a collapse prevention performance for a deterministic Marmara earthquake scenario (see the case studies from the USA (Section 3.2.7) and Mexico (Section 3.2.1)).
  - a. Use simplified analysis methods and **strict prescriptive design rules** (i.e., drift limits, minimum shear wall areas, elimination of irregularities, and capacity-design approaches). The soon-to-be-released technical standard providing these types of simple, prescriptive requirements for new buildings can serve as a model for possible simplified retrofit standards (see case studies from Mexico (Section 3.2.1), Chile (Section 3.2.3), USA (Sections 3.2.7 and 3.2.9)).
  - b. Focus on **addressing critical deficiencies** (e.g., soft stories, short columns).
  - c. Prioritize **quick solutions that reduce disruption** to and displacement of residents including external and/or less invasive solutions. For example, for a 4-5 story RC frame building built before 2000, it may be possible to improve the PERA Seismic Safety Ratio by 2 classes by addressing its main deficiency (lack of sufficient transverse reinforcement leading to brittle collapse) through external confinement of columns at the weak/soft first story where collapse usually initiates. (see case studies from Japan (Section 3.2.4) and USA (Seattle) (Section 3.2.9)).
  - d. Develop solutions that can be applied to a block of **connected buildings**.
  - e. Identify situations in which **base isolation and energy dissipation** solutions could be applied.
  - f. Consider opportunities to integrate energy efficiency improvements into retrofits (e.g., insulated external shear wall panels).
- 4 — Engage in **outreach and advocacy**, guided by the Seismic Advisory Council, to build awareness and interest among the public for seismic retrofitting of existing residential buildings (see case study from USA in Section 3.2.8). studies from the USA (Section 3.2.7) and Mexico (Section 3.2.1)).

## 4.4 Pathway B: Recommendations supporting Public Demand for Urgent Action

### PATHWAY B

#### PUBLIC DEMAND FOR SEISMIC RISK REDUCTION IS INCREASED THROUGH IMPROVED UNDERSTANDING AND COMMUNICATION OF RISK

Through two sets of recommended actions, this pathway intends to improve the public's understanding of seismic risk and their demand for action by leveraging existing and new data to support coordinated risk assessments and the development of feasible retrofit solutions and building consensus on priorities for seismic retrofits through data-driven approaches and public engagement. While the earthquakes that occurred in the southeastern part of Türkiye in 2023 renewed public awareness of Istanbul's seismic risk, this heightened awareness has not been adequately translated to demand for urgent action to improve the seismic safety of existing buildings. Some explanations for this disconnect that were discussed in the workshop include 1) a lack of knowledge among building owners and occupants of their specific risk of serious injury or death due to the high vulnerability of the buildings they occupy; 2) a lack of awareness of the existence of widely available, recognized and safe technical retrofit solutions for improving the seismic safety of existing buildings; 3) the impression that seismic retrofits are impractical, too expensive, or unfeasible for other reasons; 4) frequent policy changes and inconsistent incentives programs by the government that disincentivize early action on risk reduction; and 5) a fatalistic view that nothing can be done.

### PATHWAY B1

#### OUTPUT:

The seismic risk of the existing building inventory is understood, and there is consensus on a prioritization approach for a seismic retrofit program targeting collapse prevention retrofits for residential buildings.

#### RECOMMENDED ACTIONS:

- 1 — Develop consensus-based **guidelines for the simple, rapid visual assessment** of existing residential buildings, including potential opportunities to leverage Artificial Intelligence (AI) and remote sensing for scale and efficiency (see USA case study (FEMA P-154) in Section 3.2.5). The PERA seismic risk rating methodology, which has already been used by the Istanbul Metropolitan Municipality over the past several years, has undergone validation and improvement, and has the support of leading Turkish earthquake experts, is well-placed to be expanded in use in Istanbul and adopted for nation-wide application.
- 2 — Create a **comprehensive and consistent inventory of existing buildings. Use the building inventory to identify the highest risk archetype buildings** that can be feasibly retrofitted with targeted measures (e.g., based upon the year of construction and/or deficiencies such as soft stories, short columns) to feed into the development of a prioritization of retrofit measures as part of the seismic resilience plan in Pathway A.1. The Istanbul Metropolitan Municipality is in the process of creating such an inventory using the PERA methodology; however, it is limited in reach due to limitations in the number of engineers. Insufficient training of site engineers has also led to inconsistencies in data. Efforts to train more site engineers and to improve the training of site engineers should be prioritized to support the creation of a comprehensive and reliable buildings database.

### PATHWAY B2

#### OUTPUT:

Public demand for urgent action on residential seismic retrofits is increased through public awareness and advocacy campaigns.

#### RECOMMENDED ACTIONS:

- 1 — Develop **advocacy messages** to share widely with public officials, private sector, and public media to support education and awareness of the seismic risk in Istanbul.
- 2 — **Educate the public on retrofitting** solutions in ways that address their concerns and reluctance to support them, including showcasing buildings that have been retrofitted in Türkiye and around the world.
- 3 — Develop **compelling images and cost estimates** that demonstrate the feasibility of retrofitting an existing building within the budget range of public grants provided to homeowners as part of the Urban Transformation Law.
- 4 — Launch an international design **competition for residential retrofitting solutions** for Istanbul to draw attention to the issue and optimism for solutions.
- 5 — Highlight examples of **grassroots efforts by property owners and citizens** to promote seismic safety improvements for residential buildings.

## 4.5 Pathway C: Recommendations supporting Capacity for Seismic Risk Reduction

### PATHWAY C

**PUBLIC AND PRIVATE SECTOR CAPACITY TO MITIGATE SEISMIC RISK AND PREVENT NEW RISK IS IMPROVED**

#### PATHWAY C1

**OUTPUT:** Enforcement of building regulations is improved through public and private sector mechanisms.

##### RECOMMENDED ACTIONS:

- 1 — **Improve government enforcement mechanisms** for building construction:
  - a. Increase resources for improved site inspection during construction, including better government oversight of independent inspection companies.
  - b. Train building inspectors on construction quality, including retrofits.
  - c. Monitor completed buildings after construction for changes via Artificial Intelligence (AI) and remote sensing.

#### PATHWAY C2

**OUTPUT:** Building professionals are licensed, insured, and held to a higher standard of care.

##### RECOMMENDED ACTIONS:

- 1 — Require **professional engineering licensure** for structural engineers in Türkiye both for new design and retrofit projects (see case studies in Section 3.2.10).
- 2 — Increase liability for building professionals as well as the real estate sector (e.g., first seller responsible) (see Chile case study in Section 3.2.3) and make **professional liability insurance** mandatory.
- 3 — Create a special, **non-compulsory certification program** for building firms and professionals with special training on seismic retrofits to enhance the appeal of and draw business to qualified contractors.
- 4 — Develop a **seismic building ratings program** that is recognized by the insurance sector, financial associations, and government to reward and publicize seismic safety and resilience in new buildings and retrofitted existing buildings, including through property tax adjustments. Consider linking the program to professional certification (see USA case study on resilience ratings in Section 3.2.6).

Even if the seismic risk of Istanbul were well-understood and there was public demand, leadership and institutional coordination were in place to move a seismic retrofit program forward, the success of such a program would depend in part upon the capacity of public and private sector built environment professionals implementing the work. Furthermore, if quality controls are not in place to ensure that the city's building stock does not become more vulnerable over time, the net risk reduction from a potential seismic retrofit program in Istanbul would be negligible. Therefore, this pathway focuses on the creation of more consistent, reliable, and safe construction of both new buildings and retrofits, building on improvements that have been made to the sector over the past decade by the ISMEP program. It also suggests actions that will help ensure that the built environment is not made riskier through unauthorized construction, such as the addition of new stories to existing buildings or the removal of walls or columns. Finally, it recommends enhancements in training and qualifications for engineers and contractors engaged in building design, construction, and retrofit.

#### PATHWAY C3

**OUTPUT:** Building professionals receive training on seismic risk evaluation, seismic design, and disaster preparedness to support implementation of a seismic retrofit and risk mitigation program.

##### RECOMMENDED ACTIONS:

- 1 — **Train building firms and professionals** at scale (including by the Chamber of Civil Engineers and other associations in the construction sector) on the principles of **seismic risk reduction and common vulnerabilities** in design and construction to promote seismic safety. Include in the training practice-oriented recommendations for non-structural components to avoid damage. These training materials can be posted on the clearinghouse established in Pathway A.2.
- 2 — Develop specialized training materials for simplified retrofit solutions applicable to typical buildings for building firms and professionals (linked to non-compulsory certification program in Pathway C.2).
- 3 — Train building firms and professionals to conduct pre-disaster risk assessments according to the PERA methodology as well as post-disaster damage assessments and to repair building damage based on new damage repair standards for archetype buildings.

## 5 CONCLUSION

This report provides a set of coordinated recommendations for reducing life losses through the sustained and long-term seismic retrofit of existing high-risk residential buildings in Istanbul. The recommendations are based upon the study and adaptation of relevant international practices and precedents shared by international seismic experts. An important feature of this effort has been the collaboration between Turkish and international seismic experts to begin to build technical consensus around necessary actions.

The recommendations in this report are deliberately wide-ranging, including both high-level ideas and specific technical details, but organized in a way that is meant to enable further elaboration of specific concepts or implementation of specific components by different stakeholders.

The intent is for the recommendations in this report to support further engagement with key stakeholders including the public sector, private sector, and civil society, ultimately transforming these ideas into coordinated action plans and the sustained, on-the-ground action that is urgently needed.



**A study never saved a life or prevented property damage – studies are only effective when their results and recommendations stimulate actions that mitigate the effects and consequences of future disasters.**

– ATC-52-2 CAPSS Project



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# APPENDIX A-LIST OF PARTICIPANTS

## List of Advisory Council and Workshop Participants

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Yunus Uçar	İPKB İSMEP
Saygın Kavaz	İPKB İSMEP
Tuğkan Tanır	World Bank

# APPENDIX B-WORKSHOP AGENDA

**Workshop on Seismic Risk Reduction in Istanbul**  
organized by the Applied Technology Council

**Swissotel Istanbul**  
March 12-13, 2024

## Workshop objectives:

Together, we will identify **potential feasible solutions for seismic risk reduction** that have been successfully implemented in other countries and begin to adapt and link these solutions into recommended pathways for further exploration for improving the seismic safety and resilience of residential buildings in Istanbul.

Our ultimate goal is to contribute to the development of innovative solutions towards the preparation of a Plan for Reducing Earthquake Risk and Improving Recovery in Istanbul

WORKSHOP SCHEDULE – DAY 1 Tuesday, March 12, 2024	
9:00 – 9:30	Opening Remarks <ul style="list-style-type: none"><li>Welcome (Özdoğan)</li><li>Workshop Overview (Hortaçsu)</li></ul>
9:30 – 10:30	Understanding the Context – Gaps, Barriers, Opportunities <ul style="list-style-type: none"><li>Summary of pre-work (Erdik)</li><li>Existing Initiatives: İPKB</li><li>Existing Initiatives: KEYM</li><li>Existing Initiatives: DASK</li><li>Questions and answers</li></ul>
10:30 – 10:45	Coffee break
10:45 – 12:00	Learning from International Experience Part 1 <ul style="list-style-type: none"><li>International case study: Mexico (Alcocer)</li><li>International case study: Chile (Boroschek)</li><li>Questions and answers</li></ul>
12:00 – 13:00	Lunch break
13:00 – 14:15	Small group discussions Part 1
14:15 – 14:30	Coffee break
14:30 – 15:45	Learning from International Experience Part 2 <ul style="list-style-type: none"><li>International case study: Italy (Calvi)</li><li>International case study: Japan (Kono)</li><li>Questions and answers</li></ul>
15:45 – 16:45	Small group discussion Part 2
16:45 – 17:00	Wrap up Day 1 (Hortaçsu)
17:00	Adjourn

**WORKSHOP SCHEDULE – DAY 2**  
**Wednesday, March 13, 2024**

9:00 – 9:30	<p>Welcome and Review</p> <ul style="list-style-type: none"> <li>Welcome (Erdik)</li> <li>Summary of key findings and recommendations from Day 1 (Hortaçsu)</li> </ul>
9:30 – 10:45	<p>Learning from International Experience Part 3</p> <ul style="list-style-type: none"> <li>International case study: United States of America (Poland, Jalalian, Reis, Hortaçsu)</li> <li>Question and answer</li> </ul>
10:45 – 11:00	Coffee break
11:00 – 12:00	Small group discussions Part 3
12:00 – 13:00	Lunch break
13:00 – 14:00	<p>Improving Building Regulations to support seismic risk reduction</p> <ul style="list-style-type: none"> <li>Global examples of building regulation reform (Laberenne)</li> <li>Panel discussion (Alcocer, Boroschek, Calvi)</li> <li>Question and answer</li> </ul>
14:00 – 14:20	<p>Identifying High Priority Recommendations</p> <ul style="list-style-type: none"> <li>Group activity and voting</li> </ul>
14:20 – 14:35	Coffee break
14:35 – 15:30	Identifying High Priority Recommendations (continued)
15:30 – 15:45	Wrap and Thank you
15:45	Adjourn

