

Development of Seismic Performance Objectives for Nonstructural Components

17th U.S.-Japan-New Zealand Workshop on the Improvement of Structural Engineering and Resilience

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Acknowledgements

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ATC-120 Project

- Funded by the National Institute of Standards and Technology
- Initiated in 2014
- Objective:

Improve technical aspects of nonstructural system design in the areas that will have the largest impact for public safety and economic welfare





Furniture falling over



Phipps et al. (11NCEE)





Sprinkler Damage







Phipps et al. (11NCEE)





Egress





Phipps et al. (11NCEE)





Phase 1

- Literature review
 - earthquake observations
 - code development
 - analytical research
 - nonstructural testing
- Input from practitioners







Phase 2 - Objectives

- Develop seismic performance objectives
- Perform a comprehensive review of all factors contributing to seismic force demands on nonstructural components and systems
- Conduct a detailed assessment of U.S. code requirements.





Current U.S. Nonstructural Performance Objectives

The objectives of the 2015 NEHRP Provisions are "to provide reasonable assurance of seismic performance that will:

- 1. Avoid serious injury and life loss due to
 - a. Structural collapse

b. Failure of nonstructural components or systems

c. Release of hazardous materials

- 2. Preserve means of egress
- 3. Avoid loss of function in critical facilities, and
- 4. Reduce structural and nonstructural repair costs where practicable."











Identify Expected Performance



A qualitative measure of nonstructural damage based on <u>hazard levels</u> and <u>consequences</u>

HAZARD LEVEL	RISKS Associated with Damage
FREQUENT Eq.	SAFETY
DESIGN Eq	PROPERTY
MCE _R	FUNCTION





Expected Performance in Code-Designed Buildings

		Risk with Components Not Required to Function following the Design Earthquake (i.e., $I_p = 1.0$)			Risk with Components Required to Function following the Design Earthquake (i.e., $I_p = 1.5$)			
Performance ⁽¹⁾		Frequent Design Earthquake Earthquake		MCER	Frequent Earthquake	Design Earthquake	MCE _R	
Safety	Minor falling hazards with limited consequence	Low	Substantial	Extensive	Minimal	Low	Substantial	
	Significant falling hazards that can cause casualties of one or several individuals	Minimal	Localized and relatively small	More extensive and larger	Minimal	Minimal	Localized and relatively small	
	Significant falling hazards that can cause casualties of a large number of people	Minimal	Minimal	Low	Minimal	Minimal	Low	
	Impact to egress	Minimal	Low	More	Minimal	Minimal	Low	
	Hazardous material release	Minimal	Minimal	Low	Minimal	Minimal	Low	
	Fire	Minimal	Low	More	Minimal	Minimal	Low	
	Impact to adjacent space	Minimal	Low	More	Minimal	Low	More	
	Nonstructural damage to structural system	Minimal	Low	More	Minimal	Minimal	Low	
Property	Local nonstructural damage/repair	Low	Substantial	Extensive	Minimal	Low	Substantial	
	Global nonstructural damage/repair	Minimal	Low	More	Minimal	Minimal	Low	
Function	Loss of function	Minimal	Not applicable	Not applicable	Minimal	Minimal	More	

Performance objectives are targets; there is no guarantee that damage more severe than the target will not occur.





Expected Performance in Code-Designed Buildings

		(Risk with Components Not Required to Function following the Design Earthquake (i.e., $I_p = 1.0$)			Risk with Components Required to Function following the Design Earthquake (i.e., $I_p = 1.5$)			
Performance ⁽¹⁾			Frequent Earthquake	Design Earthquake	MCER	Frequent Earthquake	Design Earthquake	MCE _R	
	Minor falling hazards with limited consequence		Low	Substantial	Extensive	Minimal	Low	Substantial	
	Significant falling hazards that can cause casualties of one or several individuals	9	Minimal	Localized and relatively small	More extensive and larger	Minimal	Minimal	Localized and relatively small	
	Significant falling hazards that can cause casualties of a large number of people	9	Minimal	Minimal	Low	Minimal	Minimal	Low	
Safety	Impact to egress		Minimal	Low	More	Minimal	Minimal	Low	
	Hazardous material release		Minimal	Minimal	Low	Minimal	Minimal	Low	
	Fire		Minimal	Low	More	Minimal	Minimal	Low	
	Impact to adjacent space		Minimal	Low	More	Minimal	Low	More	
	Nonstructural damage to structural syste	m	Minimal	Low	More	Minimal	Minimal	Low	
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Property	Global nonstructural damage/repair		Minimal	Low	More	Minimal	Minimal	Low	
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Performance Descriptions

Translate the qualitative measures of consequences into performance to be achieved

Performance Expectation:

- Minor falling hazard with limited consequence
- Local nonstructural damage/repair

Performance Description:

- <u>Prevent</u> minor falling hazard with limited consequence
- <u>Limit</u> local nonstructural damage/repair





Performance Descriptions

	Performance Description
Safety	Prevent minor falling/overturning hazard with limited safety consequence
	Prevent significant falling/overturning hazard that causes a casualty to an individual or several individuals
	Prevent significant falling/overturning hazard that causes casualties to a significant number of people
	Prevent falling hazard that causes casualties outside building footprint
	Maintain egress
	Prevent hazardous material release
	Prevent fire
	Prevent nonstructural damage that causes damage to the structural system
Property	Limit local nonstructural damage/repair
	Limit extensive nonstructural damage/repair
Function	Maintain intended function





Explicit Performance Goals

		Components following t	Not Required to he Design Eartho (i.e., $I_p = 1.0$)	Function quake	Components Required to Functi following the Design Earthquak (i.e., $I_p = 1.5$)		
	Performance Description ⁽¹⁾	Frequent Earthquake	Dosign Earthquake	MCE _R	Frequent Earthquake	Design Earthquake	MCE _R
	Prevent minor falling/overturning hazard with limited safety consequence						
	Prevent significant falling/overturning hazard that causes a casualty to an individual or several individuals		х			Х	
	Prevent significant falling/overturning hazards that cause casualties to a significant number of people		х			Х	
Safety	Maintain egress ⁽²⁾					Х	
	Prevent hazardous material release (2)					Х	Note (3)
	Prevent fire ⁽²⁾					Х	
	Prevent falling hazard that causes casualties outside building footprint		х			х	
	Prevent nonstructural damage that causes damage to structural system		х			Х	
Property	Limit local nonstructural damage/repair					Х	
Property	Limit extensive nonstructural damage/repair		Х			Х	
Function	Maintain intended component function					Х	

"X" = Design Required

(1) Performance objectives are targets; there is no guarantee that damage more severe than the target will not occur.

(2) Required to function for life safety purposes after the Design Earthquake.

(3) There is general agreement that hazardous material release that could place large numbers of people at serious risk should be prevented in the MCE_R. The requirements of ASCE/SEI 7 Chapter 15, Seismic Design Requirements for Nonbuilding Structures, may also apply to these cases.





Explicit Performance Goals

		Components Not Required to Function following the Design Earthquake (i.e., $l_p = 1.0$)			Components Required to Function following the Design Earthquake (i.e., $I_p = 1.5$)			
	Performance Description ⁽¹⁾	Frequent Earthquake	Design Earthquake	MCE _R	Frequent Earthquak	Design Earthquake	MCE _R	
	Prevent minor falling/overturning hazard with limited safety consequence							
	Prevent significant falling/overturning hazard that causes a casualty to an individual or several individuals		х			х		
	Prevent significant falling/overturning hazards that cause casualties to a significant number of people		х			х		
Safety	Maintain egress ⁽²⁾					Х		[
	Prevent hazardous material release (2)					Х	Note (3)	
	Prevent fire ⁽²⁾					Х		
	Prevent falling hazard that causes casualties outside building footprint		х			х		
	Prevent nonstructural damage that causes damage to structural system		х			Х		
Droporty	Limit local nonstructural damage/repair					Х		ſ
Property -	Limit extensive nonstructural damage/repair		Х			Х		Ĺ
Function	Maintain intended component function					Х		ĺ
								Г

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- Need calibration studies and postearthquake data
- Ultimate goal: Affirmed through the code process





ALSO IN THIS REPORT...





NEW Component Design Force Equation!

- Accounts for the interaction between the dynamic response of the component and the building and the potential for resonance.
- Accounts for the reduction in PFA based on yielding of the structural system.
- Recognizes the varying ductility, adjusting the design force accordingly.





NEW Component Design Force Equation!







Get the Report

NIST GCR 18-917-43

https://www.nehrp.gov/library/guidance_ns.htm





