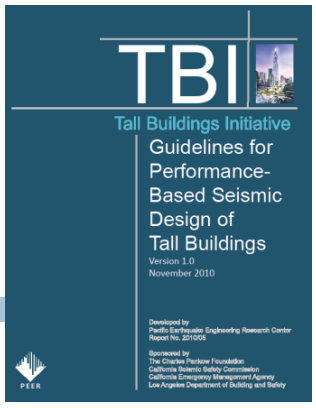
Tall Buildings Initiative (TBI) & TBI Design Guidelines



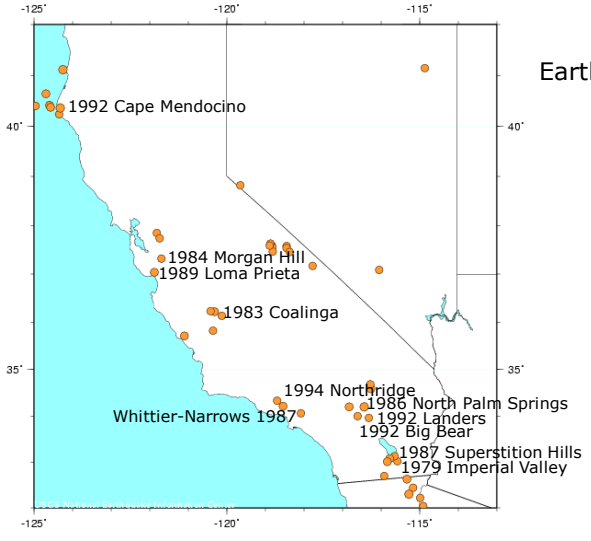
Jack Moehle

Pacific Earthquake Engineering Research Center (PEER), University of California, Berkeley

PEER

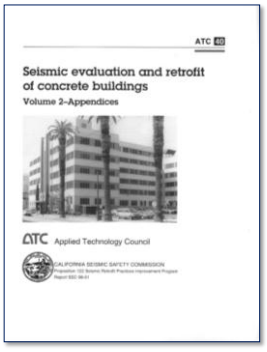
PBEE and Its Application to Tall Building Design – Long Beach – 10 September 2011

1979-1994: A period of unrest

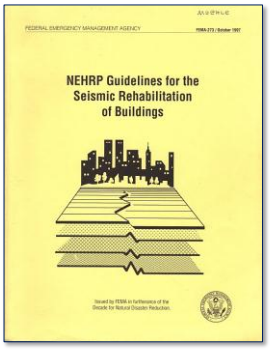


Earthquakes ≥ M5.8

Seismic rehabilitation



1996



1997

2006

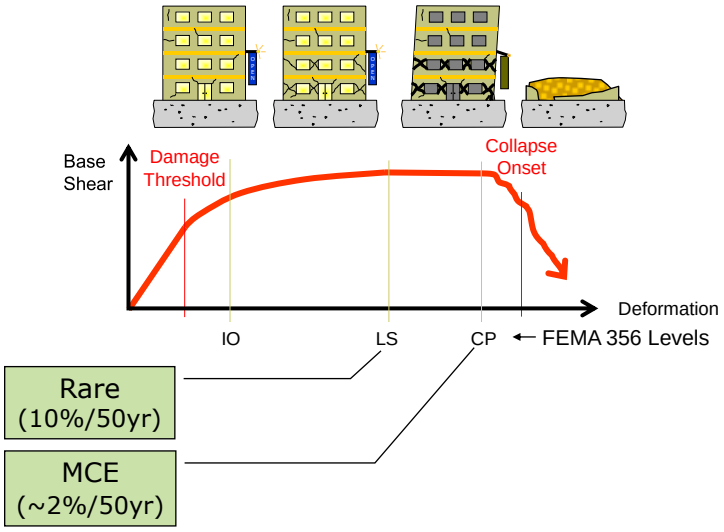
Performance objectives

Building Performance Level

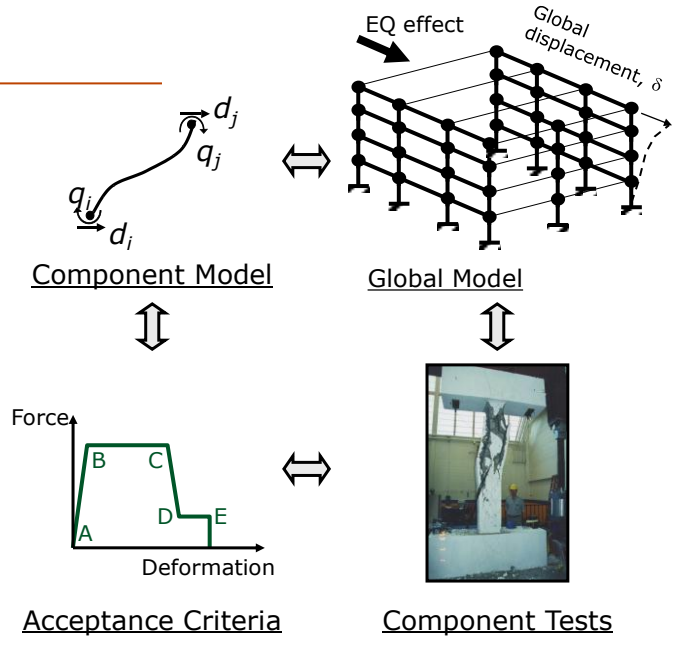
Design Shaking Level	Operational	Occupiable, Damaged	Life Safe, Major Damage	Near Collapse
Frequent (50%/50yr)	a	b	c	d
Occasional (20%/50yr	e	f	g	h
Rare (~10%/50yr)	i	j	k	l
MCE (~2%/50yr)	m	n	o	p

Most commonly selected performance objective

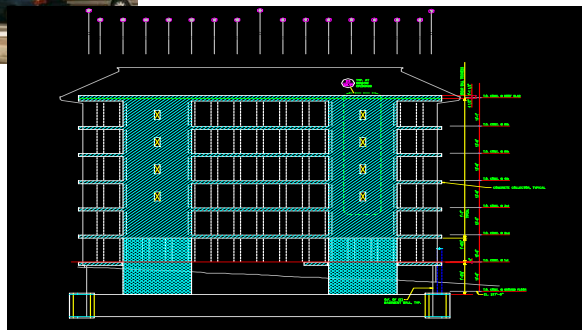
Performance objectives



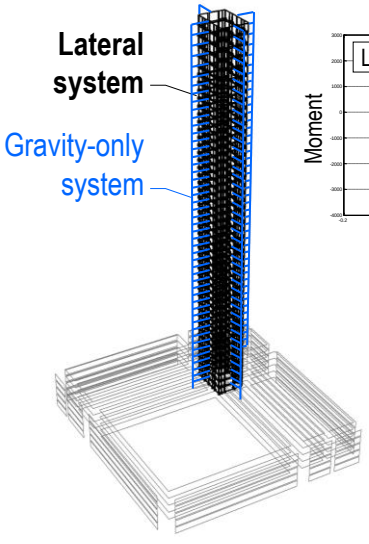
Details

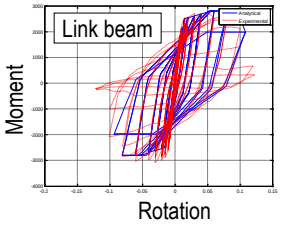


Seismic rehabilitation

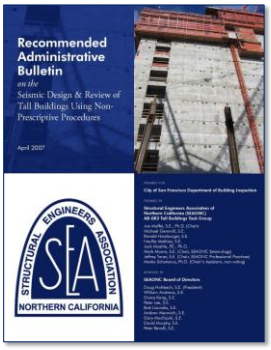


New buildings

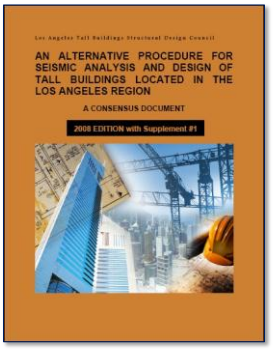




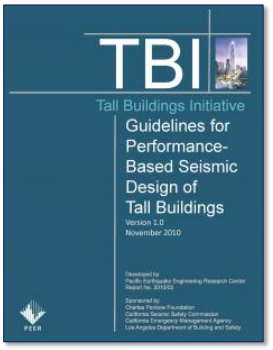
Tall buildings guidelines



2007



2008



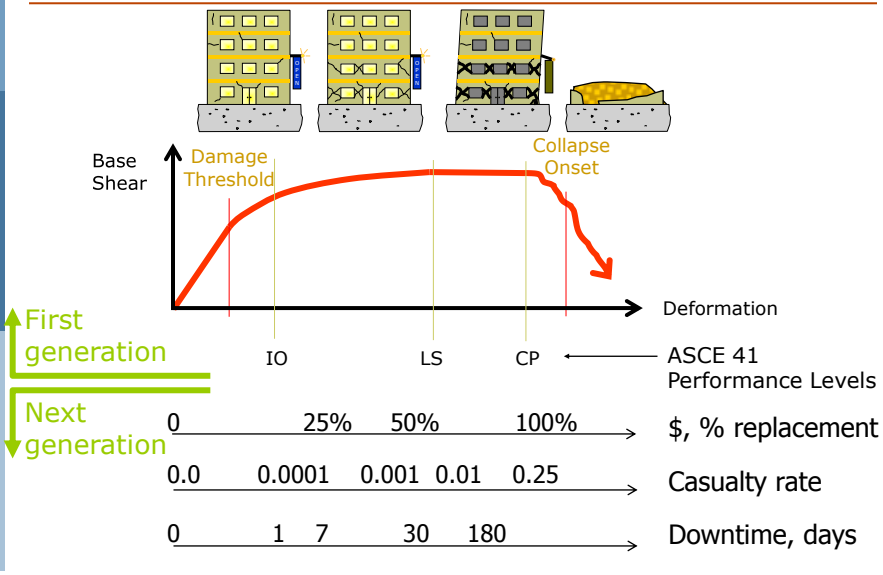
2010

Seismic performance objectives

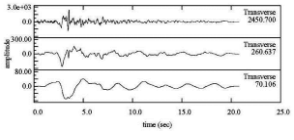
after SEAOC Vision 2000

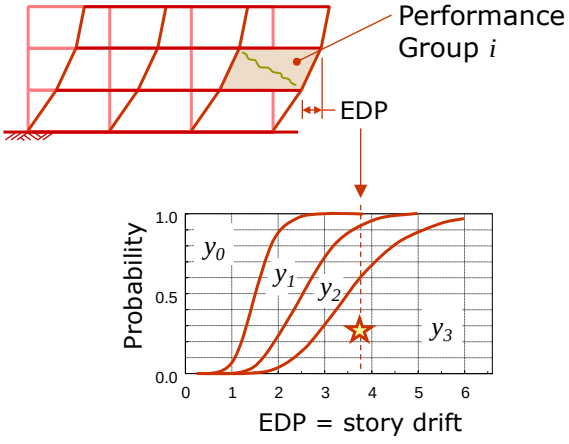
		Earthquake Performance Level			
		Fully Operational	Operational	Life Safe	Near Collapse
Earthquake Design Level	Frequent (43 years)	Basic Objective	Unacceptable	Unacceptable	Unacceptable
	Occasional (72 years)	Essential/Hazardous Objective	Basic Objective	Unacceptable	Unacceptable
	Rare (475 years)	Safety Critical Objective	Essential/Hazardous Objective	Basic Objective	Unacceptable
	Very Rare (975 years)	Not Feasible	Safety Critical Objective	Essential/Hazardous Objective	Basic Objective

Performance objectives



Conceptual damage calculation





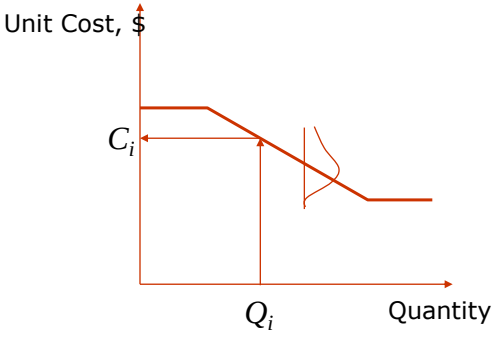
Conceptual repair quantities calculation

Performance Group *i*

Quantities	Damage State			
	y_0	y_1	y_2	y_3
concrete	0	0	0	0
steel	0	0	0	0
wallboard	0	0	100	10,000
paint	0	100	1000	10,000
electrical	0	0	0	0
…				

Conceptual repair cost calculation

Quantity *i* (e.g., running feet of wallboard partition)

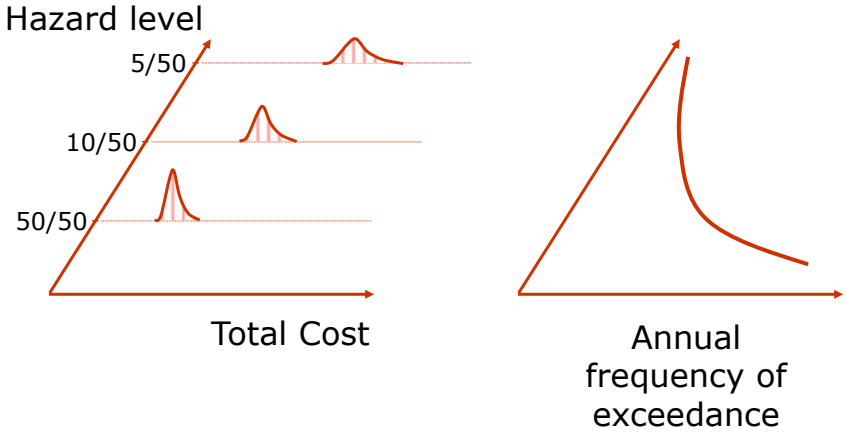


Total repair cost

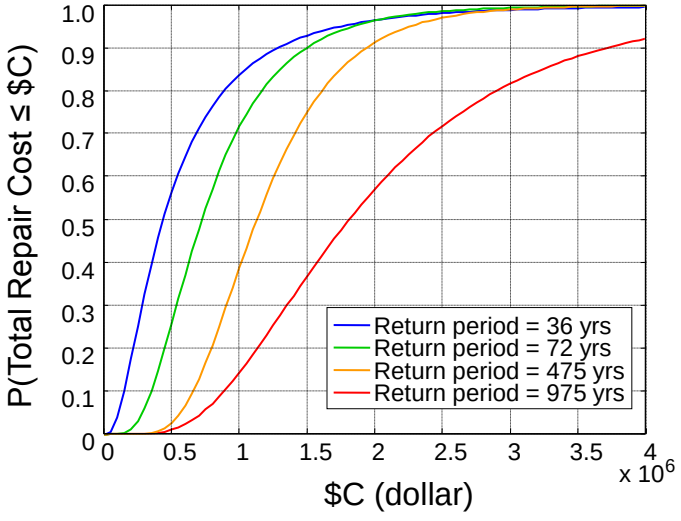
Total cost = $\Sigma C_i Q_i$

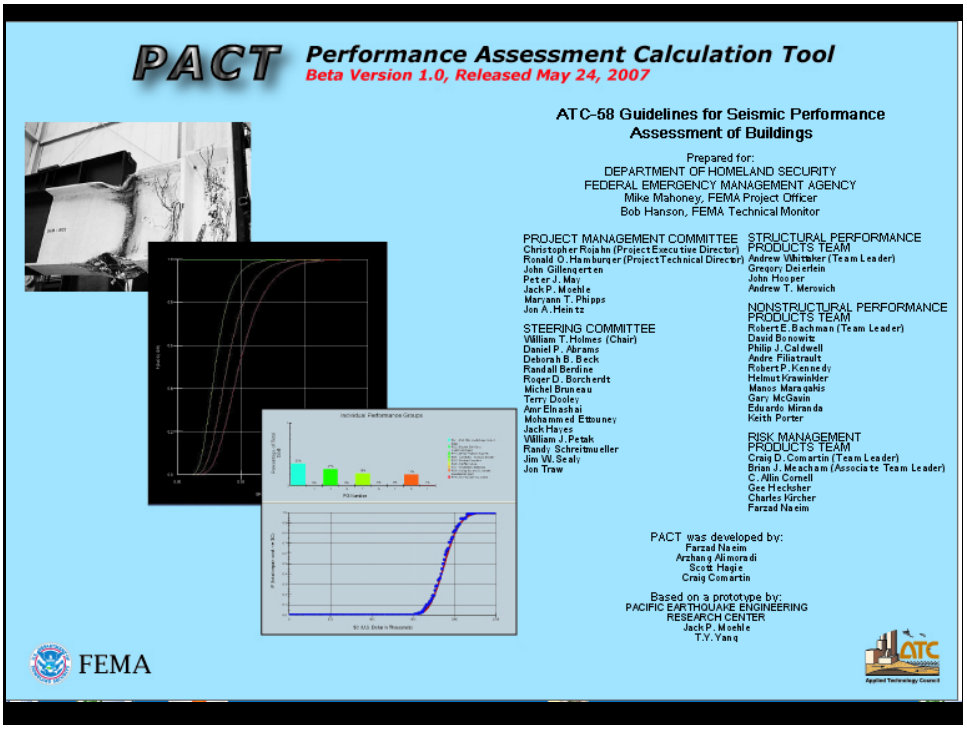
(plus contractor's OH and profit (~12%) and general project costs (design, admin etc, at 20-50%).

Conceptual repair cost calculation



Summary repair costs




PACT
Performance Assessment Calculation Tool
Beta Version 1.0, Released May 24, 2007
ATC-58 Guidelines for Seismic Performance Assessment of Buildings
Prepared for:
DEPARTMENT OF HOMELAND SECURITY
FEDERAL EMERGENCY MANAGEMENT AGENCY
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Bob Hanson, FEMA Technical Monitor
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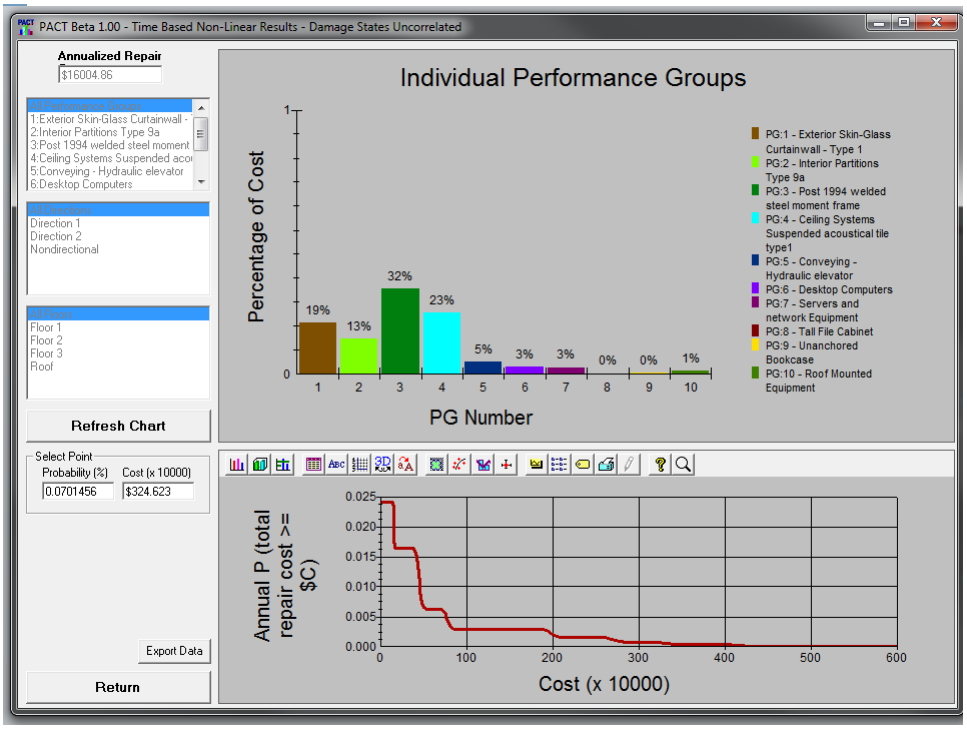
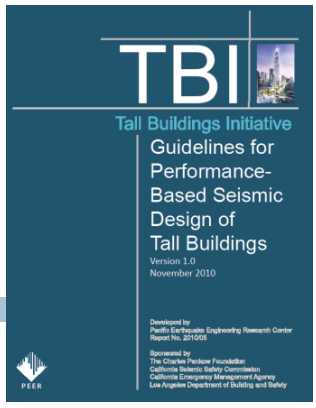
Arzhang Alimoradi
Scott Hagie
Craig Comartin
Based on a prototype by:
PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER
Jack P. Moehle
T.Y. Yang
FEMA
ATC


PACT Beta 1.00 - Time Based Non-Linear Results - Damage States Uncorrelated
Annualized Repair
$16004.86
1:Exterior Skin-Glass Curtainwall -
2:Interior Partitions Type 9a
3:Post 1994 welded steel moment
4:Ceiling Systems Suspended acou
5:Conveying - Hydraulic elevator
6:Desktop Computers
Direction 1
Direction 2
Nondirectional
Floor 1
Floor 2
Floor 3
Roof
Refresh Chart
Select Point
Probability (%)
Cost (x 10000)
0.0701456
$324.623
Export Data
Return
Individual Performance Groups
Percentage of Cost
PG Number
19%
13%
32%
23%
5%
3%
3%
0%
0%
1%
PG:1 - Exterior Skin-Glass Curtainwall - Type 1
PG:2 - Interior Partitions Type 9a
PG:3 - Post 1994 welded steel moment frame
PG:4 - Ceiling Systems Suspended acoustical tile type1
PG:5 - Conveying - Hydraulic elevator
PG:6 - Desktop Computers
PG:7 - Servers and network Equipment
PG:8 - Tall File Cabinet
PG:9 - Unanchored Bookcase
PG:10 - Roof Mounted Equipment
Annual P (total repair cost >= $C)
Cost (x 10000)

Tall Buildings Initiative (TBI) & TBI Design Guidelines



Jack Moehle

Pacific Earthquake Engineering Research Center (PEER), University of California, Berkeley

PEER

TBI Partners

- Applied Technology Council
- California Geological Survey
- California Emergency Management Agency
- California Seismic Safety Commission
- FEMA
- Los Angeles Dept. of Buildings & Safety
- Los Angeles Tall Buildings Council
- National Science Foundation
- Pankow Foundation
- PEER
- San Francisco Building Department
- SCEC
- SEAOC
- USGS

TBI thanks

- Sponsors
- TBI Project Advisory Committee (TPAC)
  - N. Abrahamson, Y. Bozorgnia, R. Hamburger, H. Krawinkler, J. Moehle, and F. Naeim
  - P. Somerville (SCEC), M. Lew (LATBSDC), M. Moore, N. Rodriguez (SEAOC), R. Lui (SFDBI)
- Task 2 – Performance Objectives
  - W. Holmes (Chair), C. Kircher, L. Kornfield, W. Petak, N. Youssef, K. Telleen
- Various Technical Studies
  - N. Abrahamson, Y. Bozorgnia, B. Chiou, C.B. Crouse, G. Deierlein, D. Dreger, M. Gemmill, R. Hamburger, J. Heintz, J. Hooper, S. Freeman, C. Kircher, H. Krawinkler, M. Lew, N. Luco, J. Maffei, S. Mahin, J. Malley, N. Mathias, C. McQuoid, A. Mikami, J. Moehle, M. Moore, Y. Moriwaki, F. Naeim, F. Ostadan, M. Pourzanjani, P. Somerville, J. Stewart, E. Taciroglu, J. Taner, T. Visnjic, J. Wallace, T. Yang, Y. Zeng
- TBI Guidelines Development Team
  - R. Hamburger, J. Moehle, Y. Bozorgnia, C.B. Crouse, R. Klemencic, H. Krawinkler, J. Malley, F. Naeim, J. Stewart
- Case Studies
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    - SGH – A. Dutta, R. Hamburger
  - Analysts
    - URS/SCEC – P. Somerville
    - UCB/UBC – T. Yang, J. Moehle, Y. Bozorgnia
    - UCLA – J. Wallace, Z. Tuna
    - UCI – F. Zareian, P. Zhong, P. Jones
  - Loss Studies
    - ATC 58 – R. Hamburger, J. Hooper, P. Morris, T. Yang, J. Moehle
    - RMS – N. Shome, M. Rahnama, P. Seneviratna; H. Aslani

Tall Buildings Initiative (TBI)

- Purpose
  - Develop design criteria and guidance for the seismic design and review of tall buildings in high seismicity regions
- Tasks
  - Develop consensus on performance objectives
  - Ground motion selection and scaling
  - Soil-foundation-structure interaction modeling
  - Benchmark studies of building dynamic response
  - Model building designs
  - Case studies: comparison of seismic performances
  - Development of performance-based design Guidelines
  - Modeling and acceptance criteria (ATC-72)

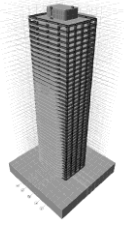
Building Design and Modeling

Three Building Systems

42-story reinforced concrete core wall

1

42-story reinforced concrete dual system



2

40-story steel special moment-frame

3

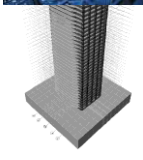
Building Design and Modeling

Three Building Systems

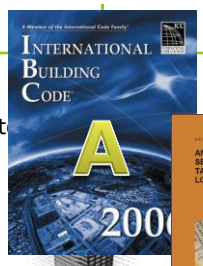
42-story reinforced concrete core wall

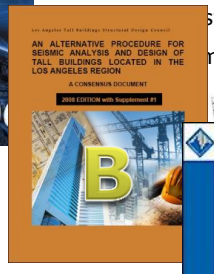
1

42-st

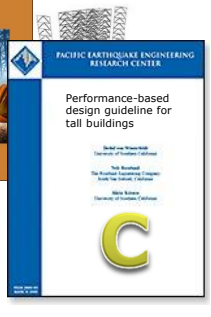


2



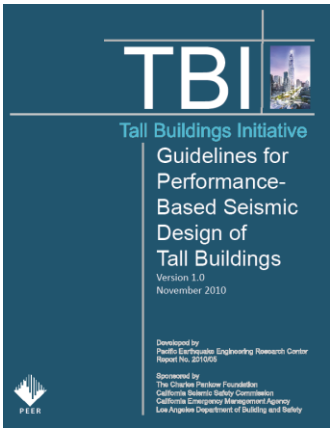


tory steel special
moment-frame



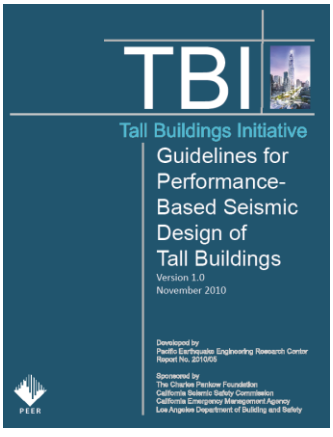
TBI Guidelines

- Key Sponsor
  - Charles Pankow Foundation
- Development team
  - R. Hamburger, J. Moehle (Co-chairs)
  - Y. Bozorgnia
  - C.B. Crouse
  - R. Klemencic
  - H. Krawinkler
  - J. Malley
  - F. Naeim
  - J. Stewart



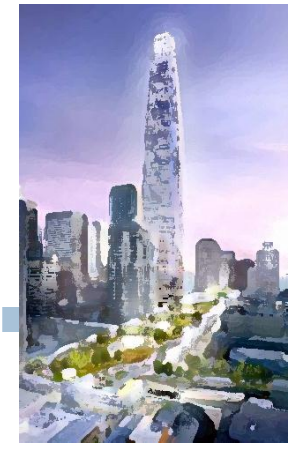
TBI Guidelines Chapters

1. Introduction
2. Performance objectives
3. Design process
4. Design criteria documentation
5. Seismic input
6. Preliminary design
7. Service level evaluation
8. MCE level evaluation
9. Presentation of results
10. Project review



Next...

Overview of PBEE and TBI	Jack Moehle
Performance Objectives, Design Criteria, & Conceptual Design	Andy Fry
Seismic Input, Soil-Structure Interaction, and Ground Motions developed for the Case Study Buildings	Yousef Bozorgnia
Service Level and MCE Analysis	Ron Hamburger
Design & Iteration Process for Case Studies: Core Wall & Dual System Buildings	Andy Fry
Analysis of the Case Study Buildings	Farzin Zareian
Performance Analysis (Loss Estimation)	Ron Hamburger
Wrap Up and Q & A	Jack Moehle



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