

Performance based engineering for buildings

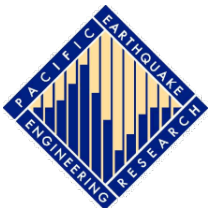
Is the glass half empty or half full ?

Craig D. Comartin, S.E.

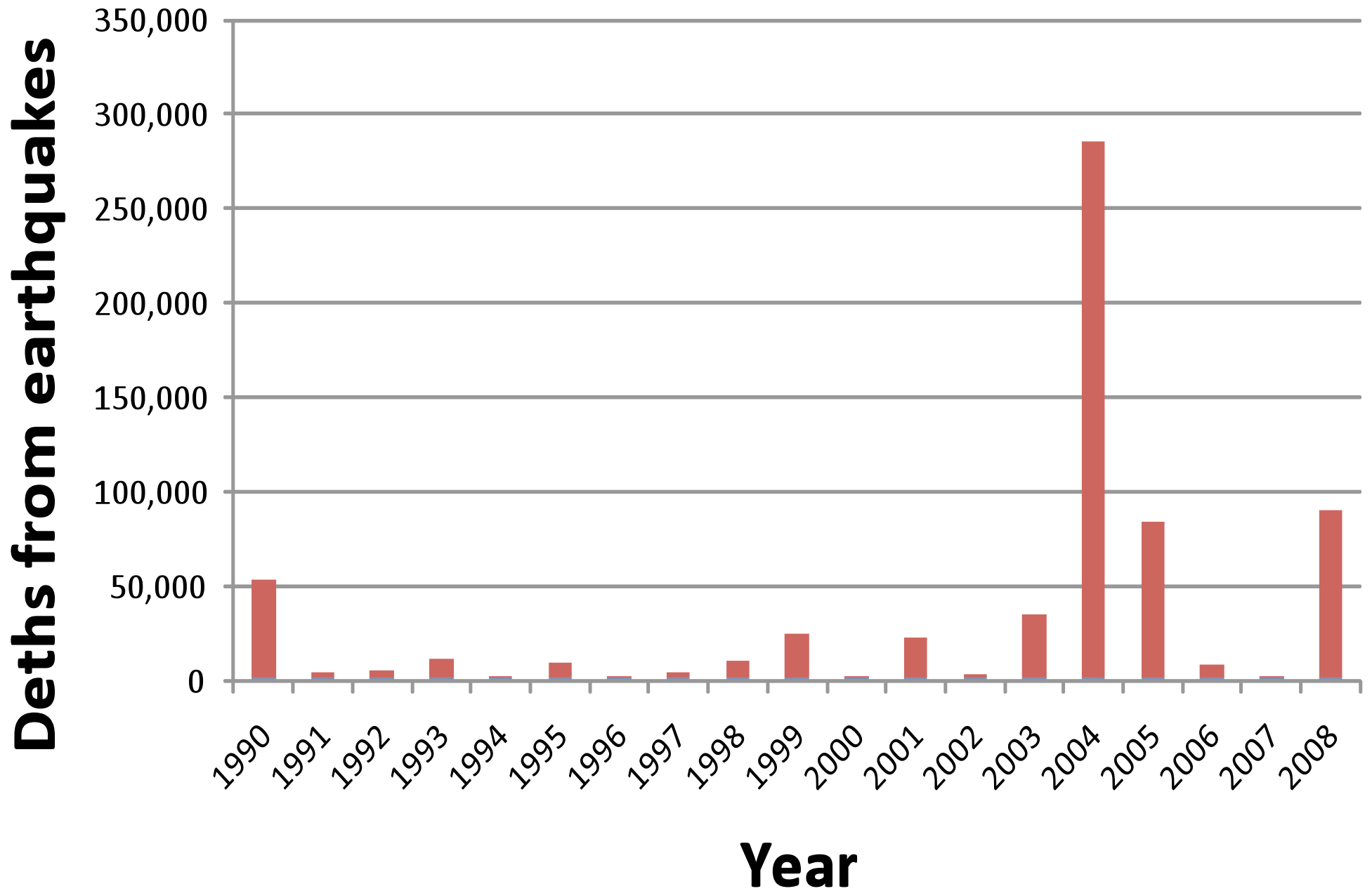


Current design and construction landscape

- Global earthquake fatalities continue to mount.
- A major urban earthquake in US is the next Katrina.
- Green Movement is a major force and seismic sustainability is not a significant part of it.
- PBE is perceived as “conservative” and costly.
- Engineers are widely viewed as a commodity.
- Designers and regulators want prescriptions.



Global seismic mortality



Chances of Dying if a Major Earthquake Occurs

San Francisco

1 in 1000

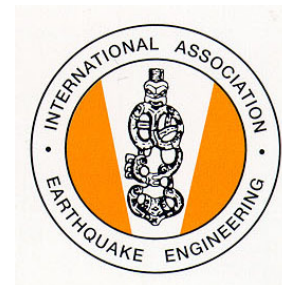
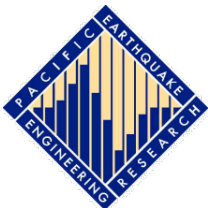
Istanbul

1 in 50



EERI and IAEE World Housing Encyclopedia (WHE)

a web-based encyclopedia and global
network of engineers, architects and
housing experts



Algeria



Armenia



Colombia



India



Turkey



Philippines



Mexico



Japan



U.S.A.



World Housing Encyclopedia



EARTHQUAKE-RESISTANT CONFINED MASONRY CONSTRUCTION



Svetlana Brzev

CDComartin, Inc

Confined masonry



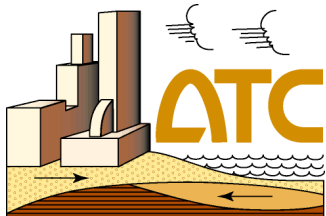
Concrete Coalition



Earthquake Engineering Research Institute
(EERI)

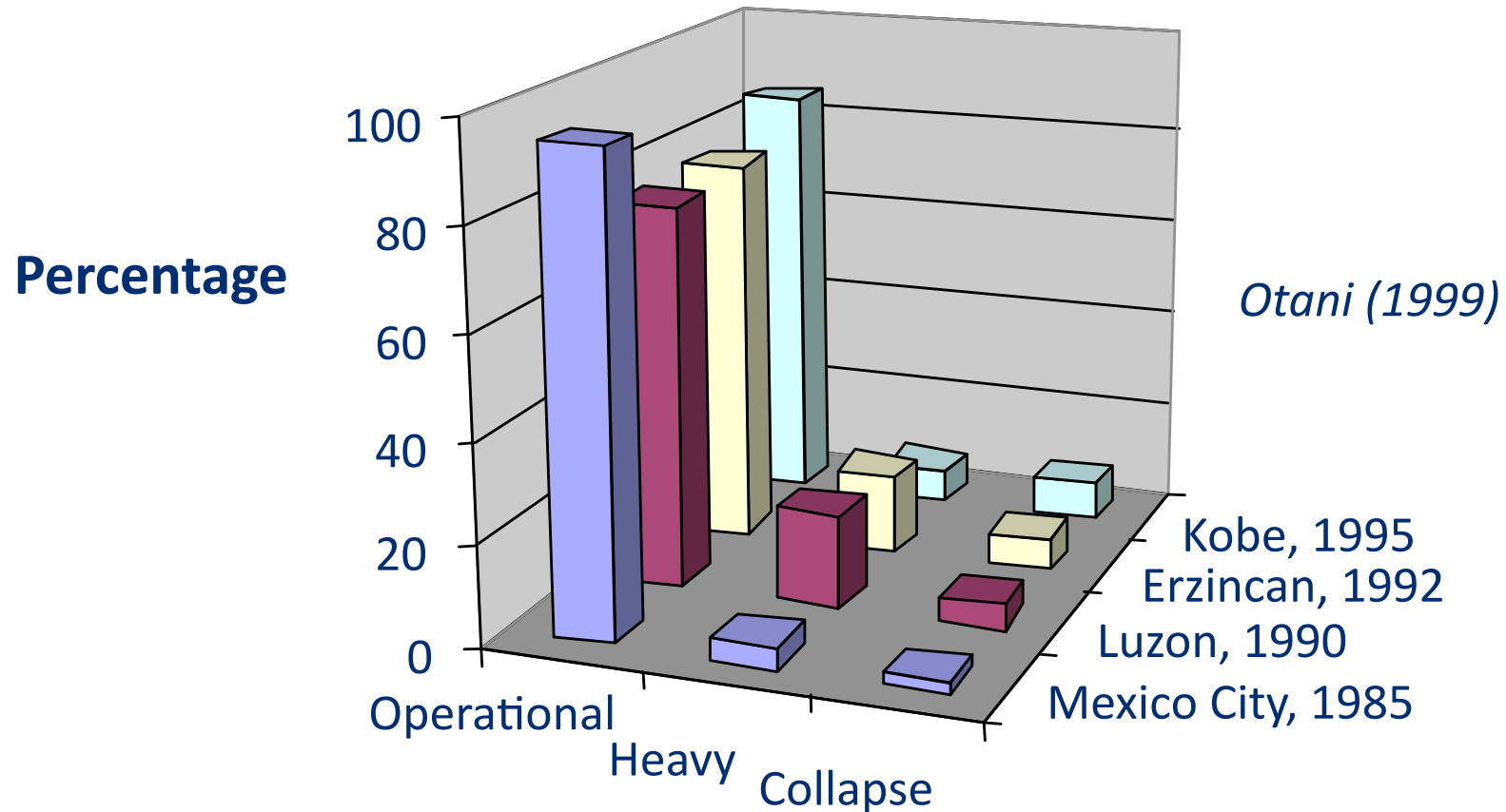


Pacific Earthquake Engineering Research
Center (PEER)



Applied Technology Council (ATC)

How many killers are there?



“50% of the casualties are coming from 5% of the buildings.”

Kircher et al., 2006



The Challenge of “Reality”

- **These buildings do not exist in a seismic vacuum.**
- **What are the economic and social implications?**
- **How can we develop community retrofit programs that represent the interests of all stakeholders?**



Soft stories in concrete frames

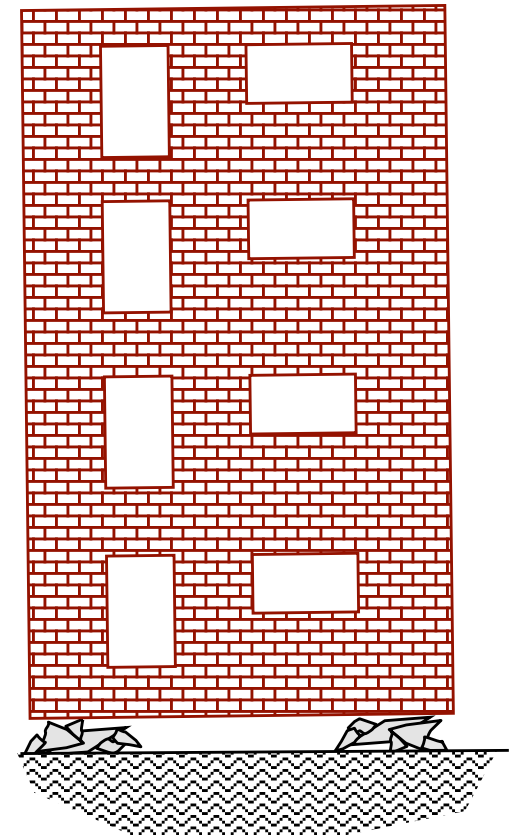
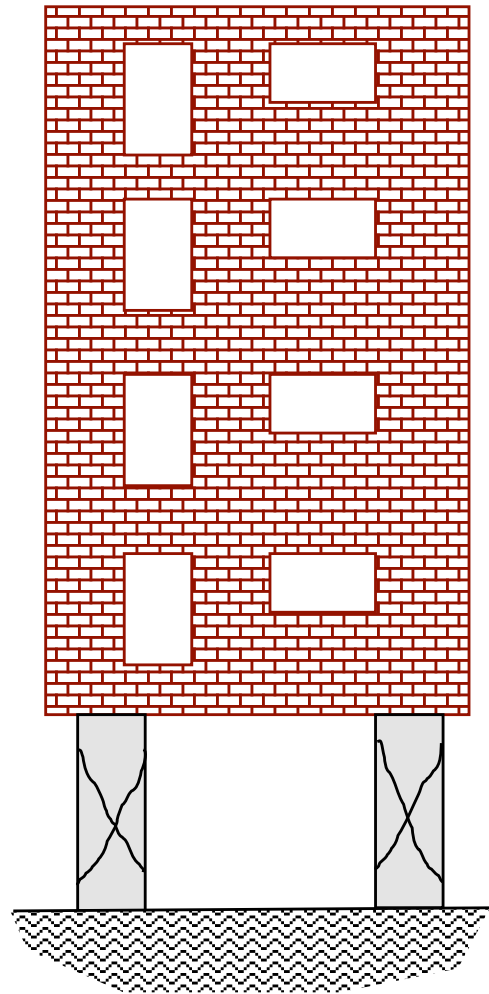
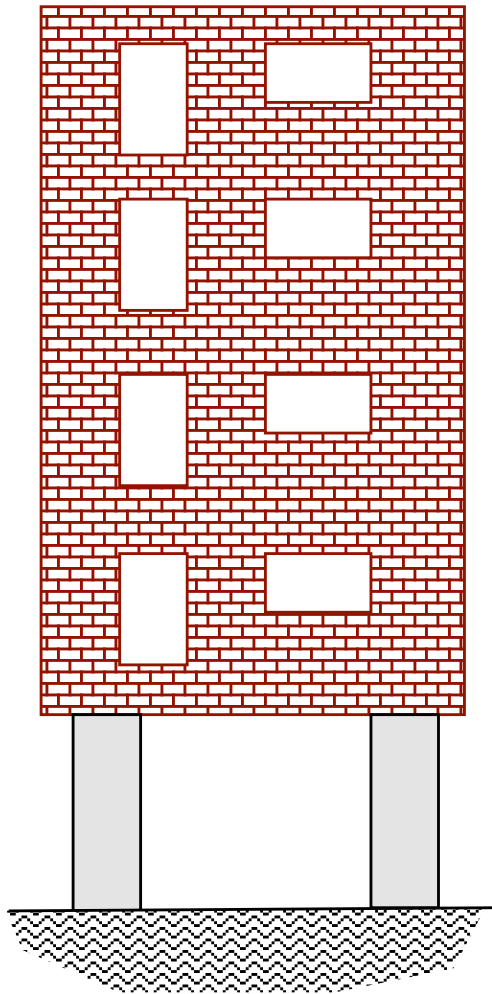


Collapse modes



Vertical load collapse

Vertical load collapse

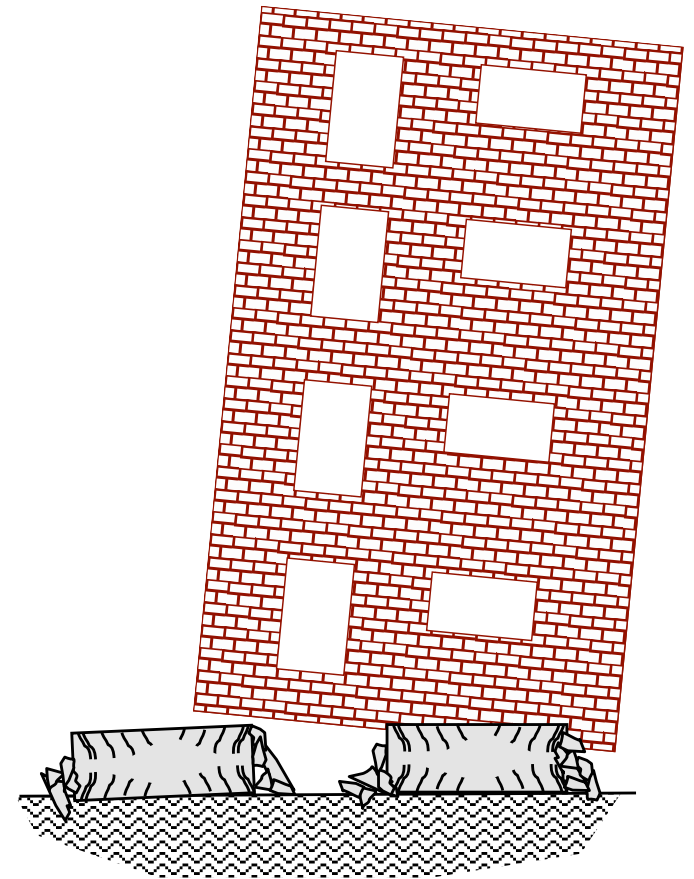
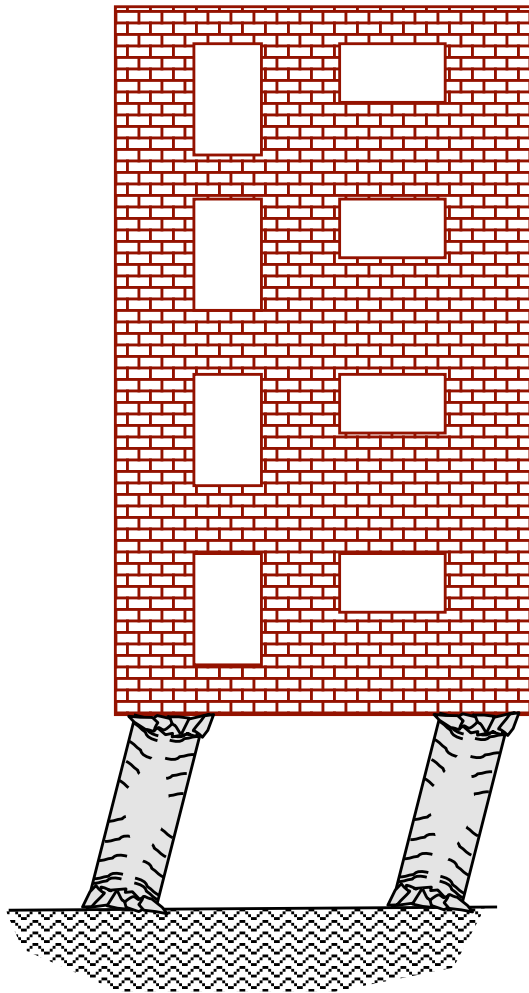
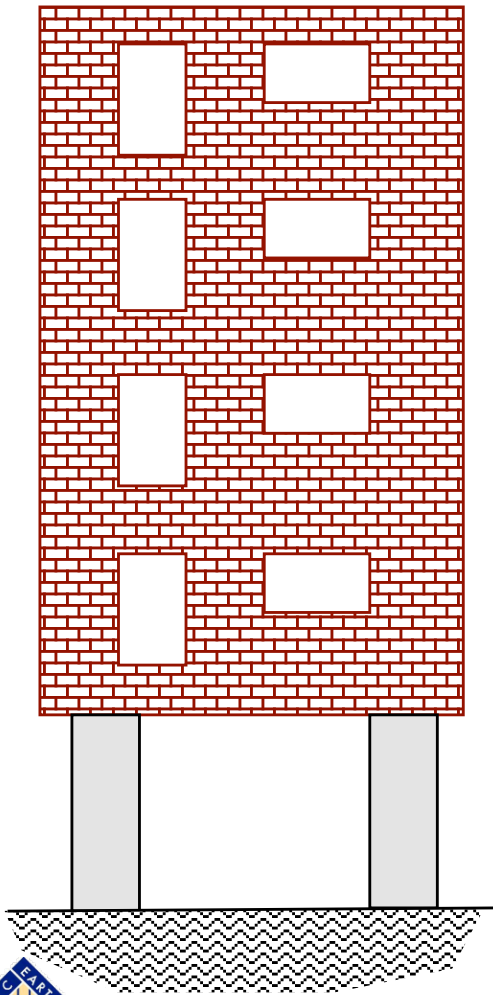


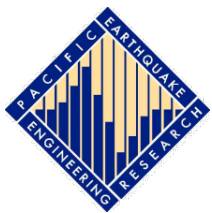
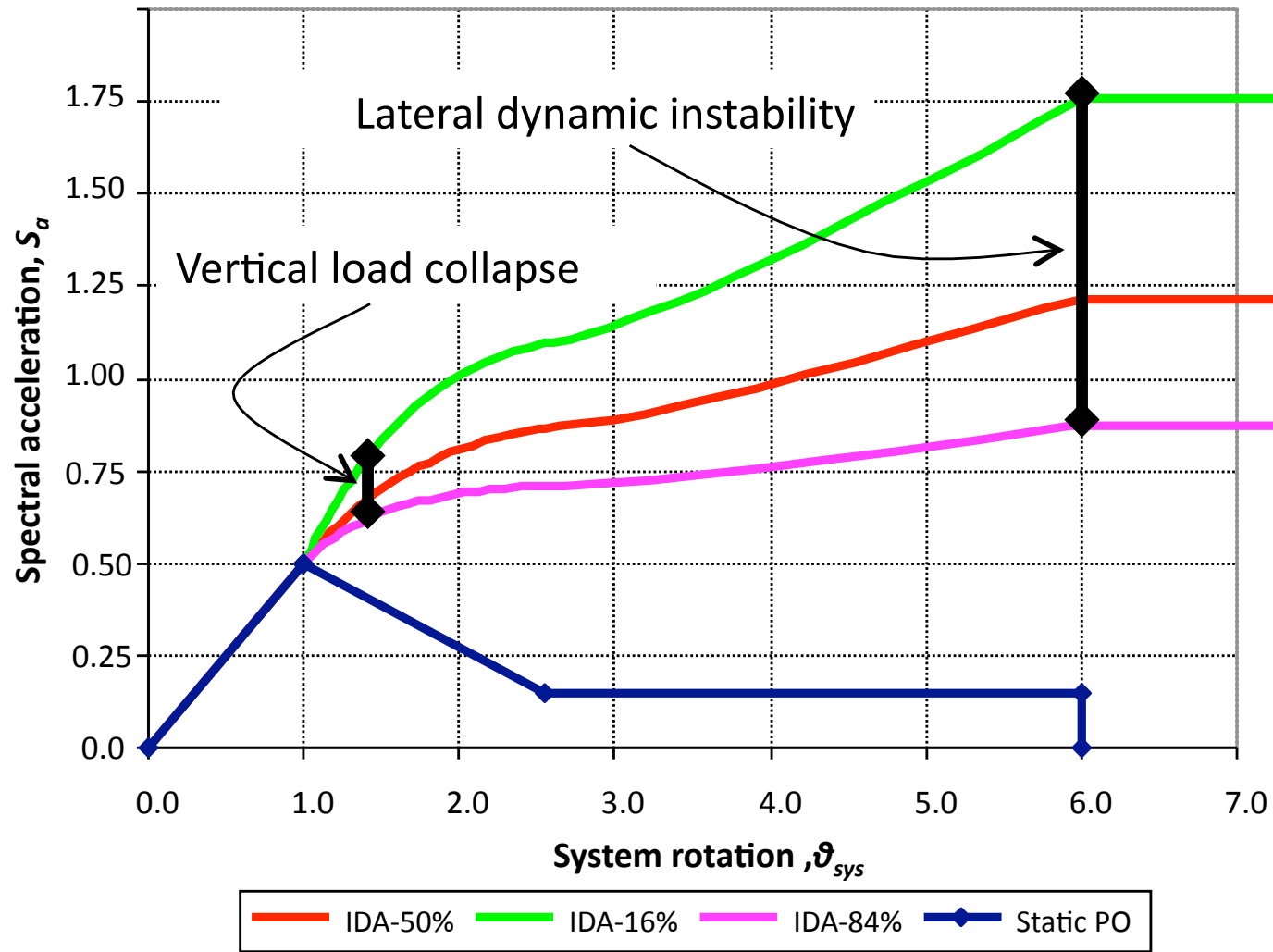
Collapse modes



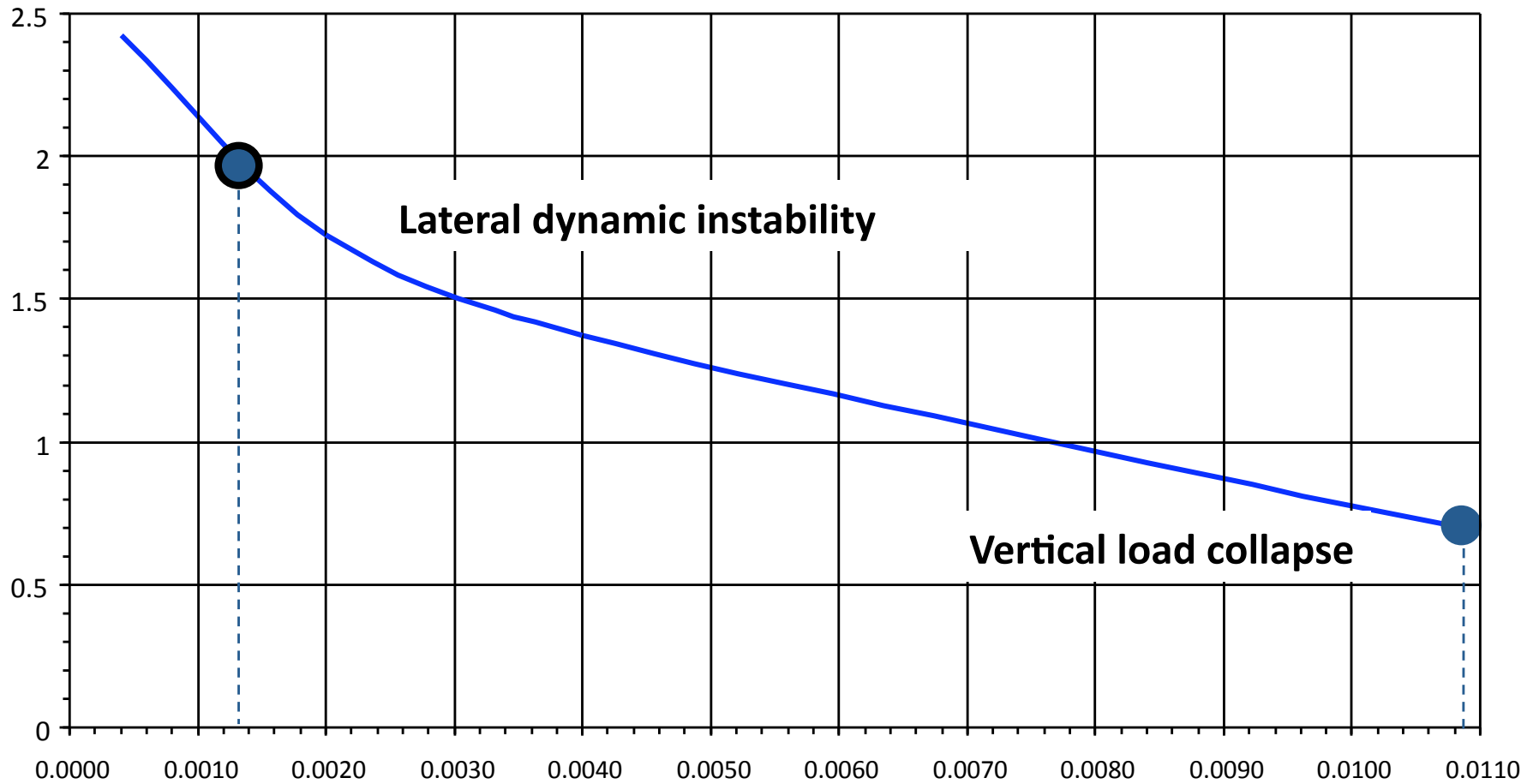
Lateral dynamic instability
(incipient collapse)

Lateral dynamic instability

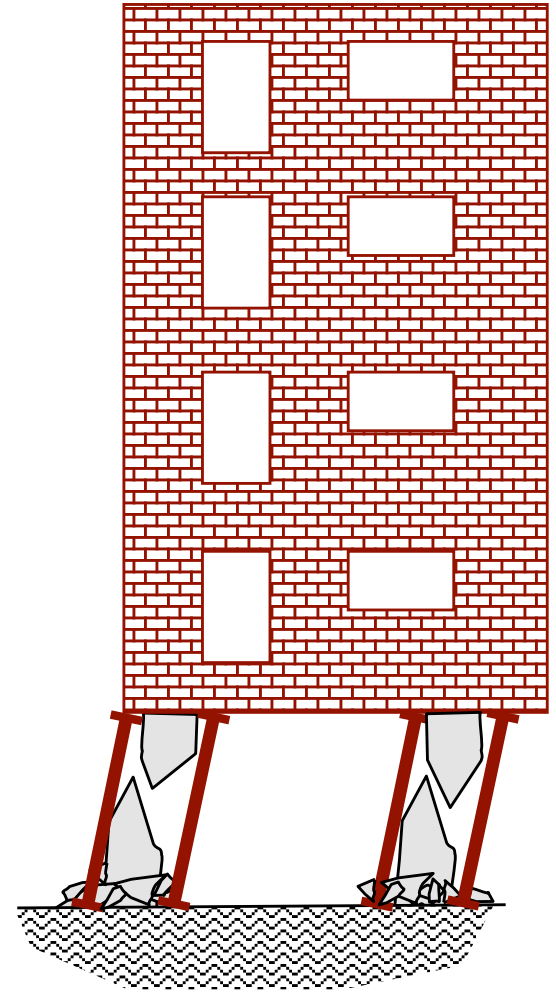
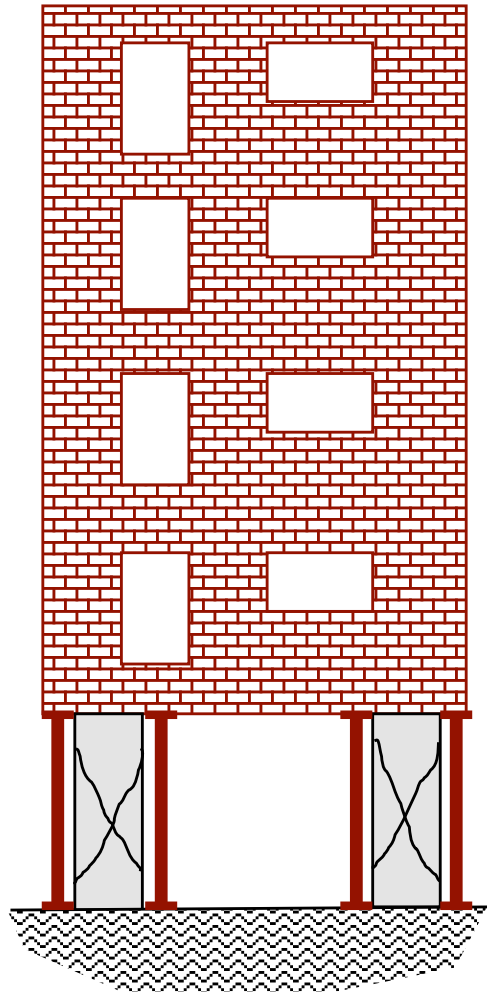
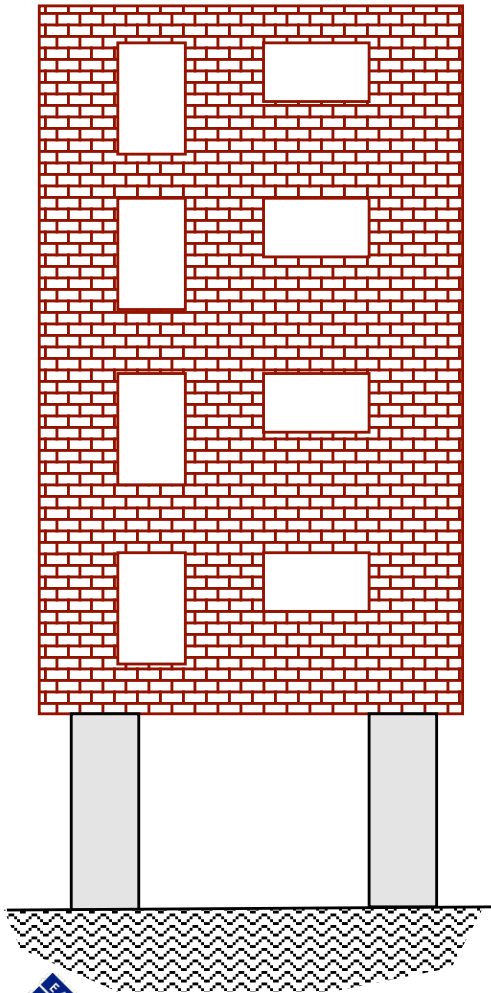




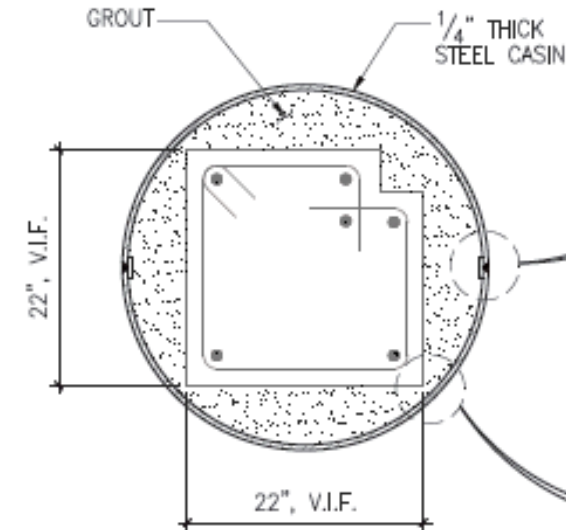
Hazard curve



Supplemental vertical support



Eshleman Hall



First floor column jackets



Katrina loses

Fatalities

1,836 confirmed, 705
missing

Damage

\$81.2 billion



Consequences of earthquakes for the US

	<u>Event</u>	<u>Deaths</u>	<u>Economic Loss</u>
<u>Previous</u>	1989 Loma Prieta	62	\$10 billion
	1994 Northridge	57	\$20 billion
	1995 Kobe Japan	>5,500	\$250 billion



Consequences of earthquakes for the US

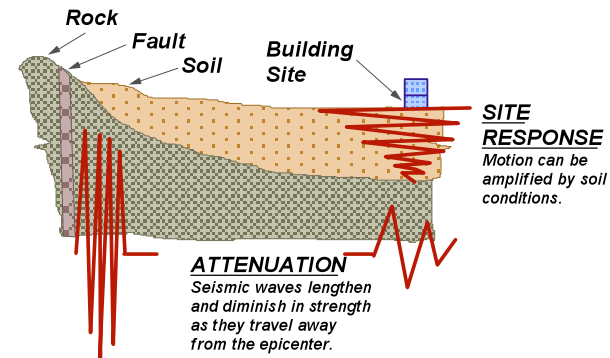
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<u>Previous</u>	1989 Loma Prieta	62	\$10 billion
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<u>Projected</u>	Hayward Fault Scenario (M7)	>4,000	\$100 billion
	Seattle Fault Scenario (M6.7)	>1,600	\$33 billion
	Repeat of 1906 San Francisco	3,000 – 8,000	\$200 billion
	Scenario Newport-Inglewood Fault (M7)	2,000 – 6,000	\$200 billion

Seismic risk and sustainability

Building



Future extreme event (e.g. earthquake)



What can happen?

$$P \left\{ \begin{array}{l} \text{Deaths (safety)} \\ \text{Dollars (damage)} \\ \text{Downtime (loss of use)} \end{array} \right\} = \text{RISK}$$

DV
DM
EDP
IM

PEER framing equation

Decision variable

- risk of losses

$$v(DV) = \iiint G(DV | DM) |dG(DM | EDP) |dG(EDP | IM) |d\lambda(IM)$$

Damage measure

- casualties
- capital loss
- downtime

Engineering demand parameter

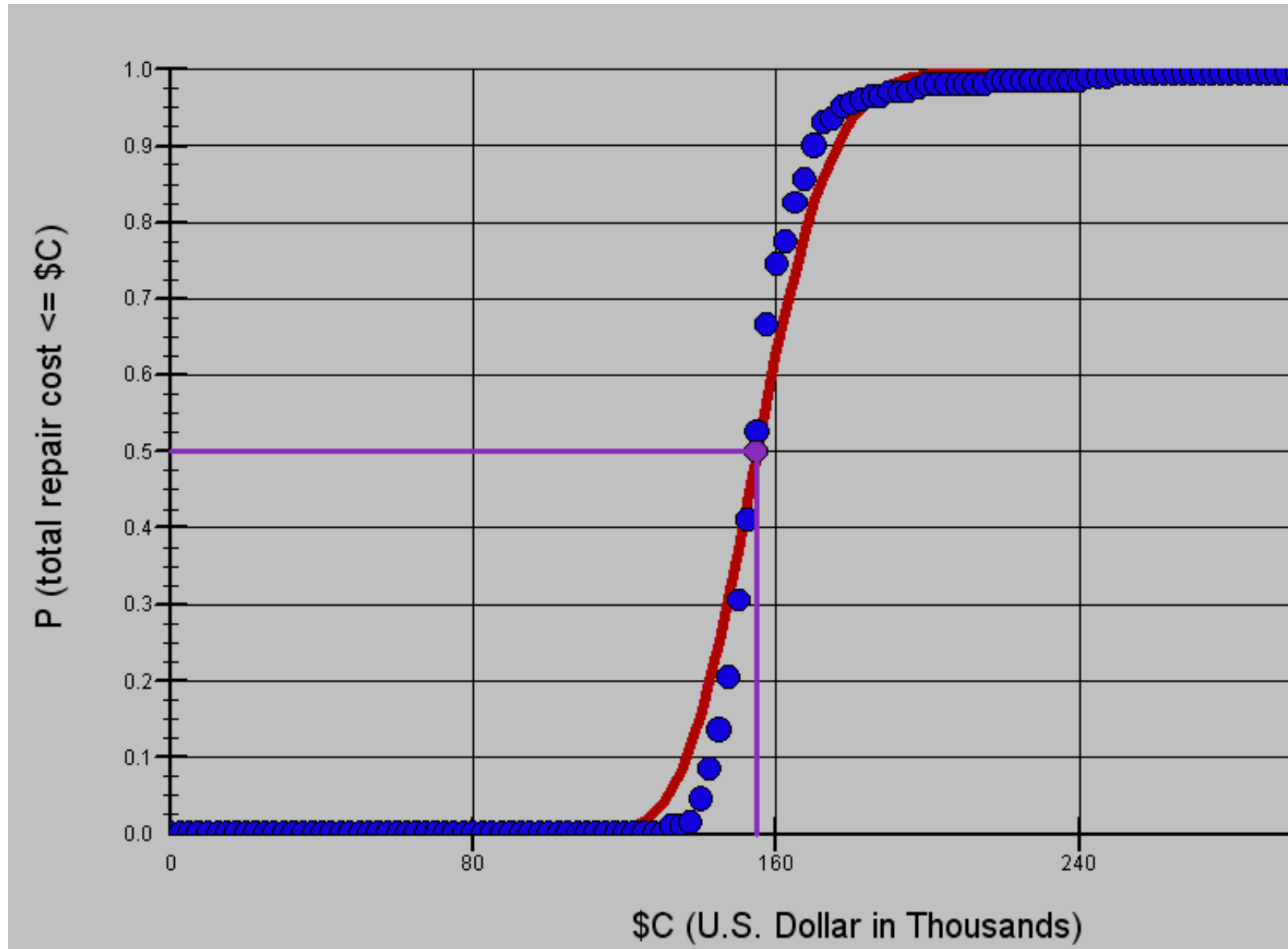
- displacement
- drift
- etc

Intensity measure

- hazard curve
- level of shaking

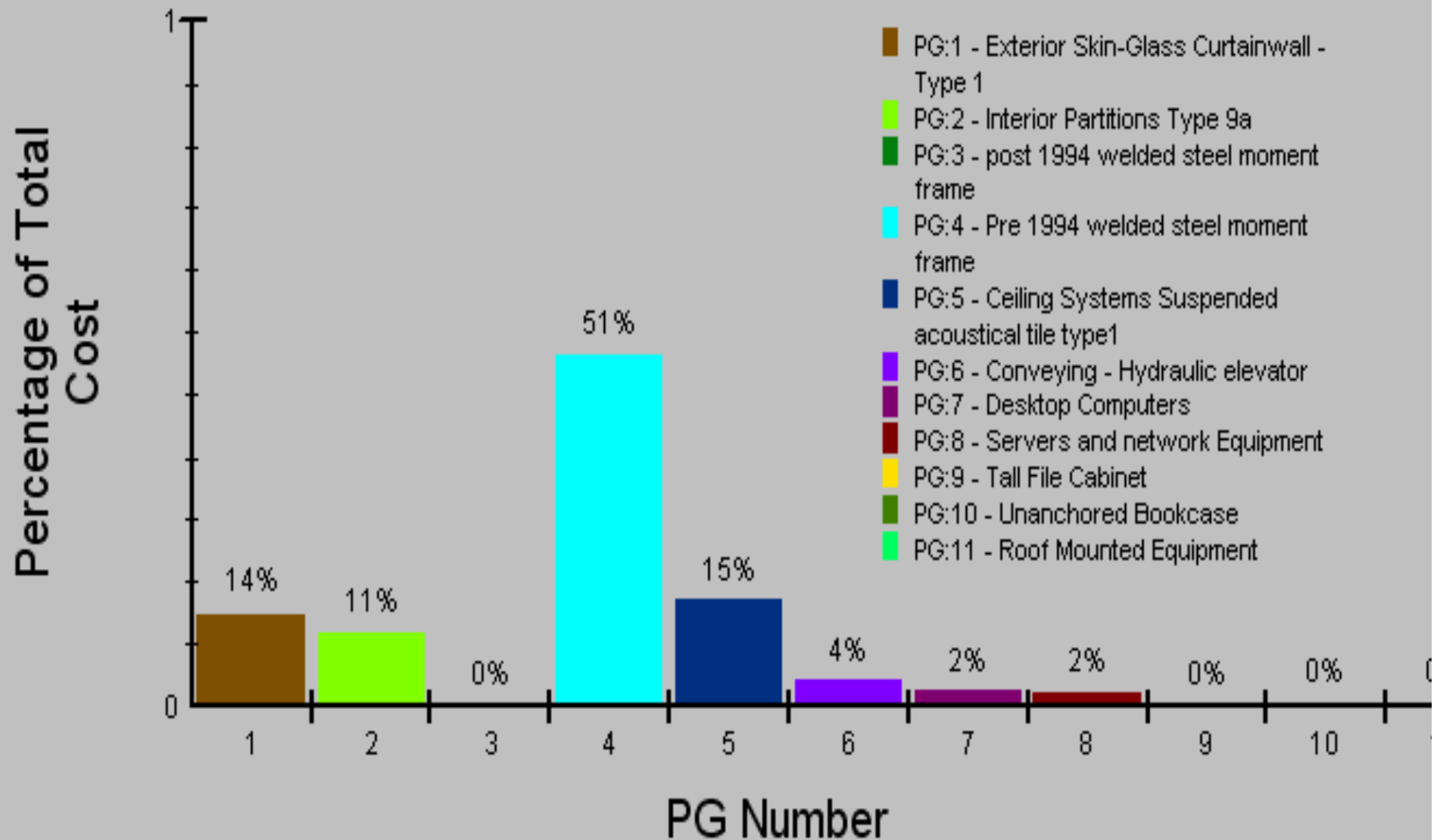


Risk of losses



Deaggregation of loss

Individual Performance Groups

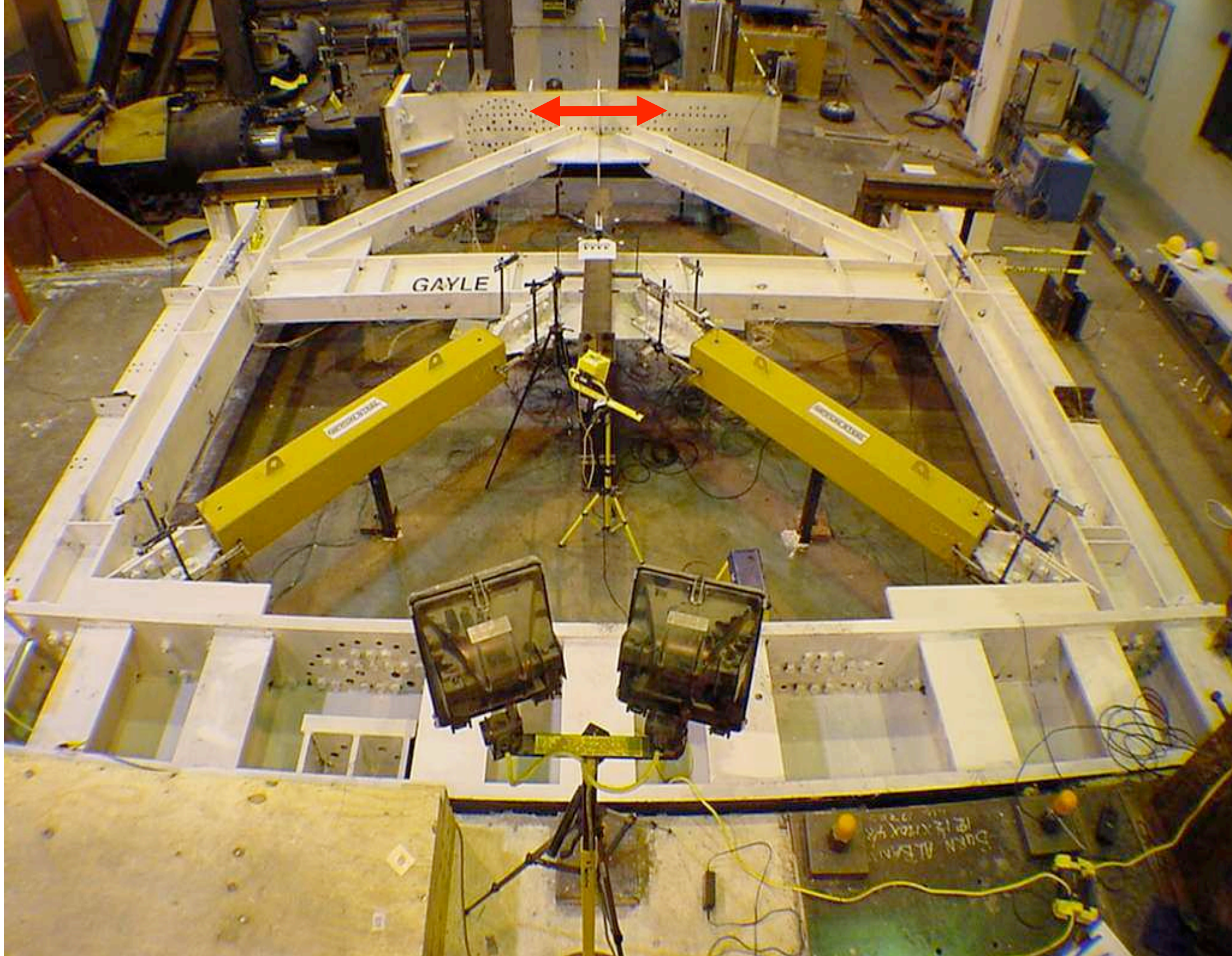


Stanley Hall-UC Berkeley

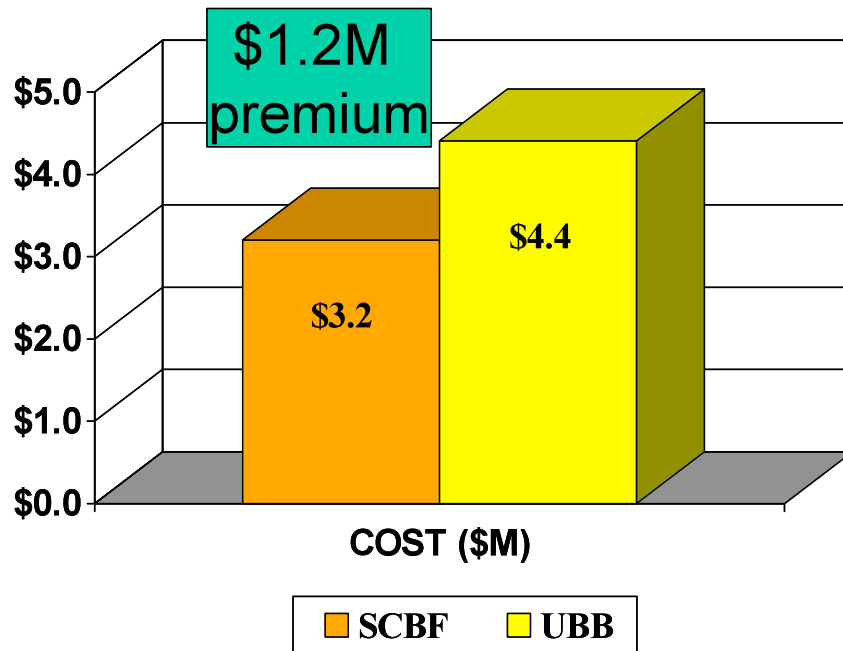


• <u>Item</u>	• <u>Cost</u>
• Capital	• \$160 million
• Contents	• \$50 million
• Business Interruption	• \$40 million annually

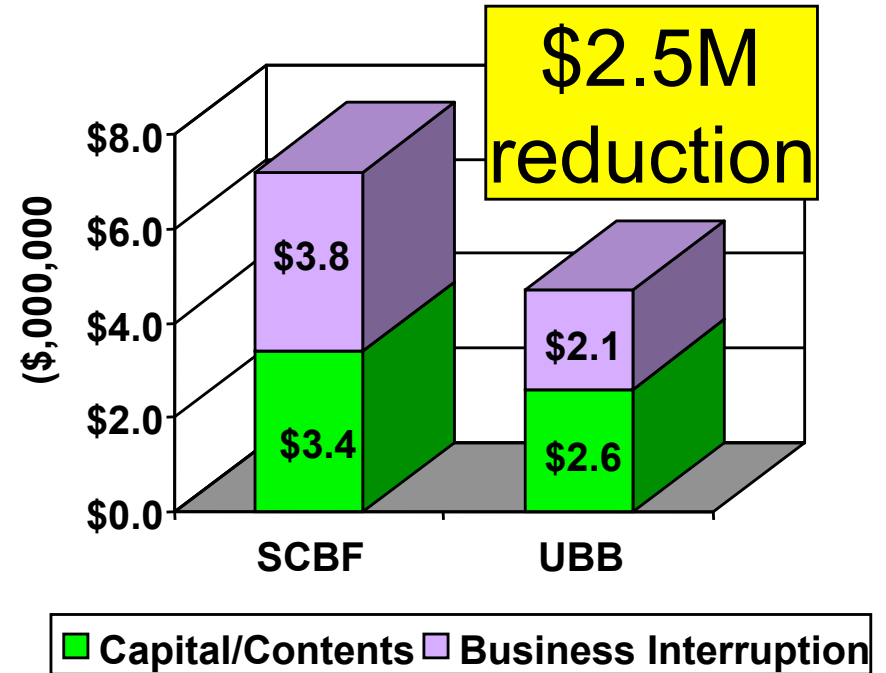




Costs



Present value of losses



Benefit-cost ratio (5% Discount, 50 year life)

~ 0.4

Equivalent to ~11% ROI



Key opportunities for performance based engineering and PEER

1. Provide realistic procedures to address life safety globally.
2. Characterize seismic sustainability in terms and procedures that are directly useful.
3. Become a central source for fragility information.
4. Develop complete packages ready for application.
5. Maintain and strengthen multi-discipline culture.
6. Set your own course.



Past and current models

- ASCE 41 Supplement
- Tall Buildings Initiative
- Concrete Coalition/Grand Challenge
- Confined Masonry Guidelines
- Soil-structure interaction

