Seismic Design of Multistorey Concrete Structures

Lecture 1
Observed Seismic Response of Concrete Buildings during Earthquakes

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Short Course for CSCE Calgary 2006 Annual Conference

CONCRETE CONSTRUCTION

- Structural walls or frames
- Cast-in-place, or precast prestressed
- Combinations of the above

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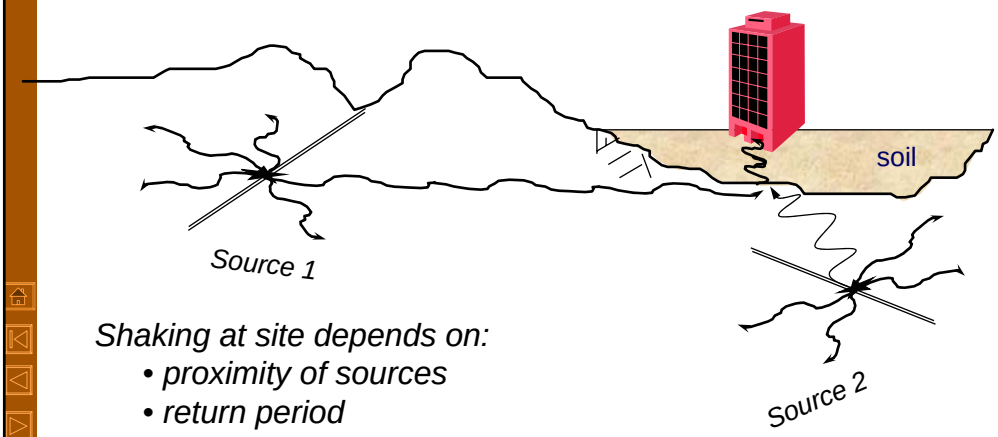
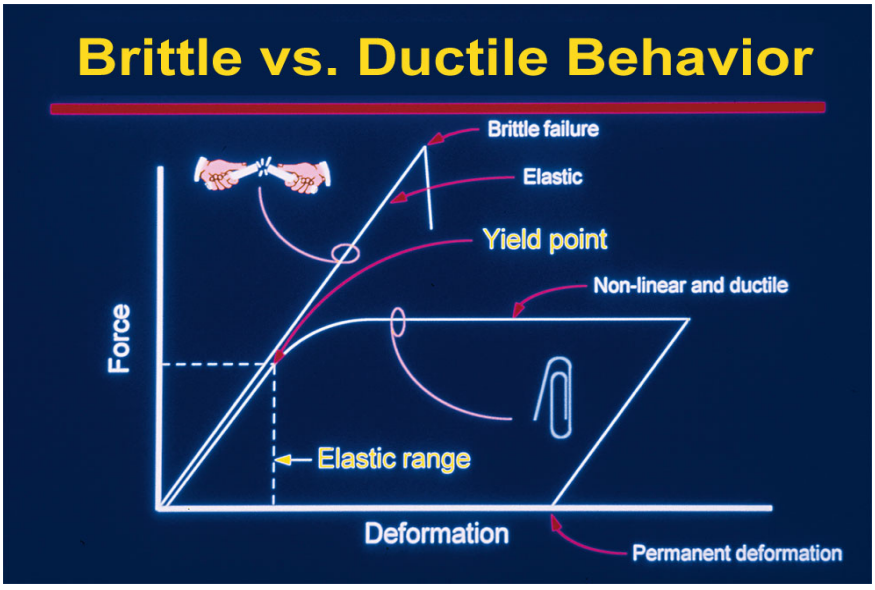
Seismic Hazard

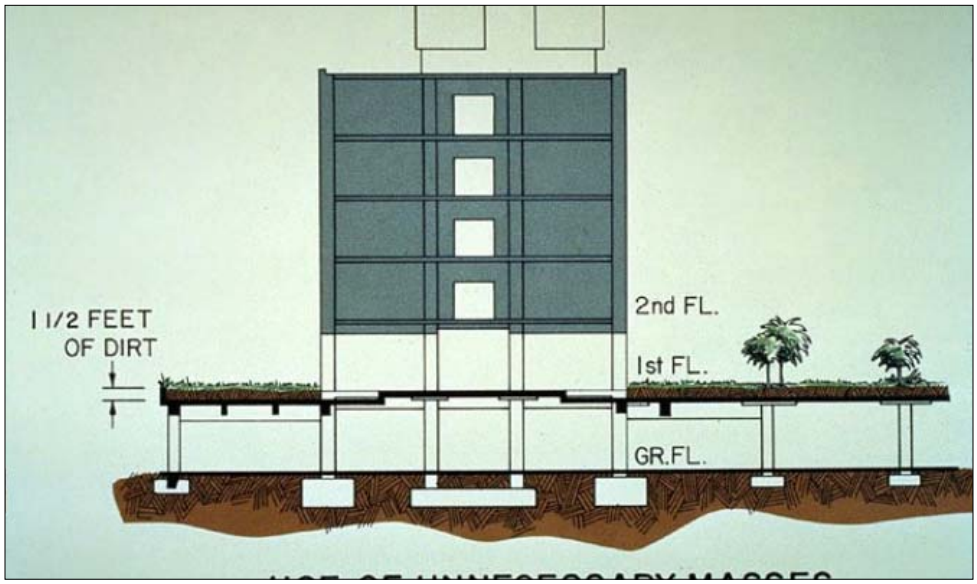


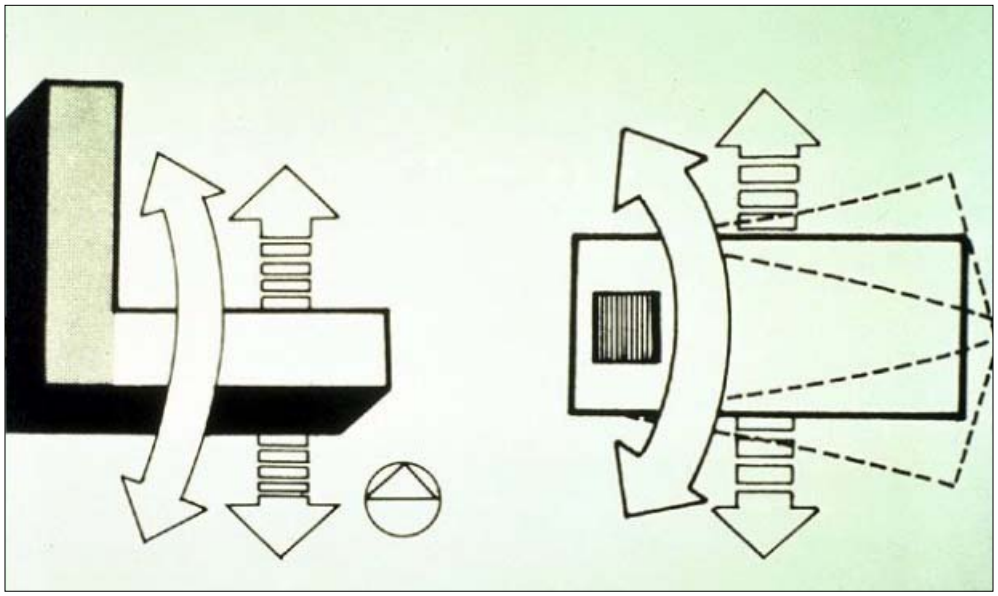
Shaking at site depends on:

- *proximity of sources*
- *return period*
- *path*
- *site conditions*

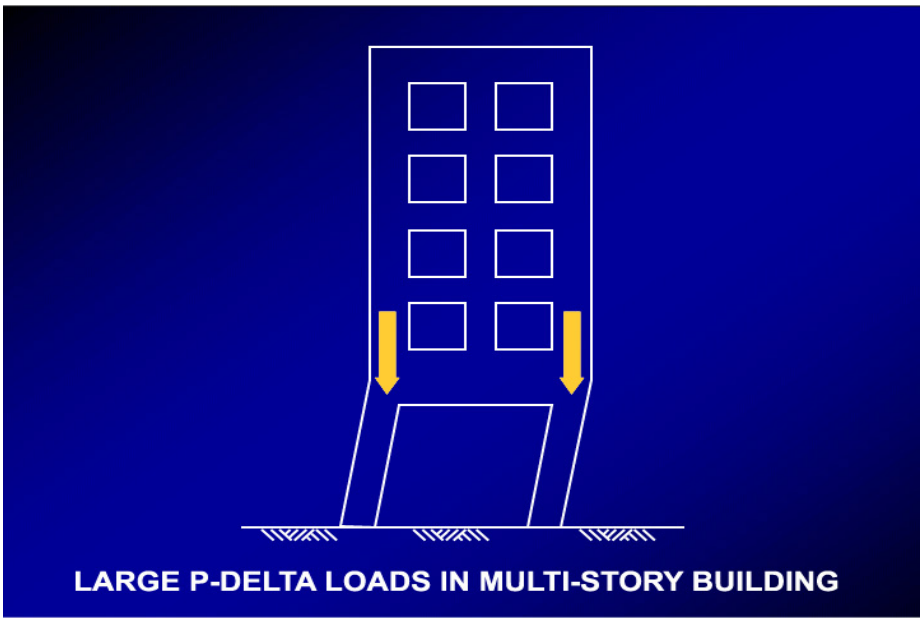


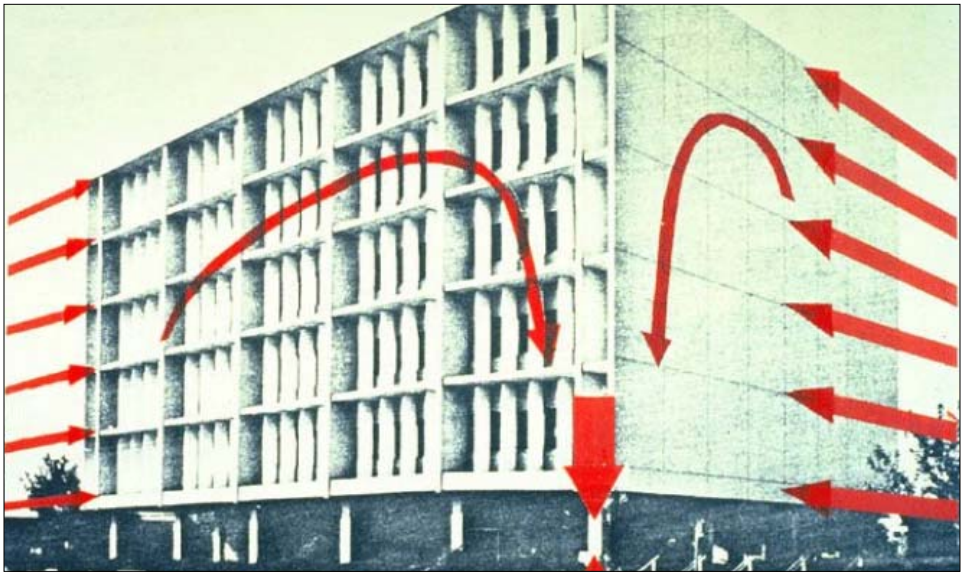

SEGUROS LA PROTECTO


1 1/2 FEET
OF DIRT
2nd FL.
1st FL.
GR.FL.



KOBE, JAPAN; JANUARY 1995


LARGE P-DELTA LOADS IN MULTI-STORY BUILDING



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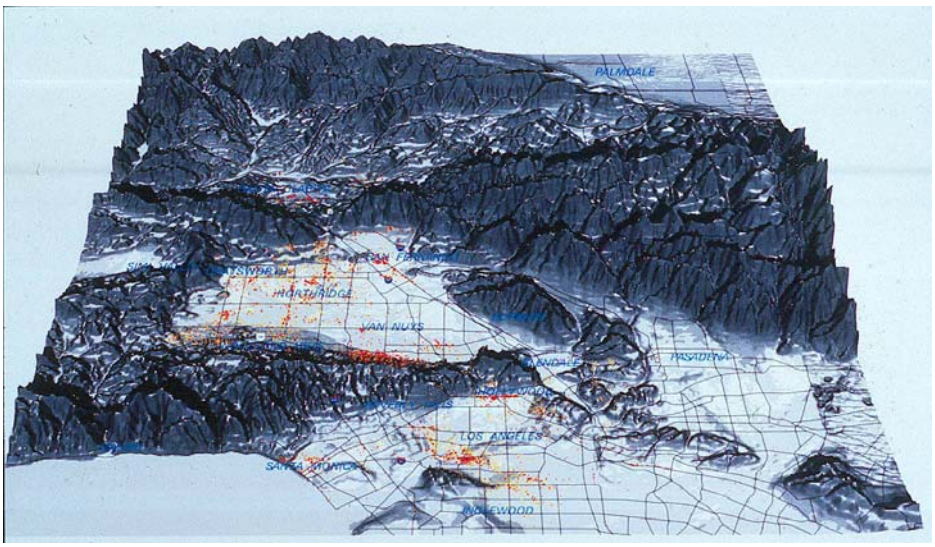
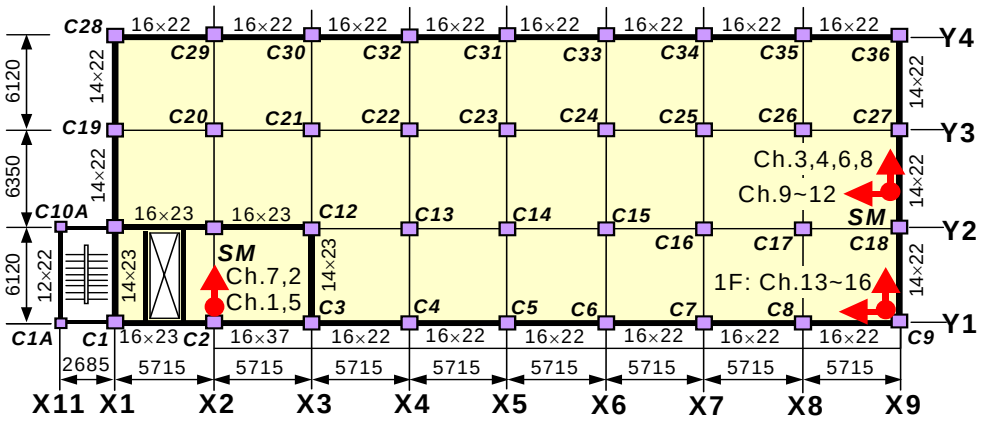
Recorded Motions in Buildings

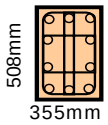
1994 Northridge Earthquake



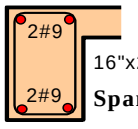
Van Nuys, California – Holiday Inn building

Typical Floor Plan and Member Sections



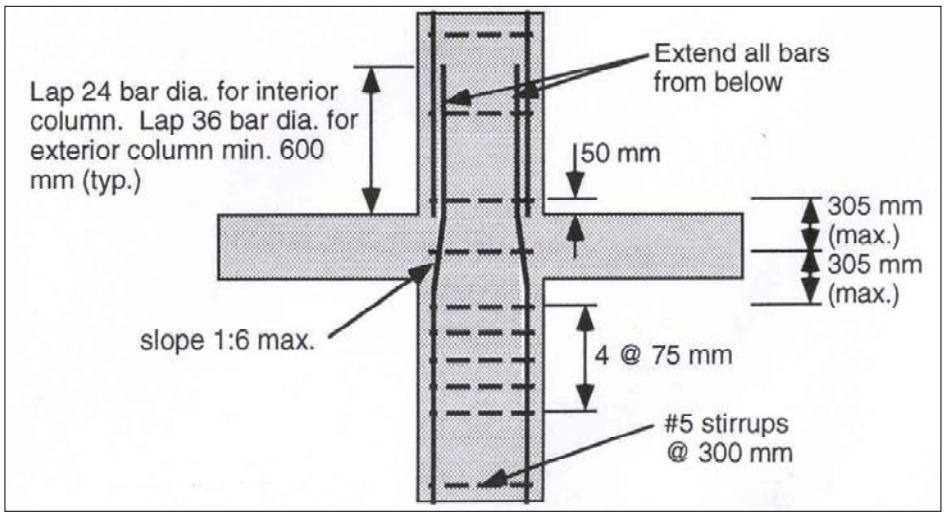


C4~C7, C30~C34
Long. bar: 10#9
Hoop: #3@300mm



16"x22"
Spandrel beam

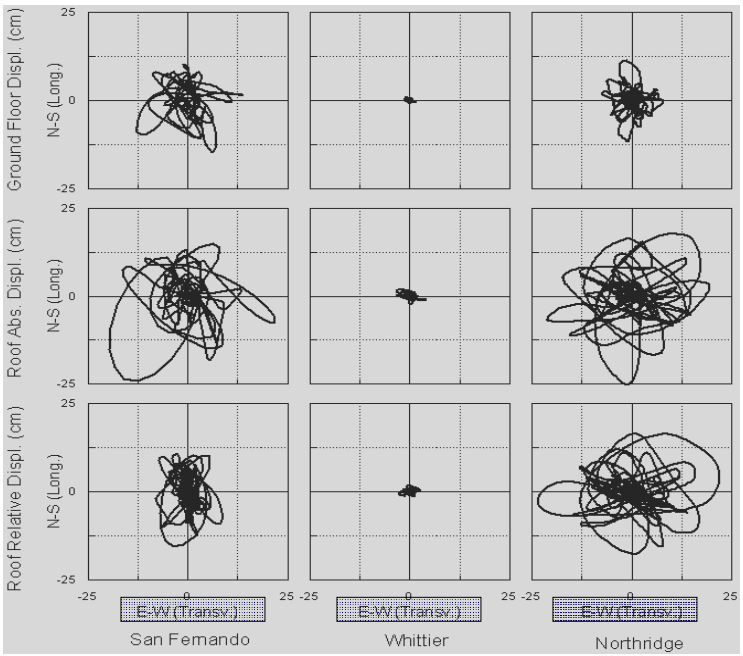
Typical column reinforcement details



Recorded Earthquakes and Vibration Tests

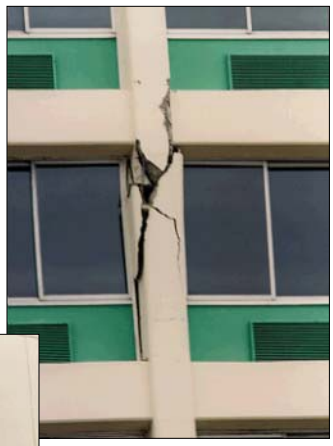
	Max. Base Accel. (g)	Max. Roof Accel. (g)	Drift R-B (cm)	Period (Sec.)	Freq. (Hz)
Pre-1971 ambient measurement	-	-	-	0.52	1.92
1971 San Fernando (M=6.5, d=20 km)	0.14	0.32	7.8	1.3	0.77
Post-1971 ambient measurement	-	-	-	0.7	1.43
1987 Whittier (M=6.1, d=41 km)	0.14	0.17	2.8	1.1	0.91
1992 Landers (M=7.5, d=187 km)	0.04	0.13	3.2	1.2	0.83
1992 Big Bear (M=6.6, d=152 km)	0.02	0.06	1.6	1.2	0.83
1994 Northridge (M=6.7, d=7 km)	0.45	0.58	23.0	1.5 - 2.0	0.67 - 0.5

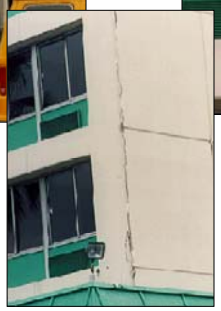
Comparison of Roof Particle Motion



Column damage

Damage Details




Courtesy of Dr. Naeim

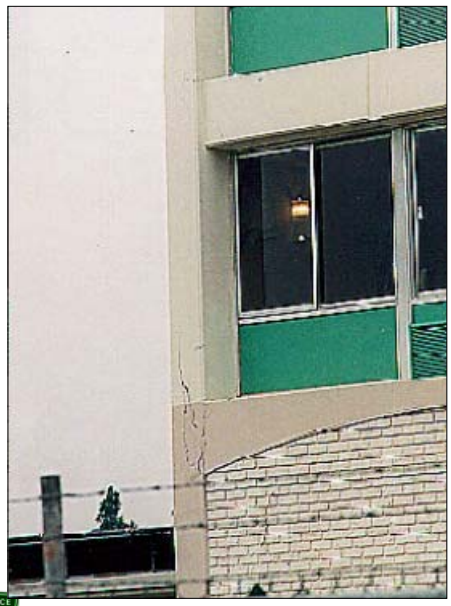
Interior Damage






Courtesy of Dr. Naeim

North side damage



Courtesy of Dr. Naeim

Temporary shoring

Courtesy of Dr. Naeim

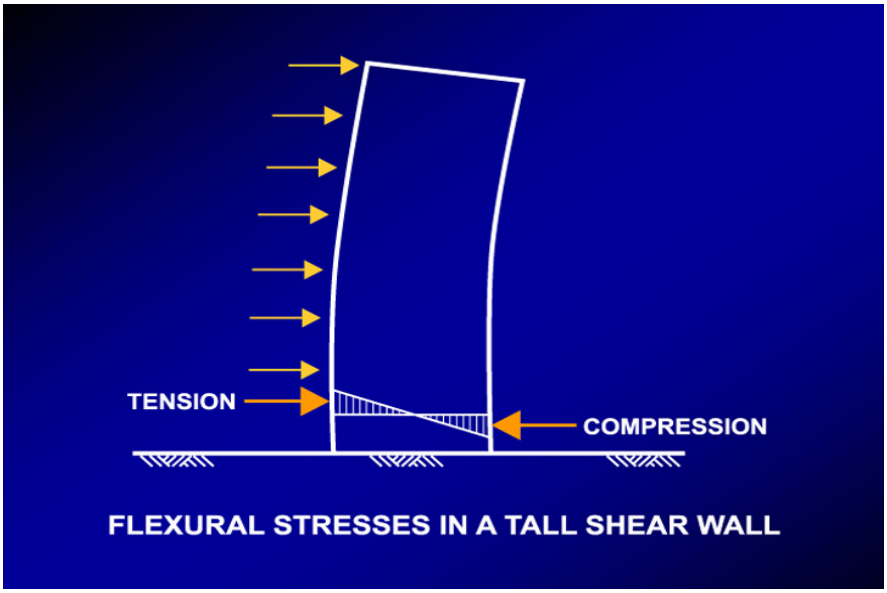
Repaired & Retrofitted Building (1996)

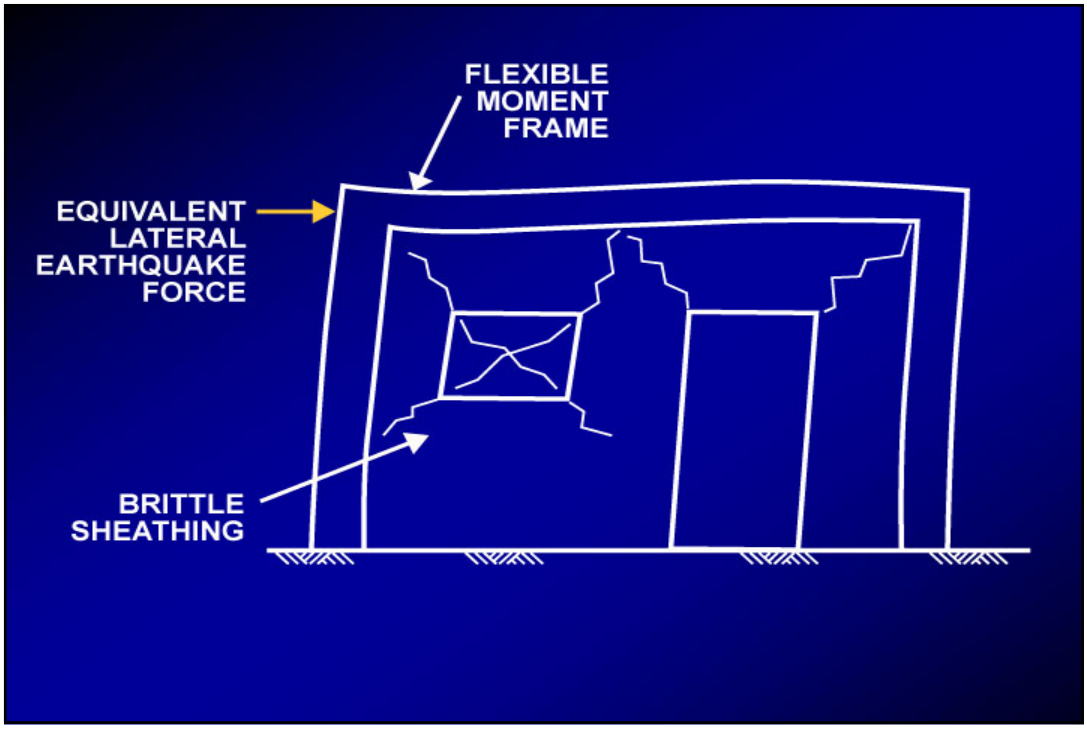
Ground Failure

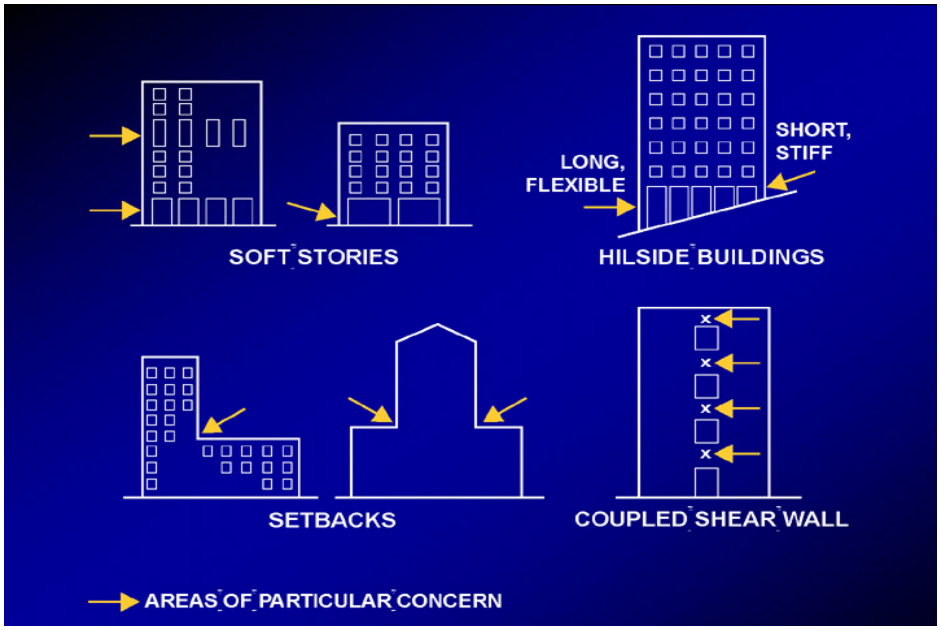
EXAMPLE – SEVERE GROUND DISPLACEMENT OR FOUNDATION DAMAGE

Liquefaction

Points to remember


TENSION
COMPRESSION
FLEXURAL STRESSES IN A TALL SHEAR WALL


FLEXIBLE MOMENT FRAME
EQUIVALENT LATERAL EARTHQUAKE FORCE
BRITTLE SHEATHING



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Remarks

- Instrumentation of buildings is valuable for understanding their response to severe shaking
- Observed response of RC buildings provides valuable information and lessons
- Ground motions with the same PGA, but different mechanisms can have very different demands upon a structure