Building Code Seismic Safety Provisions:

Should Memphis Adopt IBC/NEHRP for Seismic Safety?

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A curious result is produced by the International Building Code

The IBC establishes California-level seismic hazard for a county that has never experienced a single building collapse as the result of an earthquake.

…seismic provisions

Memphis –Shelby County Building Code Enforcement

Enforces the applicable chapter(s) of the Standard Building Code, 1999 edition and locally adopted ordinance, Appendix L

…seismic provisions

Memphis –Shelby County Building Code Enforcement is considering:

1) **Adoption - IBC using 2% PE in 50-years**
   (strong mitigation effort – equal to San Francisco)

2) **Adoption - IBC using 10% PE in 50-years**
   (moderate mitigation effort – historically accepted)

The moderate approach advised.
Use Maps for 10% PE in 50-yr.

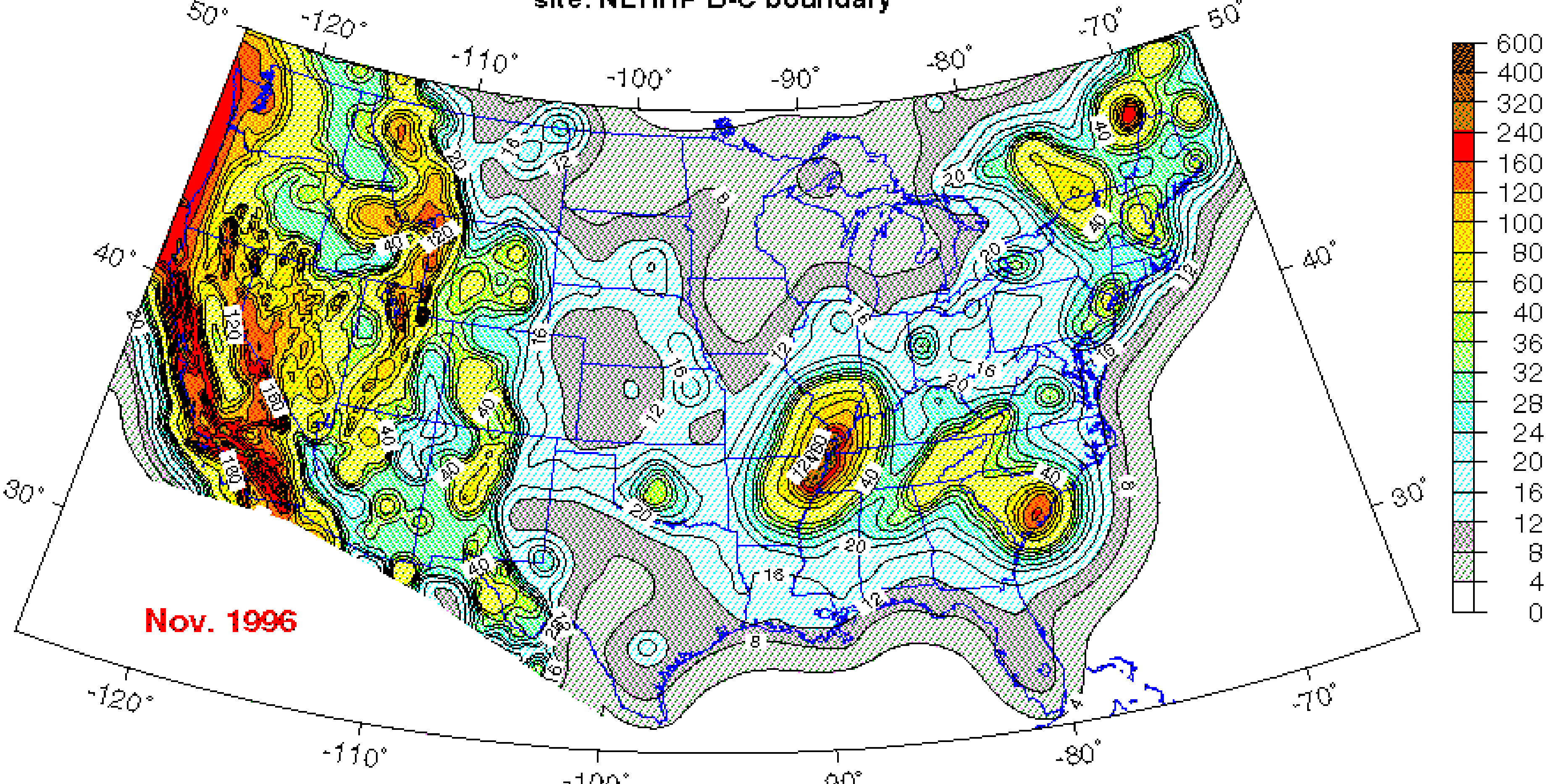
1) **Smaller uncertainties in the magnitude and recurrence interval of strong ground motion.**
2) **Cost/benefit relationship is favorable.**
3) **Provides reasonable level of collapse prevention and life safety at reasonable expense.**

The International Building Code
My Point of View

- **Overstates earthquake risks during the useful life of building.**
- **Designates the New Madrid Seismic Zone as the most hazardous/highest risk in the lower 48 states.**
- **Not cost effective for life safety; includes elements of property loss reduction.**
- **Does not reflect safety, economic, and political realities of the community.**
- **Will not promote voluntary compliance.**

0.2 sec Spectral Accel. (%g) with 2% Probability of Exceedance in 50 Years

site: NEHRP B-C boundary

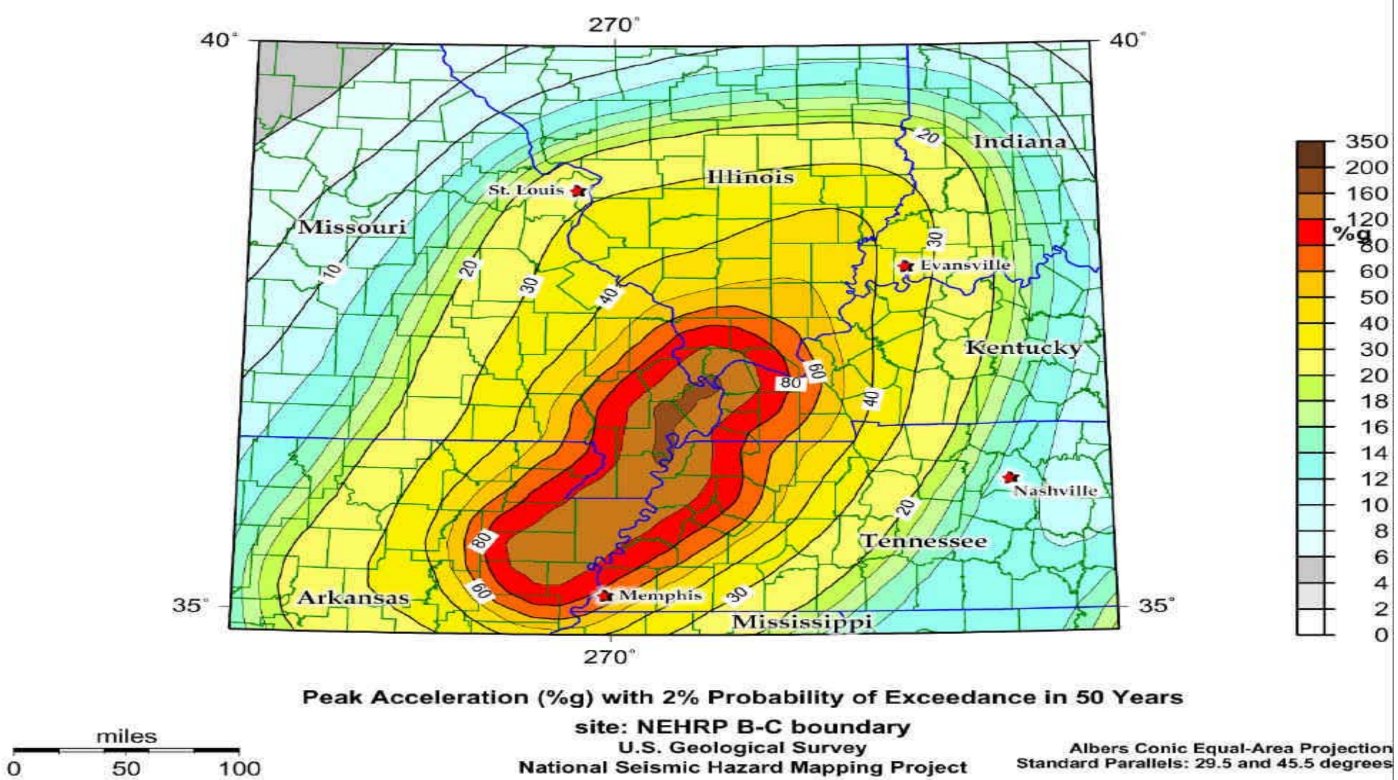


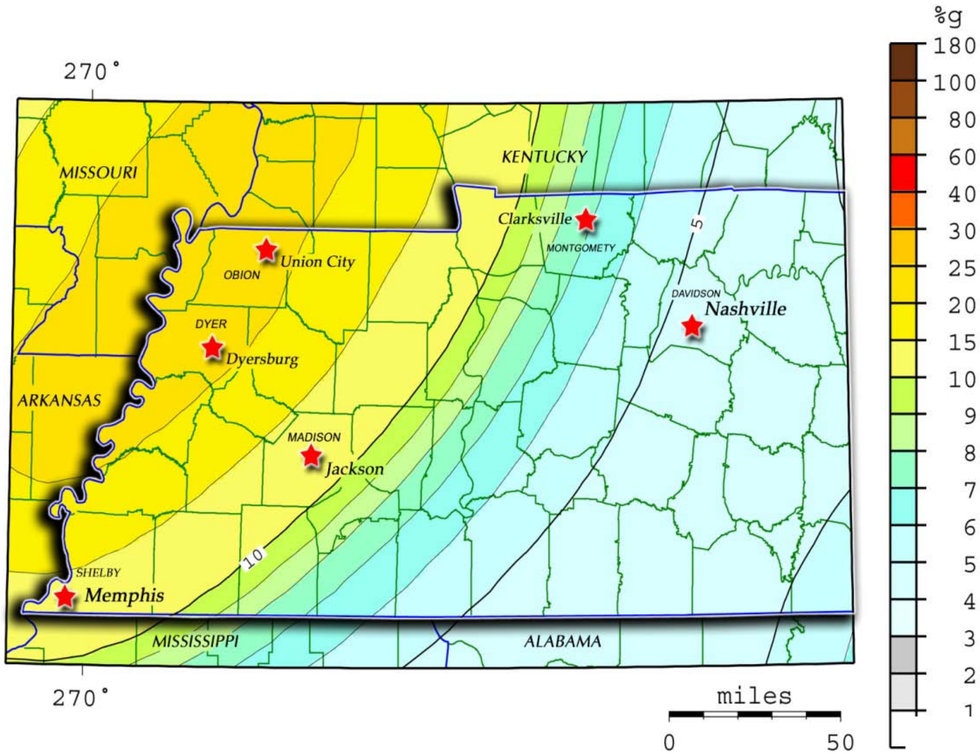
U.S. Geological Survey
National Seismic Hazard Mapping Project

New Madrid Seismic Zone - Peak Ground Acceleration
2% Probability of Exceedance in 50 years

Source: USGS

This map is the basis of design requirements for IBC





West Tennessee

Peak Acceleration (%g) with 10% Probability of Exceedance in 50 Years

Source: USGS

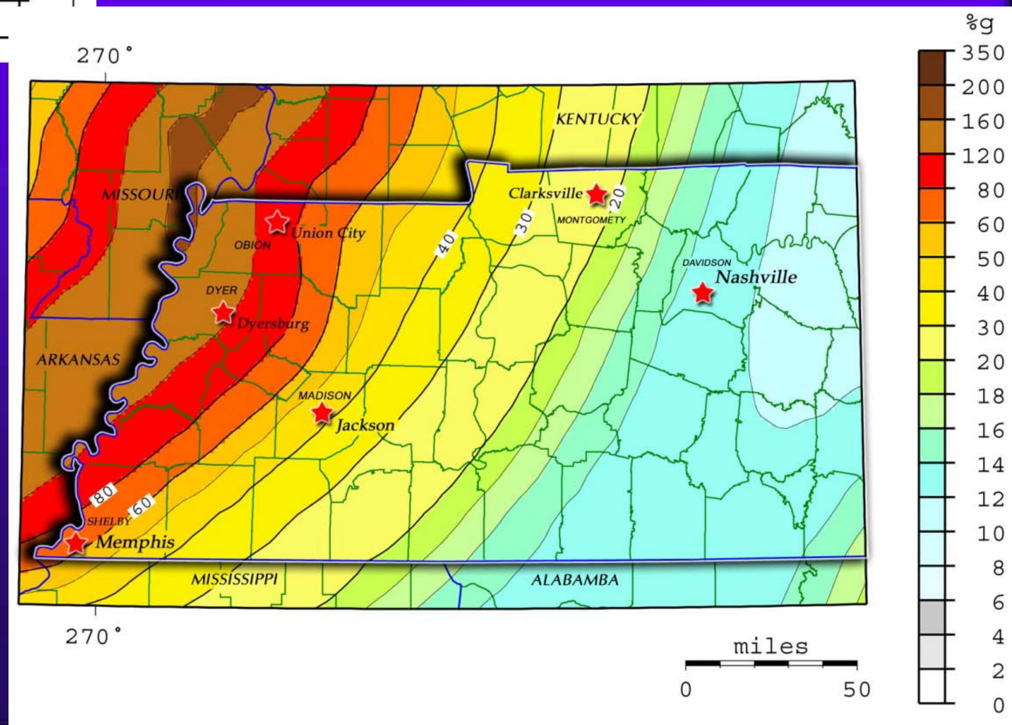
Similar to that used by SBC 99

West Tennessee

Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years

Source: USGS

Used by the 2003 IBC



IBC changes performance goals from 10% PE in 50-years (1 event exceeds HA in 500 yrs.) to 2% PE in 50-years (1/2,500 yrs.)

California

- Ratio 2 PE/10 PE = ±1.5
- With 2/3 reduction S_{DS}= same as 10% PE
- Deterministic Methods

Shelby Co.

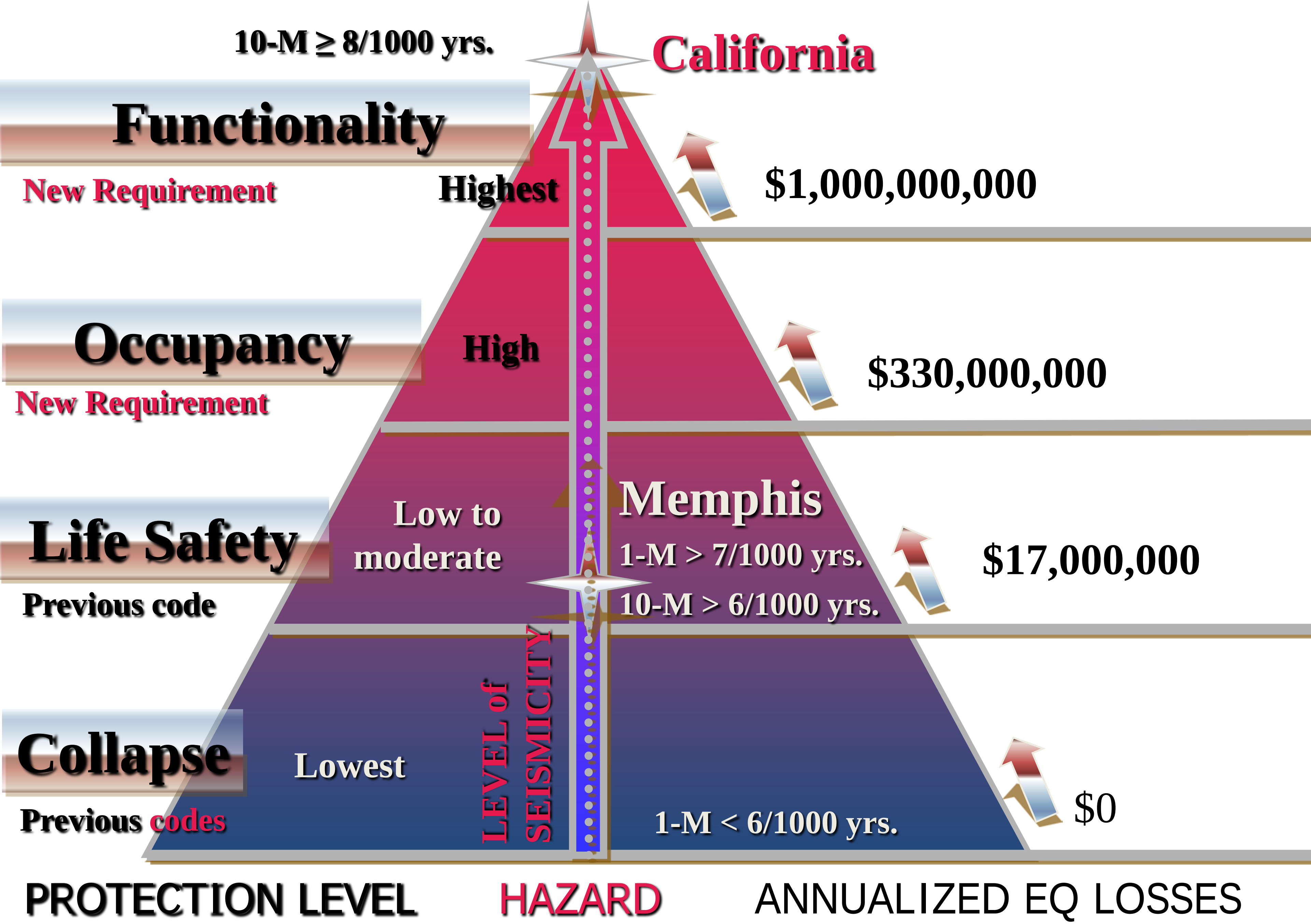
- Ratio 2 PE/10 PE = ± 5
- with 2/3 reduction S_{DS} = 3.33×10% PE
- Probabilistic Methods

- Hazard Maps do not provide uniform margin of comfort for collapse prevention nationally.
- A consequence of considering a higher recurrence interval is that underlying uncertainties in the hazard estimate become extremely high.
- Probabilistic = Guess

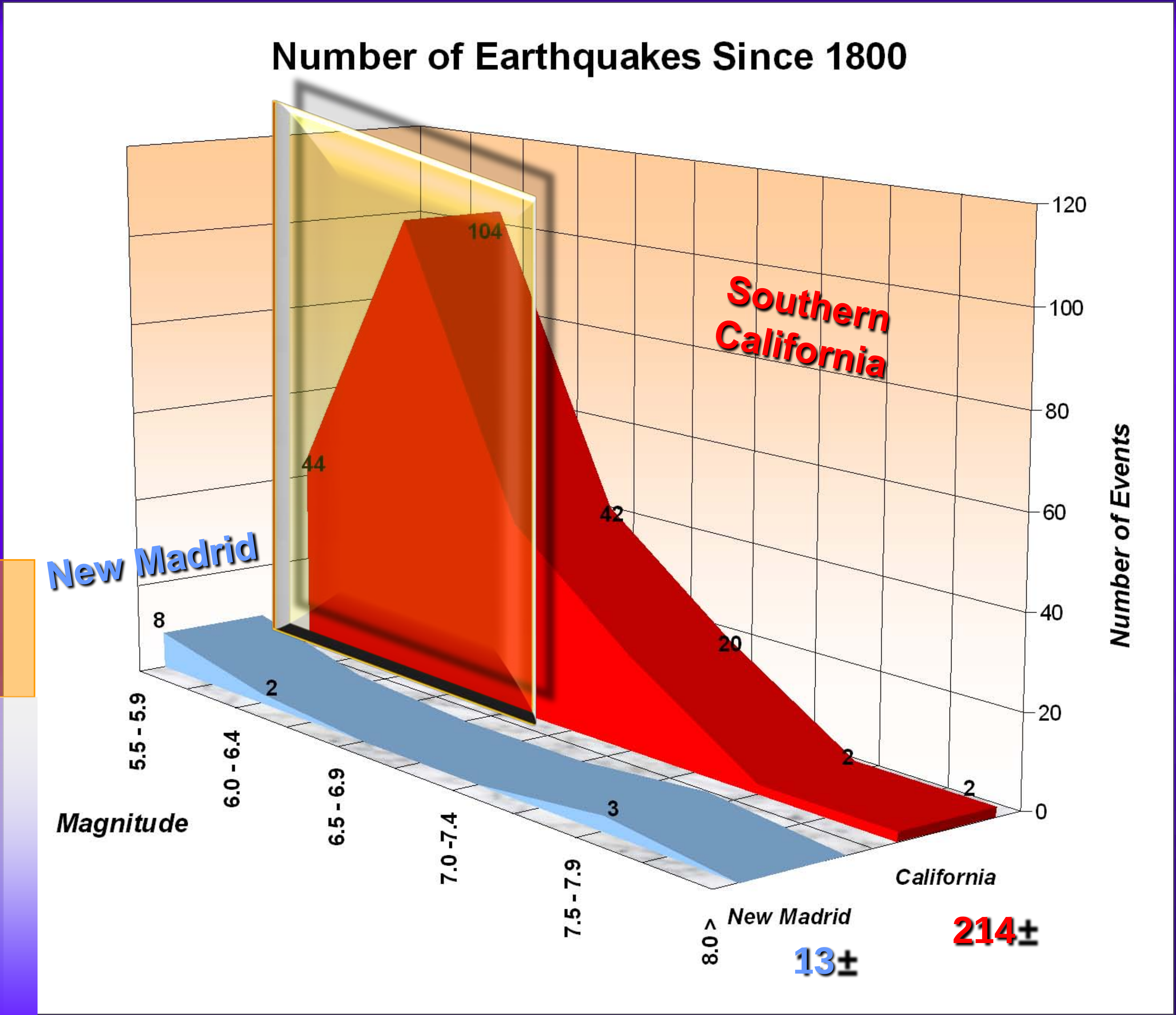
Recurrence periods for natural hazards (ASCE 7.02)

Hazard	Return Period
Regional Flooding	500-year
Local Flooding	100-year
Snow Loading	50-year
Wind Loads	500-year
Rain Loads	10-year
Ice Loads	50-year
Earthquake Pre NEHRP 97	500-year
Earthquake NEHRP/IBC	2,500-year

BUILDING LIFE
50-YEARS



10-M ≥ 8/1000 yrs.
California
Functionality
New Requirement
Highest
$1,000,000,000
Occupancy
New Requirement
High
$330,000,000
Memphis
Life Safety
Previous code
Low to moderate
1-M > 7/1000 yrs.
10-M > 6/1000 yrs.
$17,000,000
Collapse
Previous codes
Lowest
LEVEL of SEISMICITY
1-M < 6/1000 yrs.
$0
PROTECTION LEVEL
HAZARD
ANNUALIZED EQ LOSSES



Hazard

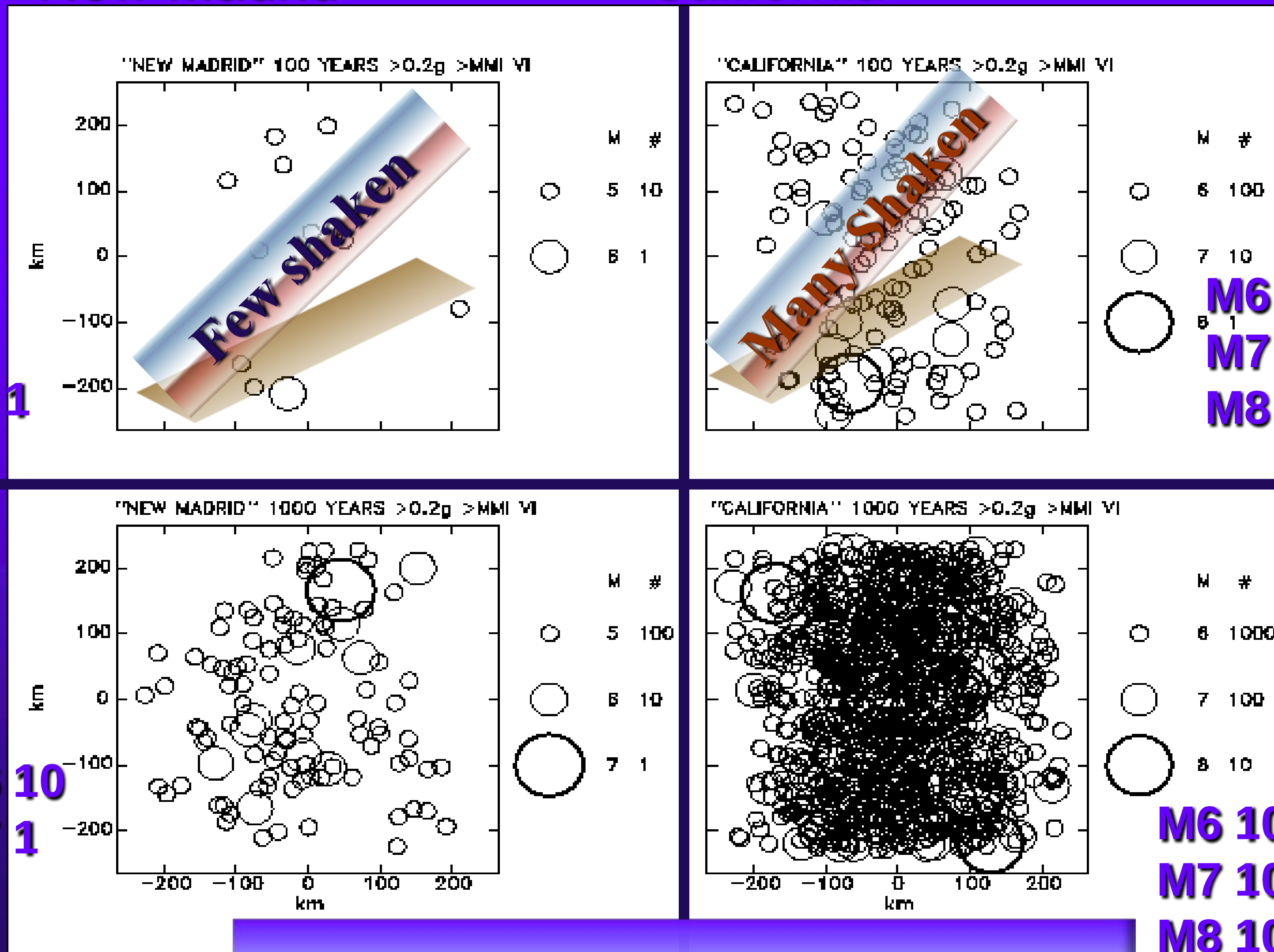
Dramatic difference in number of quakes

Relative Hazard – Strong Shaking Area

New Madrid California

100 yrs.

1000 yrs.



M6 1

M6 100
M7 10
M8 1

M6 10
M7 1

M6 1000
M7 100
M8 10

BUILDING LIFE ~ 50 yrs.

FEMA Report 366 2000
Memphis Risk 1/10th San Francisco

Annualized Earthquake Loss (AEL) and Average Earthquake Loss Ratios (AELR)

Order	Metropolitan Area*	AELR ($ / Million)	S_TRI (%)	AEL ($Million)	SRI (%)	Building Stock ($Billion)
1	San Francisco, CA	3167.5	100.0	346.0	32.4	109.23
2	San Jose, CA	3017.7	95.3	242.5	22.7	80.36
3	Oakland, CA	2954.3	93.3	348.7	32.6	118.03
4	Eureka, CA	2935.7	92.7	33.8	3.2	11.51
5	Hilo, HI	2825.4	89.2	19.7	1.8	6.97
6	Ventura, CA	2760.9	87.2	89.4	8.4	32.38
7	Riverside, CA	2673.3	84.4	356.7	33.4	133.43
8	Santa Cruz, CA	2628.9	83.0	32.9	3.1	12.51
9	Los Angeles, CA	2299.0	72.6	1069.0	100.0	464.98
10	Santa Rosa, CA	2293.7	72.4	51.2	4.8	22.32
11	Vallejo, CA	2275.2	71.8	52.7	4.9	23.16
12	Salinas, CA	1819.0	57.4	33.1	3.1	18.20
13	Santa Barbara, CA	1690.1	53.4	33.1	3.1	19.58
14	Orange, CA	1666.2	52.6	214.4	20.1	128.68
15	Anchorage, AK	1640.1	51.8	24.9	2.3	15.18
16	Redding, CA	1287.9	40.7	10.3	1.0	8.00
17	Reno, NV	1246.2	39.3	17.8	1.7	14.28
18	San Luis Obispo, CA	1232.0	38.9	15.6	1.5	12.66
19	Portland, OR	1173.0	37.0	98.4	9.2	83.89
20	Bakersfield, CA	1155.1	36.5	30.6	2.9	26.49
21	Seattle, WA	1118.8	35.3	128.4	12.0	114.77
22	Salem, OR	1083.9	34.2	15.3	1.4	14.12
23	San Diego, CA	992.6	31.3	127.5	11.9	128.45
24	Tacoma, WA	983.8	31.1	28.3	2.6	28.77
25	Salt Lake City, UT	954.7	30.1	39.5	3.7	41.37
26	Stockton, CA	824.5	26.0	19.2	1.8	23.29
27	Charleston, SC	722.2	22.8	13.3	1.2	18.42
28	Modesto, CA	629.4	19.9	11.2	1.0	17.79
29	Las Vegas, NV	599.4	18.9	28.0	2.6	46.71
30	Sacramento, CA	523.2	16.5	39.3	3.7	75.11
31	Albuquerque, NM	503.7	15.9	13.0	1.2	25.81
32	Memphis, TN	387.6	12.2	17.2	1.6	44.38
33	Fresno, CA	379.4	12.0	14.0	1.3	36.90
34	St. Louis, MO	281.8	8.9	34.1	3.2	121.01
35	Honolulu, HI	263.4	8.3	11.6	1.1	44.04
36	New York, NY	125.4	4.0	56.4	5.3	449.76
37	Newark, NJ	108.7	3.4	11.6	1.1	106.72
38	Atlanta, GA	86.9	2.7	11.3	1.1	130.03
39	Boston, MA	74.7	2.4	23.3	2.2	311.91
40	Philadelphia, PA	63.6	2.0	16.8	1.6	264.15

FEMA Report 366b 2008
Memphis Risk 1/5th San Francisco

Annualized Earthquake Loss (AEL) and Average Earthquake Loss Ratios (AELR)

FEMA 366 / April 2008

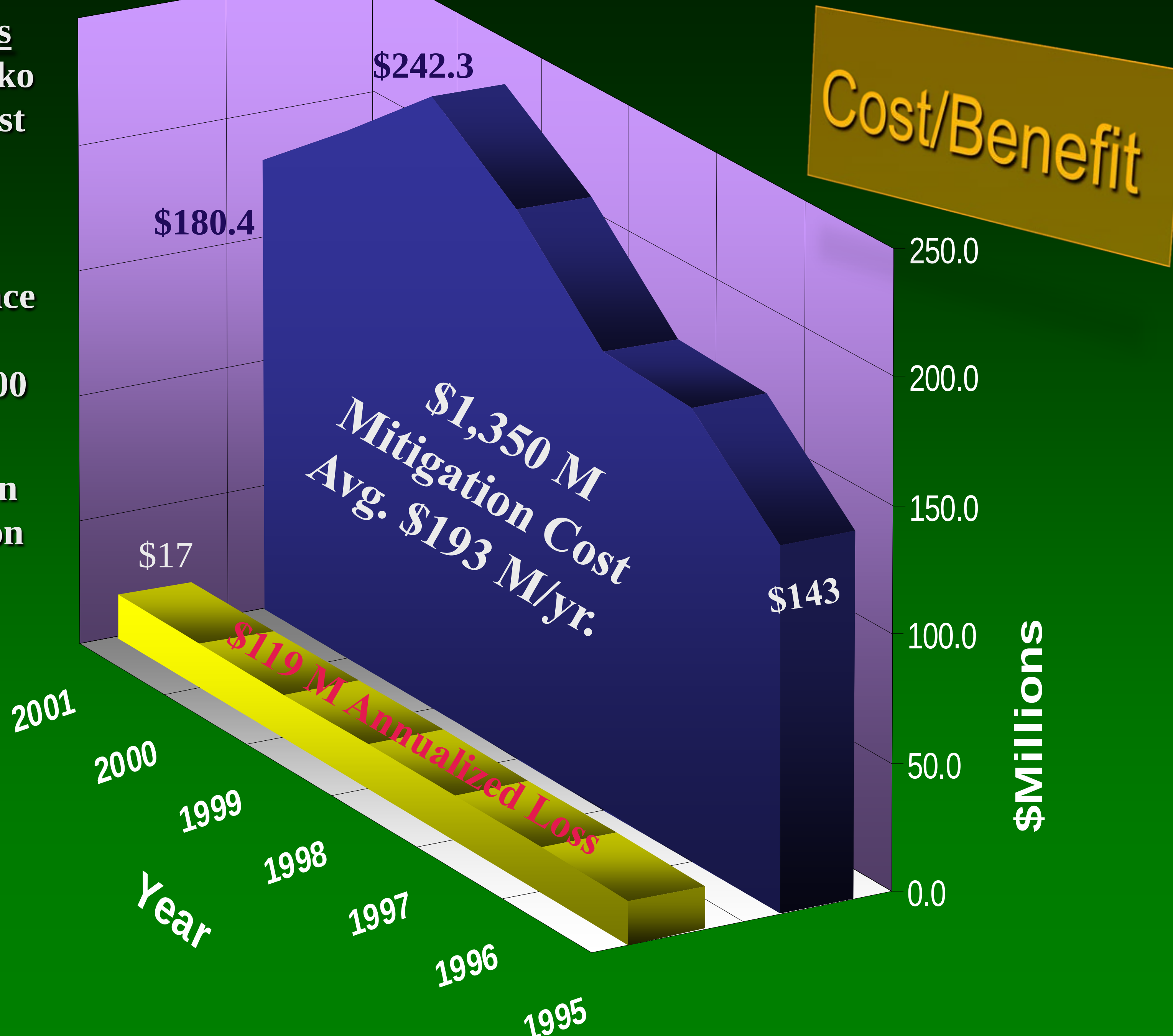
for 43 Metropolitan Areas with AEL Greater Than $10 Million

Order	Metropolitan Area*	AELR ($ / Million)	S_TRI (%)	AEL ($Million)	SRI (%)	Building Stock ($Billion)
1	San Francisco-Oakland-Fremont, CA	2,049.44	100.0	781.00	59.5	381.08
2	Riverside-San Bernardino-Ontario, CA	2,021.57	98.6	396.50	30.2	196.13
3	El Centro, CA	1,973.77	96.3	10.70	0.8	5.42
4	Oxnard-Thousand Oaks-Ventura, CA	1,963.00	95.8	111.00	8.5	56.55
5	San Jose-Sunnyvale-Santa Clara, CA	1,837.58	89.7	276.70	21.1	150.58
6	Santa Rosa-Petaluma, CA	1,662.57	81.1	68.60	5.2	41.26
7	Santa Cruz-Watsonville, CA	1,580.97	77.1	36.20	2.8	22.90
8	Los Angeles-Long Beach-Santa Ana, CA	1,574.85	76.8	1,312.30	100.0	833.29
9	Napa, CA	1,398.18	68.2	15.90	1.2	11.37
10	Vallejo-Fairfield, CA	1,375.94	67.1	39.80	3.0	28.93
11	Anchorage, AK	1,238.56	60.4	34.80	2.7	28.10
12	Santa Barbara-Santa Maria-Goleta, CA	1,207.93	58.9	34.40	2.6	28.48
13	Reno-Sparks, NV	1,150.40	56.1	29.00	2.2	25.21
14	Bremerton-Silverdale, WA	1,110.13	54.2	17.70	1.3	15.94
15	Salinas, CA	1,075.54	52.5	29.20	2.2	27.15
16	Seattle-Tacoma-Bellevue, WA	1,052.43	51.4	243.90	18.6	231.75
17	Salt Lake City, UT	984.61	48.0	52.30	4.0	53.12
18	Olympia, WA	969.50	47.3	13.70	1.0	14.13
19	Portland-Vancouver-Beaverton, OR-WA	942.62	46.0	137.10	10.4	145.45
20	Bakersfield, CA	870.43	42.5	30.30	2.3	34.81
21	San Luis Obispo-Paso Robles, CA	848.65	41.4	15.70	1.2	18.50
22	Ogden-Clearfield, UT	826.52	40.3	17.50	1.3	21.17
23	Salem, OR	797.50	38.9	17.40	1.3	21.82
24	San Diego-Carlsbad-San Marcos, CA	770.20	37.6	155.20	11.8	201.51
25	Charleston-North Charleston, SC	766.01	37.4	22.30	1.7	29.11
26	Eugene-Springfield, OR	701.95	34.3	16.50	1.3	23.51
27	Provo-Orem, UT	683.30	33.3	10.40	0.8	15.22
28	Stockton, CA	597.79	29.2	20.90	1.6	34.96
29	Memphis, TN-MS-AR	509.13	24.8	38.20	2.9	75.03
30	Evansville, IN-KY	485.60	23.7	11.70	0.9	24.09
31	Columbia, SC	478.05	23.3	21.60	1.6	45.18
32	Modesto, CA	473.60	23.1	13.00	1.0	27.45
33	Las Vegas-Paradise, NV	390.28	19.0	33.10	2.5	84.81
34	Sacramento-Arden-Arcade--Roseville, CA	374.73	18.3	52.00	4.0	138.77
35	St. Louis, MO-IL	337.23	16.5	58.50	4.5	173.47
36	Albuquerque, NM	322.20	15.7	14.70	1.1	45.62
37	Honolulu, HI	311.12	15.2	32.00	2.4	102.85
38	Fresno, CA	283.13	13.8	12.60	1.0	44.50
39	Little Rock-North Little Rock, AR	248.74	12.1	10.50	0.8	42.21
40	Nashville-Davidson--Murfreesboro, TN	167.26	8.2	15.40	1.2	92.07
41	Birmingham-Hoover, AL	115.54	5.6	11.30	0.9	97.80
42	Atlanta-Sandy Springs-Marietta, GA	65.39	3.2	19.10	1.5	292.09
43	New York-Northern New Jersey-Long Island, NY-NJ-PA	20.90	1.0	29.90	2.3	1430.62

Anticipated Range of Cost Increase to New Buildings.

- **Anticipated cost increases above SBC 99:**
  - –Residential – 10% to 15%.
  - –Commercial – 10% to 15%.
  - –Light industrial – 15% to 25%.
  - –Heavy industrial – 25% to 35%.

Annualized Losses
Dr. Stuart Nishenko
Senior Seismologist
Building Sciences and Assessment Branch, FEMA
WSSPC Conference
Seattle, WA
September 20, 2000



Mitigation based on 10% of construction cost

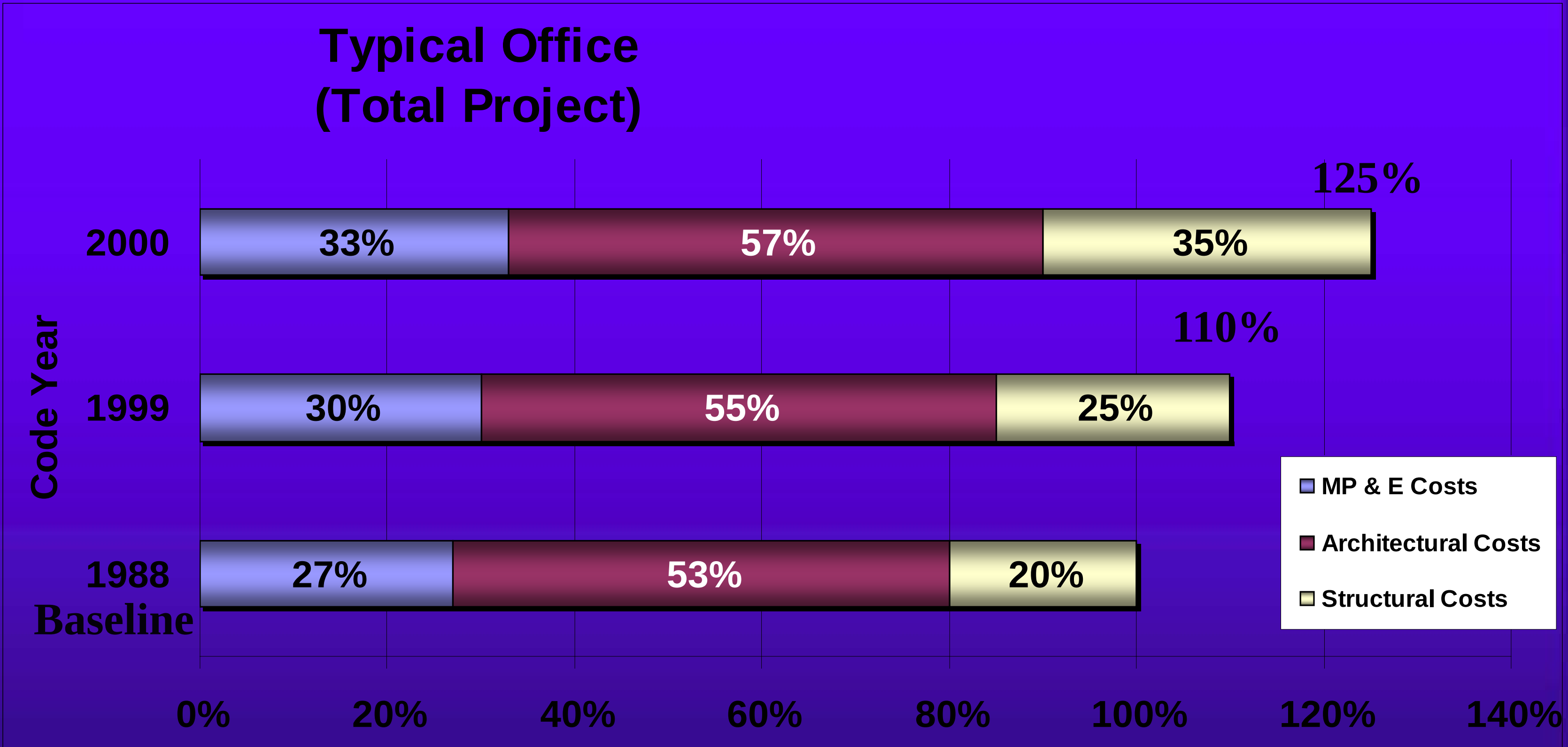
Valuation of current construction courtesy of Memphis Regional Chamber

At Risk

Statistical causes of death in the United States, 1996 (annual average)

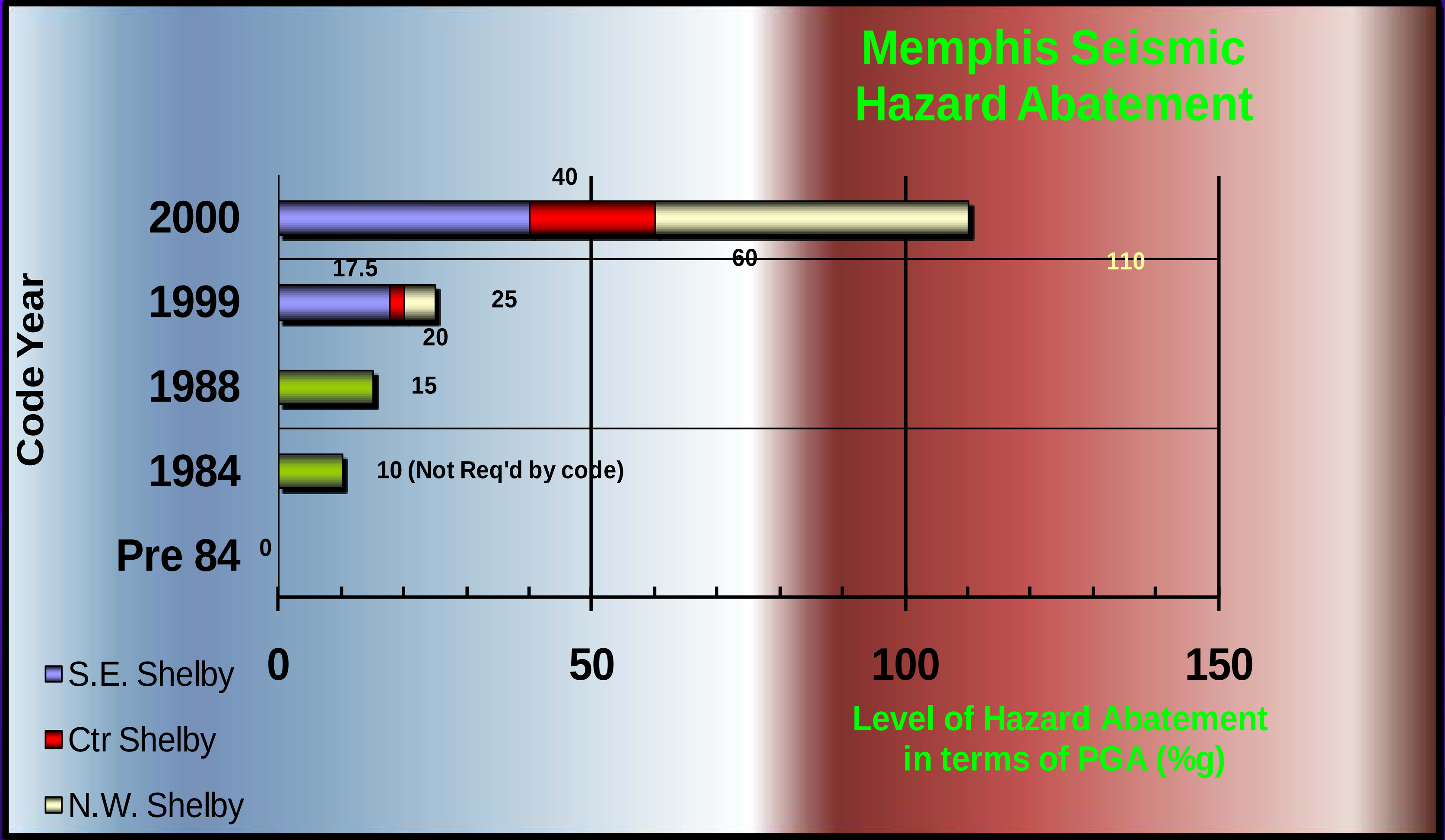
Heart Attack	733,834
Cancer	544,278
Stroke	160,431
Lung Disease	106,143
Pneumonia/Influenza	82,579
Diabetes	61,559
Motor Vehicle Accide	43,300
AIDS	32,655
Suicide	30,862
Liver Disease/Cirrhos	25,135
Kidney Disease	24,391
Alzheimer's	21,166
Homicide	20,738
Falling	14,100
Poison	10,400
Drowning	3,900
Fires	3,200
Suffocation	3,000
Bicycle Accidents	695
Severe Weather [1]	514
In-line Skating [2]	25
Football [2]	18
Skateboards [2]	10
Earthquakes (1811-1983) [3]	9
Earthquakes (1984-1998)	9

Historic and projected cost of mitigation



Based on FedEx World HQ., Memphis, TN. 2001

The Increasing Performance Level



Perspective

- The cause of earthquakes in New Madrid zone is poorly known: situation won't improve for many years.
- Seismic hazard maps used in NEHRP model code have large uncertainties and overstate hazard for the NMSZ.
- Causes, magnitude, and recurrences of large earthquakes are not understood.
- IBC changes performance goals from traditional 10% PE in 50 years (1 event in 500 yrs.) to 2% PE in 50 years (1 event / 2,500 yrs.) – dwarfs normal 50-yr life of building.
- Very strong earthquakes rare in the NMSZ

Perspective

Costly for life safety, includes elements of property loss reduction.

The public is asked to implement expensive hazard reduction program without regard to cost.

FEMA has underwritten implementation of seismic requirements without first determining the public’s willingness to spend limited private resources on superfluous seismic safety

Example of Good Intentions Gone Bad: California's Legislature passed Senate Bill 1953 (SB 1953)

- Passed in 1994, the bill was an unfunded mandate to retrofit, rebuild, or close acute care hospitals; a free lunch for California taxpayer.
- For profit and not-for profit (both public and private) were affected equally.
- Requires over 70 million square feet to be retrofitted.
- Because of regulatory agencies, only about 2 million square feet per year were retrofitted due to:
  - Lengthy review process
  - Changing codes

Example of Good Intentions Gone Bad: California's Legislature passed Senate Bill 1953 (SB 1953)

- Costs ran about $1,000 per square foot.
- Including the cost of loans, the costs exceeded $2,800
- Based on FEMA's annualized earthquake losses, $7.6 Billion in losses is expected.
- Cost of SB 1953 already exceeds $110 Billion – 14 times the annualized cost of damage over 50-yrs
- 50 hospitals closed
- 3,000 acute care beds removed from services between 2001 and 2005

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Recommendation:

Use 1/500-yr. recurrence as performance level for seismic hazard.

- Risk corresponding to 1/500 yrs. is accepted as the norm by designers in the NMSZ.
- Gives reasonable seismic safety at significantly lower cost; public and business community will be more likely to accept such a standard while providing a reasonable level of life safety.
- Based on the intensity of the earthquake (MM VII –MM VIII) and the type of construction, most modern buildings will survive high intensity shaking.