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PAGER-WHE Phase II Analytical Model

EERI/WHE-PAGER Project Review Meeting, Oakland, 23 Aug 2009

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Where we are:
Phase II (Analytical) Model

- Origin of the PAGER-WHE collaboration
- Motivation to apply an analytical model
- Cracking an Open Safe approach & s/w
- Reducing parameter set
- Using laboratory evidence to inform parameters
- Limitations of safecrack approach

Origin

Goal: rapid (fatality) loss est. shortly after earthquakes

- Inform early aid decisions
- ±½-1 order of magnitude accuracy

Available data

- Shakemap + Landscan = estimated num. people by MMI
- Piecharts: fraction of people by structure type, res/nonres, urban/rural

Needed

- Collapse or fatality rate *y* vs. intensity *s* {MMI, Sa, etc.}

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3 approaches

- Empirical: *y*(*MMI*) by country or small region by fitting curves to hindcast 30 years of loss data

$$E\left[deaths \mid Shakemap, Landscan\right] = \sum_{gridcells\ j} People\left(MMI_j\right) \cdot y\left(MMI_j\right)$$

- Semi-empirical *y*(*MMI*) by structure type from expert opinion

$$E\left[deaths \mid Shakemap, Landscan, Piechart\right] = \sum_{struct\ types\ i} \sum_{j} People\left(MMI_j\right) \cdot Frac_{i,j} \cdot y_i\left(MMI_j\right)$$

- Analytical y(Sa(0.3), Sa(1.0), M…) by structure type

$$E\left[deaths \mid Shakemap, Landscan, Piechart\right] = \sum_{i} \sum_{j} People\left(Sa_j\right) \cdot Frac_{i,j} \cdot y_i\left(Sa(0.3)_j, S_a(1.0)_j, \ldots\right)$$

Phase I: semi-empirical

- Map EMS-98 scale to numeric rating V_i for each report *i*

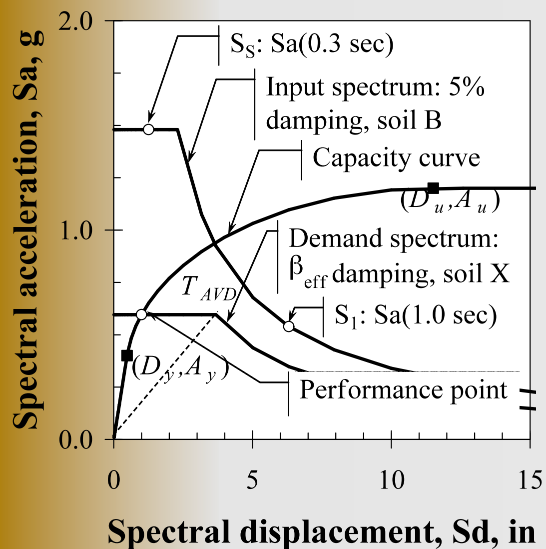
Rating	A	B	C	D	E	F
V_i	6	5	4	3	2	1

- p_i = fraction of housing of type *i*, from WHE experts
- N = 15 countries have *p* and *V*
- Calculate country-level average *V*: $$V = \frac{\sum_{i=1}^{N} p_i V_i}{\sum_{i=1}^{N} p_i}$$
- Needed benchmark B, D, & F to guide rating assignments
- Ultimately: p_i and $y_i(MMI)$ from judgment or evidence

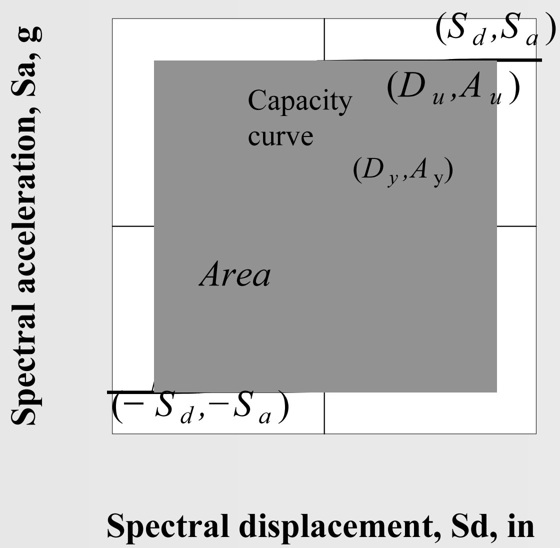
Analytical approaches

- HAZUS-based approach
  - CSM method of structural analysis
  - With fragility functions for 3 components
  - Parameter values available for all US types
- Enhanced nonlinear procedures with SDOF
  - Various FEMA 440 or European NSPs
  - Nonlinear dynamic analysis of SDOF model
  - New parameter values needed
- MDOF PEER/ATC-58 or DBELA
  - Very time consuming, much more data needed

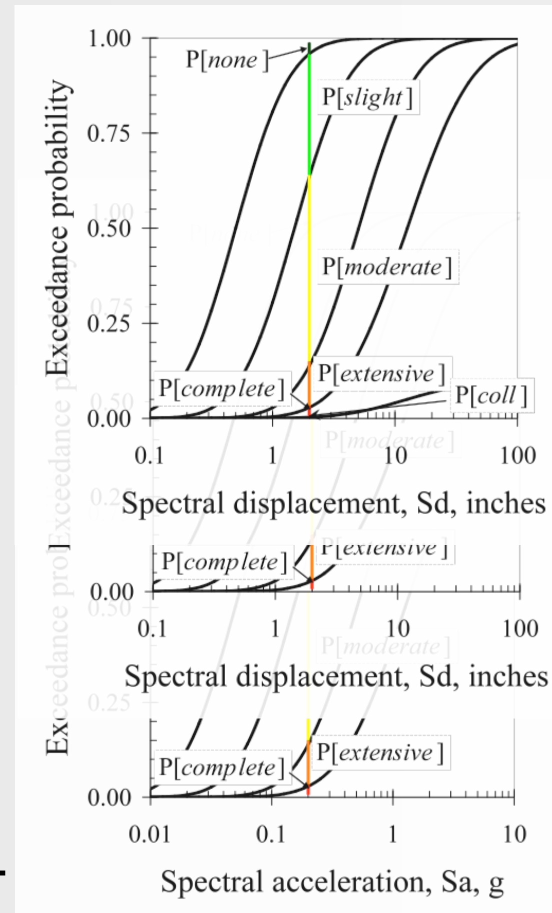
HAZUS-based approach



4 pushover parameters



Elastic damping + 3 "kappa" parameters



9 + 8 + 8 fragility parameters
+ 20 more for casualty rates
+ 12 for economic loss

Simplifying HAZUS-based approach

4 pushover

1 elastic damping

3 “kappa”

9 structural fragility

2 complete structural fragility + P_c

2 collapse fragility

8 nonstructural drift-sensitive

8 nonstructural accel-sensitive

20 casualty rates

5 casualty rates for fatal inj.

1 collapse fatality rates

12 for economic loss

Σ = 11 parameter values

Fatalities only

- Ignore nonstructural fragility
- Ditto, economic loss
- Ditto, nonfatal injuries

Collapse as main killer

- Ignore slight, moderate, and heavy damage

Use collapse fragility

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“Key” parameters

- (Dy, Ay): Spectral displacement and accel at yield
- (Du, Au): ditto, ultimate
- B_E: elastic damping ratio
- k_{short}: short duration→ less pinching of hyst. loop
- κ_{med}
- k_{long}: long duration→ more pinching
- θ_{15}: median spectral displacement, collapse
- β_{15}: ditto, logarithmic standard deviation
- L_{45}: fraction of indoor occs killed, given collapse

Automating HAZUS-based approach

Cracking an Open Safe: HAZUS Vulnerability Functions in Terms of Structure-Independent Spectral Acceleration

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ABSTRACT

The HAZUS Technical Manual clearly documents a methodology for calculating various measures of earthquake loss to ordinary buildings using in part the capacity spectrum method of structural analysis, but it does not provide tabular results relating loss to structure-independent intensity measures such as S_a(0.3 sec, 5%) or S_a(1.0 sec, 5%), and no procedure for doing so is offered. It is a minor challenge to perform such calculations owing to the sometimes iterative nature of structural analysis in the capacity-spectrum method. A technique to calculate mean loss (here, fatality rate in ordinary buildings) as a function of site-soil-adjusted S_a(0.3 sec, 5%) and S_a(1.0 sec, 5%) is presented that is consistent with HAZUS and all its parameters. The resulting seismic vulnerability functions are tabulated online at www.risk-agora.org as a resource for open risk modeling. Such seismic vulnerability functions facilitate loss analyses because they de-couple the calculation of hazard from that of loss given hazard.

INTRODUCTION

PAGER

The US Geological Survey is adding post-earthquake fatality estimation to its Prompt Assessment of Global Earthquakes for Response (PAGER) program. PAGER's goal is to inform early and rapid post-earthquake decisions about humanitarian assistance before ground-truth and news information can be acquired. It can also be used to examine hypothetical scenarios for risk-management purposes. In its post-earthquake mode, PAGER monitors the USGS's near real-time global earthquake solutions, automatically identifies

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Submitted for review to *Earthquake Spectra* 1/1/2008

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L : Table

Snplus	MBTplus	Domain	M	R	Siteclass	SSFa	S1Fv	IM	L1	L2	L3	L4
1.1	W1h	CEUS	5	10	A	0.04	0	Sa10	0	0	0	0
1.1	W1h	CEUS	5	10	A	0.09	0.01	Sa10	4.6E-08	0	0	0
1.1	W1h	CEUS	5	10	A	0.12	0.01	Sa10	1.4E-07	0	0	0
1.1	W1h	CEUS	5	10	A	0.06	0.01	Sa10	4E-09	0	0	0
1.1	W1h	CEUS	5	10	A	0.07	0.01	Sa10	1.35E-08	0	0	0
1.1	W1h	CEUS	5	10	A	0.05	0.01	Sa10	1E-09	0	0	0
1.1	W1h	CEUS	5	10	A	0.18	0.02	Sa10	1.02E-06	3.9E-09	0	0
1.1	W1h	CEUS	5	10	A	0.15	0.02	Sa10	4E-07	9E-10	0	0
1.1	W1h	CEUS	5	10	A	0.29	0.03	Sa10	5.63E-06	4.08E-08	0	0
1.1	W1h	CEUS	5	10	A	0.23	0.03	Sa10	2.49E-06	1.32E-08	0	0
1.1	W1h	CEUS	5	10	A	0.37	0.04	Sa10	1.19E-05	1.23E-07	2E-11	2E-11
1.1	W1h	CEUS	5	10	A	0.46	0.05	Sa10	2.36E-05	3.35E-07	1.6E-10	1.6E-10
1.1	W1h	CEUS	5	10	A	0.58	0.07	Sa10	4.32E-05	8.58E-07	5E-10	5E-10
1.1	W1h	CEUS	5	10	A	0.74	0.08	Sa10	7.59E-05	1.99E-06	1.53E-09	1.53E-09
1.1	W1h	CEUS	5	10	A	0.93	0.11	Sa10	0.000127	4.44E-06	4.41E-09	4.41E-09
1.1	W1h	CEUS	5	10	A	1.17	0.13	Sa10	0.000204	9.46E-06	7.19E-08	1.12E-07
1.1	W1h	CEUS	5	10	A	1.47	0.17	Sa10	0.000313	1.84E-05	1.80E-07	2.80E-07
1.1	W1h	CEUS	5	10	A	1.85	0.21	Sa10	0.000471	3.49E-05	4.62E-07	7.22E-07
1.1	W1h	CEUS	5	10	A	2.46	0.28	Sa10	0.000693	6.19E-05	1.06E-06	1.66E-06
1.1	W1h	CEUS	5	10	A	3.25	0.37	Sa10	0.001012	0.000107	2.29E-06	3.59E-06
1.1	W1h	CEUS	5	10	A	4.2	0.48	Sa10	0.001458	0.000178	4.73E-06	7.43E-06
1.1	W1h	CEUS	5	10	A	5.33	0.61	Sa10	0.002099	0.000291	9.27E-06	1.46E-05
1.1	W1h	CEUS	5	10	A	6.66	0.77	Sa10	0.002979	0.000456	1.68E-05	2.65E-05
1.1	W1h	CEUS	5	10	A	8.22	0.94	Sa10	0.004229	0.000708	2.97E-05	4.69E-05
1.1	W1h	CEUS	5	10	A	10.05	1.16	Sa10	0.005953	0.001077	4.99E-05	7.89E-05
1.1	W1h	CEUS	5	10	A	12.19	1.4	Sa10	0.008171	0.001572	7.83E-05	0.000124
1.1	W1h	CEUS	5	10	A	14.67	1.69	Sa10	0.0111	0.002258	0.000119	0.00019
1.1	W1h	CEUS	5	10	A	17.53	2.02	Sa10	0.014718	0.003141	0.000174	0.000276
1.1	W1h	CEUS	5	10	A	20.81	2.39	Sa10	0.019004	0.004221	0.000242	0.000385
1.1	W1h	CEUS	5	10	A	24.49	2.81	Sa10	0.023688	0.005427	0.000319	0.000508
1.1	W1h	CEUS	5	10	A	28.51	3.28	Sa10	0.028873	0.006806	0.000408	0.000651
1.1	W1h	CEUS	5	10	A	32.7	3.76	Sa10	0.034191	0.008251	0.000502	0.000802
1.1	W1h	CEUS	5	10	A	37.25	4.28	Sa10	0.039372	0.009682	0.000596	0.000953
1.1	W1h	CEUS	5	10	A	42.3	4.86	Sa10	0.043985	0.010971	0.000681	0.00109
1.1	W1h	CEUS	5	10	A	47.92	5.51	Sa10	0.048217	0.012168	0.000761	0.001218
1.1	W1h	CEUS	5	10	A	54.17	6.23	Sa10	0.051746	0.013175	0.000828	0.001325

Record: 1 of 1044480

Datasheet View

Parameter values from experiment

Extracting Values of Some Key
HAZUS-MH Seismic Vulnerability
Parameters from Dynamic Test Results,
with Application to Adobe Dwellings

by
Sean Michael McGowan
B.S.E., Princeton University, 2006

A thesis submitted to the Faculty of the Graduate School
of the University of Colorado in partial fulfillment of the
requirement for the degree of
Master of Science
Department of Civil, Environmental, and
Architectural Engineering
2009

- Dy, Ay, Du, & Au from dynamic response
- B_E from log dec
- θ_{15} from destructive test

- Leaving κ_S, κ_M, κ_L, β_{15}, L_{15}

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Limitations

- CSM
  - Plateau no good for brittle systems
  - Various challenges in FEMA 440
  - Approximations of all nonlinear static procedures
  - kappa values have no physical meaning
- Evidence for collapse fatality rates

Thanks

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