IRDR0008 Individual Report:
Probabilistic Seismic Risk Assessment

Aims

Write an individual 1000-word quantitative report related to the probabilistic seismic risk assessment of buildings

Learning outcomes

Subject-specific knowledge:

- Adopt statistical approaches to modelling seismic risk of buildings
- Explain how to quantify the seismic hazard of a given site
- Explain how to quantify the building vulnerability to earthquakes
- Explain how to quantify the earthquake losses of buildings

Intellectual, Academic and Research Skills:

- Discuss disasters using a common language across disciplines
- Perform basic statistical analyses

Practical and Transferable skills

- Demonstrate an appropriate awareness of an audience in the presentation of research findings and information and communicate information, ideas, problems and solutions to both specialist and non-specialist audiences
- Express arguments clearly and fluently in writing
- Use visual aids to enhance your communication
- Work across traditional disciplinary and sector boundaries
- Defend an independent point of view in argument
- Manage time and work to deadlines

The Task

The *Catastrophe Risk Engineering* practice of Verisk has nominated you as a *Risk Consultant.* They require the earthquake risk assessment of two Californian buildings located near a strike-slip fault.

Assessment Instructions

As shown in Figure 1, building A is located R_{jb}=17km away from the fault, while building B is only R_{jb}=10km away from the fault. Note: R_{jb} is the Joyner-Boore distance. Table 1 provides the Gutenberg-Richter parameters of the fault (minimum and maximum magnitude m_{min}, $m_{\max}$, b-value) and the annual rate of occurrence (λ_{min}) of earthquakes greater than $m_{\min}$.

Figure 1: Site-to-source geometry for a generic site.

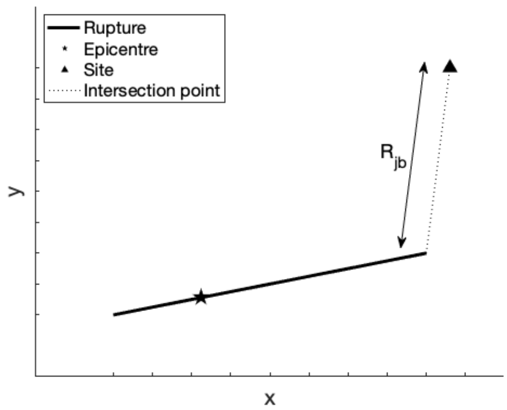

Table 1: Fault parameters.

Select $\boldsymbol{m_{min}}$ according to the last number of your candidate number:
0-3: $\boldsymbol{m_{min}}$*=4.0;* *4-6:* $\boldsymbol{m_{min}}$*=4.5;* *7-9:* $\boldsymbol{m_{min}}$*=5.0;*

Select $\boldsymbol{m_{max}}$ according to the second-to-last character of your candidate number:
A-I: $\boldsymbol{m_{max}}$*=7.0;* *J-R:* $\boldsymbol{m_{max}}$*=7.5;* *S-Z:* $\boldsymbol{m_{max}}$*=8.0;*

Select ***b*** according to the third-to-last character of your candidate number:
A-I: ***b****=0.9;* *J-R:* ***b****=1.0;* *S-Z:* ***b****=1.1;*

Select $\boldsymbol{\lambda_{min}}$ according to the fourth-to-last character of your candidate number:
A-I: $\boldsymbol{\lambda_{min}}$*=0.3;* *J-R:* $\boldsymbol{\lambda_{min}}$*=0.2;* *S-Z:* $\boldsymbol{\lambda_{min}}$*=0.1;*

Note that the “candidate number” mentioned above is not equal to the Portico student number. The example candidate number “FRTB5” would result in the parameters:
m_{min}=4.5; m_{max}=7.0; *b=1.1;* λ_{min}*=0.2;*

Assume that any potential earthquake will always rupture the entire fault segment, so that the source-to-site distance is exactly *R* km in every case (that is: no random locations are considered). The construction sites are located on rock (the average shear-wave velocity between 0 and 30-meters, $V_{s,30}$, is assumed equal to 800 m/s^2). Use the Ground Motion Prediction Equation (GMPE) expressed by Equation (1) and (2) in Akkar and Bommer (2010): http://minify.link/akkarbommer2010

The considered concrete moment frame buildings are two-storey high (Low-Rise). The building located at site A is designed considering gravity loads only (Pre-Code), while that located at site B complies with modern seismic provisions (High-Code). Table 2 provides the characterisation of the buildings' fragility according to HAZUS (HAZard United States), including some slight modifications. Those fragility curves are represented through lognormal cumulative distribution functions each defined by the median and the logarithmic standard deviation of the distribution in terms of a selected intensity measure (e.g. peak ground acceleration, PGA). The fragility curves are defined for four damage states (i.e., Slight, Moderate, Extensive, Complete), four levels of seismic code implementation (or design levels; i.e. Pre-Code, Low-Code, Moderate-Code, High-Code) and three levels of building height (i.e., Low-Rise, Mid-Rise, High-Rise).

Provide a short report, in which you should:

1. Provide PGA hazard curves for both site A and B (use the first row of Table 1 by Akkar and Bommer, 2010). Simulate a 500,000-years stochastic catalogue to provide the mean hazard curves. Describe the calculation steps [max 200 words];
2. Provide and plot the fragility curves (for the four damage states) for the buildings at site A and B. Given the damage-to-loss ratios for each damage state, i.e., 2%, 10%, 43.5% and 100% of the total reconstruction cost, compute and plot vulnerability curves. Describe the calculation steps [max 200 words];
3. Using the results in step 1 and 2, provide the loss curves for the two buildings (in terms of the building loss ratio). Describe the calculation steps [max 200 words];
4. Provide a critical discussion of the results, highlighting the main factors affecting the differences in the hazard curves of the two sites, the vulnerability curves of the two buildings, and the loss curves of the two buildings [max 400 words];
5. Provide evidence of your step-by-step calculations (.xls Microsoft Office Excel or .m Matlab files).
6. Provide a summary of your results by filling the resultSummary.xls file [the name of the submitted file must be resultsSummary_yourcandidatenumber; e.g. resultsSummary_FRTB5]. <u>Without changing the format of the file</u>, copy-paste your results in the appropriate columns. The only needed results in this file are the hazard curves for site A and B, the vulnerability curves for building A and B, the loss curves for building A and B. Report the "seed number" you used for the calculations (e.g., if your seed number is equal to 1, substitute "seed=xyz" with "seed=1").

In producing the report: use font 12; a tolerance of 5% on the total word count is allowed (1000$\pm$50 words); do not count figure/table captions in the word count for each section; appendices are allowed but not suggested - if present, they should only contain additional figures and a minimum amount of text.

Table 2: HAZUS fragility curves for reinforced concrete moment resisting frames. Units: median [g]; dispersion [-].

High Code		Equivalent-PGA Structural Fragility							
		Slight		Moderate		Extensive		Complete	
		Median	Beta	Median	Beta	Median	Beta	Median	Beta
Low-Rise	C1L	0.24	0.64	0.35	0.64	0.70	0.64	1.37	0.64
Mid-Rise	C1M	0.18	0.64	0.27	0.64	0.73	0.64	1.61	0.64
High-Rise	C1H	0.14	0.64	0.22	0.64	0.62	0.64	1.35	0.64

Pre Code		Equivalent-PGA Structural Fragility							
		Slight		Moderate		Extensive		Complete	
		Median	Beta	Median	Beta	Median	Beta	Median	Beta
Low-Rise	C1L	0.10	0.64	0.12	0.64	0.21	0.64	0.41	0.64
Mid-Rise	C1M	0.09	0.64	0.13	0.64	0.26	0.64	0.47	0.64
High-Rise	C1H	0.08	0.64	0.12	0.64	0.21	0.64	0.40	0.64

Evaluation Criteria

Consider the following when preparing your report

The report and technical document should demonstrate that you can:

- Construct a well-structured, organised and clear report
- Present a valid argument using evidence
- Provide clear visual aids if required
- Understand the material you are presenting
- Show references for information and sources for any figures
- Correctly follow instructions for calculations
- Show calculations with sufficient detail that the reader can follow the steps you did

Mark Scheme

Criteria	**Marks available (total marks /100)**
Numerically and theoretically correct and complete; clearly explain the calculation steps and assumptions	50
Comprehensive discussion of results/findings, with precise, clear, and well-justified conclusions; deep and critical analysis (including limitations)	10
Present a highly professional format; provide references and sources; figures, drawings and tables are clear and consistent	30
Any extra work that extends the original tasks	10

Expectations

Grade A

An excellent report. Students will provide a particularly informative, engaging, and well-structured report. The report will be clear, well-formatted with appropriate citations and be of high professional standard. Students will show originality in thinking through analysis, presentation style or an exceptional ability to explain relevant key concepts. All calculations will be correct, and the steps followed clearly explained with sufficient detail that the reader would be able to repeat them. Uncertainties will be explored. The technical document will be clearly laid out and easy to interpret.

Grade B

A good report. Students will provide an informative, engaging, and well-structured report. The report will be clear, well-formatted with appropriate citations. Students will show some originality in thinking through analysis, presentation style or good ability ability to explain relevant key concepts. Calculations will be correct, and the steps followed clearly explained with sufficient detail that the reader would be able to repeat them. The technical document will be clearly laid out and easy to interpret.

Grade C

A satisfactory report. Students will provide an informative report. The report will be clear with a logical format. Most calculations will be correct, and the steps followed explained with sufficient detail that the reader would be able to repeat them with some limitiations. The technical document will be laid out so the reader can determine calculations done.

Grade D

Students will provide an informative report. Some minor errors may be present in the calculations will be correct. The steps followed will be mentioned. The technical document will be laid out so the reader can determine calculations done.