Problem-Based Learning in Earthquake Engineering Courses

Incorporating a Case Study

By Jeena Rachel Jayamon

A problem-based learning case study is developed and can be incorporated as part of seismic design or earthquake engineering courses. In many universities, these courses are already part of the graduate course curriculum for students majoring in structural engineering. This is an advanced course and requires a strong background in structural analysis and dynamics of structures.

Through the proposed assignment, students will learn to select and process appropriate ground motions for use in seismic design; apply different analysis methods; select and design an appropriate structural system to resist earthquake loadings; and use required codes of practice for design and detailing. This article is intended to continue discussions among academic and industry professionals about the potential skills acquired through the assignment, and gather opinions about additional features that can be included to help students acquire more knowledge related to topics in earthquake engineering.

Course Curriculum

The proposed problem-based assignment described below can be part of a graduate level class on *Topics in Earthquake Engineering*. This course is designed to provide strong understanding of the fundamentals of earthquake engineering built on knowledge in structural dynamics and seismic hazard analysis (the basis of which are already covered in other courses). Through this course, students will learn to select and process appropriate ground motions for use in seismic design; select and design an appropriate structural system to resist earthquake loadings; use required codes of practice for design and detailing of the structural system; and, apply different dynamic or equivalent static analysis methods to check the safety of the system. Another part of this course is devoted to introducing different methods and practices for seismic performance assessment of new and existing buildings. The proposed problem-based assignment is mostly worked for the first part of the course curriculum to design a lateral load resisting system to protect buildings against earthquake hazards.

Objective of the Case Study

The main objective of this assignment is to help students learn about the design of buildings and infrastructure facilities to resist ground motions generated from natural earthquake and other seismic hazards. The student community can apply the lessons they learned about ground motion selection/scaling and the design as well as detailing of various lateral load resisting systems, in this specific assignment. During lectures, the instructor will introduce and give sufficient guidance for using different seismic codes and reference manuals. And through the assignment, the student community will practice the use of appropriate seismic design codes and manuals in the design and detailing of a given structural system.

Specific Topic of Consideration

Company 'X' located in Texas wants to build a new office in California. As Texas is a low seismically active area, the office is not designed to resist earthquakes. Now that they are building their new office in California, which is located in a high seismically active zone, the officials want to know about the various means and measures in which they could build a safe office building. The owners of the company approached you (or your office) and would like to get a set of building designs for constructing a new office building in Los Angeles. They want you to produce required drawings and designs to be supplied to a construction company, and would also like to know how this new design is sufficient to ensure appropriate safety to the building. As a structural engineer, you are ethically committed to describe to the client the various potential seismic threats and supplementary methods you have included in the design to resist these hazards.

Steps Involved in Solving the Case

Stage 1

- Once the building site location is finalized, use various tools to find different site-specific details that might be used throughout the design process.
- With the site details, use appropriate ground motion selection and scaling strategies to develop the ground motions for use in design.

Stage 2

- With the results from Stage 1, select a suitable lateral load resisting system for use in the building to resist lateral earthquake loads. You are free to choose any standard available load resisting system or design a new system. In either way, you have to judge the rationale behind the selection of the typical system. If you are proposing a new system, you have to supply enough information to substantiate that the system is equivalent, or better than, other code-complaint systems.

Stage 3

- Model the trial design of the building in a suitable structural analysis program and verify the accuracy of the model.
- Apply appropriate structural analysis methods and find the required results for use in the design of the building system.
- Check if the lateral load resisting system satisfies the requirements of seismic design guidelines for strength and serviceability limits.
- Iterate the current design to produce more economical design solutions.
- Evaluate the system to determine if various performance levels and objectives (from an immediate occupancy of the building to life safety when subjected to a probable earthquake event) are met.

Project Working Groups

Since the project involves a variety of tasks that can be performed in parallel, students are allowed to work in groups of 3 or 4 members. The various tasks involved in developing the design of a structural lateral load resisting system and analyzing it to ensure the applicability at a particular site should be collectively completed by different members in the group.

Students Final Submittals

Each group needs to submit two reports – a mid-term and final. The mid-term project should have all information about the various site-specific details that are investigated and how the group arrived at the selection of the specific structural system. The final report should be focused on the specific design details of the selected system and how this system satisfies the desired protection that may result from an expected seismic hazard. Each member should turn in a cover letter to indicate the specific tasks they have completed as part of the project team.

Assessment of Students' Submissions

Each group submission will be judged on the basis of the following criteria.

- Accurate evaluation of seismic load to be applied in the building system. (10%)
- Correct analytical structural modeling and analysis. (10%)
- How well the strength, safety and serviceability requirements are satisfied in the final design. (50%)
- Is the design efficient and practical to construct? (10%)
- Are the designs innovative and creative? (10%)
- Oral presentation and submission of reports. (10%)▪

Jeena Rachel Jayamon is a PhD student in the department of Civil and Environmental Engineering at Virginia Tech. She finished her undergraduate degree in Civil Engineering from the National Institute of Technology Calicut (NIT Calicut, India) and holds a masters degree in Structural Engineering from Virginia Tech. Jeena is an active student member of ASCE and EERI chapters, and also serves as the Vice-President of the SEI graduate student chapter at Virginia Tech. Jeena can be reached at ***jeenarj@vt.edu****.*

Input on this topic is encouraged. Please forward comments/suggestions to **publisher@STRUCTUREmag.org**.