Risk-Based Seismic Design and Evaluation

Purpose and Background

The purpose of seismic design is to reduce the risk to life and property to a tolerable level. The tolerable risk is implied in the building code procedures, but it is not explicitly stated. Moreover, building codes are intended mainly to reduce the risk to life. Code-designed structures in different parts of the country can pose very different risk to property. Therefore, it cannot be said with any certainty if the seismic risk to a code-designed structure is tolerable to the owner, occupant, investor or insurer. This seminar presents various steps needed to perform a risk-based seismic evaluation and design. All material is presented in an intuitive manner to promote deeper understanding.

There are three parts to the evaluation of seismic risk: (1) computation of seismic hazard; (2) establishing vulnerabilities, and (3) combining the hazard with vulnerabilities to compute the risk. Risk-based seismic design involves an additional step in which the vulnerabilities are varied until the computed risk matches the risk tolerance.

There is significant uncertainty in the hazard and in the vulnerabilities. The consequence of uncertainties on the assessed risk will be discussed. Possible ways to reduce the uncertainties will also be discussed.

Different applications of risk-based evaluation and design will be discussed: (1) Controlling (managing) the risk to a property; (2) Deciding among risk transfer (insurance), risk mitigation (retrofit), and diversification; (3) Evaluating the effectiveness of risk mitigation (retrofit); (4) Establishing the fair price of transferring the risk; and (5) Making investment/lending decisions regarding a property.

Seminar Instructor

PRAVEEN K. MALHOTRA, PH.D., P.E., M.ASCE, is a Principal at Strong-Motions, Inc. in Massachusetts. He has published extensively on seismic response of tanks. He is the current chair of the ACI 376 task group for seismic design of LNG tanks. He has actively participated in updating the tank design provisions in NEHRP, Eurocode and Indian Standard. Dr. Malhotra received his Ph.D. in structural/geotechnical earthquake engineering from Rice University. He is a member of the American Concrete Institute (ACI), American Society of Civil Engineers (ASCE), Earthquake Engineering Research Institute (EERI), Seismological Society of America (SSA), and the Indian Society of Earthquake Technology (ISET). He is a registered Civil Engineer in California.

- **To register your group, contact John Wyrick (JWyrick@asce.org) or Stephanie Tomlinson (STomlinson@asce.org)**

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Summary Outline

DAY ONE

Introduction

- Applications of seismic risk evaluation and risk-based seismic design. A road-map to the evaluation of seismic risk. Definitions of hazard, vulnerability and risk

Basic Concepts in Geology and Seismology of Earthquakes

- Seismic hazards: ground shaking, ground rupture, liquefaction, landslide, slope failure, fire-following and tsunami
- Uncertainties in time, location and size of earthquakes
- Seismic source model

Intensity of Ground Shaking

- Modified Mercalli Intensity (MMI), peak ground acceleration (PGA), peak ground velocity (PGV), duration of shaking, response spectrum, number of response cycles

Estimation of Shaking Intensity for a Given Earthquake

- Ground motion prediction equations (GMPE). Aleatory and Epistemic Uncertainties in GMPE

DAY TWO

Estimation of Shaking Intensity for Future Earthquakes

- Combining the uncertainties in seismic source model with the uncertainties in GMPE
- Hazard curves: probabilistic estimates of shaking intensity at a site
- Site-specific response spectrum and number of response cycles
- Adjustment for local soil conditions
- Risk-targeted ground motions in ASCE 7

Response of Structures to Shaking Produced by Future Earthquakes

- Nonlinear pushover analysis with capacity (pushover) curve and response spectrum (demand curve). Effect of foundation flexibility and number of response cycles on capacity curve. Different sources of damping. Effect of damping on demand curve
- Floor accelerations and inter-story drifts

Computation of Risk

- Damage to structure, non-structural components, and contents
- Damage curves. Uncertainty in damage
- Loss exceedance curve
- Annual average loss
- Probable Maximum Loss (PML)
- Sources of uncertainty in loss estimates, different ways to reduce the uncertainty
- Risk-based decisions: insurance, mitigation and diversification

Seminar Benefits

- Learn the applications of risk-based evaluation and design
- Learn the steps involved in risk-based evaluation and design
- Learn the limitations of code-based design
- Avoid costly mistakes resulting from false perception of risk
- Gain deeper understanding of the various concepts involved in risk-based formulation
- Learn the role of uncertainty in risk-based decision making
- Learn ways to reduce the uncertainty
- Learn the importance of a scientifically sound risk-based approach
- Learn the limitations of different definitions of seismic risk
- Learn about different alternatives to reduce the risk
- Learn about risk-targeted seismic design loads in ASCE 7

Learning Outcomes

- Understand the role of uncertainty in seismic hazard and risk
- Identify different hazards associated with an earthquake
- Understand why the risk to code-designed structures varies throughout the country
- Understand how hazard and risk curves are derived and used
- Explain difference between site-specific and aggregate hazard and risk
- Identify the shortcomings of commonly used risk measures such as the Probable Maximum Loss (PML) or the Maximum Foreseeable Loss (MFL)
- Understand the limitations of code-based seismic design
- Explain the role of non-structural components in seismic risk
- Identify how a risk-based approach can be used to strike a balance between mitigation, insurance and diversification

Who Should Attend?

Structural engineers, geotechnical engineers, architects, regulators, risk managers, geologists, seismologists and professionals in related fields.

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