Credits: 3 + 0
PG 2019
Spring 2020 Semester

Performance-based Seismic Design of Structures

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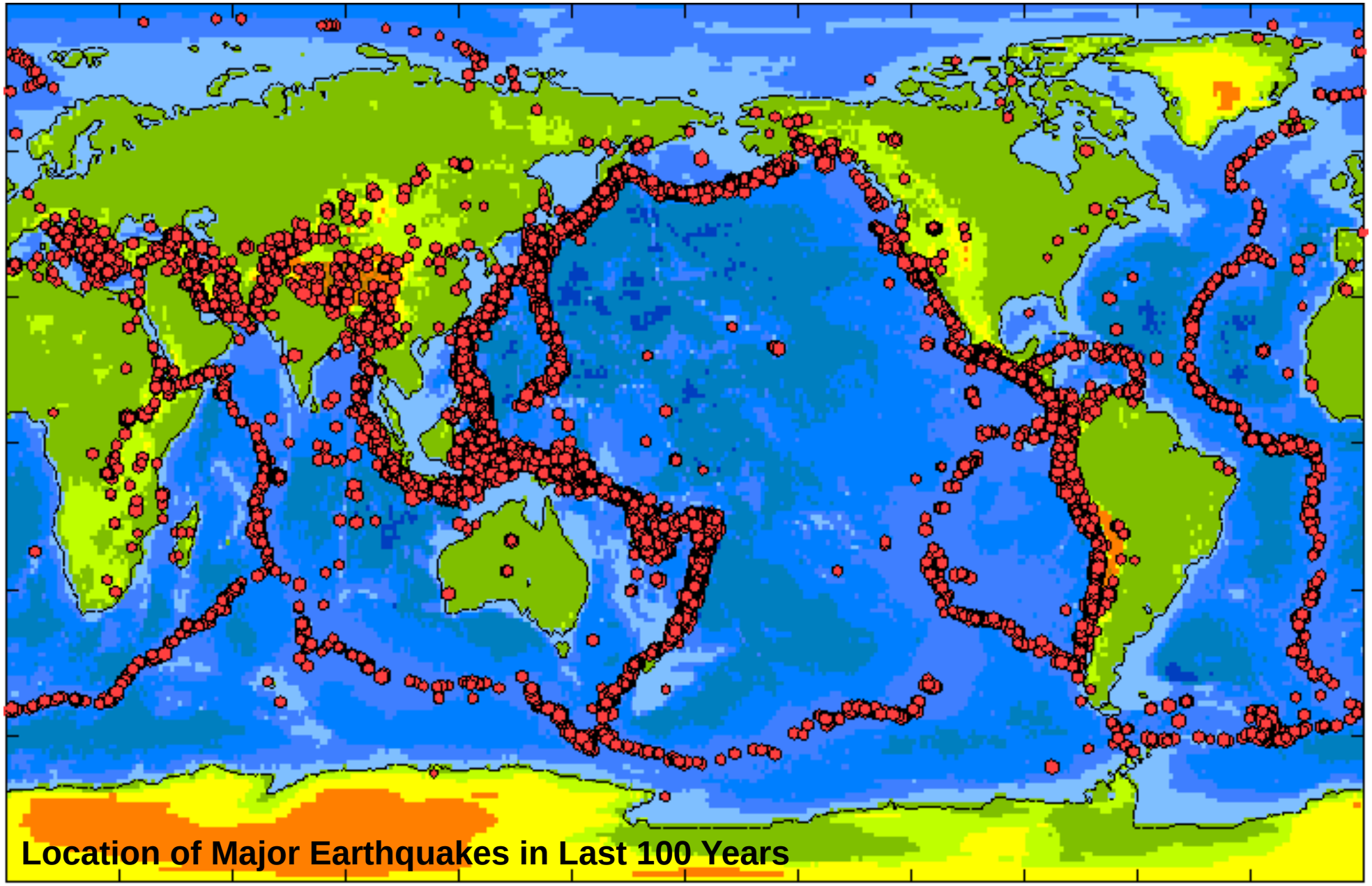
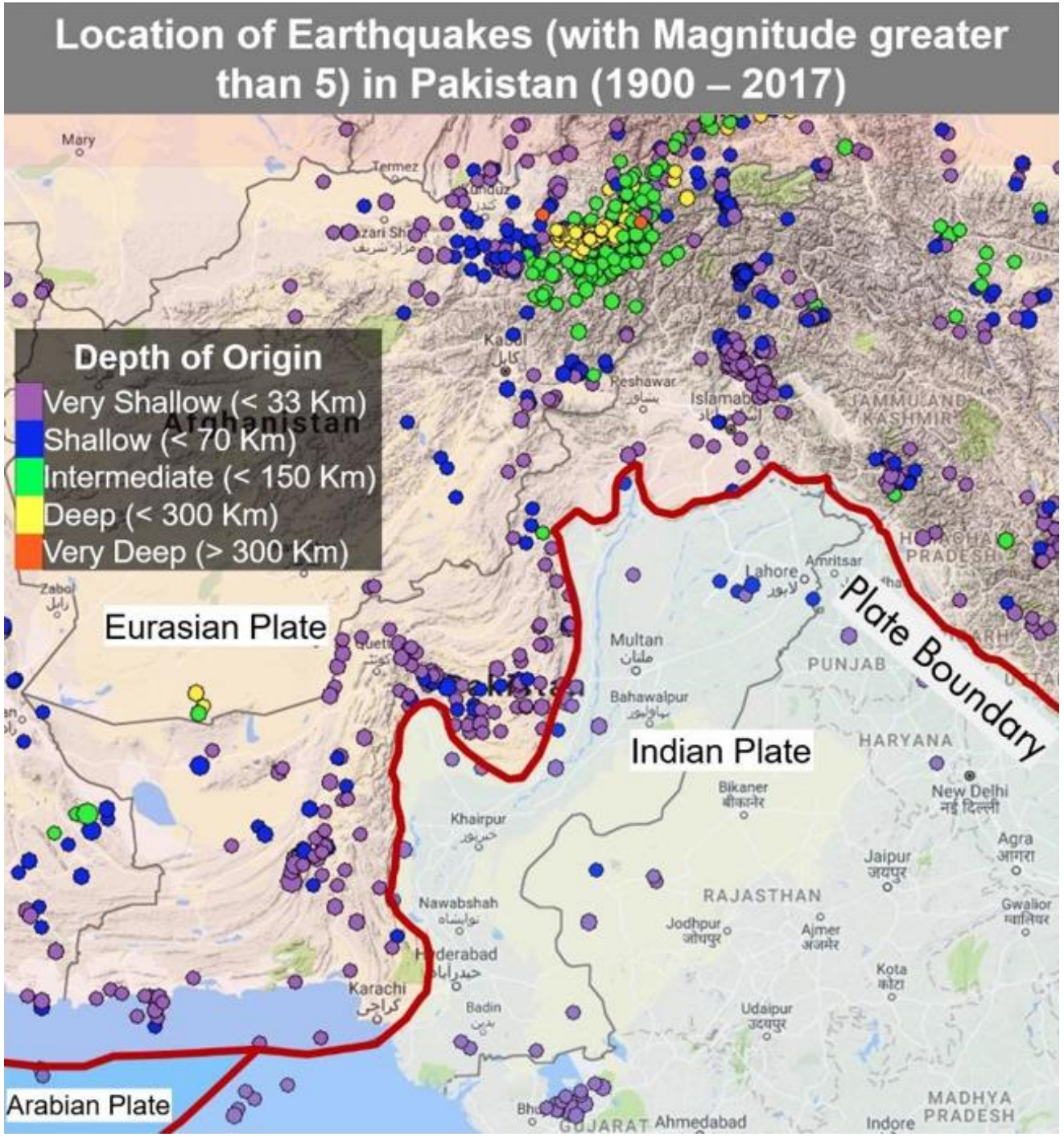
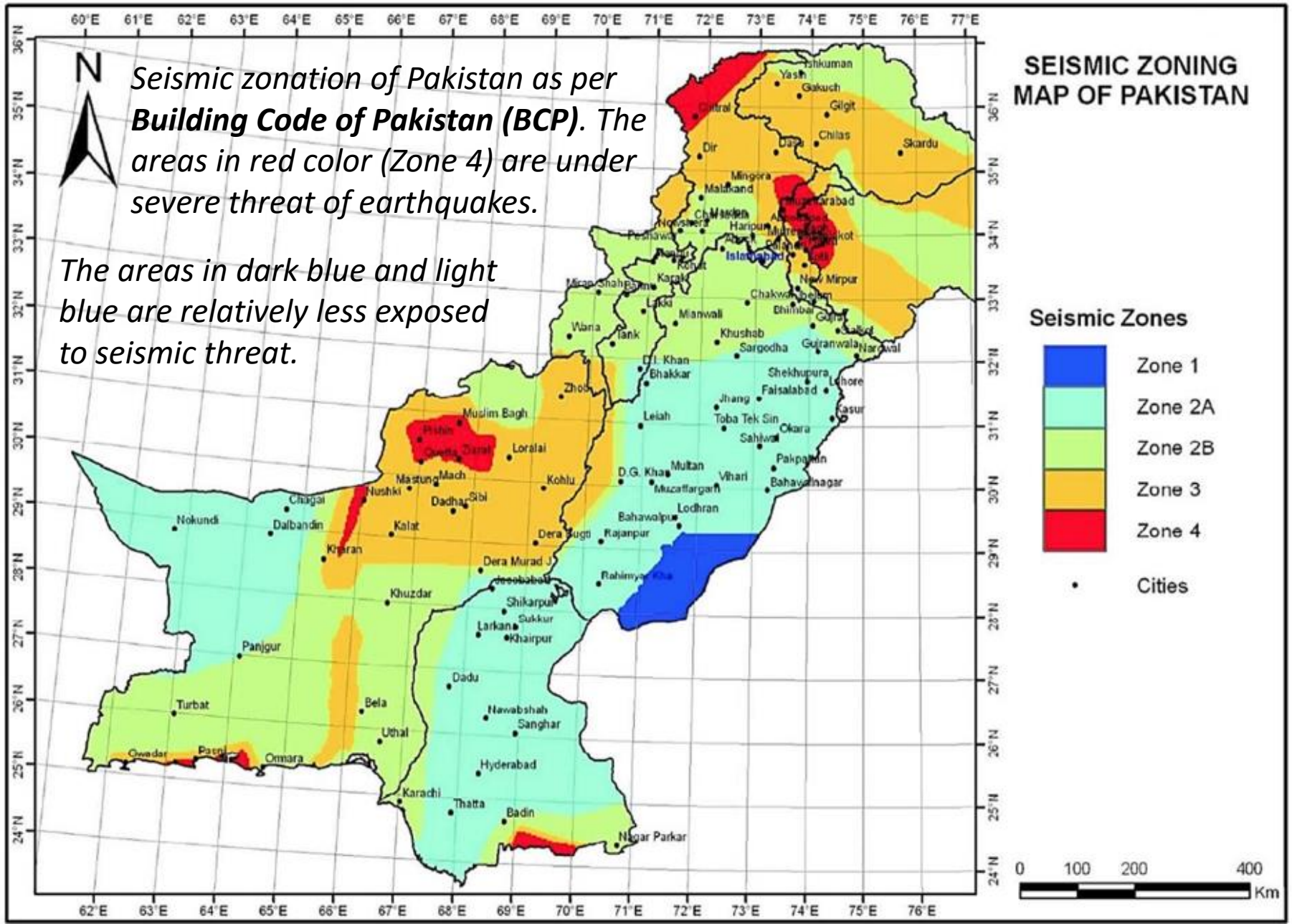
Why This Course?



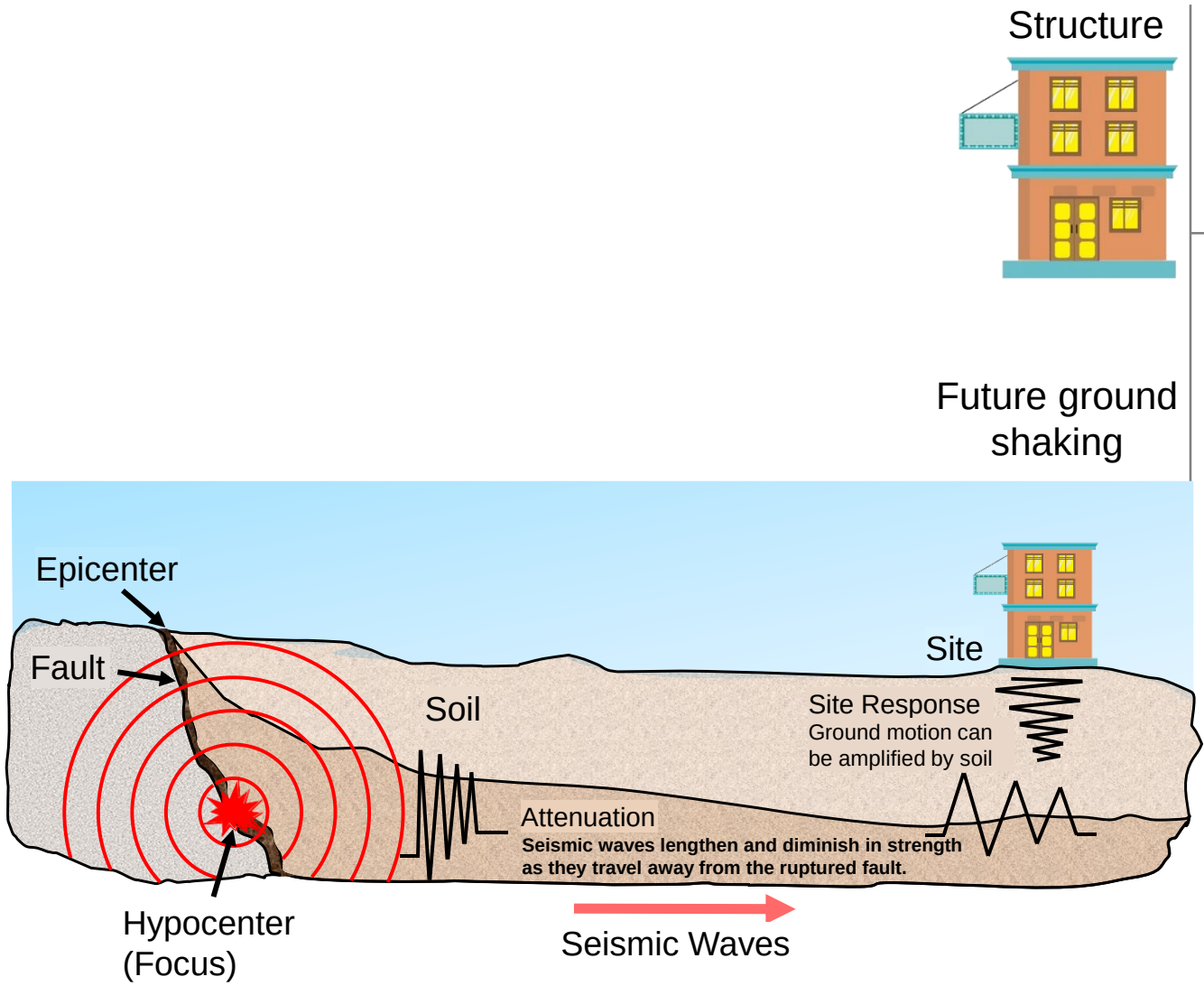
Seismicity of Pakistan



Why This Course?



The Earthquake Problem



Linear/Nonlinear Analysis Model

Characterization of Seismic Ground Motions

Estimation of Linear/Nonlinear Seismic Demands

- Global-level Responses
- Inter-story Responses
- Component-level Responses

Why This Course?

- Pakistan is located on a highly earthquake-prone and seismically active part of the world.
- The country lies on a tectonically active Himalayan orogenic belt developed as a result of slow collision (extended over last 30-40 million years) among the Indian, Arabian, and Eurasian tectonic plates.
- This geological setting has resulted in a number of active seismic sources and faults in the region which are capable of producing moderate- to large-magnitude earthquakes.
- Besides having a high level of seismic hazard, the country is also confronted over the years with high rate of population increase and rapid growth of urbanization.
- With all these challenges and high seismic risk, there is an urgent need of equipping the civil engineering students with state-of-the-art information about seismic hazard, risk and its mitigation.
- This course aims to develop basic expertise and skill among the students about various practical aspects of seismic design of buildings and structures.

Course Contents

- **Part 1: Understanding the Seismic Hazard**
  - Introduction to Seismology
  - Seismic Hazard Assessment

- **Part 2: Introduction to Performance-based Design Approach**
  - Dynamics of Structures – A Review
  - Basic Philosophies of Seismic Design of Structures
  - Introduction to Code-based Seismic Design
    - Classical Modal Analysis Procedure
    - Equivalent Lateral Force Procedure
    - Response Spectrum Analysis Procedure
  - From Code-based Design to PBD: Basics and Methodology
  - Structural Performance Levels and Acceptance Criteria

Course Contents

- **Part 3: Nonlinear Modeling and Behavior of Building Structures**
  - A Quick Overview of Linear Elastic Modeling (+ A Hands-on Training on ETABS 2016)
  - Fundamentals of Nonlinear Modeling – Distributed and Lumped Plasticity Approaches – Hysteretic Behaviors, Strength Loss, Cyclic Degradation
  - Hands-on Training Session on “PERFORM 3D” (Nonlinear Modeling of various Structural Components)

- **Part 4: Nonlinear Dynamic Analysis of Buildings**
  - Selection of Seismic Input (Response Spectra and Ground Motion Records) for Dynamic Analysis of Buildings, Scaling and Matching of Ground Motion Records Nonlinear Time History Analysis Procedure (NLTHA)
  - Interpreting the Dynamic Response and Seismic Performance of Buildings, Understanding the Analysis Results from Nonlinear Time History Analysis
  - Understanding the Analysis Results from Pushover Analysis and Nonlinear Time History Analysis
  - Service-level Evaluation of Structural Performance
  - Maximum Considered Earthquake (MCE) level Evaluation of Structural Performance

Course Contents

- **Part 5: Nonlinear Modeling and Behavior of Building Structures**
  - Nonlinear Static Procedures, NSPs (Pushover Analysis Procedures)
    - Single-mode Pushover Analysis Procedures
    - Multi-mode Pushover Analysis Procedures
  - Capacity Spectrum Method, Displacement Coefficient Method, FEMA 440 NSPs.
  - Introduction to Modal Pushover Analysis (MPA) Procedure and Uncoupled Response History Analysis (UMRHA) Procedures
  - Ductility Design of Structures
  - Direct Displacement-based Seismic Design (DDBD) of Structures

- **Part 6: Term Project: The Performance-based Seismic Evaluation of a Real Case Study Building**

Who Should Attend?

- The expected audience for this course includes the following.
  - Masters and Ph.D. students
  - Structural designers, practicing engineers and consultants
  - Architects, planners
  - Real-estate developers and owners

Textbooks References and Reading Material

- Textbook
  - Lecture notes provided by instructor
- Reference Books

1) T. Pauley, and M. J. N. Priestley, (1992): Seismic Design of Reinforced Concrete and Masonry Buildings, John Wiley and Sons, New York.
2) A. K. Chopra, (1995): Dynamics of Structures-Theory and Applications to Earthquake Engineering, Prentice Hall, New Jersey.
3) R. W. Clough, and J. Penzien, (1993): Dynamics of Structures, McGraw-Hill, New York, 2nd Edition.
4) J. W. Smith, (1988): Vibration of Structures: Applications in Civil Engineering Design, Chapman and Hall, London.
5) W. F. Chen and C. Scawthorn (2003), Earthquake Engineering Handbook.
6) T. Y. Lin and S.D. Stotesbury (1988): Structural Concepts and Systems for Architects and Engineers, 2nd edition, Van Nostrand Reinhold.
7) Graham H. Powell (2010): Modeling for Structural Analysis, Computers & Structures Inc.
8) Edward L. Wilson (2000): Three-Dimensional Static and Dynamic Analysis of Structures, Computers & Structures Inc.
9) Tall and Super-tall Buildings: Planning and Design (2014): Editor: Akbar Tamboli, Publisher: McGraw-Hill Professional, with CTBUH and ICC, ISBN13: 978-0071818711 ISBN: 0071818715
10) James K. Wight (2016): Reinforced concrete: Mechanics and design, 7th edition, Prentice Hall.
11) E. G. Nawy (2009): Reinforced concrete: A Fundamental Approach, 6th edition, Prentice Hall International
12) Arthur H. Nilson, David Darwin, Charles W. Dolan (2005): Design of Concrete Structures, 13th Edition.
13) Bungale S. Taranath (2010): Reinforced Concrete Design of Tall Buildings, Taylor and Francis Group, LLC.

Textbooks References and Reading Material

- International Standards/Guidelines
  1) TBI (2010): Guidelines for Performance-Based Seismic Design of Tall Buildings - PEER
  2) FEMA 356 (2000): Pre-standard and Commentary for the Seismic Rehabilitation of Buildings
  3) ATC-40 (1996) Seismic Evaluation and Retrofit of Concrete Buildings, USA
  4) ASCE/SEI 41-13 (2014): Seismic Rehabilitation of Existing Buildings (ASCE/SEI 41-13)
  5) Council on Tall Buildings and Urban-Habitat (2008): Recommendations for the Seismic Design of High-Rise Buildings.
  6) PEER/ATC-72-1 (2011): Modeling and Acceptance Criteria for Tall Buildings, USA
  7) ASCE 7-16 (2017): Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE/SEI 7-16)

Textbooks References and Reading Material

- Research Journals
  1) Earthquake Engineering & Structural Dynamics, Wiley
  2) Engineering Structures, Elsevier
  3) The Structural Design of Tall and Special Buildings
  4) Soil Dynamics and Earthquake Engineering, Elsevier
  5) Journal of Structural Engineering, ASCE
  6) ACI Structural Journal, ACI7)
  7) Structural Engineering International Journal, IABSE
  8) Magazine of Concrete Research, ICE

Internet Resources

- Learning Resources
  - http://peer.berkeley.edu/
  - https://www.fema.gov/
  - www.ctbuh.org
  - www.structuralengineering.info
  - https://earthquake.usgs.gov/
  - http://www.iris.edu/hq/
  - http://ds.iris.edu/ieb/
- Major Ground Motion Databases
  - USGS Earthquake Catalog
    - ✓ https://earthquake.usgs.gov/earthquakes/search/
  - PEER Ground Motion Database
    - ✓ https://ngawest2.berkeley.edu/site
  - British Geological Survey Database
    - ✓ http://quakes.bgs.ac.uk/
  - COSMOS Ground Motion Data Center
    - ✓ http://strongmotioncenter.org/vdc/scripts/default.plx
    - ✓ http://www.cosmos-eq.org/
  - K-NET and KiK-net, the NIED Strong-motion Seismograph Network Database
    - ✓ http://www.kyoshin.bosai.go.jp/

Internet Resources

- Magazines/Articles
  - ✓ http://www.structuremag.org/
  - ✓ https://www.istructe.org/thestructuralengineer
  - ✓ http://ctbuh-korea.org/ijhrb/index.php
  - ✓ https://www.express.pk/story/968021/
  - ✓ http://www.technologyreview.pk/the-science-of-earthquakes/
  - ✓ http://www.technologyreview.pk/12-years-october-earthquake-pakistan-prepared-handle-another-big-one/

Internet Resources

- Video Playlists
  - Nonlinear Modeling and PERFORM 3D Seminar by Graham H. Powell
    Description: Four valuable sessions on nonlinear modeling of structural components + Hands-on training sessions PERFORM 3D.
    Link: Will be provided by instructor

  - Title: “PBD Seminar and Workshop” – AIT Solutions (Youtube Channel)
    Description: International Seminar and Workshop on Performance Based Design of Reinforced Concrete Buildings - 27-28 August 2013 - Hosted by the Asian Center for Engineering Computations and Software (ACECOMS) in collaboration with AIT Consulting.
    Link: https://www.youtube.com/playlist?list=PLVjfkNRH6tRfSEM1vPIgKeL3tA7PQFAPE

  - Computers and Structures, Inc. (Youtube Channel)
    Description: CSI Watch and Learn Video Tutorials
    Link: https://www.youtube.com/user/computersNstructures

  - International Seminar on Design of Tall Buildings – November 2016 (Bangkok)
    Description: Hands-on training sessions of different finite element modeling and analysis software (SAP, ETABS, SAFE and PERFORM 3D)
    Link: Will be provided by instructor

Grading Scheme and Instructor

- Grading Scheme

Assignments + Quizzes	20%
OHT Exams	30%
Term Project	10%
ESE	40%
Total	100%

- Instructor

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- Dropbox link for downloading course material.

  https://www.dropbox.com/sh/7vi5f7wh8bfjoxw/AAD88ZZWy9rs4vY_T9DbCURFa?dl=0

Thank you for your attention