



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

EARTHQUAKE RESISTANT DESIGN OF FOUNDATIONS: Lecture 1: Introduction

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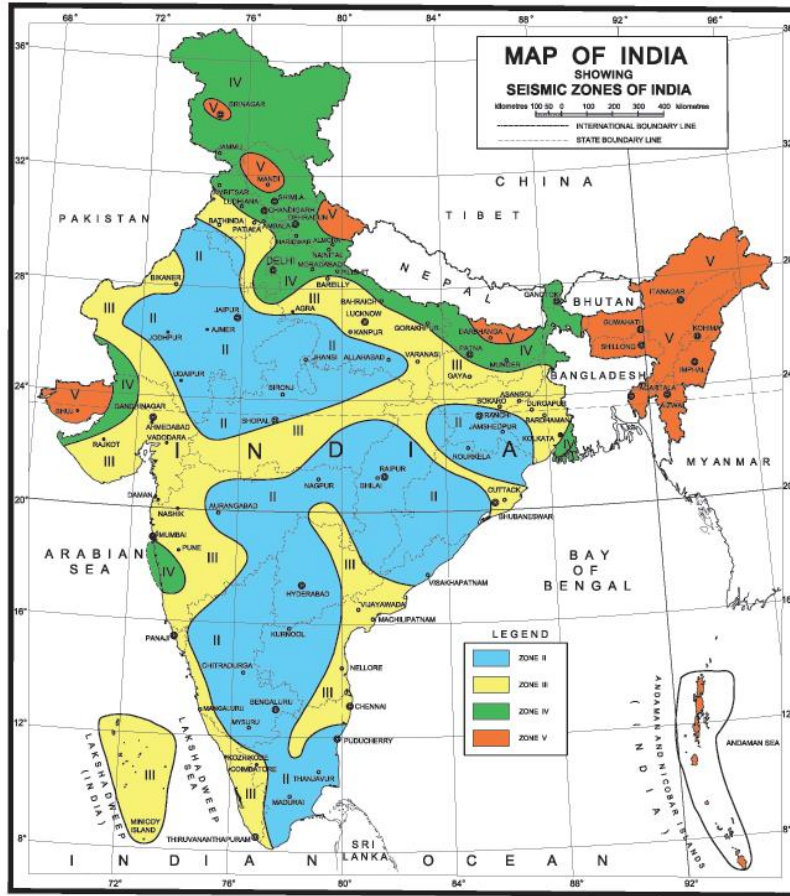
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ERD of Foundations – Importance of the Course

India is seismically very active. Safety of foundations is utmost important during earthquakes. This course is being offered first time, which deals with Earthquake Resistant Design of Foundations. This course will go long way for those working with foundations and need to account for EQ loads. The course will teach the students, academicians and practicing engineers, the design of foundations so that these are safe during earthquakes.





Seismic Zones of India (IS: 1893-2016), BIS

Target Audience and Pre-requisite

This is basically a PG course, however, may be offered to final year UG students of Civil Engineering. Soil Mechanics and Foundation Engineering is a Pre-requisite for this course, however, some back ground of foundation engineering will be discussed so that practicing engineer, who have left studies long back, may not face any difficulty.

ERD of Foundations – Course Contents

The course covers various types of foundations, required soil investigations, soil parameters, and codes of practice. Design considerations for seismic resistant design of foundations. The course will focus on techniques of design of foundations so that it does not fail during earthquakes. This will cover both shallow and deep foundations. Major focus will be on the design of deep foundations for lateral loads.



ERD of Foundations - Modules

M1. Introduction

M2. Shallow Foundations

M3. Pile Foundations

M4. Well Foundations

M5. SSI for Deep Foundations

M1. Introduction

- **Objective of a Foundation**
- **Major Issues during Earthquakes**
- **Performance of Foundations during Past Earthquakes**

M2. Shallow Foundations: Chapters

- 1. General Requirements**
- 2. Bearing Capacity and Settlement**
- 3. Combined Footings**
- 4. Raft Foundations**
- 5. Dynamic Bearing Capacity**

M3. Pile Foundations: Chapters

1. Types of Piles
2. Laterally Loaded Piles
3. Discrete and Finite Element Idealization

M4. Well Foundations: Chapters

1. Types, Scour Depth, Bearing Capacity
2. Laterally Stability of Wells
3. Pseudo-static analysis
4. IRC Method for Lateral Load

M5. SSI for Deep Foundations: Chapters

1. Soil-Structure Interaction (SSI)
2. Modeling of Unbounded Soil Media
3. Free Field Motion, Kinematic Interaction and Inertial Interaction
4. Soil-Pile Interaction

References

1. Prakash S. (1981), "Soil Dynamics", McGraw-Hill Company, New York
2. Kramer S.L. (1996), "Geotechnical-Earthquake Engineering", Pearson Education Pvt. Ltd., Singapore
3. Bowles, J.E (1997), "Foundation Analysis and Design", McGraw Hill International Editions, Singapore.
4. Murthy V.N.S. (2018), "Advanced Foundation Engineering", CBS Publishers and Distributors
5. Ranjan G. and Rao A.S.R. (2004), "Basic and Applied Soil Mechanics", New Age Int. Ltd., New Delhi.
6. Saran S. (2006), "Soil Dynamics & Machine Foundation", Galgotia Pub. Pvt. Ltd, New Delhi.

Module - 1

Introduction



1. Introduction

- **Objective of a Foundation**
- **Major Issues during Earthquakes**
- **Performance of Foundations during Past Earthquakes**

Objective of a Foundation

The earth provides the ultimate support to structures. The foundations are the **sub-structural elements** which transmit the structural load to the earth in such a way that the

- The supporting soil is **not overstressed**
- Does **not undergo deformation** that would cause excessive settlement of the structure

Major Issues during Earthquakes

During earthquakes, the foundations and surrounding soil are subjected to time varying dynamic loads, its behavior is different than that during static loads.

- The behavior of soil may be **nonlinear**
- Excessive or Large **Settlement**
- If foundation is on loose saturated cohesionless soil, there may be problem of **Liquefaction**

Performance of Foundations during Past Earthquakes

During past earthquakes there are numerous examples in which foundations damaged causing collapse of buildings, bridges, dams and many other structures. Deep foundations are considered one of the most effective means of mitigating foundation movement during an earthquake.

These are discussed in next few slides

Performance of Deep Foundations

The Niigata earthquake (1964, M7.5) resulted in dramatic damage due to liquefaction. At the time of EQ, there were approximately **1500** reinforced concrete buildings in Niigata City, and about **310** of these buildings were damaged, of which approximately **200** settled or tilted rigidly without appreciable damage to the superstructure. The damaged buildings were built on very shallow foundations or friction piles in loose soil. Similar buildings founded on piles bearing on firm strata at a depth of 20 m did not suffer damage.



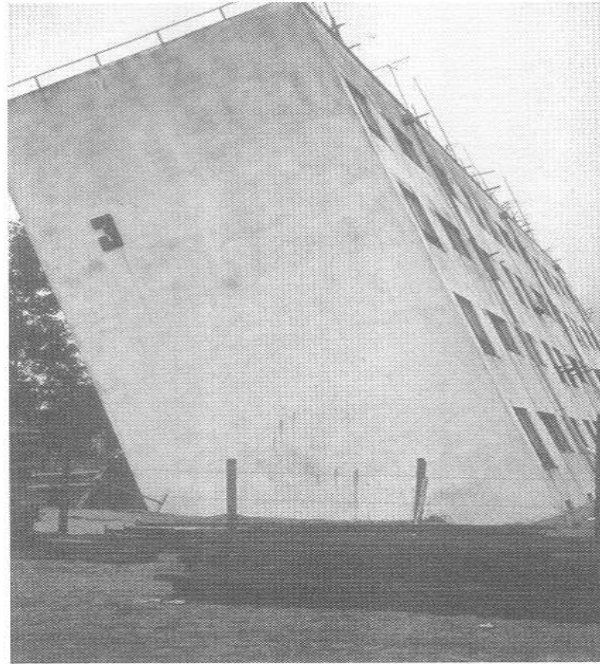
Liquefaction-induced Bearing Capacity Failure



Kawagichi-cho apartment buildings, Niigata EQ (Japan)

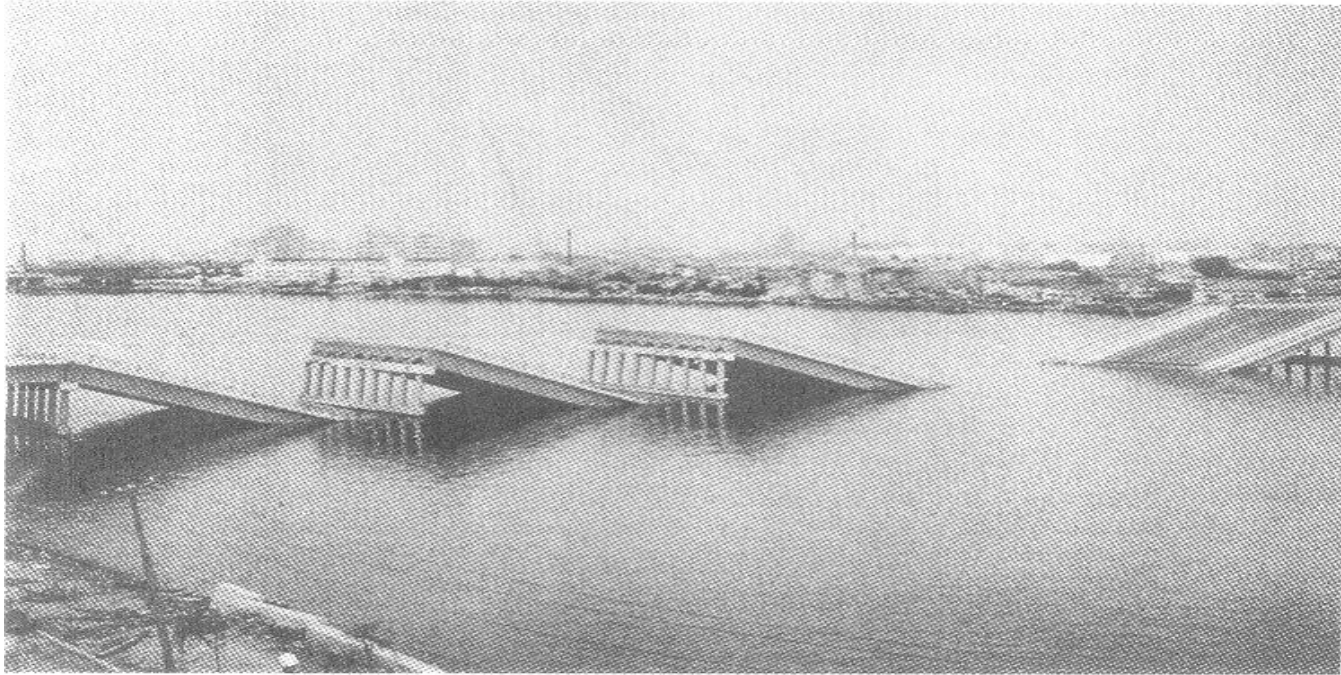


Liquefaction-induced Settlement & Tilting



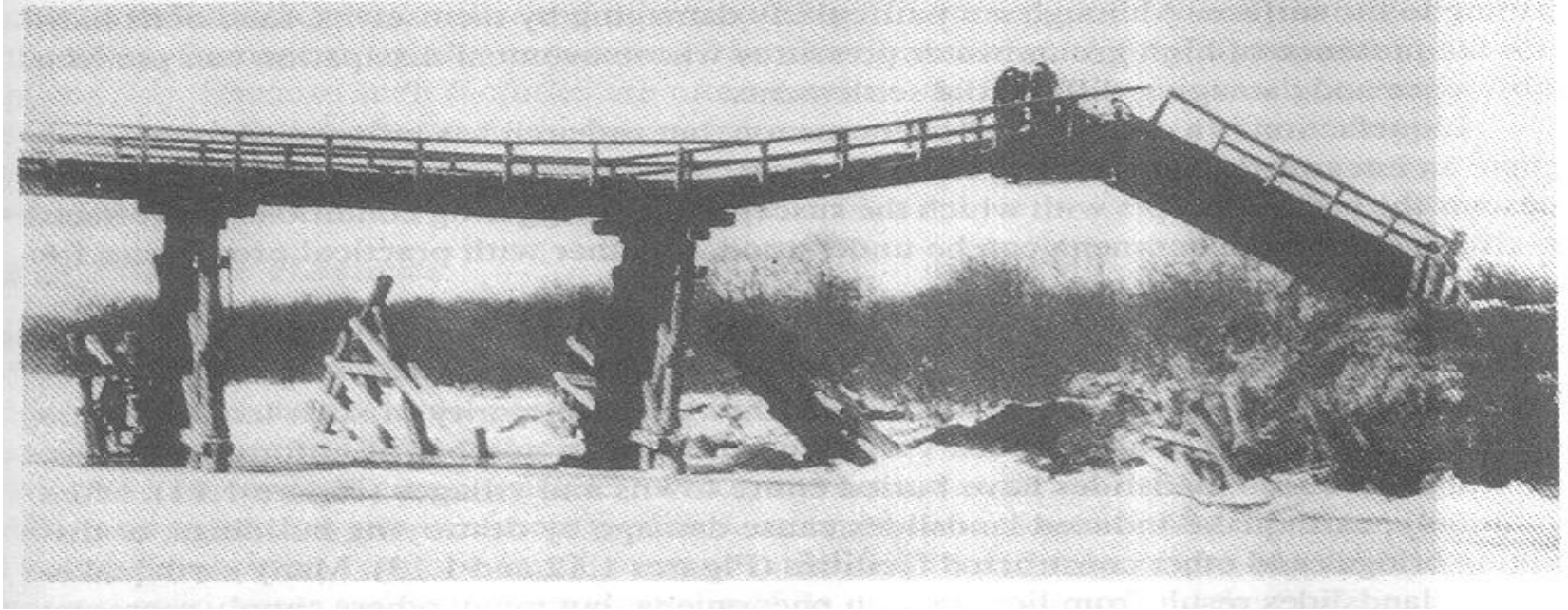
Settlement & tilting of an apartment building, Niigata EQ

Damages due to Lateral Spreading



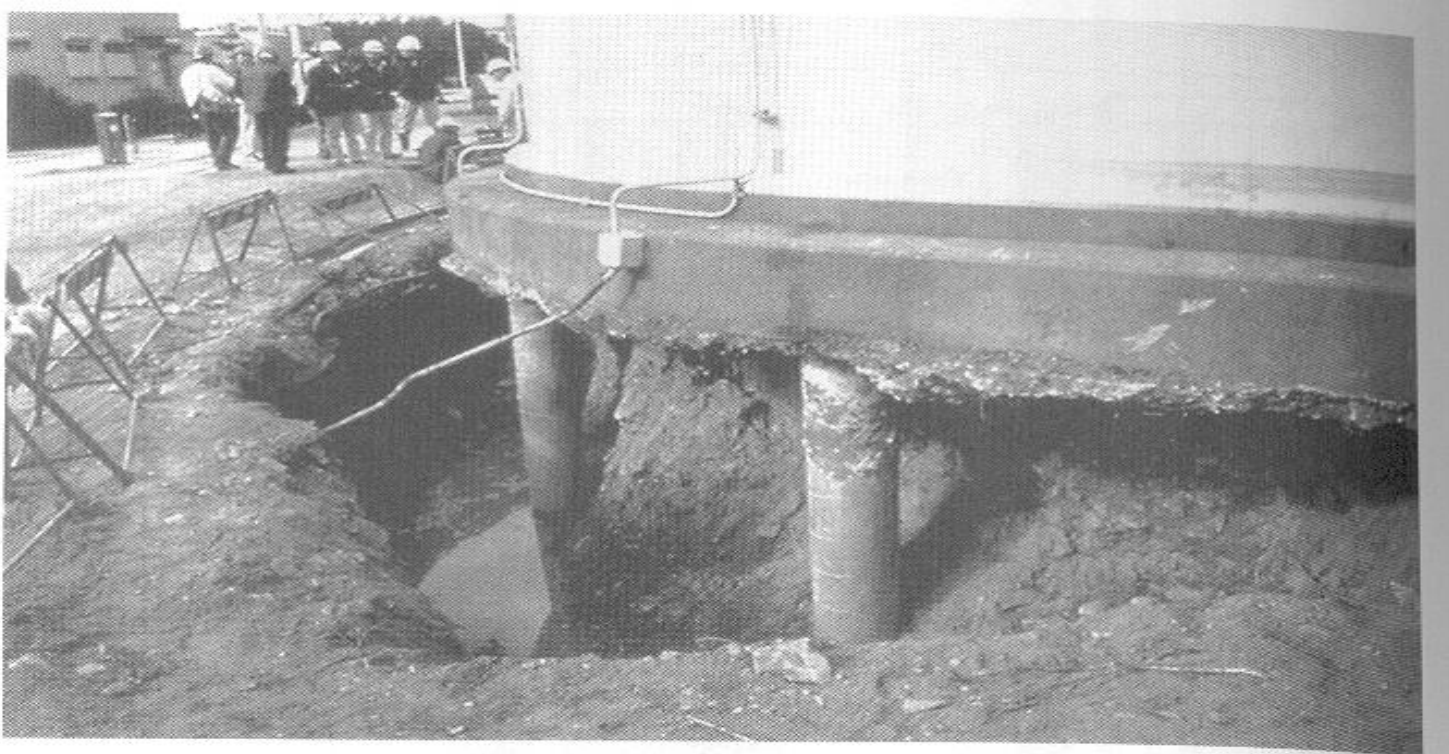
Lateral spreading caused bridge pier foundation to move and rotate sufficiently for simply supported bridge span to fall (Niigata Earthquake)

Damages due to Lateral Spreading



Lateral spreading of the soil at the abutment buckled the bridge deck following 1952 Tokachi-Oki earthquake (M 8.1), Japan

Role of Pile Foundation in EQ Mitigation



Storage tank supported by concrete piles, soil underneath liquefied, 1995 Kobe EQ (M6.9)

Damage of Bridges in Past EQs



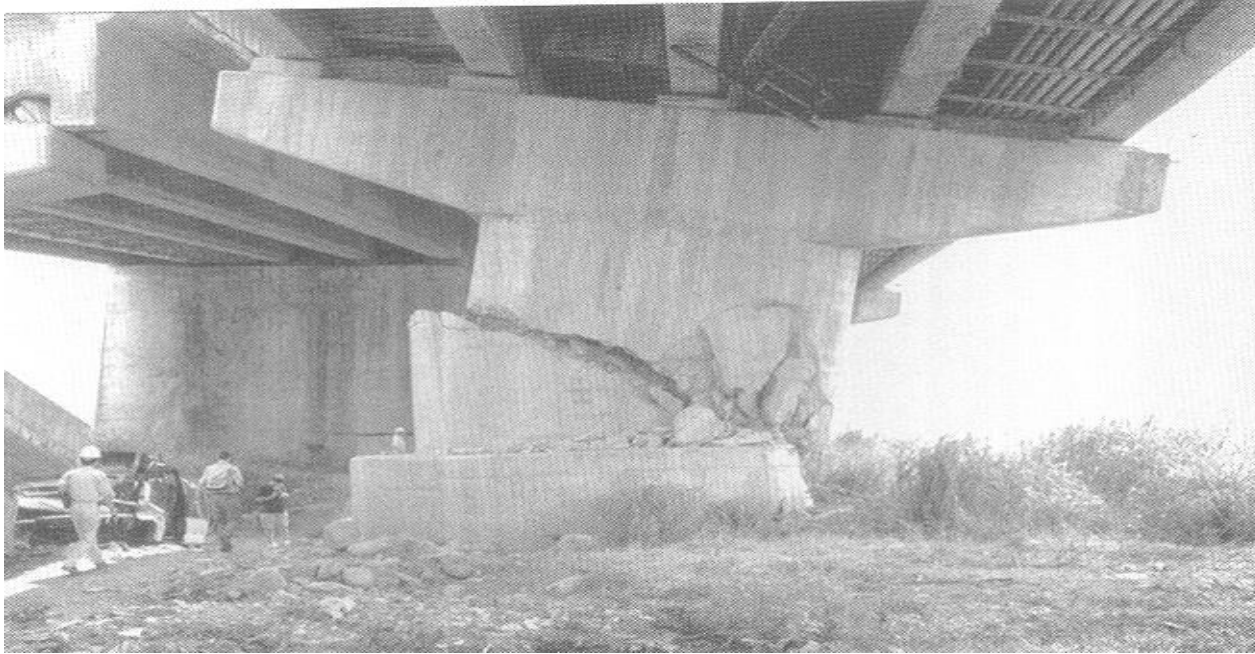
Higashi-Nada Viaduct collapse due to foundation failure, 1995 Kobe EQ (M6.9)

Damage of Bridges in Past EQs



Nishinomiya-ko Bridge approach span collapse, 1995 Kobe EQ (M6.9)

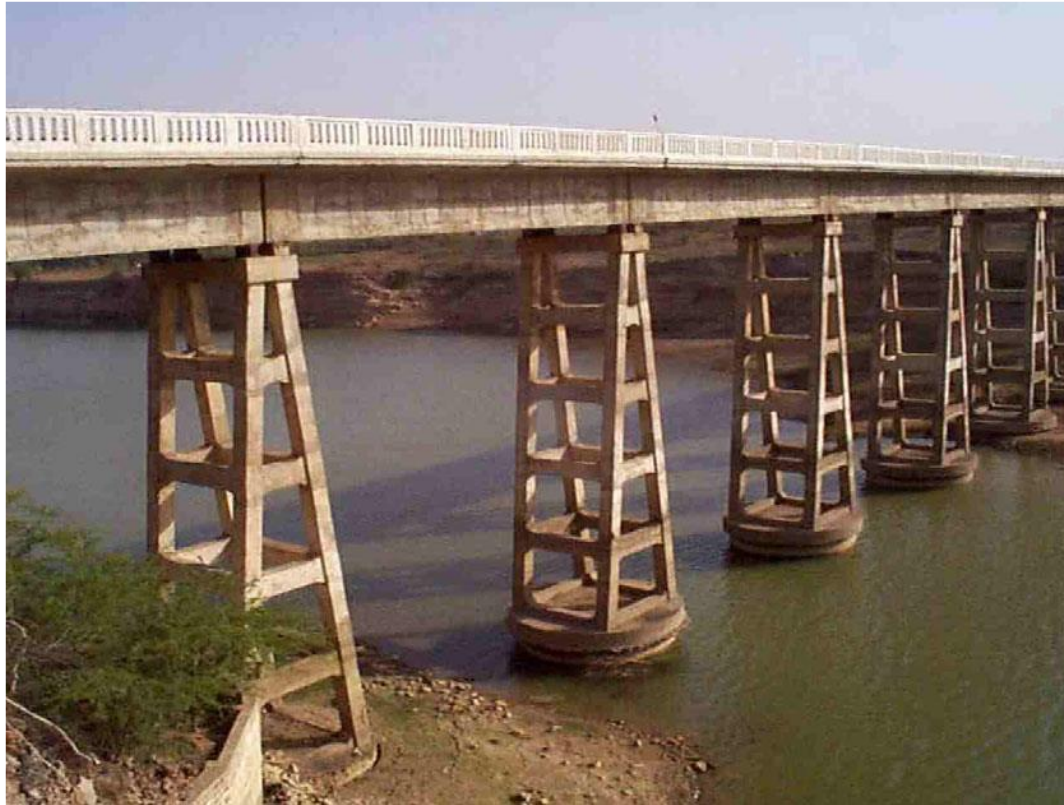
Damage of Bridges in Past EQs



Wu-Shi Bridge pier damaged in 1999 Chi-chi (Taiwan) Earthquake (M7.6)



Damage to Pier-Cap of a Bridge in 2001 Bhuj EQ (M7.7)



Status of the Rudra Matha bridge, after 2001 Bhuj EQ (M7.7)



Lateral Spreading Next to the Well Caisson, Rudra Matha bridge, Bhuj



Damaged bridge on the river Palyar, Kerala by Tsunami due to 2004 Sumatra EQ (M9.0)

Thank You

