13 LECTURES
on
GEOTECHNICAL EARTHQUAKE ENGINEERING

by
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1. Introduction

Earthquake-induced damages to above- and underground structures are directly related to the seismic ground response and failure during shaking. With few exceptions (e.g. damages due to tsunamis), this reality is verified in every old and recent earthquake.

For example ........

Recent strong earthquakes in Greece and abroad . . . . .

Kobe, Japan, M=7.2, 17-01-1995
Kobe 1995
Collapse of columns in DAIKAI underground metro station
Izmit - Turkey, M=7.2, 17-08-1999
Fault trace

Düzce, Turkey, M=7.2, 12-11-1999
Collapse of Bolu Tunnel

Chi-Chi earthquake, Taiwan, M=7.6, 21-09-1999
(a) photo of Chi-Shue Tunnel before Chi-Chi Earthquake; (b) photo of Chi-Shue Tunnel after Chi-Chi Earthquake; (c) slope failure induced tunnel collapse at Sta. 45k+573 of Highway No. 8; (d) sketch of damage pattern.

(from Wang et al. 2001)
Longitudinal cracks from “ovalization” of Yuluh tunnel section, Chi-Chi 1999 earthquake (Schiff and Tang eds, 2000)
Athens-Greece, $M=5.9$, 12-09-1999

- 100 buildings collapsed
- 143 casualties
- 2,000 injured
- 100,000 homeless

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STIFF SOIL AMPLIFICATION at Ano Liosia municipality

Cross-section N-S

<table>
<thead>
<tr>
<th>DEPTH (m)</th>
<th>V_s (m/sec)</th>
<th>V_s,30</th>
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<tbody>
<tr>
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<td>=697</td>
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<tr>
<td>Conglomerates</td>
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<td>=613</td>
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<td>V_s,30</td>
<td>=545</td>
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<td>Clayey Marl</td>
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<td>=500</td>
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<td>=496</td>
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</tbody>
</table>

N S

Conglomerates

V_s,30 =697 m/sec

V_s,30 =613

V_s,30 =545

V_s,30 =500

V_s,30 =496

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Bhuj - India
M = 7.9
26-1-2001
Alaska
M=7.9
3-11-2002

Colima-Mexico
M=7.6
21-01-2003

• 48” pipe dynamically pushed to limit of VSM
• Shattered pipe housing indicates high velocity impact with vertical support member
Lefkas, M=6.4, 14-8-2003

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Earthquake of

Bam – Iran
M=6.6
26-12-2003

…….. 30,000 casualties
Satellite image of Arg-e Bam: the day after earthquake (27/12/2003)

Photo by www.spaceimaging.com
Interpreted by Dr Mehdi ZARE
Summary of seismic hazards...

Topography aggravation

Slope failure

Foundation & structural failure

Soil amplification

Retaining wall failure

Liquefaction

Damage to underground structures

P & S WAVES

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Seismic design of underground tunnels and pipelines

Example: Mexico 1985 earthquake
Seismic Ground response - «Soil Amplification»

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Liquefaction
- Prediction
- Settlements
- Lateral spreading
- Ground improvement
- etc.
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Seismic slope failure → Pseudo static analysis

(a/t) \( \frac{(a/g)W}{B} \)

Seismic slope failure → Displacement computation with the “sliding block” method

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Seismic design of retaining walls

- Dynamic earth pressures
  Mononobe-Okabe
- Hydrodynamic pressures
  Westergard
- Displacements with the "sliding block" method

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