Prevention First 2010 Symposium, Long Beach

MOTEEMS Division 6 Revisions - Geotechnical Hazards and Foundations

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History of MOTEMS Development

- **Approved** – California State Lands Commission
  - August 17, 2004

- **Adopted** – California Building Standards Commission
  - January 19, 2005

- **Published** – California Building Standards Code
  - August 6, 2005
  - (Title 24, Part 2, Vol. 2, Chapter 31F)

- **Effective** (CBC 2001, CBC 2007)
  - February 6, 2006

- **First Revision in 2009** (CBC 2010)
  - January 1, 2011

First Revision has Minimal Changes on Division 6 - Geotechnical Requirements
# Chapter 31F: Marine Oil Terminals

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<td>Electrical Systems</td>
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## Some Marine Structures/Bulkhead Types

### Quay Walls / Piers

- **Caisson structure**
  - Monolithic, gravity, soil-retaining structure.
  - Foundation on rubble and soil or rock.

- **Massive**
  - Monolithic, gravity, soil-retaining structure.
  - Foundation on rubble and soil or rock.

- **Cantilever**
  - Monolithic, gravity, soil-retaining structure.
  - Foundation on rubble and soil or rock.

- **Block**
  - Block work, gravity, soil-retaining structure.
  - Foundation on rubble and soil or rock.

- **Sheet pile**
  - Soil-retaining sheet pile structure with auxiliary structures for anchoring.
  - Sheet pile, fill-soil foundation.

- **Sheet pile with platform**
  - Soil-retaining sheet pile structure with horizontal pile-supported slab.
  - Sheet pile, pile, fill-soil foundation.

- **Pile**
  - Pile structure, often partly soil-retaining and with auxiliary structures for anchoring.
  - Pile foundation.

- **Cellular sheet pile**
  - Gravity, soil-retaining structure.
  - Sheet pile, fill-soil foundation.

- **Column**
  - Structure on columns with auxiliary structures for horizontal force absorption.
  - Sometimes partly soil-retaining.
  - Column foundation.

- **Pile-supported pier**
  - Pile structure with or without batter piles.
  - Pile foundation.
Geotechnical Hazards
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Section 3106F – GEOTECHNICAL HAZARDS AND FOUNDATIONS

3106F.1 General
3106F.2 Site Characterization
3106F.3 Liquefaction
3106F.4 Other Geotechnical Hazard
- Stability of Earth Structures
- Earthquake Induced Ground Movements
3106F.5 Soil Structure Interaction
3106F.6 Mitigation Measures and Alternatives

Significant Revisions to “Seismic Hazards” Requirements are being Made.
Current MOTEMS Division 4 – MOT Risk Classification & Seismic Ground Motions

- Design Accelerations for Geotechnical Analyses based on Probabilistic Seismic Hazard Analyses (PSHA)
- Design Values depend on Risk Classification and Two Level Seismic Performance Requirements:
  - Level 1: Minor Damage
  - Level 2: No collapse and repairable damage

### TABLE 31F-4-1
MOT RISK CLASSIFICATION

<table>
<thead>
<tr>
<th>RISK CLASSIFICATION</th>
<th>EXPOSED OIL (bbis)</th>
<th>TRANSFERS PER YEAR PER BERTHING SYSTEM</th>
<th>MAXIMUM VESSEL SIZE (DWTx1000)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>≥ 1200</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Medium</td>
<td>&lt; 1200</td>
<td>≥ 90</td>
<td>≥ 30</td>
</tr>
<tr>
<td>Low</td>
<td>&lt; 1200</td>
<td>&lt; 90</td>
<td>&lt; 30</td>
</tr>
</tbody>
</table>

### TABLE 31F-4-2
SEISMIC PERFORMANCE CRITERIA

<table>
<thead>
<tr>
<th>RISK CLASSIFICATION</th>
<th>SEISMIC PERFORMANCE LEVEL</th>
<th>PROBABILITY OF EXCEEDANCE</th>
<th>RETURN PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>Level 1</td>
<td>50% in 50 years</td>
<td>72 years</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>10% in 50 years</td>
<td>473 years</td>
</tr>
<tr>
<td>Medium</td>
<td>Level 1</td>
<td>65% in 50 years</td>
<td>48 years</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>15% in 50 years</td>
<td>308 years</td>
</tr>
<tr>
<td>Low</td>
<td>Level 1</td>
<td>75% in 50 years</td>
<td>36 years</td>
</tr>
<tr>
<td></td>
<td>Level 2</td>
<td>20% in 50 years</td>
<td>224 years</td>
</tr>
</tbody>
</table>
MOTEMS Division 6 - Revisions

Revisions are being developed under auspices of CSLC
Will incorporate most recent practice adopted in several new Codes and Design Guidelines or Criteria:

- Port of Long Beach Wharf Design Criteria (2009)
- Proposed ASCE Standards for Seismic Design of Piers and Wharves
GUIDELINES FOR EVALUATING AND MITIGATING SEISMIC HAZARDS IN CALIFORNIA

2008
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Site Characterization:
- Adequate Site-Specific Borings / Cone Penetration Tests (CPT)
- At Least One Boring Next to CPT Sounding
- Depth Criteria Specified
- Presence of Low Strength / Continuous Thin Soil Layers
- Appropriate and Adequate Laboratory Tests
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Cone Penetration Tests (CPT) – Preferred Site Investigation Method for Liquefaction Evaluations

- Borings are always Required to Collect Soil Samples for Laboratory
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CPT Plots and Borings Showing Liquefaction Zones on Site Cross-Section

- CPT-1
- CPT-2
- CPT-3
- B-1

Key:
- Zone of Liquefaction

Legend:
- Sand to Silty Sand (Lakewood-San Pedro Formation)
- Sand
- Marine
- Backfill
- Quarry Run Fill
- Rock Rip-Rap
- Clay / Silt (Lagoonal Clay)
- Harbor Bottom Sediments
- Sand to Silty Sand (Hydraulic Fill)

Soil Classification (USCS):
- SM
- CL
- ML
- MH
- SC
- SP-SM
- SP

Friction Ratio (%)
Tip Resistance (tsf)
SPT Blowcounts (N)

Scale: 0 20 40 feet
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- Slopes or Embankments – Seismic Stability
  - Displacement Based Approach using Newmark Sliding Block Method
  - Assumed Rigid Sliding Block on Critical Failure Surface
  - Firm Ground Time History Input at Base of Block
  - Yield Acceleration from Pseudo-Static Stability Analysis
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- Slopes or Embankments – Seismic Stability
- Analytical studies based on regression analyses of large data base of WUS Accelerations (Over 1,800 records)
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Slopes or Embankments – Seismic Stability – Yield Acceleration
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Slopes or Embankments – Post Earthquake Static Stability $\geq 1.1$
Soil-Pile-Structure Interaction

- Inertial Loading (Structure Pushing the Pile => Pile Pushing the Ground)
- Kinematic Loading (Slope Movement => Ground Pushing the Pile)
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- Inertial Loading

- p-y Springs
  - Best-Estimate (Level Ground)
  - Upper Bound
  - Lower Bound
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Kinematic Loading

Courtesy - Bill Bruin of Halcrow

Was a Battered Pile
NOW Plumb!

Was a Plumb Pile
NOW Battered!
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**Kinematic Loading**

- Use Consistent Ground Displacement and p-y Springs
- Best-Estimate Ground Displacement and p-y Springs are appropriate
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Combination of Inertial and Kinematic Loadings
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Earth Pressures on Retaining Structures
- Current Version, 3107F.4 Provides Some Guidance
- Text Complementing 3107F.4 will be added in Division 6
- Will address design issues for cellular structures
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Ground Improvement

- Densification Techniques
  - Vibro Compaction
  - Vibro Replacement
  - Deep Dynamic Compaction
  - Compaction Grouting

- Hardening (Mixing) Techniques
  - Permeation Grouting
  - Deep Soil Mixing
  - Jet Grouting
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Ground Improvement – Stone Columns

General Process of Improvement
(Vibratory probe applies ~ 30 tons of centrifugal force to the surrounding ground)

Courtesy: Advanced GeoSolutions, Inc.
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Ground Improvement – Stone Columns

Water is used to Assist Penetration of the Probe

Courtesy: Advanced GeoSolutions, Inc.
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Ground Improvement – Jet Grouting

Courtesy: Hayward Baker
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Ground Improvement – Deep Soil Mixing

Courtesy: Hayward Baker
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Deep Soil Mixing – Site Logistics

Courtesy: LC Technology Inc.
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Deep Soil Mixing – Site Logistics
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- Deep Soil Mixing – Site Logistics
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Ground Improvement – Compaction Grouting

Installation of grout pipe:
- Drill or drive casing
- Location very important
- Record ground information from casing installation

Initiation of grouting:
- Typically bottom up, but can be top down
- Grout quality important
- Pressure and/or volume of grout is usually limited
- Slow, uniform stage injection

Continuation of grouting:
- On-site batching can aid control
- Grout quality important
- Pressure, grout quantity and indication of heave are controlling factors
- Sequencing of plan injection points very important

Courtesy: Hayward Baker
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Anticipated Schedule

- Draft to be Completed by Q1 2011
- Incorporate into Draft Revised MOTEMS by Q3 2011
- Public Comments by Q4 2011
- Adoption by CBSC by Q1 2012
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Geotechnical Hazards and Foundations

QUESTIONS?