SCREENING METHODOLOGIES
FOR USE IN OFFSHORE PLATFORM
ASSESSMENT AND REQUALIFICATION:
PHASE IV

Professor Robert G. Bea
Graduate Student Researcher James D. Stear
Graduate Student Researcher Zhaohui Jin
Post-Doctoral Researcher Tao Xu

Department of Civil and Environmental Engineering
University of California at Berkeley

January 29-30, 1998
MEETING AGENDA

Wednesday:

1:00 PM  Introduction and project review - Bob Bea
1:30  ULSLEA Enhancements (foundations, earthquakes, input/output) - Jim Stear
2:30  Marine Pile Foundations - Zhaohui Jin
3:30  Break
3:45  Tubular Joint Uncertainties and Biases - Tao Xu
4:30  Discussion
5:00 PM  Conclude

Thursday:

8:00 AM  Review issues from previous day - Bob Bea
8:30  ULSLEA Professional - Jun Ying
9:00  Expanding the Simplified Analysis Concept: TOPCAT, SADWS - Jim Stear, Bob Bea
10:00  Phase IV Spring Work Plan - Bob Bea, Jim Stear, Zhaohui Jin
10:30  Discussion, sponsors’ directions
11:00 AM  Adjourn
Goal: Develop engineering and management technology that will help improve the QUALITY (safety, serviceability, durability, compatibility - economy) of marine systems.

RESEARCH AREAS
Human & Organization Factors
Ships & Floating Systems
Platforms & Pipelines
<table>
<thead>
<tr>
<th>Human and Organization Factors</th>
<th>Researcher</th>
<th>Goals and Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management of Rapidly Developing Crises: A Multi-Community Study</td>
<td>Bob Bea, Karlene Roberts</td>
<td>Develop a real-time system to assist in arresting rapidly developing sequences of events that can lead to catastrophic accidents.</td>
</tr>
<tr>
<td>Human &amp; organization factors in diving operations</td>
<td>Shawn Cullen</td>
<td>Promote dive safety through identification, analysis, and management of human and organization factors in diving operations.</td>
</tr>
<tr>
<td>Human &amp; organization error risk reduction assessment instrument - SMAS</td>
<td>Brant Pickrell</td>
<td>Develop, code, and verify a computer program for use in assessing the risks of human and organization errors in operations of offshore platforms and marine terminals.</td>
</tr>
<tr>
<td>Human and Organizational Factors in Emergency Medicine</td>
<td>Karlene Roberts</td>
<td>Develop and implement research in seven medical units, ranging from paramedic units in fire departments to adult and child critical care units. This research tests a model of risk mitigation.</td>
</tr>
<tr>
<td>Center for Risk Mitigation - CRM</td>
<td>Bob Bea, Karlene Roberts, Admiral Tom Mercer</td>
<td>Organize a research center that will provide a forum for research, development, application, education, and information exchange among diverse industries to improve the safety of high technology systems with a key focus on the human and organizational aspects of such systems.</td>
</tr>
<tr>
<td>Ships, Platforms, Pipelines</td>
<td>Researcher</td>
<td>Goals and Objectives</td>
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<tr>
<td>Ship Structural Integrity Information System - SSIIIS</td>
<td>Henry Reeve</td>
<td>Develop and verify one component of a comprehensive ship quality information system that addresses the structural aspects of ships over their life.</td>
</tr>
<tr>
<td>Design and construction of long-life marine composite structures</td>
<td>Paul Miller</td>
<td>Develop and test panels of marine composites subjected to repeated loadings in submerged conditions. Develop and verify an analytical procedure to allow the evaluation of the long-term performance characteristics of marine composite panels.</td>
</tr>
<tr>
<td>Optimal strategies for the inspections of ships and offshore platforms for fatigue and corrosion damage (R. G. Bea, Martec, Inc.)</td>
<td>Tao Xu</td>
<td>Develop procedures and strategies to optimize the inspection and repair of ship and offshore platform structures. The inspection strategies will address predictable damage (e.g. fatigue of critical structural details) and unpredictable damage (e.g. due to accidents and errors).</td>
</tr>
<tr>
<td>Ultimate Limit State Limit Equilibrium Analyses of template-type offshore platforms - ULSLEA Phase 4</td>
<td>Jim Stear, Zhaohui Jin, Pending Assignment</td>
<td>Continue development and verification of a simplified procedure to characterize the ultimate limit state loadings and capacities of offshore platforms and their reliabilities for extreme condition storms and earthquakes.</td>
</tr>
<tr>
<td>Analyses of the nonlinear performance of platforms and caissons subjected to hurricanes</td>
<td>John Kareolis, James Wiseman</td>
<td>Continue study of the performance characteristics of platform and caisson systems when the storm loadings force the structures to their ultimate limit states.</td>
</tr>
<tr>
<td>Performance of pile foundations subjected to earthquake excitations (Profs. Seed, Bray, Pestana)</td>
<td>Philip Meymand, Thomas Lok, Chris Hunt</td>
<td>Develop and verify analytical models to assess the performance characteristics of groups of piles supporting structures subjected to intense earthquake excitations. Perform shaking tests on model pile groups to provide test data to verify the analytical models.</td>
</tr>
<tr>
<td>Pipeline Integrity and Maintenance Information System - PIMPIS</td>
<td>Boytond Farkis</td>
<td>Develop and verify an inspection and maintenance decision support system for submarine pipelines using a knowledge-based approach. PIMPIS will provide a means of embedding expert knowledge to help select options for pipeline inspections and maintenance.</td>
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<tr>
<td>Platform, pipeline, and floating systems design and requalification criteria for the Bay of Campeche and offshore Tampico - Tuxpan</td>
<td>Tao Xu, Zhaohui-Jin, Pending Assignment</td>
<td>Develop and verify a general platform and pipeline design and reassessment - requalification system tailored to the unique environmental, operational, and economic characteristics of PEMEX operations in the Bay of Campeche.</td>
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<tr>
<td>Pipeline design criteria for second trunkline North West Shelf Australia</td>
<td>Bob Bea</td>
<td>Develop risk based deformation - strain stability criteria for a 48-inch diameter gas pipeline offshore North West Shelf Australia.</td>
</tr>
<tr>
<td>ISO earthquake guidelines for design and reassessment of offshore platforms</td>
<td>Bob Bea</td>
<td>Continue development of reliability based platform earthquake design and reassessment guidelines for the International Standards Organization.</td>
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<tr>
<td>Reliability based earthquake LRFD design guidelines for offshore Indonesia</td>
<td>Bob Bea</td>
<td>Develop platform load and resistance factor design guidelines for offshore Indonesia.</td>
</tr>
<tr>
<td>Decommissioning and re-use of offshore platforms</td>
<td>James Wiseman, Brian Collins</td>
<td>Develop a general process for the assessment and evaluation of alternative procedures for the decommissioning of offshore platforms. Assist in conduct of MMS / CSLC workshop on decommissioning.</td>
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</table>
Current Publications

1996 - 1997:


Evaluation of the West Cameron 5452 #6 and #7 Well Caisson Capacity Characteristics, Report to Chevron (Operator), & Partners (Unocal, CNG Production Co., & Phillips), Ocean Engineering Services, Department of Civil and Environmental Engineering, University of California at Berkeley, May 1997 (R. G. Bea).


1995 - 1996:


SCREENING METHODOLOGIES FOR USE IN OFFSHORE PLATFORM ASSESSMENT AND REQUALIFICATION

Project Objective:

Further develop and verify simplified quantitative screening methodologies for Level 2 platform assessments so these methodologies may be used in practice

Phase I: June 1993 to May 1995
Phase II: June 1995 to May 1996
Phase III: June 1996 to May 1997
Phase IV: June 1997 to December 1998
PHASE IV PROJECT SPONSORS

ARCO Exploration and Production Technology

Exxon Production Research Company

Mobil Technology Company

Shell Deepwater Development Company

Unocal Corporation

US Minerals Management Service

IMP / Brown & Root

New Sponsor:

Chevron Petroleum Technology Company
PHASE IV DELIVERABLES

#1:
Documentation of ULSLEA program enhancements, comparisons, developments, evaluations, and verifications

#2:
Updating of ULSLEA user and modeling guide; updating of ULSLEA software

#3:
Two meetings
ULSLEA PHASE I

- Aero and hydrodynamic loadings ✓
- Unbraced deck legs capacity ✓
- Jacket capacity (legs, braces, joints) ✓
- Foundation capacity ✓
- Deterministic ULS analysis ✓
- Probabilistic ULS analysis ✓
- Damaged and grout-repaired members ✓
- Verification case studies (5) ✓
- ULSLEA program documentation ✓
- Meetings (2) ✓
ULSLEA PHASE II

- Modeling enhancements ✓
- Code updating and enhancement ✓
- Preliminary design of braces ✓
- Jacket horizontal framing effects ✓
- Additional verifications (2) ✓
- Linear analysis comparisons ✓
- User - modeling guide ✓
- Reporting and documentation ✓
- Meetings (2) ✓
ULSLEA PHASE III

- Fatigue analysis algorithms ✓
- Earthquake analysis algorithms ✓
- Verifications of earthquake analysis (3) ✓
- Earthquake deck spectra ✓
- Additional configurations ✓
- Platform strength and robustness studies ✓
- Code updating ✓
- Reporting and documentation ✓
- Meetings (2) ✓
• Platform Damage Studies (1 of 3) ✔
• Ductility-Level Earthquake Analysis
• Diagonal Loads on Platforms
• Additional Configurations (2) ✔
• Tubular Joint Uncertainties ✔
• Platform Foundations ✔
• Improved Input / Output
• Lifetime Reliability (Storms and Quakes)
• Wave Spatial Effects
• Shallow Water Kinematics
• Deck Elements
• Reporting and documentation
• Meetings (2)
ULSLEA Updating and Enhancements

- Simple Modeling of Foundations
- Ductility-Level Earthquake Analysis
- Program Input / Output Enhancements

by James D. Stear

ULSLEA Foundation Model

Current Model:
- Foundation strength and stiffness is based only on piles
- Jacket weight assumed carried by mudline elements

Proposed Changes:
- Include strength and stiffness formulations for conductors, mud mats and mudline braces
- Present "bounding" capacities and stiffnesses to user
Conductors

- Model as piles
- Deduct for group effects
- No vertical strength or stiffness

Mats and Braces

- Establish projected areas of resistance
- Capacity is based on weakest of brace or mat, leg or soil
- For upper-bound stiffness, consider jacket to be fixed at mudline
Bounding Stiffness

Modeling Pile Stiffnesses

Horizontal Pile-Head Springs (kips / in)

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<th>12EI/L^3_{30}</th>
<th>12EI/L^3_{10D}</th>
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Vertical Pile-Head Springs (kips / in)

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Piles in Layered Soils

Axial:

\[ P_{u,v} = \int_0^L q_v(z)dz + Q_p \]

Lateral:

\[ P_{v,i} = \int_0^{L_d} S_u(z)dz \]

\[ P_{v,i} = \frac{2M_P}{L_d} + \frac{1}{L_d} \int_0^{L_d} S_u(z)dz \]

Earthquake Analysis: Overview

- Previous effort devoted to strength-level analysis
- Procedures developed for determination of vibration properties
- Current focus is on ductility-level analysis
**Bounding DLE Demands**

**APPROACH 1: NEWMARK / HALL**
- Perform elastic modal analysis
- Assume $D_{\text{elastic}} = D_{\text{inelastic}}$

**APPROACH 2: SCALED PUSHOVER**
- 1. Find Forces
- 2. Push to $D$
- 3. Select R-Factor
- 4. Push to $DF_\mu$
- 5. Check Demands
Response Factors

- Relate displacements of linear and nonlinear SDOF systems
- Previous comprehensive studies have examined EPP, bilinear, stiffness degrading systems

Study will determine response factors for systems with stiffness and strength degrading behavior
- Statistical properties of factors will be identified
## Example: Bounding

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<td>1.5</td>
<td>0.73</td>
<td>1.13</td>
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## Component Capacities

Unbraced Jacket Sections:

\[ \mu_{cr} = \frac{\phi_u}{\phi_y} \]

\[ \Delta_u = \mu_{cr} \Delta_y \]
Component Capacities

Braces:
\[ \mu_{cr} = \frac{\epsilon_u}{\epsilon_y} \]

Bay Behavior:
\[ F, \Delta \]
\[ \Delta_u = \mu_{cr} \Delta_y \]

Pile Lateral Capacity:
Component Capacities

Pile Axial Capacity:

- Principal source of uncertainty is in ground motion
- Uncertainty in R-Factor may be significant at large displacements

Reliability
Verification:

- Models and results from 3-D TH ductility-level analyses of platforms are needed
- Sponsor input is requested

Program Enhancements: Revised Input

Interface Revision is 70% Complete:
- Excel 4.0 macros removed
- New inputs for braces, joints and piles
- Special input screens for additional configurations
- Program is now a single file of 1MB
- Development done in Excel 7.0 for Windows 95
Program Enhancements: Improved Output

Tabular Output:
- Revised printing features, no more blank pages
- Pile capacities and loads, with self-weight added to load
- Mode shapes and periods
- Fatigue damage
- Shears at framing levels and bay capacities
- Brace capacities with and without local forces

Program Enhancements: Improved Output

Graphical Output:
- Mode shapes
- Fatigue criticality for main diagonals
- Correct titles for plots
- Base shear and overturning moment
INFORMATION REQUEST FOR DUCTILITY-LEVEL VERIFICATIONS

INTRODUCTION:

To assist in benchmarking the proposed simple ductility-level earthquake analysis approach, data from comprehensive ductility-level earthquake time-history analyses of jacket-type platforms is being requested from the sponsors.

TYPES OF PLATFORMS:

Initial focus will be on fairly simple structures, of which three are desired. These structures should have the following characteristics:

1. 4-legs, symmetric mass and stiffness on both end-on and broadside axes (to minimize torsion effects).
2. If piled through the legs, grouted pile-leg annuluses.
3. Sited in water depths from 50 ft to 600+ ft.
4. Platforms without conductors are preferred.
5. A variety of framing systems is preferred (single braced, X-braced, K-braced).

Later studies will consider larger, more redundant structures. Again, it is preferred that the structures be fairly symmetric, and have grouted pile-leg annuluses if piled through the legs.

INFORMATION NEEDED FOR EACH CASE:

Data is needed both on the model developed for the time-history analyses, and on the results obtained from the time-history analyses.

Model:

1. Structural drawings of platform.
2. Weight distribution of platform used in model. Lumped masses at horizontal framing levels.
3. Description of program used.
4. Description of how added mass was accounted for. Marine growth assumed?
5. Description of element used to represent tubular members, and sample cyclic hysteresis plots for several elements. How were member yield and post-yield behavior established?
6. Description of how foundation was modeled. Were mats and mudline braces accounted for? Were conductors accounted for? How were piles and conductors modeled? Pile-head load-deflection plots (for principal directions) for piles and conductors under cyclic loading. If equivalent pile-head springs were used, the stiffness, yield strengths, and post-yield cyclic behavior assigned to each spring on each principal direction.
7. Description of how deck was modeled. Rigid deck assumed?
8. What earthquake time-histories were used? What scaling was applied? How were motions applied to the model?
9. Local member loads.
10. What damping was used?
11. Soil profile at the site, including soil shear strengths, elastic modulus and poisson's ratio.
12. Description of how joints were modeled.

Analysis:

1. Principal vibration characteristics of model (periods, mode shapes).
2. Diagrams showing where yielding occurred, and how much. Envelopes for peak member stresses and strains.
3. Collapse criteria used (Critical strain on members exceeded? Instability in model?).
4. Deck deflection vs. base shear plots if static pushover analysis was performed, along with load pattern used and collapse mechanism identified.
5. Any simple or approximate dynamic analysis results (inelastic response spectrum approach, etc.).
6. Envelopes for peak global loads on the platform: base shear, overturning moment, shears at each horizontal framing level.

Any questions or comments should be forwarded to:

James Stear
Civil Engineering / Construction
215 McLaughlin Hall
Berkeley, CA 94720-1712

Phone: 510 526-2501

e-mail: stear@loke.berkeley.edu
Loading and Capacity Characteristics of Marine Pile Foundations
Correlation of Calculation Results with ULSLEA

Some general conclusions from the current research in the field of pile response

- Dynamic response depends primarily on external loading patterns and the inherent structure properties;
- Environmental loading are dynamic;
- Nonlinearity is a key concern in the analysis: at presence of soil, which are highly nonlinear, the pile foundation exhibits complicated coupling action between the soil and the steel piles;
- High strain rates increase strength and stiffness;
- Cyclic strains decrease strength and stiffness;
- Cyclic loading leads to accumulated displacements;
- Damping developed from pile foundation is important;
Analysis models used in the study

+ SPASM: lateral Response
  - linear pile
  - non-linear, degrading, hysteretic soil supports
  - extended capacity to estimate the ultimate pile foundation resistance
+ DRAIN3D: Both lateral and axial response
  - non-linear pile up to the ultimate state
  - non-linear, hysteretic, displacement-softening soil supports
+ ULSLEA: both lateral and axial response
  - simplified estimation of the ultimate capacity

Basic Approaches in the simulation of the coupling of the pile and the near-field Soils

+ Winkler pile foundation model
+ Typical p-y curve, t-z curve and q-z curve
Soil profiles and computer-internal representation of the p-y,t-z and q-z springs

Illustration of the SPASM analytical model

Mechanism of cyclic degradation:

\[
\Omega_i = (1 - \lambda)(\Omega_i - \Omega_{\text{max}}) + \Omega_{\text{max}}
\]

[Equation]

\[
\frac{P}{P_i} = 0.75 \frac{X}{X_i}
\]

[Equation]
Expression of Laterally and Axially Loaded Pile in DRAIN3D Program

- Equivalent truss frame simulating the lateral pile-soil response
- Equivalent truss frame simulating the axial pile-soil response

Details of the nodes in the discrete DRAIN3D models

- Sections of the elements are divided into plastic fibers with the non-linear stress-strain relationships
- Artificial rigid bars are added to the soil elements with one end nodes rotationally fixed. This is intended to filter the unreasonable small bending moments at the connection nodes. These bending moments can induce the buckling of the soil elements, which is not true for the soils in field.
Simplified ULSLEA Static Pile Ultimate Capacity Estimation

Illustration of the simplified approach: lateral and axial:

Lateral capacity calculation:

\[ P_L = \int S(z) dz \]

\[ P_L = \frac{2M}{L} + \frac{1}{L} \int S(z) dz \]

Axial capacity calculation:

\[ Q_A = Q_A + Q_L = qA_f + f_A \]

\[ Q_A = \frac{q \pi D_t}{4} (f_A \pi D_t - w_t) \]

\[ w_t = \gamma A_f + \gamma A - \frac{1}{4} [\gamma (A_f + \lambda \pi D_t)] \]

\[ q = 9S \quad f_A = kS \]

Results from SPASM: load-deflection relationship for the standard cases with best estimated soil characteristics: rotationally fixed and free pile heads

Comparison of Load-Displacement Curves for Different Loading History (Rotationally Fixed Pile Head)

Comparison of Load-Displacement Curves for Different Loading History (Free Pile Head)
Results from SPASM: bending moments in the pile at the point when the first yielding occurs (fast load and cyclic load)

Analysis results of DRAIN3D Lateral Response Model

Results and Conclusions Obtained from the DRAIN3D Model:

- There are satisfactory agreements in the pile lateral response before the occurrence of the first yielding with the SPASM model. Pile performances, both in resistance to loading and pile head displacement are comparable.
- The prediction of the ultimate capacities are quite different from those of SPASM. For each case of loading pattern, the ultimate capacities of the pile-soil system tend to converge to one value for fixed, grouted and shimmed pile head. For the case of free pile head, the ultimate capacity is much lower than those with pile head restraint.
- Different loading patterns have different ultimate capacities.
- It seems that there is a maximum pile head displacement for this pile configuration. The pile is doomed to fail if the pile head displacement exceeds this maximum value for all cases.
Analysis results of DRAIN3D Lateral Response Model (continued)

Typical Bending Moment Distribution along the Pile length for the First Yielding and Ultimate States
Comparison of the lateral capacities obtained by different models

Comparison of the Axial Ultimate Capacities Obtained by Different Methods

There are satisfactory agreements between the different calculation methods:

- Drain3D model proved the axial response is quite sensitive to the load rate effect.
- ULSLEA model tends to capture the lower bound of the static ultimate capacity.
- More efforts needed to figure out the cyclic load effects on the ultimate capacities.
Summary and Conclusions

- For lateral loaded pile, three failure modes exist: excessive pile head displacement; permanent damage to the pile; and ultimate collapse.
- For the pile configuration under study, pile rigidity is not an important factor influencing the ultimate capacity, all shimmed, grouted, and fixed pile heads have the similar lateral ultimate capacity. Free pile head is an exception.
- For the pile configuration under study, pile rigidity is an important factor influence the first yielding capacity, and the reserve strength of the pile. Stiff pile head is prone to suffer permanent damage but has large reserve strength. Flexible pile head is not easy to yield, but has little robustness.
- For the pile configuration under study, there exists a maximum later pile head displacement. The pile is doomed to fail if the pile head displacement exceeds this value.
- The cyclic degradation will cause 20-30% loss of static lateral capacity, both first yielding capacity and ultimate capacity.
- The loading rate effect will cause around 20% increase in lateral dynamic capacity with respect to the static capacity.

Summary and Conclusions (cntd)

- For the pile-soil system under study, the axial loading rate effect increases the dynamic capacity by 70-80% with respect to the static axial capacity.
- The end bearing capacity is not as important as the side friction for the axially loaded piles. For the pile configuration under study, the maximum pile head displacement is a little larger than 10% of the pile diameter.
- The displacement softening occurring during the axial loading process decreases the ultimate axial capacity by around 20%.
- For the case of lateral loading, ULSLEA can give a very good estimation of the ultimate capacities no matter the pile heads are fixed, shimmed or grouted.
- For the case of axial loading, ULSLEA captures the lower bound of the ultimate capacity, thus is conservative in practice.
- In practice, ULSLEA has good validity in predicting the ultimate capacities of the platforms' pile foundations.
Screening Methodologies for Use in Platform Assessments & Requalification

REASSESSMENT OF TUBULAR JOINT CAPACITY
UNCERTAINTY AND RELIABILITY

By
Dr. Tao Xu
Marine Technology & Management Group
Dept. of Civil & Environmental Engineering
University of California at Berkeley
Berkeley, CA 94720

January, 1998

Uncertainty and Reliability

1 - Uncertainty

Natural (Type I) → irreducible
Model (Type II) → reducable
Human (Type III)

2 - Reliability and Uncertainty
Tubular Joint Capacity

- Failure Modes
  - Plastic failure of the chord,
  - Cracking and gross separation
  - Cracking of the brace
  - Local Buckling
  - Shear failure of the chord
  - Lamellar tearing

- Principal Factors
  - Chord outside diameter
  - Brace outside diameter
  - Chord wall thickness
  - Gap
  - Angle between chord & brace
  - Chord material yield stress

Development of Joint Capacity Equations

- Dimensional Analysis

\[ (P_u) \text{ or } (M_u) = F(D, d, T, g, \theta, \lambda, F_y, F_t) \]

- Calibration with Experimental Data
Uncertainty of Tubular Joint Capacity

Evaluation of Existing Guidelines

- Data Screening and Validity
  1. Scale Effects: Small & Large ✓
  2. Material Properties: Yield Stress
  3. Chord/Brace Length and Boundary Conditions
  4. Joint and Structural System

- Multiplanar Joints
  1. AWS Code
  2. API Code

- Complex Joints
Development of Uncertainty Models

1 - Data Screening and Acceptability

2 - Database Development
   - Yura/API Database
   - HSE Database
   - JISSP (Joint Industry Static Strength Project) Database
   - Database for Multiplanar Joints
   - Database for Cracked Joints
   - Others

Uncertainty Analysis of Simple Joints
Database for Simple Joints

1 - Yura/API Database
2 - HSE Database
3 - JISSP Database

Simple Joint Behavior
Uncertainty Analysis of Simple Joints

Uncertainty of Tension Loaded T, Y and DT Joints Based on HSE Database (Ultimate Strength Criteria)

Uncertainty of Simple Joints

<table>
<thead>
<tr>
<th>Joint Type</th>
<th>Load Type</th>
<th>Yura Database</th>
<th>HSE Database</th>
<th>JSSP</th>
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<tr>
<td>T &amp; Y</td>
<td>Tension</td>
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<td>K &amp; YT</td>
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<td>1.32</td>
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<td>In-Plane Bend</td>
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<td>1.18</td>
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<tr>
<td>All</td>
<td>Out-Plane Bend</td>
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Uncertainty Analysis of Multiplanar Joints

Multiplanar Joint Database

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<td>(90^\circ \leq \alpha \leq 90^\circ)</td>
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<td>(45^\circ \leq \alpha \leq 90^\circ)</td>
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<td>(9 \leq 40)</td>
<td>Wenshur et al (1993)</td>
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<td>TT</td>
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<td>(60.1^\circ \leq \gamma \leq 120.4^\circ)</td>
<td>Scott et al (1948)</td>
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<tr>
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<td>(0.222 \leq \beta \leq 0.732)</td>
<td>Scott et al (1948)</td>
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<td>(17.2 \leq \gamma \leq 6.3)</td>
<td>Scott et al (1948)</td>
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<td>XX</td>
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<td>(\chi = 0.99)</td>
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## Uncertainty of Multiplanar Joints

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<td>1.214</td>
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<td>Out-of-plane</td>
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<td>Out-of-plane</td>
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<tr>
<td>TT Joint</td>
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<td>API T Joint</td>
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<td>KK Joint</td>
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<td>1.642</td>
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<td>XX Joint</td>
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<td>API X Joint</td>
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## Uncertainty of Complex Joints

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<td>Through</td>
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<tr>
<td>Overlap</td>
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<td></td>
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<tr>
<td>Grouded</td>
<td>1.27</td>
<td>0.30</td>
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<td>Can Reinforced</td>
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<tr>
<td>T Joint</td>
<td>1.1</td>
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<tr>
<td>X Joint</td>
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<td>0.074</td>
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<tr>
<td>Cracked Joint</td>
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<td>0.154</td>
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Uncertainty Analysis of Complex Joints

Summary and Conclusions

1 - Development of the Database
2 - Evaluation of the Existing Codes
3 - Development of Uncertainty Models
Recommendations

- Joint and Structural System

- Fatigue of Tubular Joints - Uncertainty Model

- Risk Based Management of Joint System

  Inspection, Maintenance, Monitoring, and Repair System √
Development of Stand-Alone Version of ULSLEA v4.0

Dr. J. Ying
Prof. R.G. Bea

University of California, Berkeley

Background

- Excel 4.0 macros and Excel 5.0 Visual Basic
- Compatibility with new versions of Excel
- Spreadsheets data storage is inefficient
- Macros are limited in size, and not good for efficient computing
- Hard for maintenance and update
Objective and Scope

- A stand-alone version of ULSLEA
  - Input, output features of ULSLEA v3.0
  - Update the calculation procedure
  - MS Visual C++ & Visual Basic
  - Run on the Windows 95/NT

Deliverables and Schedule

- ULSLEA v4.0, a stand-alone program
- Document of the program structure and source code.
- February 1st to June 30th 1998.
## Personnel and Budget

<table>
<thead>
<tr>
<th>Category</th>
<th>Budget $</th>
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</thead>
<tbody>
<tr>
<td>Personnel:</td>
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<tr>
<td>Prof. Bea (20 hours)</td>
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</tr>
<tr>
<td>Dr. Ying (500 hours)</td>
<td>$25,000</td>
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<td>Expenses and Supplies:</td>
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<td>VC++/VB Package</td>
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<td>Miscellaneous</td>
<td>$500</td>
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<td>Total Direct Cost</td>
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<td>University Overhead</td>
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<td>Total Cost</td>
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Proposal

Development of Stand-Alone Version of ULSLEA v4.0

Background:

During the past three years, as a result of the Joint Industry Project (JIP) “Screening Methodologies for Use in Platform Assessments and Requalifications,” a computer program identified as ULSLEA (Ultimate Limit State Limit Equilibrium Analysis) has been developed and verified for use in performing rapid assessments of platform lateral loading capacity.

The ULSLEA program has shown much promise as a tool to help engineers in the following tasks:

- Quickly assess a platform’s fitness for purpose with regards to environmental loads (both deterministically and probabilistically)
- Damage and repair studies, and preliminary design studies
- Checking the results of detailed non-linear analyses

The current version of the ULSLEA program, v3.0 beta, consists of two linked Microsoft Excel 5.0 workbooks. Intended solely as a prototype, the program makes use of the spreadsheet environment within Excel to store data and show tabular and graphical output. Program input is largely controlled by Excel 4.0 macros, while the actual strength, load and reliability calculation routines have been written in Visual Basic, the macro language for Excel 5.0. This arrangement, while functional, has the following drawbacks:

- The program is dependent on the user having a full version of Microsoft Excel 5.0 installed
- Macros (essentially subroutines) contained within the workbooks are limited in size, and not written for efficient updating
- There is no assurance of backwards compatibility as new versions of Excel are released.
- Data storage using Excel spreadsheets is very inefficient
Objective and Scope:

The objective of this project is to produce a stand-alone executable version of ULSLEA which possesses all of the current input, storage, calculation and output features of ULSLEA v3.0 beta, but is no longer dependent upon Microsoft Excel as an operating environment. The program development will be done in Microsoft Visual C++ and Visual Basic. The end result will be a standard MS application which is more versatile, faster, better graphic user interface (GUI), and better hardware resource management. This program will run on the Windows 95/NT operating system. To every extent possible, the final product will replicate the features and functionality of the existing ULSLEA Excel macros, and more, will introduce more powerful functions which are available from Microsoft applications.

Tasks:

The project is organized into four tasks:

1. Program design (input, calculation procedures, output)
2. Program coding (input, calculation procedures, output)
3. Installation procedures
4. Testing and verification

Deliverables:

As a result of the foregoing tasks, there will be two deliverables:

1. ULSLEA v4.0, a stand-alone executable program with all the features and capabilities of ULSLEA v3.0 beta.
2. A report documenting the program structure and source code.

Schedule:

The project will be initiated February 1st 1998, and conclude June 30th 1998. The estimated man-hours to be spent on each task are listed below:
1. Design:
   A. Input: 50 hours
   B. Output: 50 hours
   C. Algorithm: 50 hours

2. Coding:
   A. Input: 100 hours
   B. Output: 100 hours
   C. Algorithm: 50 hours

3. Testing:
   60 hours

4. Document:
   40 hours

Total: 500 hours

<table>
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<tr>
<th>Task</th>
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<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
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<tr>
<td>Coding</td>
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<tr>
<td>Install</td>
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<td>Testing &amp; Document</td>
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Personnel and Organization:

This project will be managed by Prof. R.G. Bea and conducted by Dr. Jun Ying, operating as an outside consultant in cooperation with the Marine Technology and Management Group (MTMG).

Budget:

The total cost associated with the project is estimated to be $30,000. The project will be initiated when commitments have been obtained by five sponsors, each contributing $6,000. The budget outlay is as follows:

<table>
<thead>
<tr>
<th>Category</th>
<th>Budget $</th>
</tr>
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<tbody>
<tr>
<td>Personnel:</td>
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<tr>
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<td>$500</td>
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<tr>
<td>Total Cost</td>
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FROM ULSLEA TO TOPCAT: Template Offshore Platform Capacity Assessment Tools

"Limit Equilibrium" is now only one part of the current program... hence "TOPCAT"

Topics of Future Research / Program Enhancement:

1. Fatigue of horizontals
2. Fatigue reliability
3. Benchmarking of simplified fatigue method against more comprehensive analyses
4. Analysis of pile-only structures
5. Distributed loads and torsion
6. Wave loads on decks
7. Continued work on earthquakes
## PHASE IV:
### PLAN FOR NEXT 11 MONTHS

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