Thursday:
1:00 PM  Introductions and project review
           Bob Bea
1:30     ULSLEA Enhancements: Fatigue Analysis, Seismic
           Loads, Different Structural Configurations
           Jim Stear
2:30     Discussion
3:00     Break
3:15     ULSLEA: Parametric Studies of Local Damage on
           Global Platform Strength
           Teresa Aviguetero
3:45     Discussion
4:00     Minimum Structures, ULSLEA 4
           Bob Bea
4:30     Discussion
5:00 PM  Conclude

Friday:
8:00 AM  Review issues from previous day
8:15     Information Management for Fleets of Platforms
           Steve Stanef
8:45     Discussion
9:00     Sponsor Presentations, ULSLEA Troubleshooting,
           User Help, Discussion
10:00    Future work: Phase 3 winter/spring work plan
           Bob Bea, Jim Stear
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>Human &amp; organization factors in design, construction, and operation of Ships</td>
<td>Duane Boniface</td>
<td>Develop a comprehensive system to evaluate the life-cycle reliability characteristics of ships including human factors considerations. Validate system with Estonia accident analysis.</td>
</tr>
<tr>
<td>FLAIM II (with Prof. Williamson, and Paragon Engineering Inc.)</td>
<td>Derek Hee</td>
<td>Develop, test, and help validate an assessment system to evaluate the risks associated with loss of hydrocarbon containment on offshore platforms and marine terminals.</td>
</tr>
<tr>
<td>Human &amp; organization factors in evacuation of marine systems</td>
<td>Jun Ying</td>
<td>Develop and verify a computer based simulation tool to evaluate the reliability of personnel evacuation procedures for tropical cyclone (hurricane) conditions.</td>
</tr>
<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. The system addresses operators, their organizations and environments, procedures, and hardware. The communities include commercial and military aviation, nuclear power, emergency medical care, shipping, platform and refinery operations, police and fire operations.</td>
</tr>
<tr>
<td>Human &amp; organization factors in diving operations</td>
<td>Mike Blumenberg</td>
<td>Promote dive safety through identification, analysis, and management of human and organization factors in diving operations. Develop and verify strategies and procedures to help reduce the occurrence of diving accidents. The process includes proactive (evaluate, mitigate) and reactive (sense, mitigate) strategies.</td>
</tr>
<tr>
<td>Human &amp; organization error risk reduction instrument</td>
<td>Brent 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. This program will be used in the field trials described in the following project.</td>
</tr>
<tr>
<td>Assessment of Human and Organization Performance in Operations of Marine Systems (with Profs. Brady Williamson and Karlene Roberts)</td>
<td>Derek Hee</td>
<td>Develop a two-level assessment instrument to help qualified assessors evaluate human and organization performance in operations of offshore platforms and marine terminals. The instrument will be verified at two locations (Chevron Richmond Long Wharf and on a platform offshore California) with qualified assessors.</td>
</tr>
<tr>
<td>Human &amp; organization factors in marine flight operations (Prof. Roberts Principal Investigator)</td>
<td>Rich Lawson</td>
<td>Assist in development, application, and analysis of results from a surveying instrument to help identify undesirable human and organization factors in marine flight operations. Develop and test a marine flight operations human and organization error task assessment process.</td>
</tr>
<tr>
<td>Human &amp; organization factors in operations / inspections of bulk cargo carriers (Prof. Demsetz Principal Investigator)</td>
<td>Mat Miller</td>
<td>Develop and verify a process to evaluate the roles of human and organization errors in the design, construction, maintenance, and operations of bulk cargo carriers.</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. Other investigators participating in this research include Daved Van Stralen - Loma Linda Hospital, Greg Bigley - UC Irvine, Carolyn Libuser - California School of Professional Development)</td>
</tr>
<tr>
<td>International Workshop: Human and Organizational Factors (with PrimaTech Inc.)</td>
<td>Bob Bea</td>
<td>Organize and conduct an international workshop that will address key human and organization factors considerations in platform operations (Dec. 16-18, New Orleans).</td>
</tr>
<tr>
<td>Ships and Floating Systems</td>
<td>Researcher</td>
<td>Goals and Objectives</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------------------</td>
<td>------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Assessment of cracked critical structural details: fracture mechanics and S-N evaluations</td>
<td>Tao Xu</td>
<td>Develop and verify a practical engineering process to address the fitness for purpose of cracked critical structural details in marine structures. The process includes inspections, assessment of cracked details using traditional S-N analyses, load shedding (load redistribution during cracking), and stiffness effects.</td>
</tr>
<tr>
<td>Ship Structural Integrity Information System - SSIIIS III</td>
<td>Henry Reeve</td>
<td>Develop and verify one component of a comprehensive ship quality information system. This component deals with the structural aspects of the ship over its life. The system will permit the documentation of the condition of the structure throughout its life, updating it as new information becomes available, and allow the evaluation of the future behavior of the structure including effects of alternative inspection, maintenance, and repair programs.</td>
</tr>
<tr>
<td>Reliability based siting of mobile drilling units</td>
<td>Jun Ying</td>
<td>Develop a computer based simulation process to help evaluate the forces, movements, and probabilities of collisions of MODU's. Verify the process with movements data from MODU's during hurricane Andrew.</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>Inspection of critical structural details in ships (Prof. Demsetz, Principal Investigator)</td>
<td>Juan Caberra</td>
<td>Perform tests in ships to evaluate the probability of detection of cracks in critical structural details. Based on the test data, characterize the probabilities of detection of fatigue cracks and fractures.</td>
</tr>
<tr>
<td>Optimal strategies for the inspections of ships and offshore platforms for fatigue and corrosion damage (with 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>Feasibility and reliability of tanker single point mooring systems offshore California</td>
<td>Aaron Salancy</td>
<td>Develop an analytical model to evaluate alternative single point mooring systems for the transshipment of oil offshore two California locations. Based on the model results, evaluate the feasibility, costs, and reliability of two alternative single point mooring systems.</td>
</tr>
</tbody>
</table>
### Platforms & Pipelines

<table>
<thead>
<tr>
<th>Researcher</th>
<th><strong>Goals and Objectives</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Platforms</strong></td>
<td></td>
</tr>
<tr>
<td>Steve Stanef</td>
<td>Develop a computer based information and data management system for the reassessment and requalification of fleets of offshore platforms.</td>
</tr>
<tr>
<td>Anne Sturm</td>
<td>Reassess two operating platforms in the Gulf of Mexico using recently developed procedures for the analysis of platform loadings, capacities, and reliabilities.</td>
</tr>
<tr>
<td>Jim Stear</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>Agnes Brandtzaeg</td>
<td>Develop a reliability based procedure to evaluate the life-cycle risk characteristics of alternative minimum structures including the influences of human and organization errors. Apply the procedure to three minimum structures and one traditional four-leg well protector.</td>
</tr>
<tr>
<td>James Wiseman, assignment pending</td>
<td>Continue study of the performance characteristics of platform systems when the storm loadings force the structures to their ultimate limit states. Define and characterize the important loading and response variables. Verify the analytical models with platform failures and near failures in past hurricanes.</td>
</tr>
<tr>
<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>Jun Ying</td>
<td>Reassess a Cook Inlet platform to determine its performance characteristics when subjected to intense dynamic ice loadings and earthquakes. Characterize the reliabilities of the platform. Compare the notional reliabilities with economics and standard of practice guidelines.</td>
</tr>
<tr>
<td>Tarek Elsayed, assignment pending</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>
</tr>
<tr>
<td>Bob Bea, assignment pending</td>
<td>Develop and verify a general platform and pipeline reassessment and requalification system tailored to the unique environmental, operational, and economic characteristics of PEMEX operations in the Bay of Campeche.</td>
</tr>
<tr>
<td>James Wiseman, Brian Collins</td>
<td>Continue development of reliability based platform earthquake design and reassessment guidelines for the International Standards Organization. Develop probability based earthquake guidelines for marine terminals and harbor facilities in California.</td>
</tr>
<tr>
<td><strong>Pipelines</strong></td>
<td></td>
</tr>
<tr>
<td>Steve Stanef</td>
<td>Develop a general process for the assessment and evaluation of alternative procedures for the decommissioning of offshore platforms. Validate and demonstrate application of the process with example platforms from the Gulf of Mexico and offshore California.</td>
</tr>
</tbody>
</table>
Platforms & Pipelines | Researcher | Goals and Objectives
--- | --- | ---
Workshop on Decommissioning Platforms Offshore California (with California State Lands Commission, U. S. Minerals Management Service, and California Sea Grant College) | Bob Bea | Assist in development and conduct of a workshop (March 1997) to bring together the various communities concerned to discuss the critical considerations involved in decommissioning platforms offshore California. Regulatory, legal, engineering, scientific, economic, environmental, and research considerations will be addressed as they pertain to the viable options including reefing, complete and partial removal, use as scientific and engineering research stations, use as commercial and recreational diving and aquaculture sites.
Robustness and repair of offshore platforms | Teresa Aviguetero | Perform parametric studies on a Gulf of Mexico platform to determine its robustness (damage tolerance) characteristics for different degrees, locations, and types of damage. Perform parametric studies to determine the effectiveness of alternative repairs to damaged brace, joint, and pile elements.

SELECTED CURRENT PUBLICATIONS


Marine Technology & Management Group - University of California at Berkeley


Screening Methodologies for Use in Offshore Platform Assessments and Requalifications

PROJECT OBJECTIVE:

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

Phase 1: June 93 - May 95
Phase 2: June 95 - May 96
Phase 3: June 96 - May 97
Project Sponsors

ARCO Exploration and Production Technology
Exxon Production Research Company
Mobil Technology Company
Shell Offshore Incorporated
Unocal Corporation

New Sponsor:
Phillips Petroleum Company

US Minerals Management Service
(Associated Project: Nonlinear Dynamic Performance)

Approval Pending:
California State Lands Commission
Pemex/IMP
Phase 3 Deliverables

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

#2
Updating of ULSLEA user and modeling guide, including updating software and coding

#3
2 x Meetings

Budget

$75,000 (5 sponsors @ $15,000)

GSR $40,000 / PI $20,000 / Expenses $15,000
ULSLEA Project Scope: Phase 1 Review

- Aero and hydrodynamic loadings ✓
- 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 and documentation ✓
ULSLEA Project Scope:
Phase 2 Review

- Modeling enhancements ✓
- Code updating and enhancement ✓
- Preliminary design algorithms ✓
- Horizontal jacket framing effects ✓
- Additional verifications (2) ✓
- Linear analysis comparisons ✓
- User-modeling guide ✓
- Reporting and documentation ✓
ULSLEA Project Scope: Phase 3

- Fatigue analysis algorithms ✓
- Earthquake analysis algorithms ✓
- Analysis of additional platform configurations ✓
- Additional verifications ✓
- Platform strength and robustness studies ✓
- Code updating ✓
- Reporting and documentation
SIMPLIFIED FATIGUE ANALYSIS

OBJECTIVE:

Develop a simple approach by which the cumulative damage from fatigue to critical structural elements can be estimated.

SCOPE:

Focus is on joint regions where vertical diagonal braces connect to the jacket legs. Only principal directions of loading will be considered when estimating stresses in these regions.
OVERVIEW OF FATIGUE ANALYSIS APPROACH

1. Establish Long-Term Global Load History For Platform
2. Correlate Global Loads on Platform to Local Stresses in Critical Regions
3. Determine Local Response History From Global Load History
4. Compare Local Response History with Local Capacity to Evaluate Fatigue Damage
SIMPLIFIED FATIGUE ANALYSIS APPROACH ASSUMPTIONS

1. The maximum stress range at the critical area is dependent only on the wave heights, by:

   \[ S = C H^g \]

2. The S-N curve characterizing the fatigue behavior is given by:

   \[ N S^m = K \]

3. Miner's rule applies:

   \[ D = \sum_i \frac{n_i}{N_i} \]

4. The long-term wave-height distribution is a sum of two Weibull distributions:

   \[ F_{H_0}(h) = 1 - \exp \left[ - \left( \frac{h}{H_0} \right)^{\xi_0} \ln N_0 \right] \]

   \[ F_{H_1}(h) = 1 - \exp \left[ - \left( \frac{h}{H_1} \right)^{\xi_1} \ln N_1 \right] \]
**CUMULATIVE FATIGUE DAMAGE**

Cumulative damage is then:

$$D_d = \frac{T_d C^m}{K} (Y_0 + Y_1)$$

where:

$$Y_0 = \frac{N_0}{T} H_0^{g_m} (\ln N_0)^{\frac{g_m}{\xi_0}} \Gamma \left( 1 + \frac{g_m}{\xi_0} \right)$$

$$Y_1 = \frac{N_1}{T} H_1^{g_m} (\ln N_1)^{\frac{g_m}{\xi_1}} \Gamma \left( 1 + \frac{g_m}{\xi_1} \right)$$

By using:

$$C = \frac{S_f}{H_f^g}$$

$$S_f = S_p (1 - R)$$

Damage may then be expressed by:

$$D_d = \frac{T_d}{K} \left( \frac{S_p (1 - R)}{H_f^g} \right)^m (Y_0 + Y_1)$$
SPECIFYING PARAMETERS

K, m from S-N curve

g either 1.2, 1.3

R between -0.15 to -0.5

H₀, H₁, ξ₀, ξ₁, N₀, N₁ from regional wave data
USING ULSLEA PROGRAM FOR FATIGUE ANALYSIS

- User will input parameters to define S-N curves, wave height distributions, stress concentration factors

- By analyzing structure for $H_f$, peak stresses may be calculated for each critical region

- Cumulative damage is calculated for each region, and then output in ranked order of severity
CALCULATION OF PEAK STRESSES

Stress ranges in components are evaluated only for principal directions of loading.

Peak stresses are dominated by two effects:

- Axial force carried by attached brace
- Bending of attached brace due to local hydrodynamic forces
USING ULSLEA TO FIND PEAK STRESSES

Utilize ULSLEA program to perform simple structural calculations.

Estimate axial force in individual braces due to global application of $H_f$.

Use fix-fix beam moments at brace ends to find bending stresses, with moments due to distributed load $w$. 
STRESSES AND CUMULATIVE DAMAGE

Total stress is then:

\[ \sigma = \frac{F_{\text{axial}}}{A_{\text{brace}}} + \frac{M_{\text{end}}}{I_{\text{brace}}} \]

with axial and bending stresses modified by SCF's input by user.

Joints will be presented by ranking in terms of amount of accumulated damage.

No fatigue life estimate is made due to large uncertainties in calculation.
ADDITIONAL CONFIGURATIONS

Tripods, multi-jackets will have same critical details as regular jackets.

Braced caisson fatigue analysis will focus on connection between caisson and brace.

Guyed caisson fatigue analysis will focus on attachment lug for cable on caisson.
SEISMIC SCREENING OF FIXED OFFSHORE STRUCTURES

OBJECTIVE:

Determine seismic load and perform capacity check.

INITIAL FOCUS:

Strength-level evaluations of symmetric structures in moderate water depths.
EVALUATION APPROACH OPTIONS CONSIDERED

Use elastic response spectrum analysis:

- Determine Structure's Elastic Vibration Properties
- Get Accelerations from Earthquake Response Spectrum Corresponding to Periods of Vibration
- Find Lateral Forces Associated with Each Mode
- Find Mode Responses and Combine
- Compare to ULSLEA Lower Bound

Use design code approach:

- Calculate Code Forces
- Compare to ULSLEA Lower Bound
RESPONSE SPECTRUM ANALYSIS

Discretize structure:

Determine vibration periods and modes:
\[ k_n \phi_n = \omega_n^2 m_n \phi_n \]

Combine with response spectrum to find forces:
\[ p = \frac{\sum_{j=1}^{N} m_j \phi_{j_n}}{\sum_{j=1}^{N} m_j \phi_{j_n}} m_n S_{A_n} \]

Compute response quantities and combine:
\[ r = \sqrt{r_1^2 + r_2^2 + r_3^2 + \ldots} \]
FACTORS AFFECTING VIBRATION PROPERTIES

- Bending, shear deformations
- Stiffness irregularities
- Flexible, non-linear foundations
- Hydrodynamic effects
- P-∆ effects
OBSERVATIONS OF RSA

• Most response quantities captured by 1-2 modes

• 1st lateral mode dominated evenly by base drift, base rocking, and structure deformations

• Structure deformations dominated by shear

• Foundation effects are concentrated in 1st mode
SIMPLIFIED RESPONSE SPECTRUM ANALYSIS

- Use simple model with masses lumped at framing levels

- Analyze for rigid base, including hydrodynamic mass, and considering only shear deformations

- Modify fundamental period and damping to account for foundation and P-Δ:

$$T_{mod} = T \left(1 + \frac{k}{K_x} \left[1 + \frac{K_x h^2}{K_\phi - wH}\right]\right)^{0.5}$$

$$\zeta' = \zeta_o + \frac{\zeta}{\left(T_{mod} / T\right)^3}$$
SIMPLIFIED RESPONSE SPECTRUM ANALYSIS

- Use 1-2 modes to capture response quantities

- Foundation load calculated separately and combined with base shears from fixed base analysis

- Use SRSS for response combination
COMPARISON: MODIFIED UBC

Period:

\[ T = C_i (h_n)^{3/4} \]

modify for foundation

Base Shear:

\[ V = \frac{ZIC}{R_w} \]

\[ C = \frac{1.25}{T^{2/5}} \]

Lateral Force

\[ F_x = \left( V - \sum_{i=1}^{n} \right) w_x h_x \]

\[ \sum_{i=1}^{n} i h_i \]

\[ F_t = 0.07 \ V \]
TEST CASE 1:
SOUTHERN CALIFORNIA TEST STRUCTURE
PLATFORM CHARACTERISTICS

- Hypothetical 4-leg production platform
- Analyzed and structurally tested at UC Berkeley in late 1970's
- Designed for 100 ft water depth
- Deck at +50 ft supporting 5000 kip DL+LL
PLATF0R M C H A R A C T E R I S T I C S

• Main structure is A36 steel

• Main diagonals are 24 inch diameter and 30 inch diameter

• Legs are grouted with heavy joint cans

• 72 inch diameter piles designed for 150 ft penetration in medium to stiff clay
**ANALYSIS**

- Previously analyzed by Mahin, et al. using response spectrum analysis and time-history analysis

- Analyzed using simplified response spectrum analysis and modified UBC

- SRSA uses API Spectra, 5% damping, Zone 4, Soil B, scaled to 0.5 g

- Modified UBC uses UBC Zone 4 (0.4g) with $S = 1.0$
1st Natural Period Estimates:

Mahin, et al. = 1.53 sec
Simplified RSA = 1.21 sec
Modified UBC = 1.44 sec
TEST CASE 2: PLATFORM G

Diagram showing two platforms with labeled sections I, II, III, and IV.
PLATFORM CHARACTERISTICS

- 8-leg drilling platform

- Installed in 265 ft of water off Southern California

- End-on frames are battered 1:12; broadside frames are battered 1:7
PLATFORM CHARACTERISTICS

• Majority of main structure is 35 ksi steel, with 50 ksi piles

• Main diagonals range from 20 inch diameter to 30 inch diameter

• Legs are ungrouted with heavy joint cans

• 48 inch and 66 inch diameter piles driven to 232 ft and 264 ft penetration in medium to stiff clays and silts
ANALYSIS

- Previously analyzed by sponsor using response spectrum analysis and time-history analysis

- Analyzed using simplified response spectrum analysis and modified UBC

- SRSA uses API Spectra, 5% damping, Zone 4, Soil C, scaled to 0.25 g

- Modified UBC uses UBC Zone 4 scaled to 0.25 g with $S = 1$.

- Broadside case analyzed for deck load of 9,050 kips and no marine growth

- End-on case analyzed for deck load of 11,450 kips and marine growth
1st Natural Period Estimates:

- Design = 2.4 sec
- Simplified RSA = 1.83 sec
- Modified UBC = 2.26 sec
1st Natural Period Estimates:

Design = 3.1 sec
Simplified RSA = 1.98 sec
Modified UBC = 2.24 sec
OBSERVATIONS

- Simplified response spectrum analysis gives good estimates of lateral load compared to detailed RSA studies, and envelopes time-history results.

- Period estimates by SRSA are lower than true structural period.

- Modal analysis for SRSA requires knowledge of stiffness properties, but is more realistic relative to code procedure.

- Modified UBC approach ignores stiffness properties, making it difficult to capture effects of stiffness irregularities in structure.
FUTURE EFFORT

- Further evaluation and calibration
- Ductility-level analysis approach using RSA
- Incorporation of RSA using modal analysis into ULSLEA
- Adaptation of deck response spectra generation procedure for ULSLEA
ADAPTING ULSLEA FOR OTHER TYPES OF FIXED OFFSHORE STRUCTURES

Developing load routines and capacity calculations for:

- Multi-leg jackets
- Tripods
- Braced Caissons
- Guyed Caissons
MULTI-LEG JACKETS

Assumptions:

- Supporting jackets are identical
- Jackets are rigidly connected by deck

- Structure fails if any jacket fails
Assumptions:

- The tripod faces have identical braces
- Tripod legs share load equally
- Load taken to act in-line with one tripod face when checking braces

\[
F_{ubay} = \left( \frac{P_{u brace}}{K_{brace}} \right) K_{brace} \cos \phi + 2 \left( \frac{P_{u brace}}{K_{brace}} \right) K_{brace} \cos \phi \cos^2 \alpha
\]

- Load taken to act perpendicular to tripod face for checking piles
Assumptions:

- Caissons have one diagonal brace in each principal direction

- Capacity of caisson is governed by capacity of brace

\[ F_u = P_{u_{brace}} \left( \cos \phi + \left( \frac{K_{tower}}{K_{brace} \cos \phi} \right) \right) \]
GUYED CAISSONS

Assumption:

- Capacity of caisson is governed by capacity of single guy-wire in tension

\[ F_u = P_{u_{wire}} \left( \cos \varphi + \left( \frac{K_{tower}}{K_{wire} \cos \varphi} \right) \right) \]
ULSLEA:
PARAMETRIC STUDIES OF LOCAL DAMAGE ON GLOBAL PLATFORM STRENGTH

Researcher: Teresa A. Aviguetero
PROJECT OBJECTIVES

Investigate effects of local damages and repairs on global structure capacity:

- Verification of ULSLEA program formulations

- Implementation of ULSLEA to study damages and subsequent repair effects
The following have been verified:

- Dents and global bending damage (Loh’s Interaction Equations)
- Grout-repaired tubular members (Parsenejad Method)
- Ultimate strength of tubular joints
- Grout-filled joints
Shell SP62A: Platform Characteristics

- Drilling and production platform installed in 1967
- Perimeter framing battered 1:10
- Braces, jacket legs and piles yield strength = 43 ksi
- Skirt piles are grouted in guides
**ENVIRONMENTAL CONDITIONS**

Chosen based on Hurricane Camille which hit the South Pass area in 1969:

- Water Depth (ft) 340
- Surge Depth (ft) 3
- Wind Velocity @ EL 30' (mph) 100
- Wave Height (ft) 80
- Wave Period (sec) 13.5
- Current Velocity @ SWL (fps) 0
- Current Velocity @ ML (fps) 0
APPLIED DAMAGES

- Denting

- Bending

- General corrosion
  - Members
  - Piles

- Pitting corrosion

- Tensile joint cracking

- Underdriven piles

- Unanticipated changes in soil strength

- Grout-repair
  - Members
  - Joints
Shell SP62A: Location of Applied Damages

Frame A

Frame 1

1st member failure:
- End-on loading
- Broadside loading
Figure 2 Effect of Circular Hole Size on the Strength of Damaged Members

NORMALIZED STRENGTH, P/P_Y

HOLE DIAMETER / TUBE DIAMETER, w/D

59
Global Loading Factor v. Δt/t
Global Loading Factor v. Friction Angle, \( \phi \)
(degrees)
SUMMARY: OBSERVATIONS AND RESULTS

- Broadside loading case governs
  - denting
  - bending
  - general corrosion (members & piles)
  - pitting corrosion
  - unanticipated changes in soil strength

- End-on loading case governs
  - tensile joint failure
  - underdriven piles
<table>
<thead>
<tr>
<th>SUMMARY: OBSERVATIONS AND RESULTS (continued)</th>
</tr>
</thead>
</table>

**Broadside loading case**

**MEMBERS**

- first failure
  - bay 2; bay 2 member damaged
  - bay 1; bay 2 member grouted
    - undamaged & max. damage
- grout-repair damaged member-increase structure capacity

**JOINTS**

- first failure
  - bay 2; bay 2 joint damaged
  - bay 3; bay 2 joint is:
    - undamaged
    - undamaged & grouted
    - damaged & grouted
- grout-repair damaged joint can-increase structure capacity
End-on loading case
MEMBERS
• first failure
  • bay 2; bay 4 member dmg. (low)
  • bay 4; bay 4 member dmg. (high)
  • bay 2; bay 4 member grouted
    • undamaged & max. damage
• grout-repair damaged member-increase structure capacity

JOINTS
• first failure
  • bay 4; bay 4 joint damaged
  • bay 5; bay 4 damaged joint grout-repaired
• grout-repair damaged joint can-increase structure capacity
Broadsie and End-on loading cases FOUNDATION

Failure mode: axial compression

• General corrosion of piles

• Unanticipated changes in soil strength

• Piles driven to:
  • >63% full driven length (b-side)
  • >89% full driven length (end-on)
  • ≤ switches modes to lateral failure
CONCLUSIONS

ABOVE THE MUDLINE:

GENERAL
• Grout-repair effective

MEMBERS & JOINTS
• increase degree of damage-decrease global capacity of structure

• approximately linear relationship
  • Exception (members, end-on):
    • global capacity shows:
      • plateau-bay 2
      • linear behavior-bay 4

• Grout-repair: failure location change
CONCLUSIONS (continued)

BELOW THE MUDLINE:

- increase degree of pile corrosion damage-decrease capacity of foundation
  - approximately linear relationship

- decrease driven pile length-decrease capacity of structure
  - axial compression (plateau)
  - lateral (approx. linear)

- foundation failure due to unanticipated changes in soil strength unlikely
Joint Industry Project

COMPARATIVE EVALUATION OF MINIMUM STRUCTURES AND JACKETS

Invitation for Sponsors

Proposal Prepared by
WS Atkins Science & Technology, UK
University of California, Berkeley, USA
MSL Engineering Ltd., UK, and
Ramboll, Denmark
START

Data Collection

Task II.1
Methodology & Software Development

UCB

 Structures from Stage - 1

Task II.2
Quantification of Error Probabilities

UCB & Ramboll

 Results from Stage - 1

Task II.3
Reliability Analysis of Error Scenarios

WS Atkins & MSL

Reporting

Input to Stage - III
Framework for the evaluation of safety and durability of minimum structures considering human and organisational errors
5.0 TIME-SCALE, BUDGET AND PARTICIPATION FEE

1. The estimated total cost of the project for all four stages is Three hundred and thirty thousand pounds (£330,000) (exclusive of VAT), which is distributed as shown below.

<table>
<thead>
<tr>
<th>Stage</th>
<th>Budget (£)</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Stage-I:</strong> Comparative reliability analyses</td>
<td>£</td>
<td>100,000</td>
</tr>
<tr>
<td>Data collection</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Conceptual design</td>
<td>25,000</td>
<td></td>
</tr>
<tr>
<td>Reliability under extreme storm &amp; fatigue</td>
<td>22,500</td>
<td></td>
</tr>
<tr>
<td>Reliability under ship collision condition</td>
<td>22,500</td>
<td></td>
</tr>
<tr>
<td>Review, Conclusions and Reporting</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td><strong>Stage-II:</strong> Analysis of human and organisational factors</td>
<td>110,000</td>
<td>12 Months</td>
</tr>
<tr>
<td>Data Collection</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td>Methodology and software development</td>
<td>20,000</td>
<td></td>
</tr>
<tr>
<td>Quantification of error probabilities</td>
<td>20,000</td>
<td></td>
</tr>
<tr>
<td>Reliability analysis for error scenarios</td>
<td>50,000</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>10,000</td>
<td></td>
</tr>
<tr>
<td><strong>Stage-III:</strong> Parametric and sensitivity analysis (Approx.)</td>
<td>60,000</td>
<td>6 Months</td>
</tr>
<tr>
<td><strong>Stage-IV:</strong> Multi-criteria decision analysis (Approx.)</td>
<td>60,000</td>
<td>6 Months</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td>330,000</td>
</tr>
</tbody>
</table>

2. At present, sponsorship is invited for only Stages I and II of the project. The Participation Fee is Thirty thousand pounds (£30,000) per sponsor and has been estimated on the assumption that seven organisations will participate in the project. If more organisations participate, the additional funds will be used for Stage-III and Stage-IV of the project, the scope of work for which will be developed in consultation with the Steering Committee.

3. The project is scheduled to start from 1st January 1997, provided sufficient number of organisations join the project. Stages I and II will be completed in about 15 months duration. The provisional bar-chart for the project is shown in Fig.10.
<table>
<thead>
<tr>
<th>Activity</th>
<th>1997 (Month)</th>
<th>1998 (Month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage - I: Comparative Reliability Analyses</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task I.1: Conceptual Design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task I.2: Reliability under Extreme Storm &amp; Fatigue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task I.3: Reliability under Ship Collision</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report on Stage 1 Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage - II: Analysis of Human &amp; Organisational Factors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task II.1: Methodology &amp; Software Developme</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task II.2: Quantification of Error Probabilities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task II.3: Reliability Analysis for Error Scenarios</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report on Stage II Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kick-off Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>First Review Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Second Review Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Third Review Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Project Meeting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bar-chart for Stages I and II of the project
ULSLEA Phase 4: Proposal

Extends Phase 3 effort, with inclusion of:

- Damage and repair studies
- Diagonal loads and capacities
- Tabulate biases and uncertainties
- More detailed member input
- Improved input/output
- More detailed foundation input
- Reliability sensitivity factors
- Shallow water wave kinematics
- Analysis of deck structures
Phase 4 Deliverables

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

#2
Updating of ULSLEA user and modeling guide, including updating software and coding

#3
2 x Meetings

Budget

$120,000 (6 sponsors @ $20,000)

2 GSRs $40,000 / PI $18,000 / Expenses $22,000
Update: An Information Management System for the Reassessment of Offshore Platforms

Stephen T. Stanef, C. William Ibbs, and Robert G. Bea

Construction Engineering and Management Group
Department of Civil Engineering
University of California at Berkeley
Objective

• Develop an Information Management System (IMS) for managing engineering analyses in the screening of large numbers of structures
  – Focus not on engineering methodologies, but on supervision & integration of individual analyses
  – Provide information for decision making
Goals (1)

- Determine which structures need immediate attention, and which can wait
- Serve for all types of marine structures and incorporate all levels of technical analyses
- Iterative approach
  - Initial assessment
  - Reassessment w/other procedures as developed
Goals (2)

• Integration w/other research
  – California IMS
  – Bea & Craig L1 RSR
  – ULSLEA
  – L3, L4 Assessment
Features (1)

- **PROJECTED**
  - Bea & Craig L1
  - RSR
  - L1 Risk
  - ULSLEA, if possible
  - L2 Consequence
  - Data sharing
  - Analysis management
  - Uncertainty handling

- **ACTUAL**
  - L1I1, L1RSR1
  - L1II, L1C1 (example)
  - L2I1, L2Eng1, L2RSR1, L2RSR2
  - L2I1, L2C1 (example)
  - √
  - √
  - √
Features (2)

- **PROJECTED**
  - Technology transfer
  - Other analyses
  - Other capabilities

- **ACTUAL**
  - √
  - L1Risk1, L2Risk1
  - L2Vmax1
  - Fleet management
    - L1Risk1_Fleet 1
    - L2Risk1_Fleet 1

- Policy analysis
- Historical database
Features (3)

- Engineering flexibility - down within screening cycle for 1 platform, or across within fleet
- Policy analysis - examine effects of various safety standards upon fleet
- Programming flexibility - native database code, interaction w/other programs, or just data I/O
Data Structure

- Data structure allows arrays to be stored as efficiently as possible in a relational format
- Able to handle iterative variables / geometries
V_{\text{max}} = 124.00 \text{ miles/hr} \quad \text{(StdDev = 7.77), at Max Wave Height of 65.0 feet}
L2I1 - Manual Input (ULSLEA)

Processing...

Click a button:
- All
- Input Global Parameters that Iterate
- Input Other Global Parameters
- Input Environmental Conditions
- Input Local Deck Bay Parameters
- Input Foundation Parameters
- Input Force Coefficients
- Input Boat Landing and Apparentness Data
- Input Member Strength, Material, and Sell Properties
- Input Uncertainties and Biases

Input Deck Data
Input Bay Data
Input Bay Data per Orientation
Input Bay / Brace Data per Orientation
Input Joint Data
Done

Type
Add
Review
Add
Review
Add
Review
Add
Review
L1Risk1_Fleet1 Results

STANDARDS - Acceptable: C = 2.571 * RSR - 2.7125; Marginal: C = 2.571 * RSR - 0.14275. Standards are fixed for this evaluation type. Create a new evaluation type if other standards are desired.
L2Risk1_Fleet1 Results

STANDARDS: Standards are fixed for this evaluation type. Create a new evaluation type if other standards are desired.
Future Work

- Refine software
- Distribute evaluation copies
- Submit final report & software
Plans for Next 6 Months

Task 5: Continue verification of earthquake analysis procedure

Task 6: Finish robustness studies report

Task 7: Code updating

Task 8: Final reporting and documentation

<table>
<thead>
<tr>
<th>Task</th>
<th>1st Quarter</th>
<th>2nd Quarter</th>
<th>3rd Quarter</th>
<th>4th Quarter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Configurations</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 - Fatigue Analysis</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 - Earthquake Loads</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 - Earthquake Deck Response Spectra</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>5 - Earthquake Verification Studies</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>6 - Robustness Analyses</td>
<td></td>
<td></td>
<td>-X</td>
<td></td>
</tr>
<tr>
<td>7 - Documentation and Coding</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>8 - Meetings</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Next Meeting Date: JUNE 1996