Marine Technology and Management Group - University of California at Berkeley

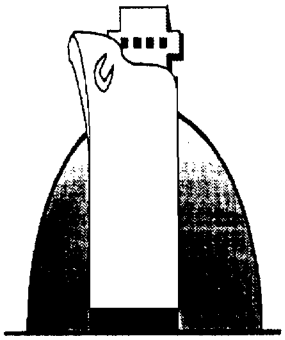
AGENDA

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:

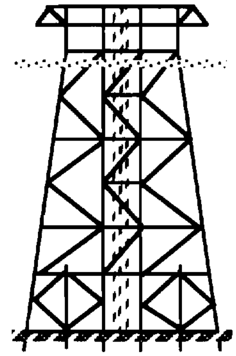
8:00 AM	**Review issues from previous day**
8:15	**Information Management for Fleets of Platforms** *Steve Staneff*
8:45	**Discussion**
9:00	**Sponsor Presentations, ULSLEA Troubleshooting, User Help, Discussion**
10:00	**Future work: Phase 3 winter/spring work plan** *Bob Bea, Jim Stear*
10:30	**Discussion, sponsors' directions**
11:00 AM	**Adjourn**



1996 - 1997

MARINE TECHNOLOGY & MANAGEMENT GROUP

INDUSTRY & GOVERNMENT AGENCIES SPONSORED RESEARCH PROJECTS SUMMARIES



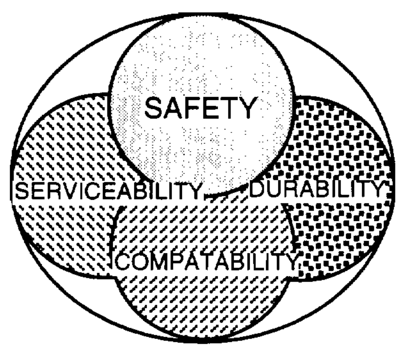
Professor Robert Bea
College of Engineering
Tel: (510) 642-0967
Fax: (510) 643-8919
e-mail: rgbea@euler.berkeley.edu

Professor Karlene Roberts
Haas School of Business
Tel: (510) 642-5221
Fax: (510) 631-0150
e-mail: karlene@haas.berkeley.edu

215 McLaughlin Hall
UNIVERSITY OF CALIFORNIA
Berkeley, CA 94720-1712

Goal: Develop engineering and management technology that will help improve the QUALITY (safety, serviceability, durability, compatibility - economy) of marine systems

QUALITY



RESEARCH AREAS

Human & Organization Factors
Ships & Floating Systems
Platforms & Pipelines

Human and Organization Factors	Researcher	Goals and Objectives
Human & organization factors in design, construction, and operation of Ships	Duane Boniface	Develop a comprehensive system to evaluate the life-cycle reliability characteristics of ships including human factors considerations. Validate system with Estonia accident analysis.
FLAIM II (with Prof. Williamson, and Paragon Engineering Inc.)	Derek Hee	Develop, test, and help validate an assessment system to evaluate the risks associated with loss of hydrocarbon containment on offshore platforms and marine terminals.
Human & organization factors in evacuation of marine systems	Jun Ying	Develop and verify a computer based simulation tool to evaluate the reliability of personnel evacuation procedures for tropical cyclone (hurricane) conditions.
Management of Rapidly Developing Crises: A Multi-Community Study	Bob Bea, Karlene Roberts	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.
Human & organization factors in diving operations	Mike Blumenberg	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.
Human & organization error risk reduction instrument	Brent Pickrell	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 followiing project.
Assessment of Human and Organization Performance in Operations of Marine Systems (with Profs. Brady Williamson and Karlene Roberts)	Derek Hee	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.
Human & organization factors in marine flight operations (Prof. Roberts Principal Investigator)	Rich Lawson	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.
Human & organization factors in operations / inspections of bulk cargo carriers (Prof. Demsetz Principal Investigator)	Mat Miller	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.
Human and Organizational Factors in Emergency Medicine	Karlene Roberts	Develop and implement research in seven medical units, ranging from paramedic units in fire deaprtments to adut 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)
International Workshop: Human and Organizational Factors (with PrimaTech Inc.)	Bob Bea	Organize and conduct an international workshop that will address key human and organization factors considerations in platform operations **(Dec. 16-18, New Orleans)**.

Ships and Floating Systems	Researcher	Goals and Objectives
Assessment of cracked critical structural details: fracture mechanics and S-N evaluations	Tao Xu	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.
Ship Structural Integrity Information System - SSIIS III	Henry Reeve	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.
Reliability based siting of mobile drilling units	Jun Ying	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.
Design and construction of long-life marine composite structures	Paul Miller	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.
Inspection of critical structural details in ships (Prof. Demsetz, Principal Investigator	Juan Caberra	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.
Optimal strategies for the inspections of ships and offshore platforms for fatigue and corrosion damage (with Martec, Inc.)	Tao Xu	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).
Feasibility and reliability of tanker single point mooring systems offshore California	Aaron Salancy	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.

Platforms & Pipelines	Researcher	Goals and Objectives
Reassessment & Requalification system for offshore platforms (Prof. Bill Ibbs, Principal Investigator)	Steve Staneff	Develop a computer based information and data management system for the reassessment and requalification of fleets of offshore platforms.
Reassessment of SS 209 platforms	Anne Sturn	Reassess two operating platforms in the Gulf of Mexico using recently developed procedures for the analysis of platform loadings, capacities, and reliabilities.
Ultimate Limit State Limit Equilibrium Analyses of template-type offshore platforms - ULSLEA III	Jim Stear	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.
Reliability based evaluation of 'minimum' platforms in the Gulf of Mexico	Agnes Brandtzaeg	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.
Analyses of the nonlinear performance of platforms subjected to hurricanes	James Wiseman, assignment pending	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.
Performance of pile foundations subjected to earthquake excitations (Profs. Seed, Bray, Pestana)	Philip Meymand, Thomas Lok, Chris Hunt	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.
Reassessment and requalification f a Cook Inlet platform subjected to ice and earthquake loadings (with Hopper and Associates)	Jun Ying	Reassess a Cook Inlet platform to determine its performance characteristics when subjected to intense dynamic ice loadings and earthquakes. Characterize the reliabililties of the platform. Compare the notional reliabilities with economics and standard of practice guidelines.
Pipeline Integrity and Maintenance Information System - PIMPIS	Tarek Elsayed	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.
Platform requalification system for the Bay of Campeche (with National University of Mexico and Hopper and Associates)	assignment pending	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.
Earthquake guidelines for design and reassessment of offshore platforms and marine terminals	Bob Bea, assignment pending	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.
Decommissioning and re-use of offshore platforms (with Twatchman, Snyder, and Thornton)	James Wiseman, Brian Collins	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.

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 assignment pending	Assist in development and conduct of a workshop (March 1997) to bring together the various communities concerned to discuss the critical considerations involved in decommissioniing 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

"The Mutual Influence of Technological Advancement and Other Organizational Processes," in S. R. Clegg, C. Hardy, and W. Nord (eds.), Handbook of Organization Studies, Sage Publishers, London, 1996 (with M. Grabowski)

"A Decision Analysis Framework for Assessing Human and Organizational Error in the Marine Industries," Proceedings of the SSC/SNAME Symposium '96, *Human and Organizational Error in Marine Structures*, Arlington, VA, 18-20 Nov. 1996 (with Lt. Duane Boniface).

"High Reliability Tanker Loading & Discharge Operations: Chevron Long Wharf, Richmond, California," Proceedings of the SSC/SNAME Symposium '96, *Human and Organizational Error in Marine Structures*, Arlington, VA, 18-20 Nov. 1996 (with S. Stoutenberg, T. Mannarelli, and Paul Jacobson).

"Assessing the Risks of an Countermeasures for Human and Organizational Error," *Proceedings of the Annual Meeting,* Society of Naval Architects and Marine Engineers, New York, Ocboer 1996.

"Consideration of Human and Organizational Factors in Development of Design, Construction, and Maintenance Guidelines for Ship Structures," Proceedings of the SSC/SNAME Symposium '96, Human and Organizational Error in Marine Structures, Arlington, VA, 18-20 Nov. 1996.

"Human and organization Factors in Design, Construction and Operation of Offshore Platforms," *Journal of the Society of Petroleum Engineers*, SPE 30899, Sept. 1995 (with K. Roberts).

"Risk-Management System for Infrastructure-Condition Assessment," Jl. of Infrastructure Systems, ASCE, Vol. 1, No. 4, Dec. 1996 (With S. T. Staneff, C. W. Ibbs).

"Nonlinear Performance of Offshore Platforms in Extreme Storm Waves," *Journal of Waterway, Port, Coastal, and Ocean Engineering,* ASCE, Vol. 122, No. 2, March/April, 1996.

"Learning How Organizations Mitigate Risk," *Journal Of Contingencies and Crisis Management,* June, 1996.

Reassessment and Requalification of Infrastructure: An Application to Offshore Structures," *Journal of Infrastructure Systems*, ASCE, Vol. 2, No. 2, June 1996.

Probability Based Earthquake Load & Resistance Factor Design Criteria for Offshore Platforms," Proceedings of the International Workshop on Wind and Earthquake Engineering for Coastal and Offshore Facilities, University of California at Berkeley, January 1995.

"Simplified Earthquake Floor Response Spectra for Equipment on Offshore Platforms," Proceedings of the International Workshop on Wind and Earthquake Engineering for Coastal and Offshore Facilities, University of California at Berkeley, January 1995 (with C. Bowen).

"Men, Ships, and the Sea," Proceedings of the Marine Safety Council, U. S. Coast Guard, Washington, D. C., May-June 1995.

"Management of Human and Organizational Error Throughout a Ship's Life Cycle," Proceedings of the Institute of Marine Engineers, Symposium on Management and Operation of Ships, London, U. K., May 1995 (with W. H. Moore).

"Simplified Evaluation of the Capacities of Template-Type Offshore Platforms," Proceedings of the 5th International Offshore and Polar Engineering Conference, The Hague, The Netherlands, ISOPE Paper No. 95-JSC-214, June 1995 (with M. Mortazavi).

"Evaluation of the Capacities of Template-Type Gulf of Mexico Platforms," Proceedings of the 5th International Offshore and Polar Engineering Conference, The Hague, The Netherlands, ISOPE Paper No. 95-JSC-215, June 1995 (with K. J. Loch and P. L. Young).

"A Methodology for Assessing and Managing Fire and Life Safety for Offshore Production Platforms," Proceedings of the 5th International Offshore and Polar Engineering Conference, The Hague, The Netherlands, ISOPE Paper No. 95-JSC-215, June 1995 (with W. E. Gale, W. H. Moore, and Prof. R. B. Williamson).

"Fatigue Life Estimation for Repaired Ship Critical Structural Details," Proceedings of the 14th International Offshore Mechanics and Arctic Engineering Conference, OMAE Paper No. 95-731M, Copenhagen, Denmark, June 1995 (with K. Ma).

"Organization Factors in the Quality and Reliability of Marine Systems," Proceedings of the 14th International Offshore Mechanics and Arctic Engineering Conference, OMAE Paper No. 95-1354, Copenhagen, Denmark, June 1995 (with K. Roberts).

"Quality, Reliability, Human and Organization Factors in Design of Marine Structures," Proceedings of the 14th International Offshore Mechanics and Arctic Engineering Conference, OMAE Paper No. 95-1355, Copenhagen, Denmark, June 1995.

"Evaluation of Human and Organization Factors in Design of Marine Structures: Approaches & Applications," Proceedings of the 14th International Offshore Mechanics and Arctic Engineering Conference, OMAE Paper No. 95-1233, Copenhagen, Denmark, June 1995.

"Human Factors in Operationial Reliability of Offshore Production Platforms: The Fire and Life Safety Assessment Index Methodology (FLAIM), Proceedings of the Offshore Mechanics and Arctic Engineering Conference, American Society of Mechanical Engineers, Copenhagen, Denmark, June 1995 (with W. E. Gale, W. H. Moore, R. B. Williamson).

"A Repair Management System for Fatigue Cracks in Ships," Transactions, The Societyof Naval Architects and Marine Engineers, Vol. 103, 1995 (with K. T. Ma).

"Simulation Model for Development of Siting Strategies for Mobile Offshore Drilling Units," Proc. Of the 6th Int. Offshore and Polar Eng. Conf., Los Angeles, CA, May 1996 (with J. Ying).

"Fatigue of Cracked Ship Critical Structural Details: Cracked S-N Curves and Load Shedding," Proc. Of the 6th Int. Offshore and Polar Eng. Conf., Los Angeles, CA, May 1996 (with T. Xu).

"A Simplified Structural Reliability Analysis Procedure for Use in Assessments and Requalifications of Template-Type Offshore Platforms," Proc. Of the 6th Int. Offshore and Polar Eng. Conf., Los Angeles, CA, May 1996 (with M. Mortazavi).

"Ship Qualify Information Systems," Proceedings of the Institute of Marine Engineers, ICMES '96, Safe and Efficient Ships, Oslo, Norway, June 1996.

"Life-Cycle Reliability Characteristics of Minimum Structures," Proceedings of the 15th Int. Conf. On Offshore Mechanics and Arctic Engineering, OMAE Paper No. 96-1205, ASME, June 1996 (with A. Brandtzaeg, M. J. K. Craig).

"A. Reliability Based Screening Procedure for Platrform Assessments and Requalifications," Proceedings of the 15th Int. Conf. On Offshore Mechanics and Arctic Engineering, OMAE Paper No. 96-1421, ASME, June 1996 (with M. Mortazavi).

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

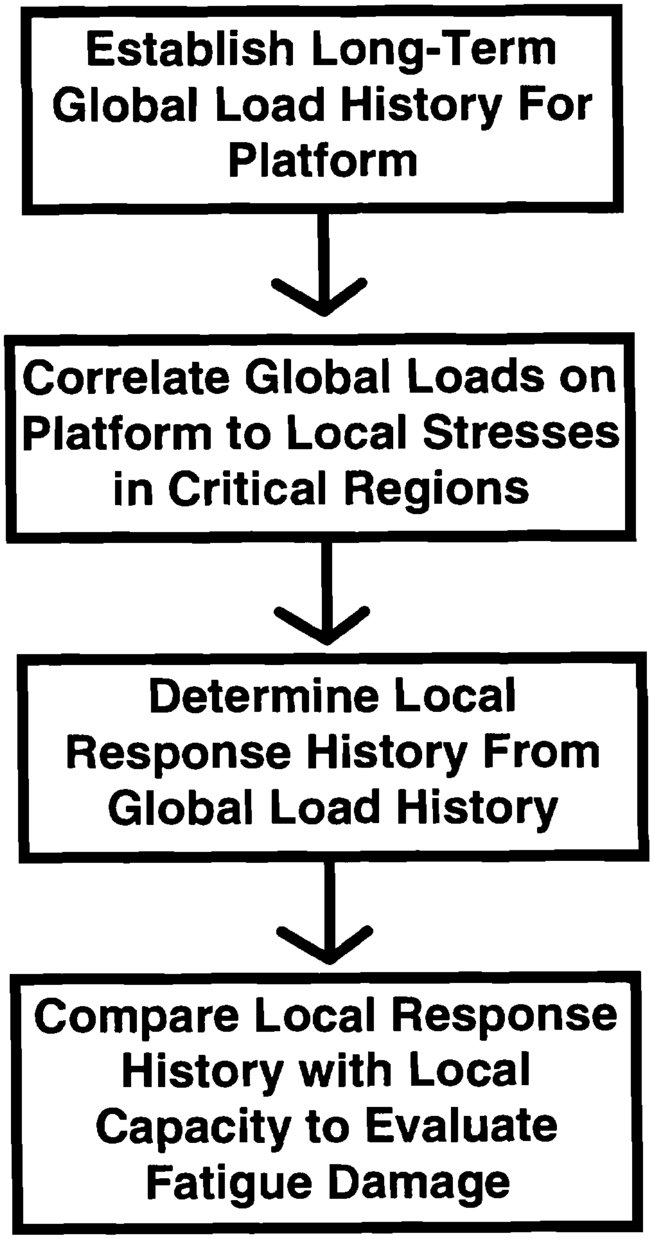
OBJECTIVE:

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



SIMPLIFIED FATIGUE ANALYSIS APPROACH ASSUMPTIONS

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

$$S = CH^g$$

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:

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

where:

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

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

By using:

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

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

Damage may then be expressed by:

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

SPECIFYING PARAMETERS

K, m from S-N curve

g either 1.2, 1.3

R between -0.15 to -0.5

H_0, H_1, ξ_0, ξ_1, N_0, N_1 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.

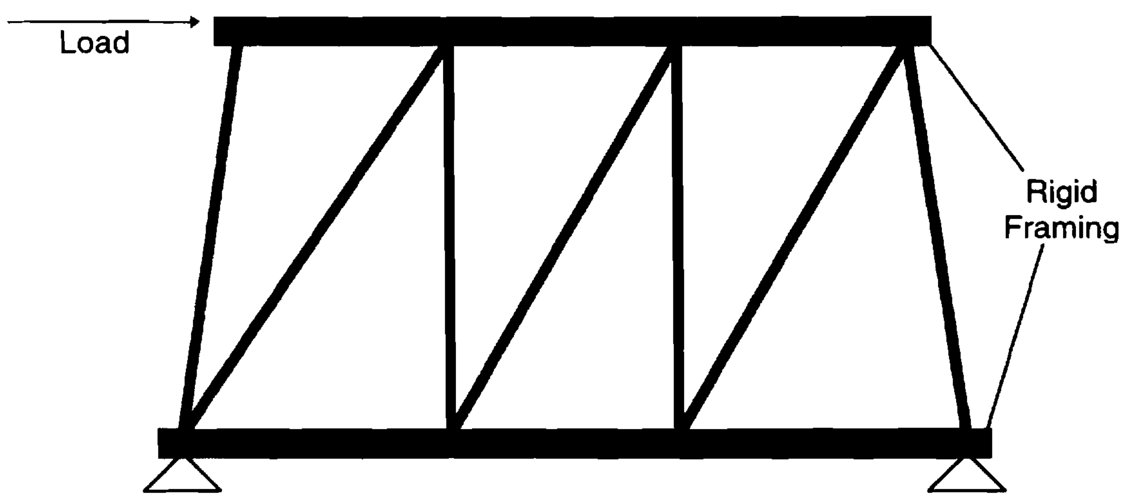
Peak stresses are dominated by two effects:

- 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:

$$\sigma = \frac{F_{axial}}{A_{brace}} + \frac{M_{end} r_{brace}}{I_{brace}}$$

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:

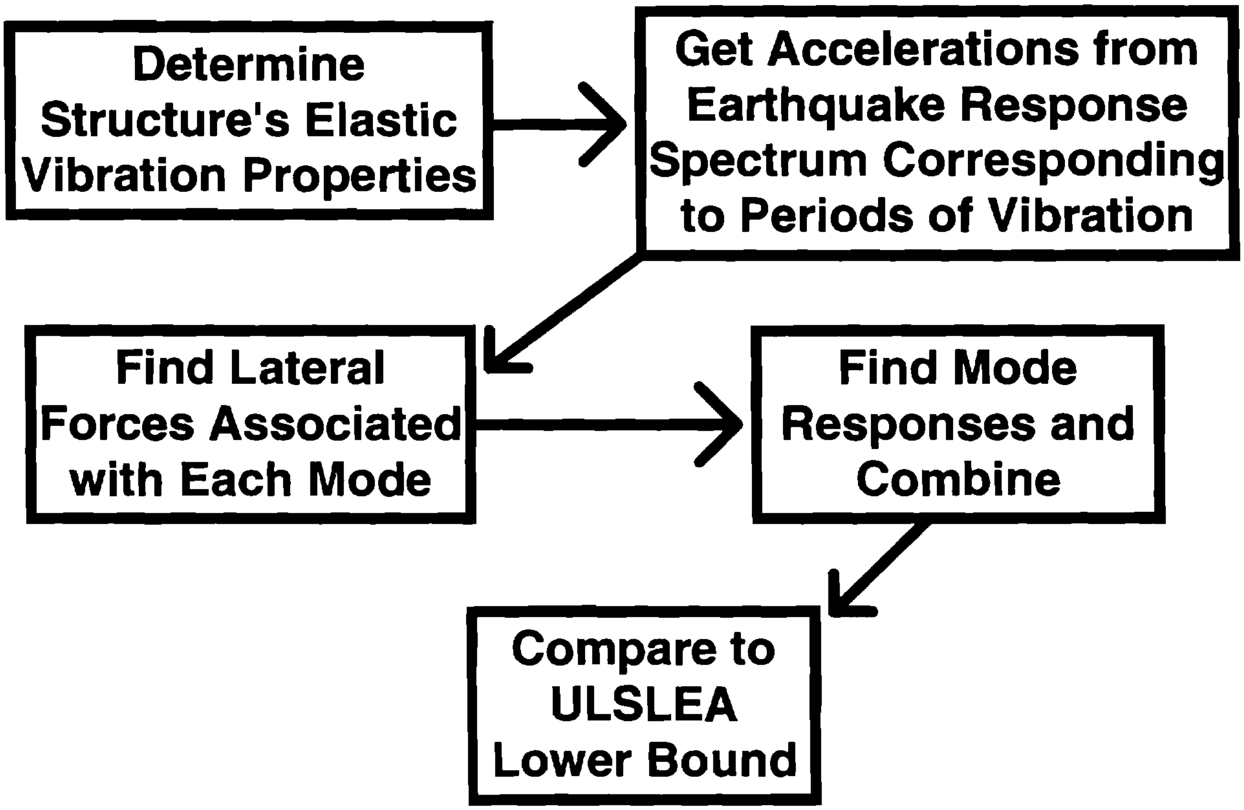
Determine seismic load and perform capacity check.

INITIAL FOCUS:

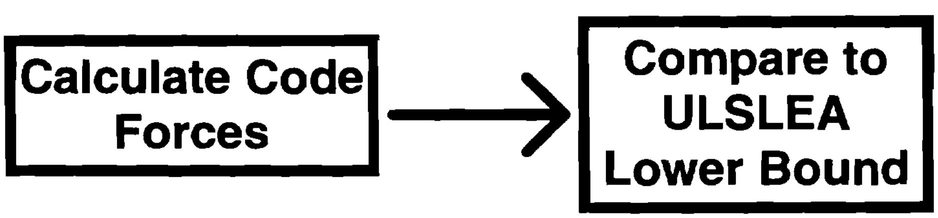
Strength-level evaluations of symmetric structures in moderate water depths.

EVALUATION APPROACH OPTIONS CONSIDERED

Use elastic response spectrum analysis:

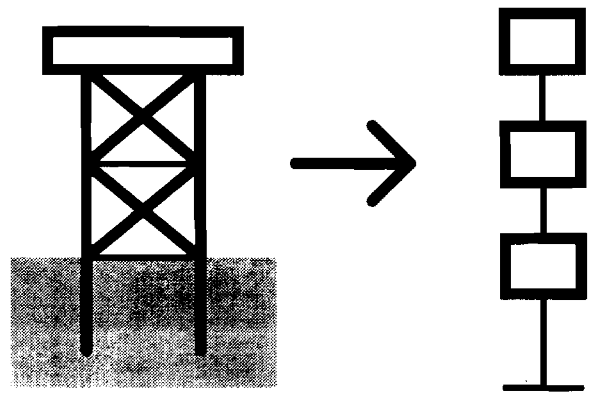


Use design code approach:



RESPONSE SPECTRUM ANALYSIS

Discretize structure :



Determine vibration periods and modes:

$$\mathbf{k}\phi_n = \omega_n^2 \mathbf{m}\phi_n$$

Combine with response spectrum to find forces:

$$\mathbf{p} = \frac{\sum_{j=1}^{N} \mathbf{m}_j \phi_{jn}}{\sum_{j=1}^{N} \mathbf{m}_j \phi_{jn}} \mathbf{m} \phi_n S_{A_n}$$

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-Δ 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:

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

$$\zeta` = \zeta_o + \frac{\zeta}{(T_{\text{mod}} / T)^3}$$

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:

$$T = C_t\left(h_n\right)^{3/4}$$, modify for foundation

Base Shear:

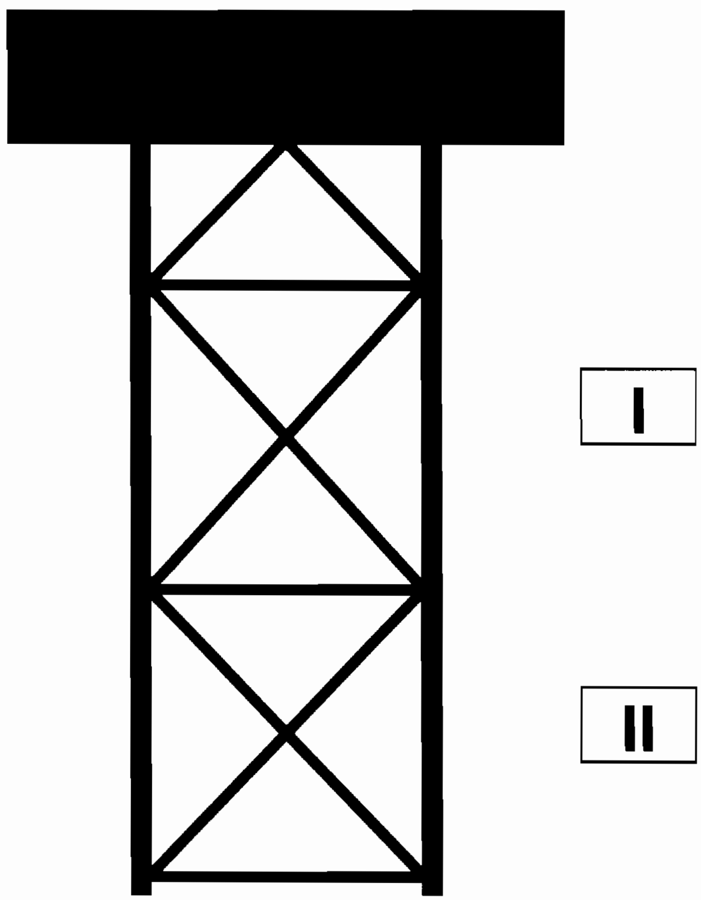
$$V = \frac{ZIC}{R_W} W \quad , \quad C = \frac{1.25S}{T^{2/3}}$$

Lateral Force

$$F_x = \frac{\left(V - \quad\right) w_x h_x}{\sum_{i=1}^{n} w_i h_i}$$

$$F_t = 0.07 \quad V$$

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

PLATFORM CHARACTERISTICS

- 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

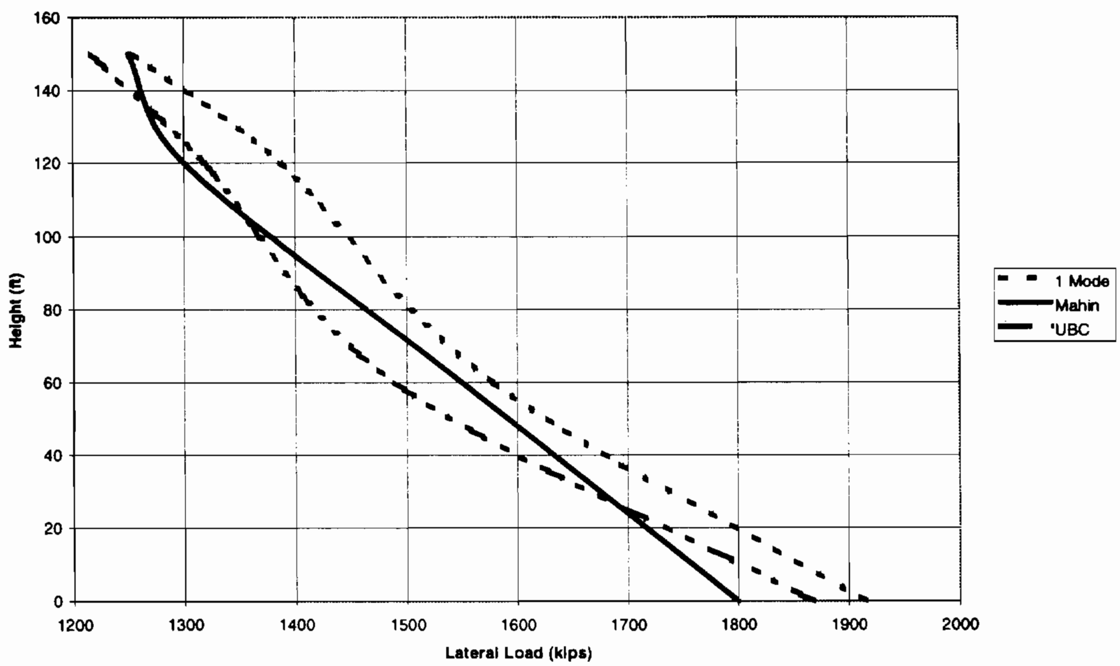
- Previously analyzed by Mahin, et al. using response spectrum analysis and time-history analysis

- 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

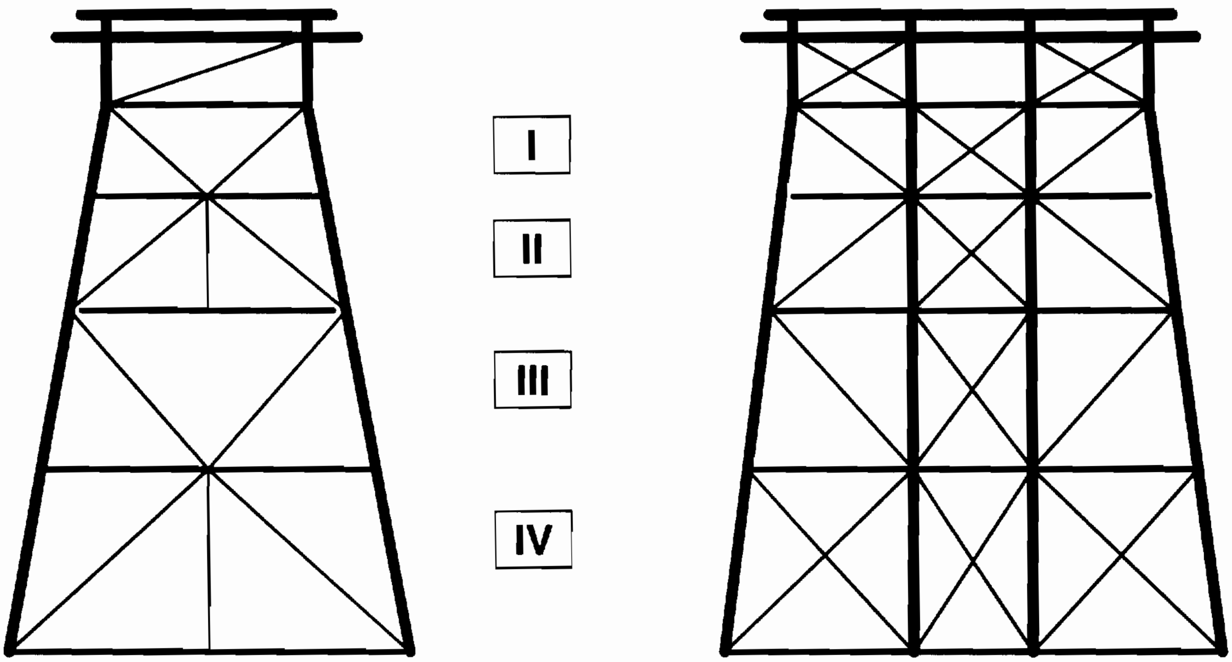
SOUTHERN CALIFORNIA TEST STRUCTURE: LATERAL LOAD AND 1ST PERIOD



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



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

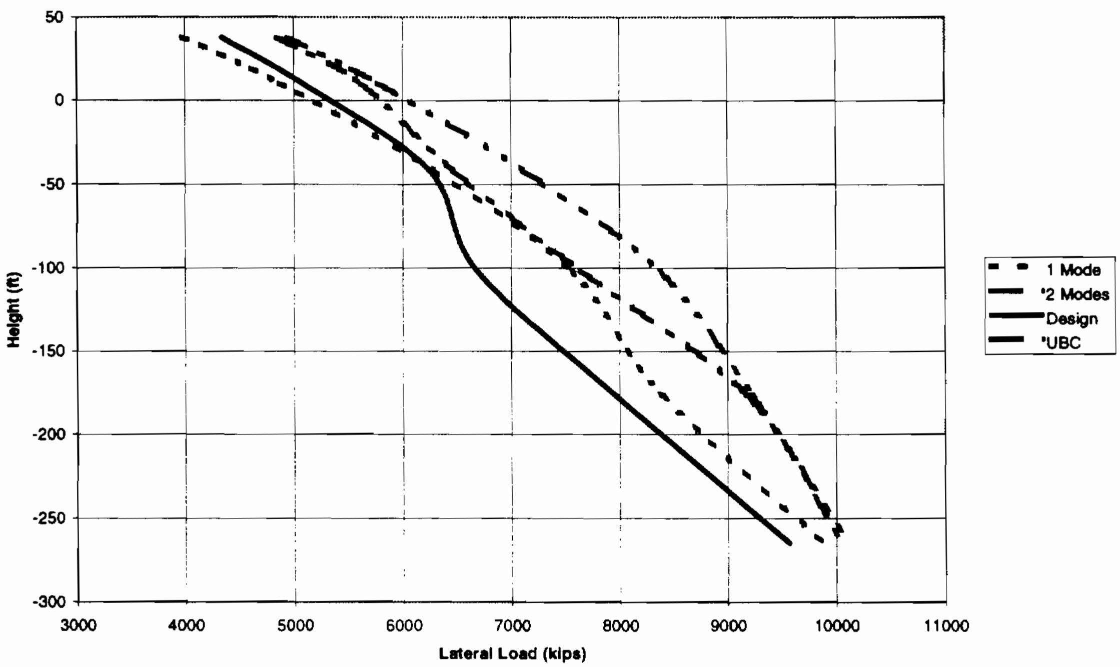
- SRSA uses API Spectra, 5% damping, Zone 4, Soil C, scaled to 0.25 g

- 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

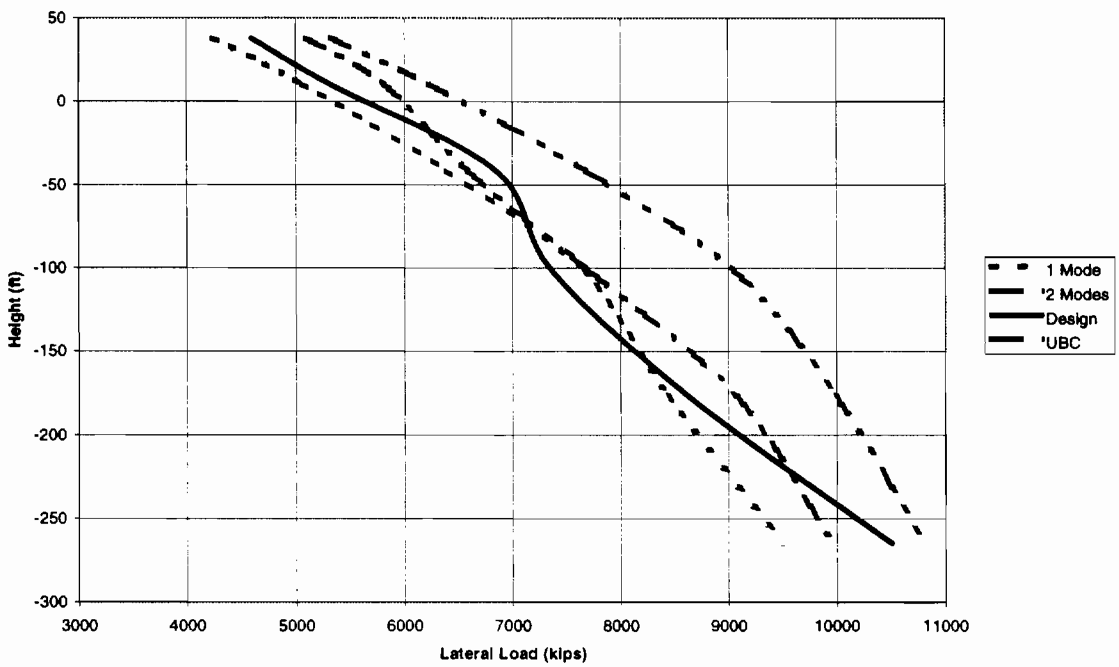
PLATFORM G: BROADSIDE LATERAL LOAD AND 1ST PERIOD



1st Natural Period Estimates:

Design	=2.4 sec
Simplified RSA	=1.83 sec
Modified UBC	=2.26 sec

PLATFORM G: END-ON LATERAL LOAD AND 1ST PERIOD



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

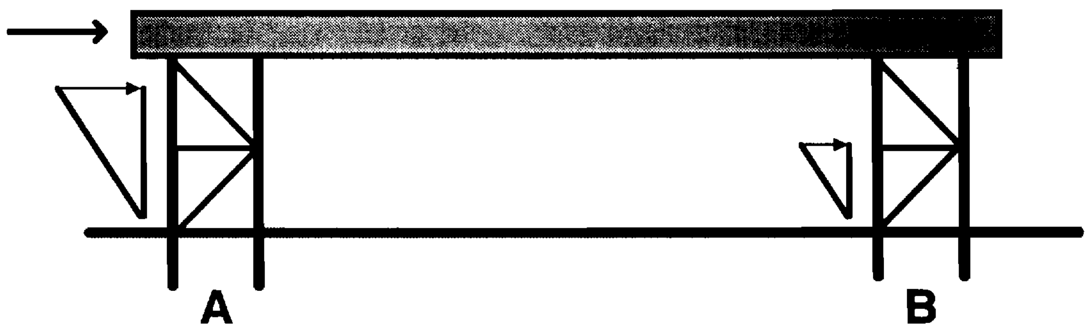
Developing load routines and capacity calculations for:

- Multi-leg jackets
- Tripods
- Braced Caissons
- Guyed Caissons

MULTI-LEG JACKETS

Assumptions:

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

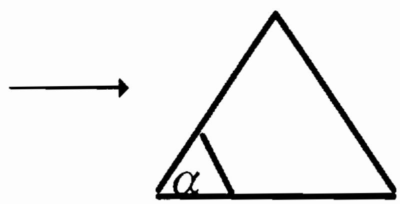


- Structure fails if any jacket fails

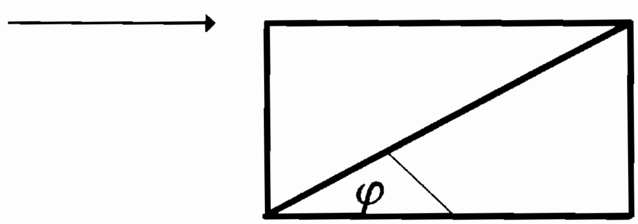
TRIPOD JACKETS

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



PLAN



ELEVATION

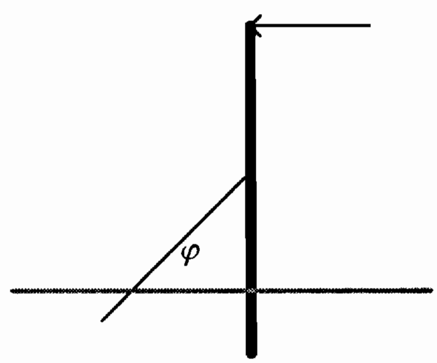
$$F_{u_{bay}} = \left(\frac{P_{u_{brace}}}{K_{brace}}\right) K_{brace} \cos\varphi + 2\left(\left(\frac{P_{u_{brace}}}{K_{brace}}\right) K_{brace} \cos\varphi \cos^2\alpha\right)$$

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

BRACED CAISSONS

Assumptions:

- Caissons have one diagonal brace in each principal direction
- Capacity of caisson is governed by capacity of brace

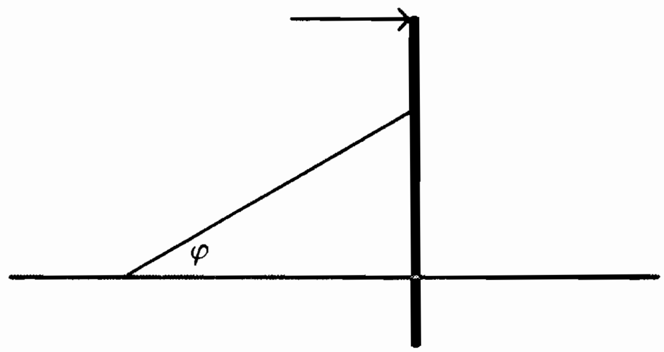


$$F_u = P_{u_{brace}}\left(\cos\varphi + \left(\frac{K_{tower}}{K_{brace}\cos\varphi}\right)\right)$$

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:

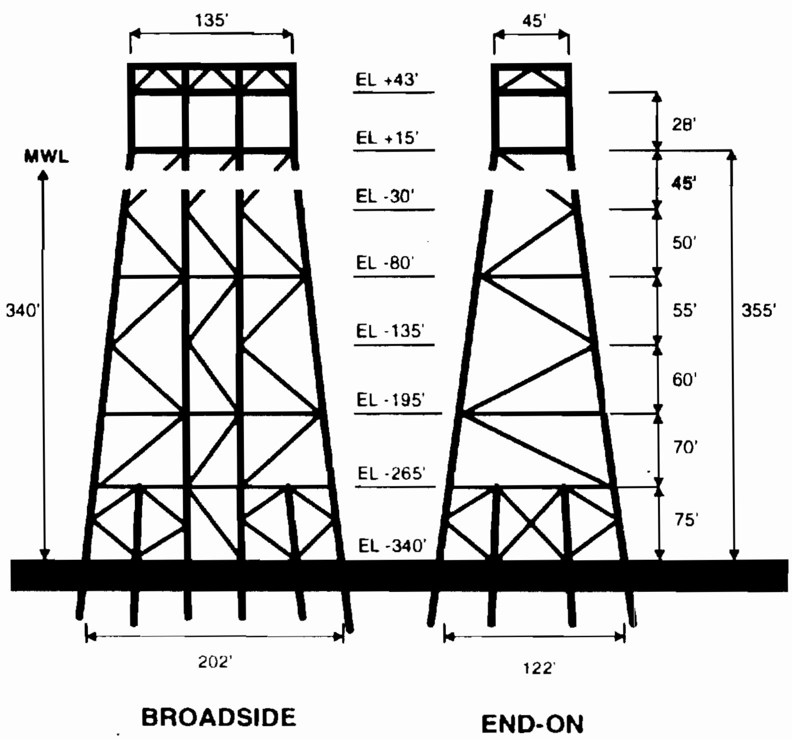
- Verification of ULSLEA program formulations
- Implementation of ULSLEA to study damages and subsequent repair effects

PROGRAM VERIFICATION

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

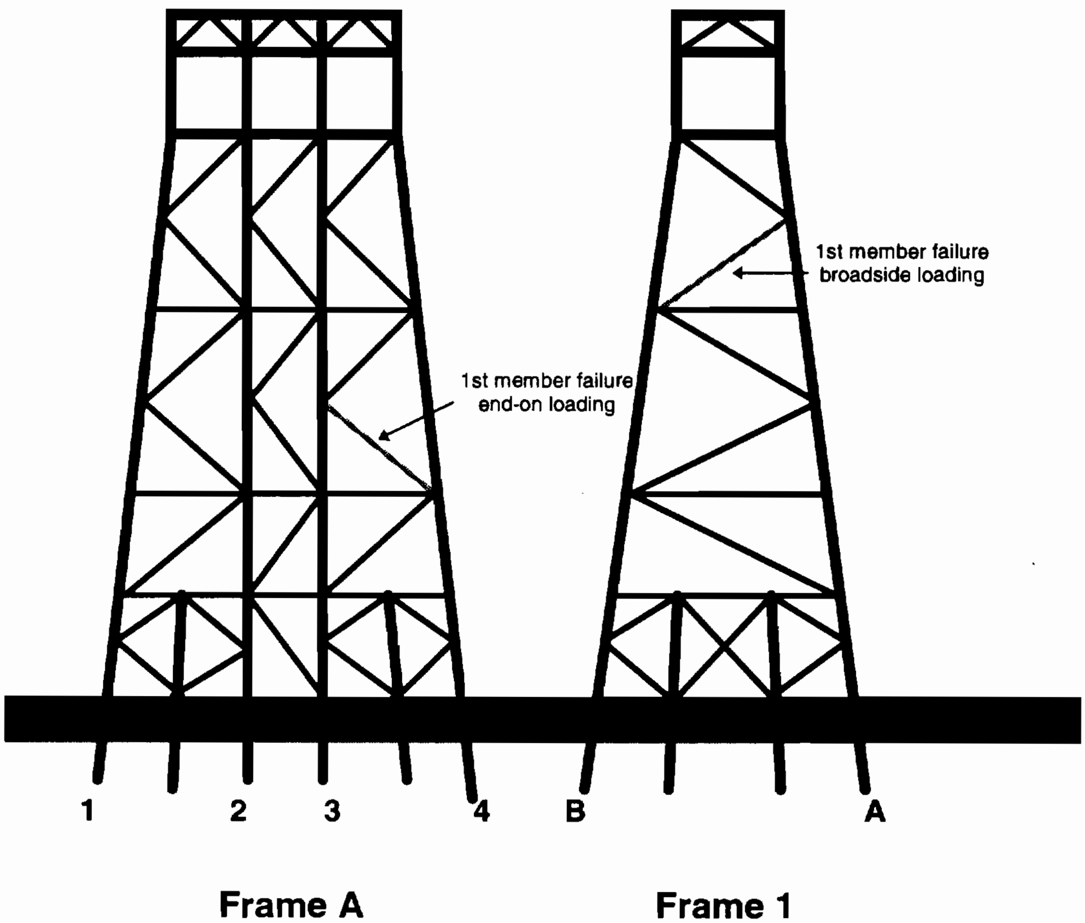
Chosen based on Hurricane Camille which hit the South Pass area in 1969:

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

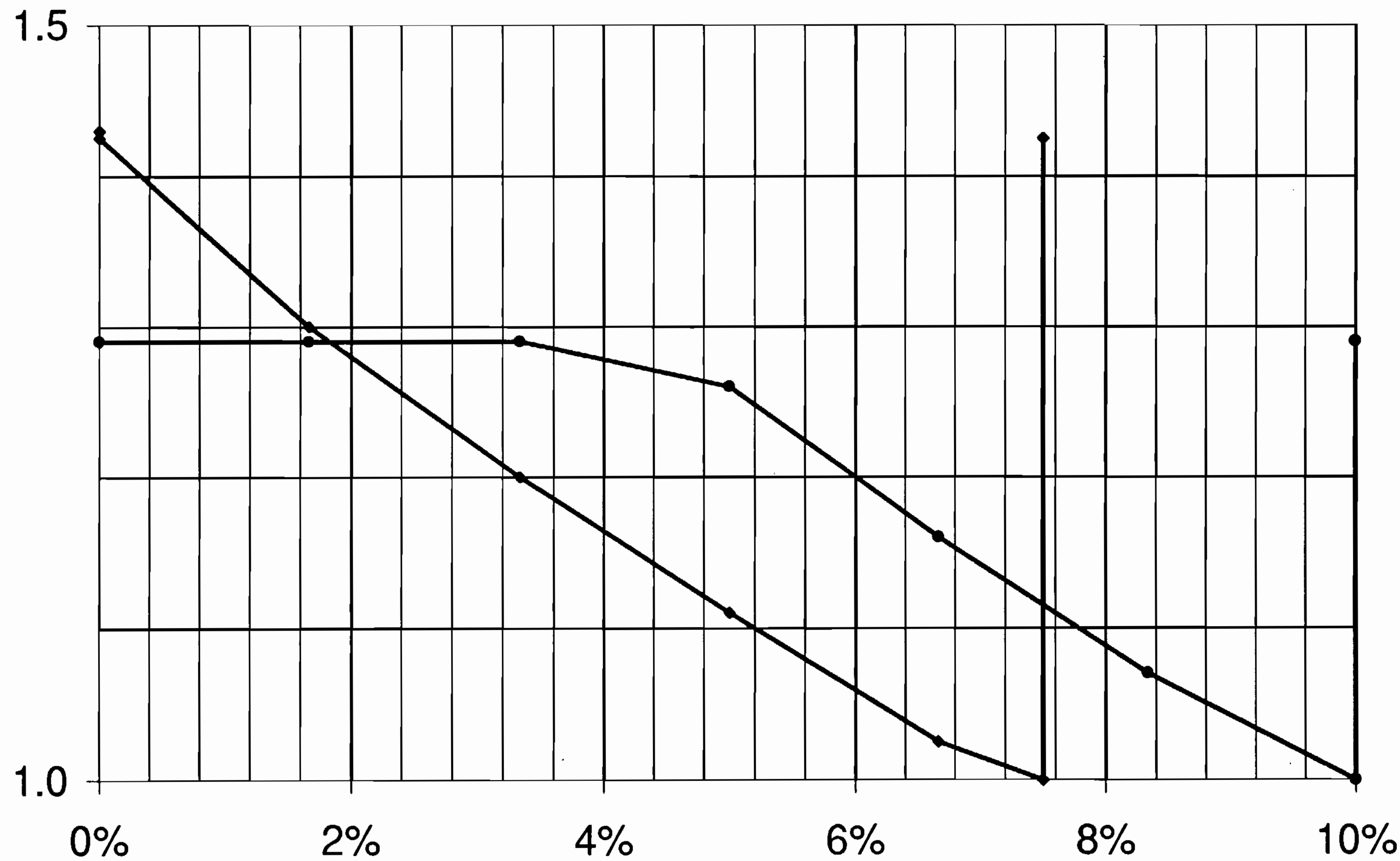
APPLIED DAMAGES

- Denting
- Bending
- General corrosion
  - Members
  - Piles
- Pitting corrosion
- Tensile joint cracking
- Underdriven piles
- Unanticipated changes in soil strength
- Grout-repair
  - Members
  - Joints

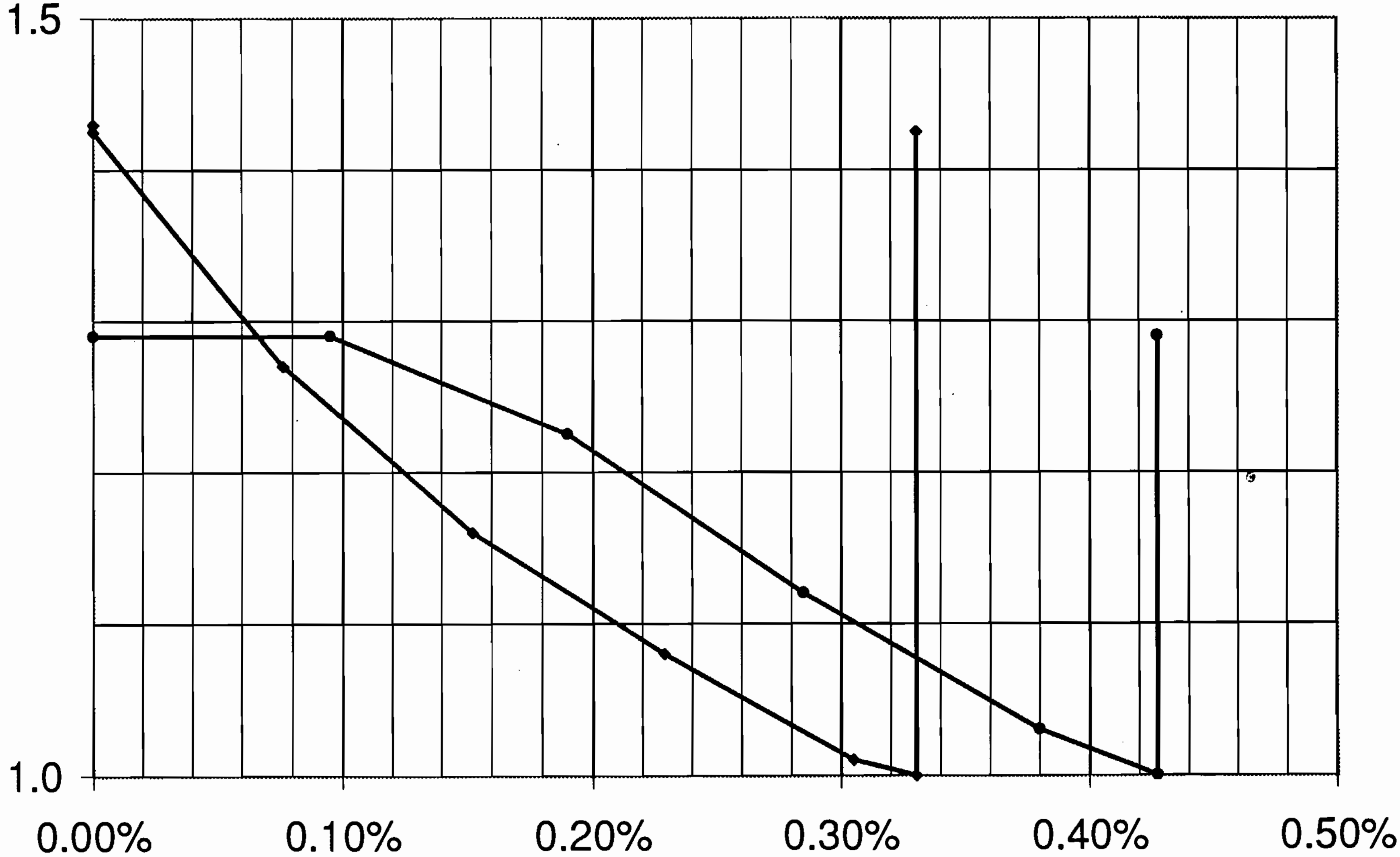
Shell SP62A: Location of Applied Damages



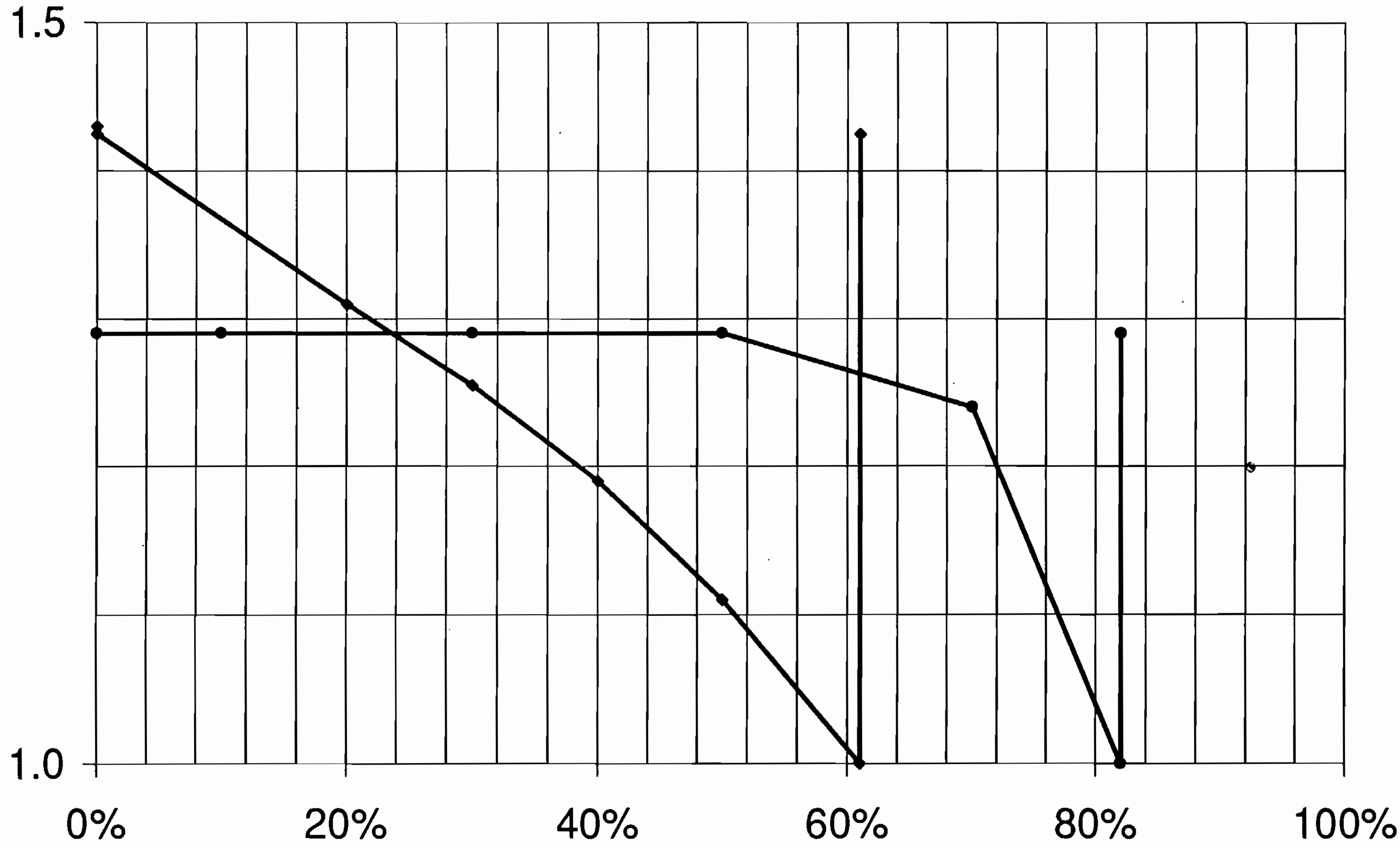
Global Loading Factor v. dd/D

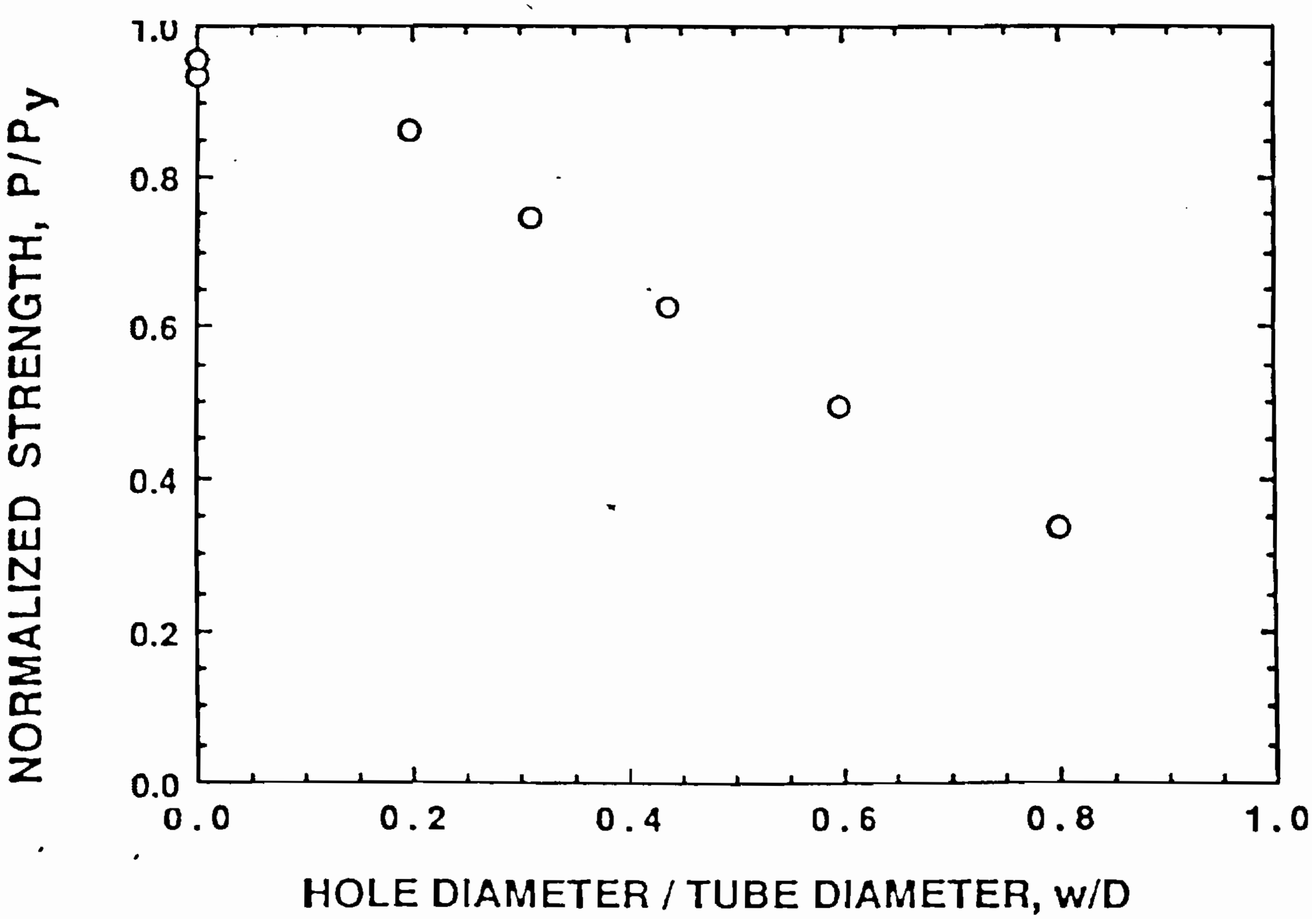


Global Loading Factor v. Δ/L



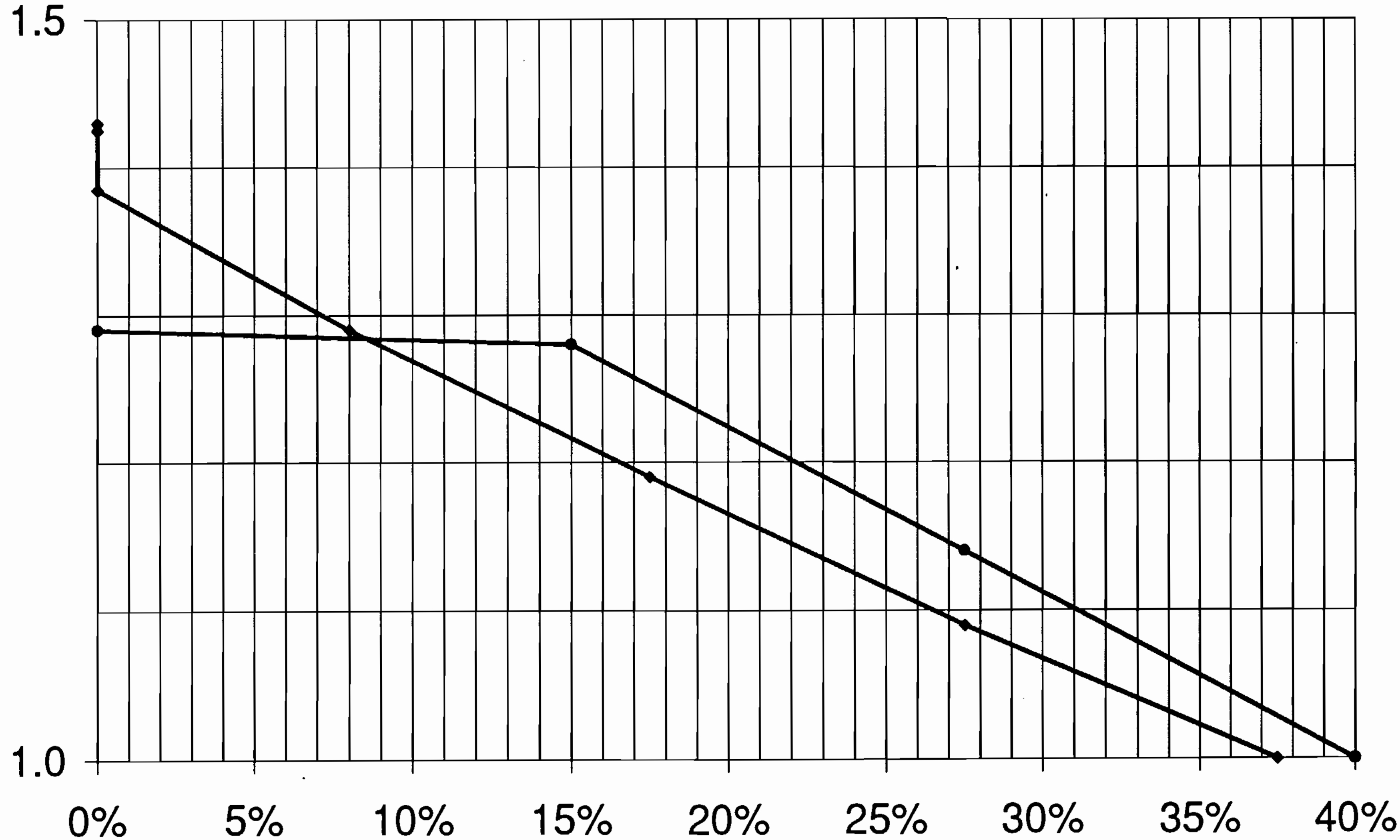
Global Loading Factor v. Δt/t



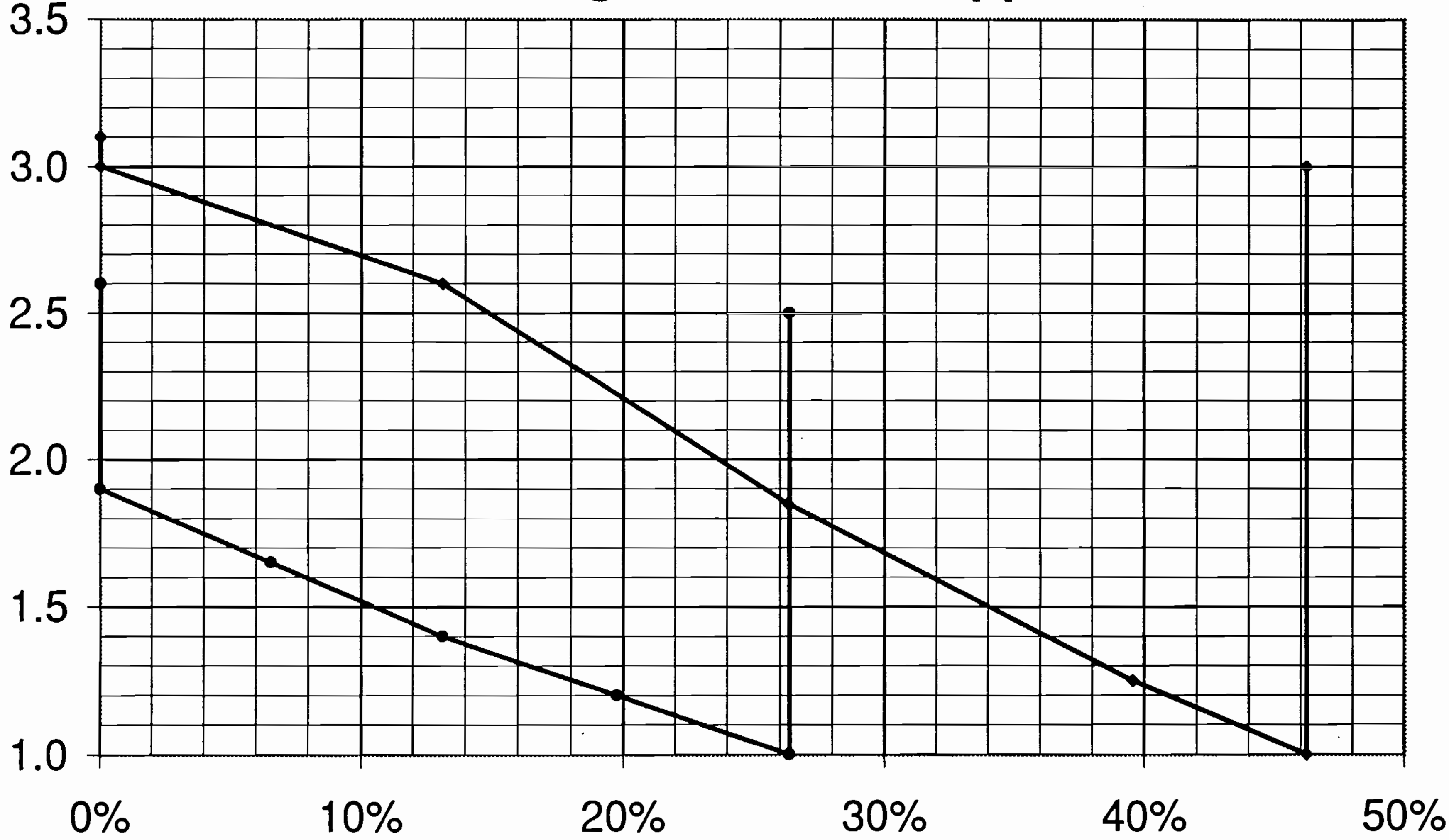


'igure 2 Effect of Circular Hole Size on the Strength of Damaged Members

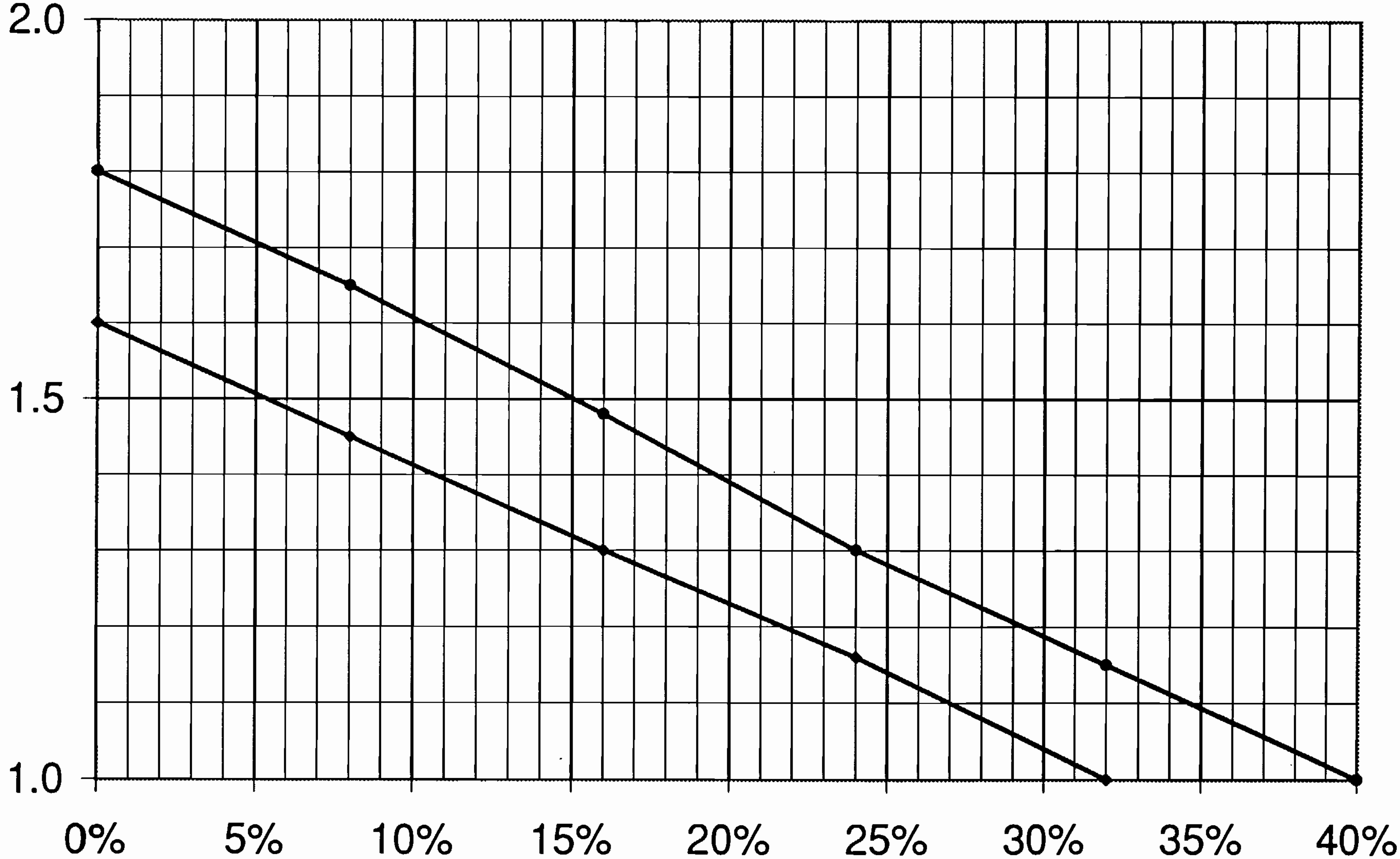
Global Loading Factor v. w/D



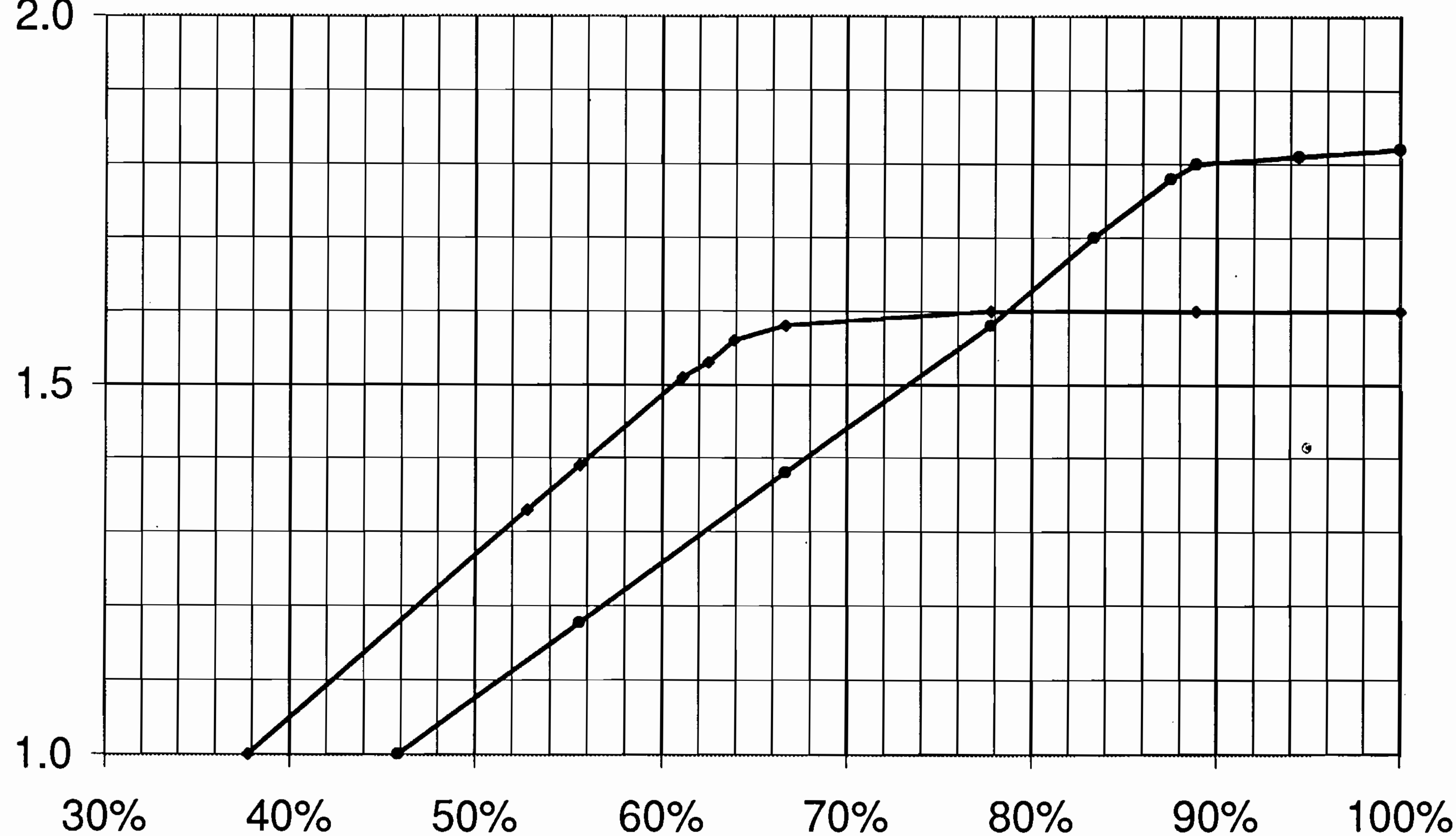
Global Loading Factor v. Percentage of Weld Unzipped



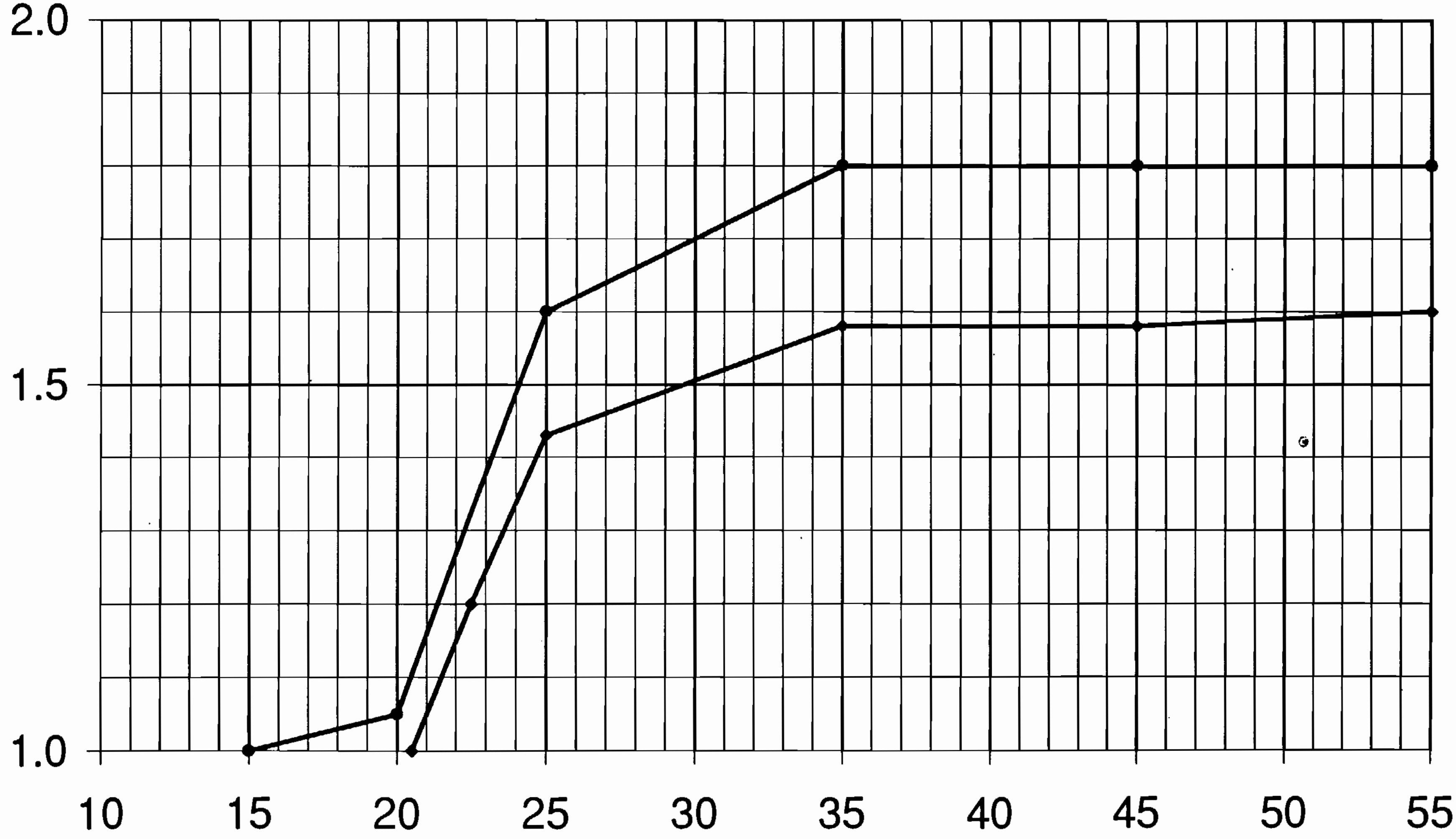
Global Loading Factor v. $\Delta t/t$



Global Loading Factor v. Percentage of Full Driven Length



Global Loading Factor v. Friction Angle, Φ (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

SUMMARY: OBSERVATIONS AND RESULTS (continued)

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

SUMMARY: OBSERVATIONS AND RESULTS (continued)

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

SUMMARY: OBSERVATIONS AND RESULTS (continued)

Broadside 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)
  - $\leq$ 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

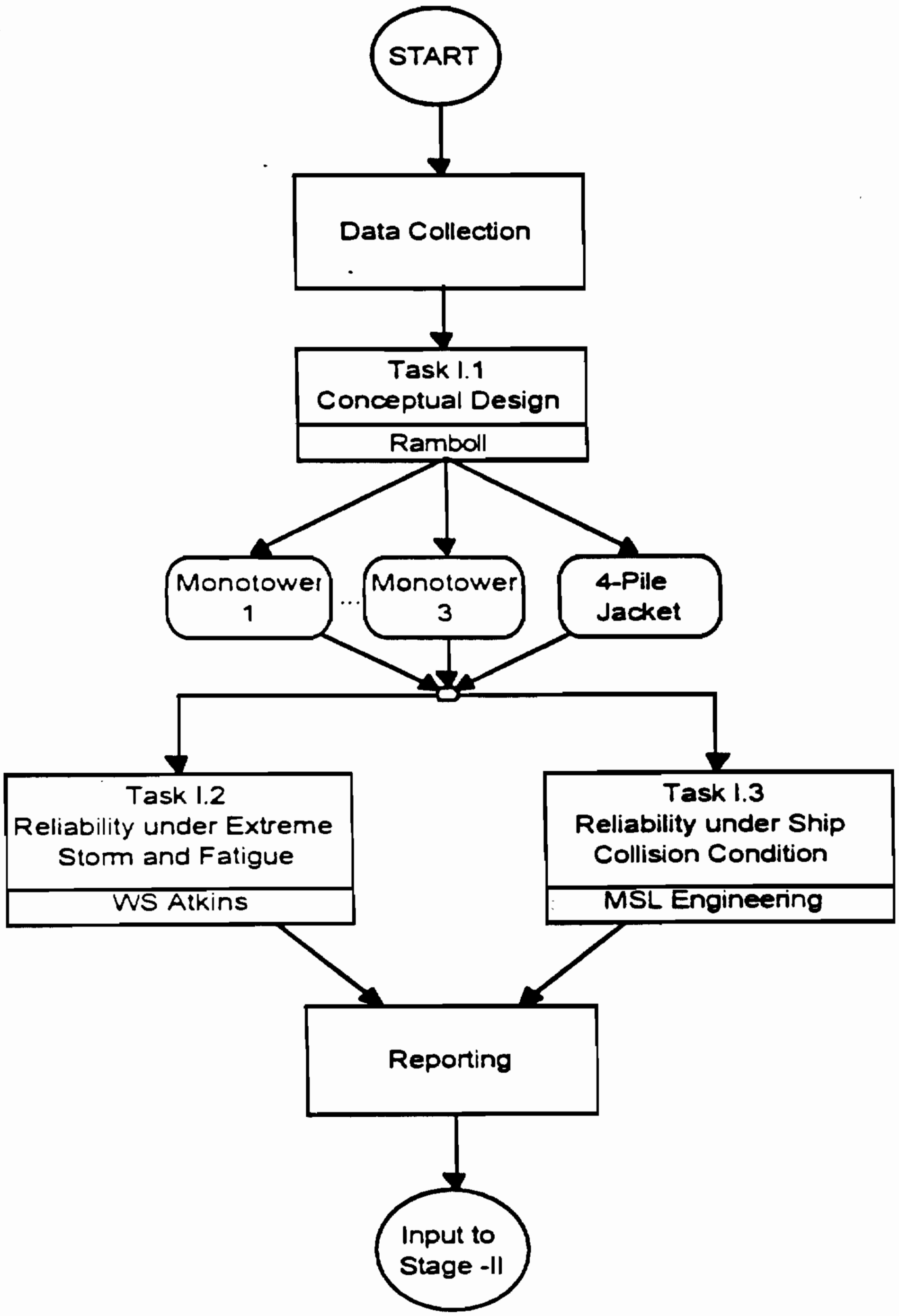
Proposal Prepared by

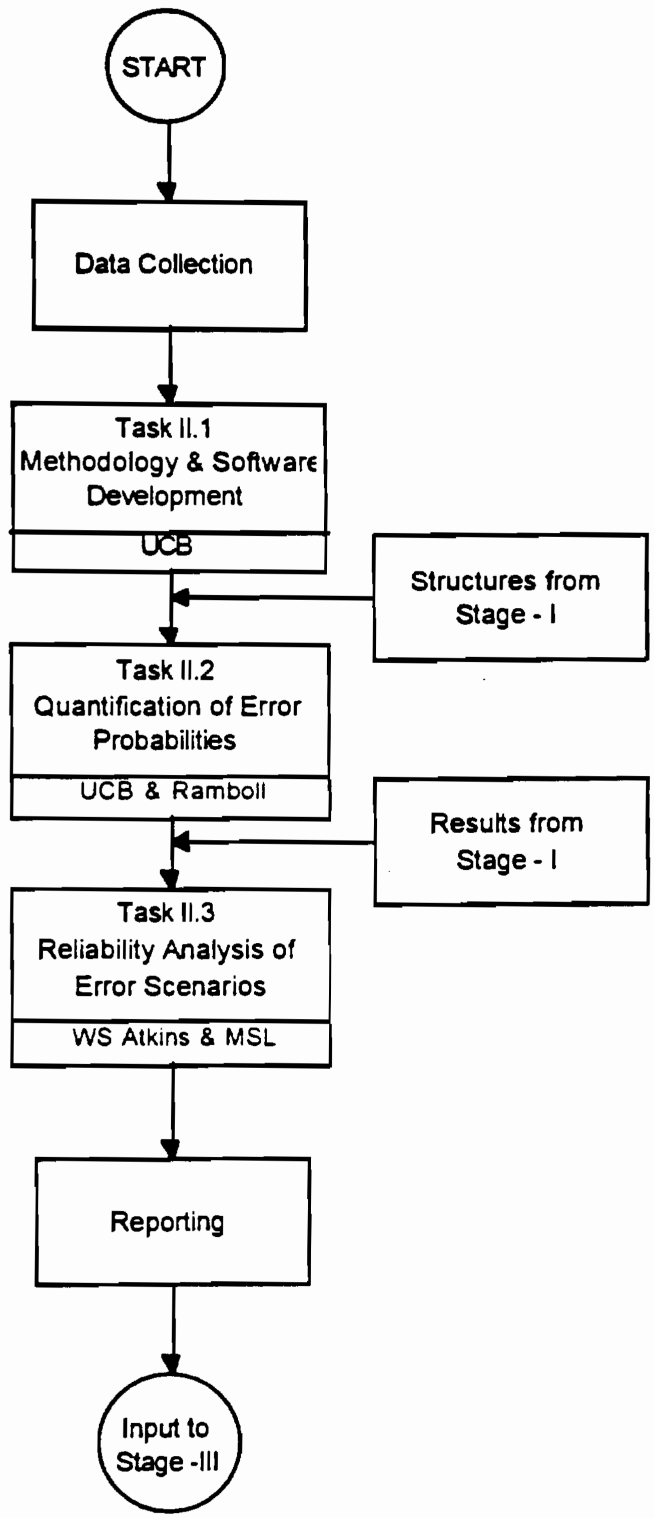
WS Atkins Science & Technology, UK

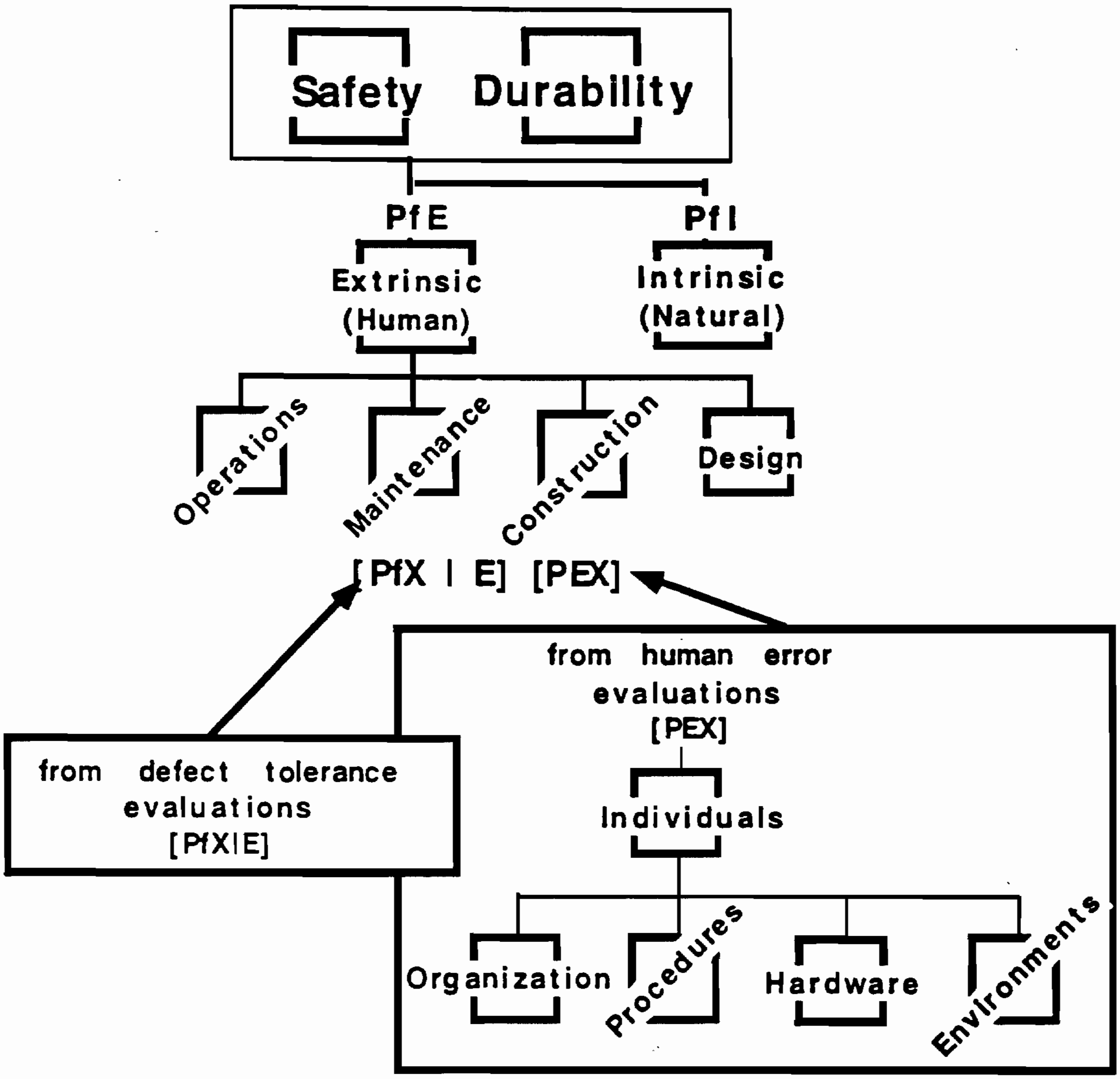
University of California, Berkeley, USA

MSL Engineering Ltd., UK, and

Ramboll, Denmark


START
Data Collection
Task I.1
Conceptual Design
Ramboll
Monotower 1
...
Monotower 3
4-Pile Jacket
Task I.2
Reliability under Extreme Storm and Fatigue
WS Atkins
Task I.3
Reliability under Ship Collision Condition
MSL Engineering
Reporting
Input to Stage -II


START
Data Collection
Task II.1
Methodology & Software
Development
UCB
Structures from
Stage - I
Task II.2
Quantification of Error
Probabilities
UCB & Ramboll
Results from
Stage - I
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

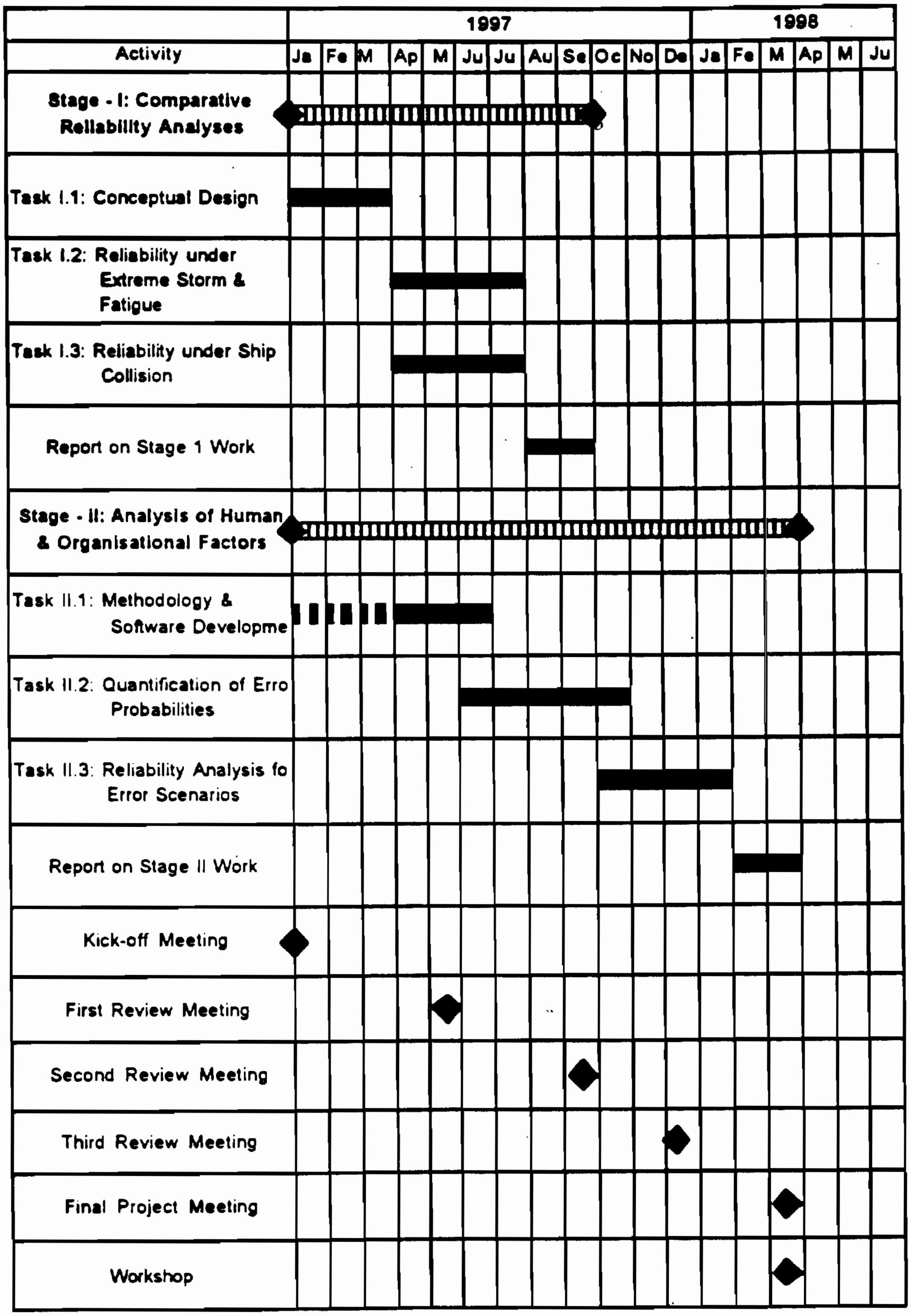
5.0 TIME-SCALE, BUDGET AND PARTICIPATION FEE

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.

Stage		Budget (£)	Duration
Stage-I: Comparative reliability analyses	£	100,000	9 Months
Data collection	10,000		
Conceptual design	25,000		
Reliability under extreme storm & fatigue	22,500		
Reliability under ship collision condition	22,500		
Review, Conclusions and Reporting	10,000		
Project Management	10,000		
Stage-II: Analysis of human and organisational factors		110,000	12 Months
Data Collection	10,000		
Methodology and software development	20,000		
Quantification of error probabilities	20,000		
Reliability analysis for error scenarios	50,000		
Project Management	10,000		
Stage-III: Parametric and sensitivity analysis	(Approx.)	60,000	6 Months
Stage-IV: Multi-criteria decision analysis	(Approx.)	60,000	6 Months
TOTAL		330,000	

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.



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. Staneff, 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	ACTUAL
Bea & Craig L1 RSR	L1I1, L1RSR1
L1 Risk	L1I1, L1C1 (example)
ULSLEA, if possible	L2I1, L2Eng1, L2RSR1, L2RSR2
L2 Consequence	L2I1, L2C1 (example)
Data sharing	√
Analysis management	√
Uncertainty handling	√

Features (2)

- <u>PROJECTED</u>
- Technology transfer
- Other analyses
- Other capabilities

- <u>ACTUAL</u>
- √
- L1Risk1, L2Risk1
- L2Vmax1
- Fleet management
  - L1Risk1_Fleet1
  - L2Risk1_Fleet1
- Policy analysis
- Historical database

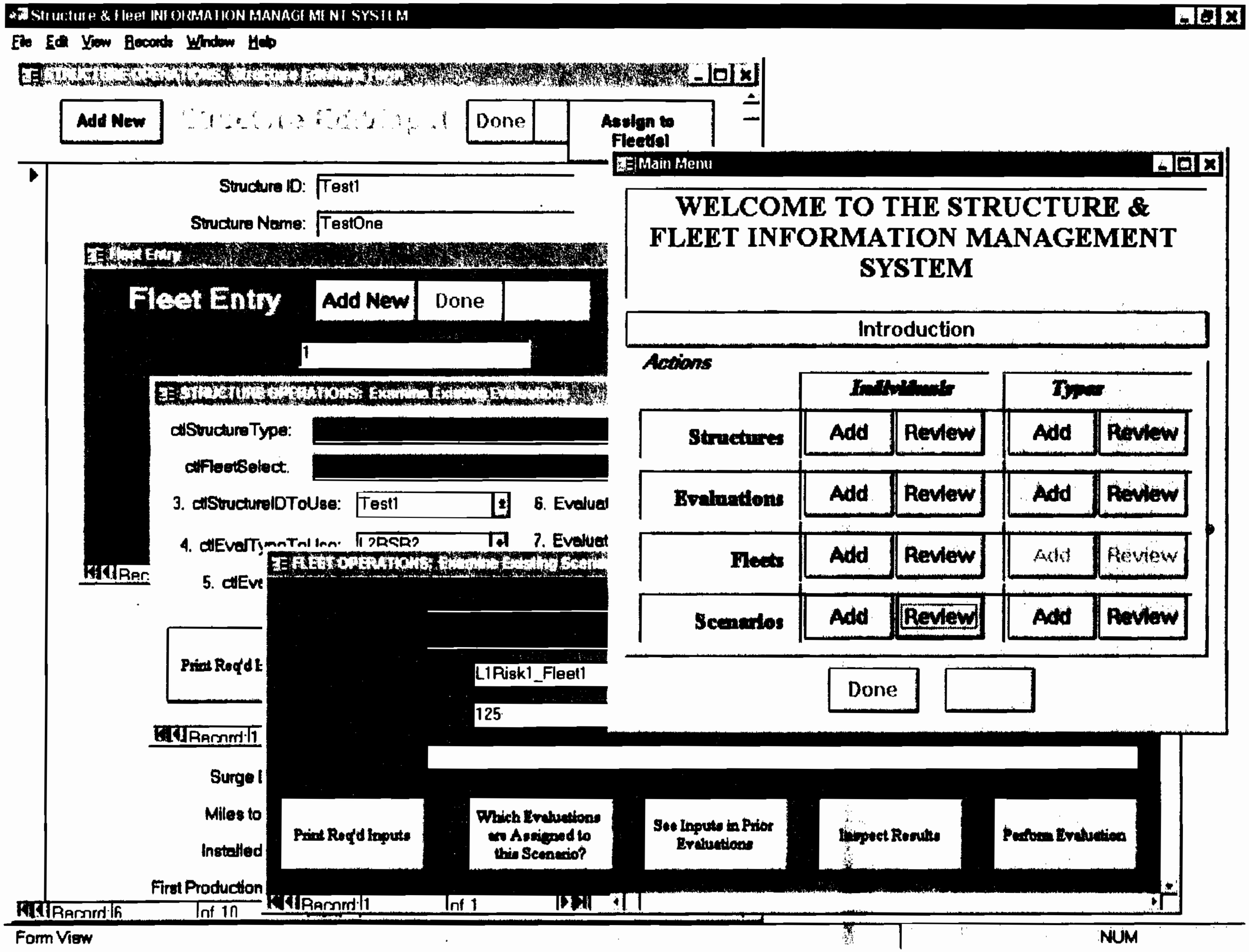
Features (3)

- 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

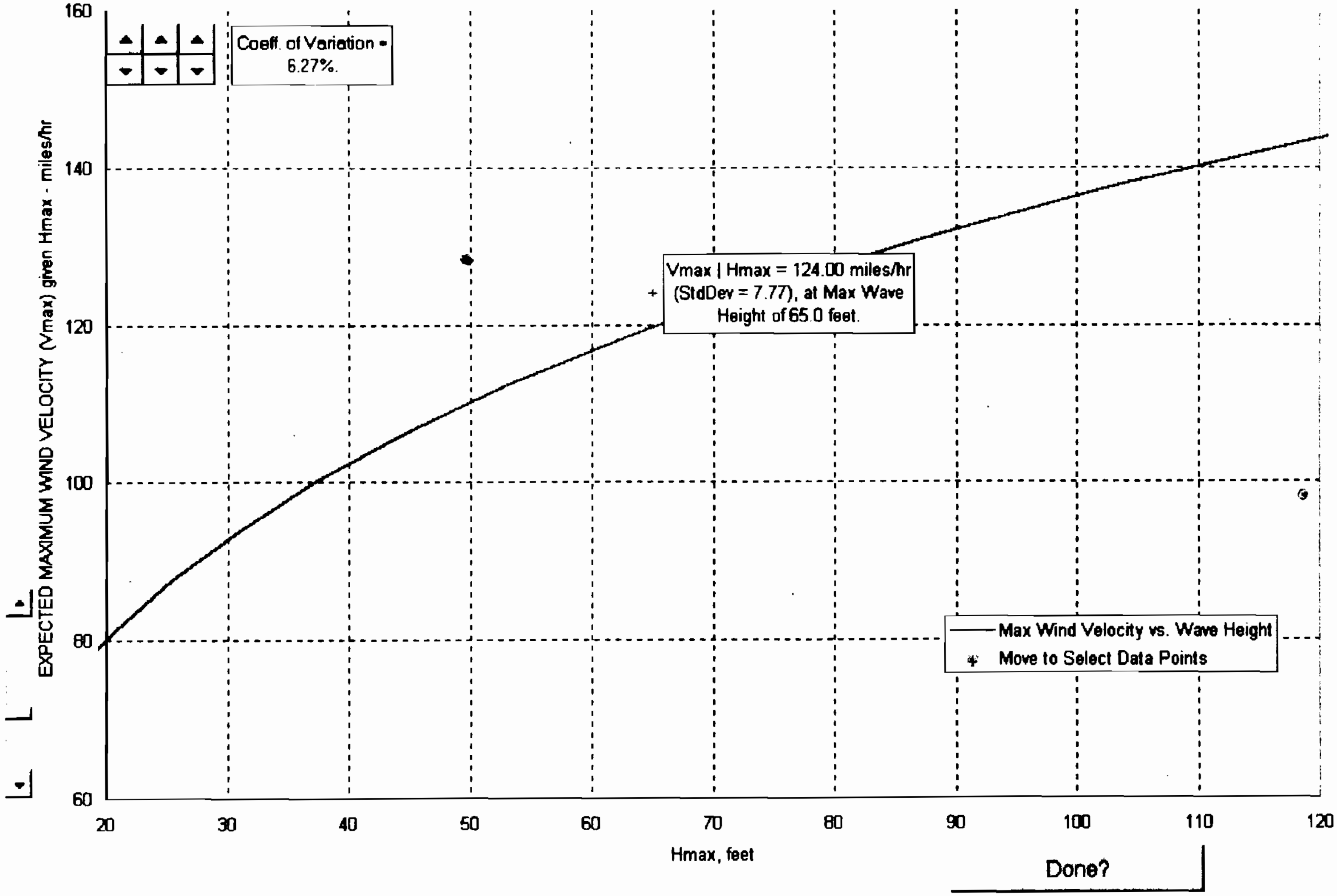
Data Structure

- Data structure allows arrays to be stored as efficiently as possible in a relational format
- Able to handle iterative variables / geometries

IMS Overview

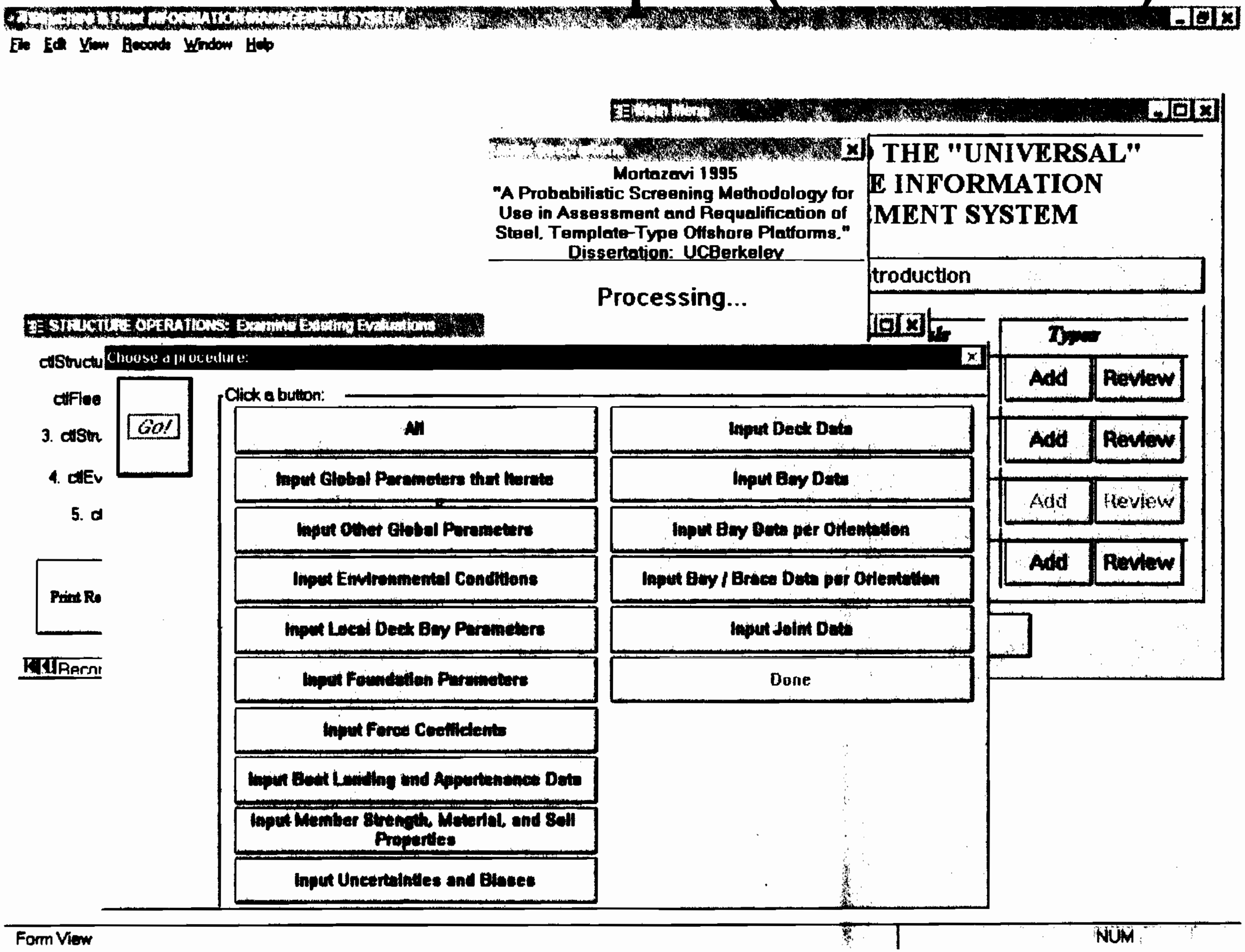


L1Vmax1

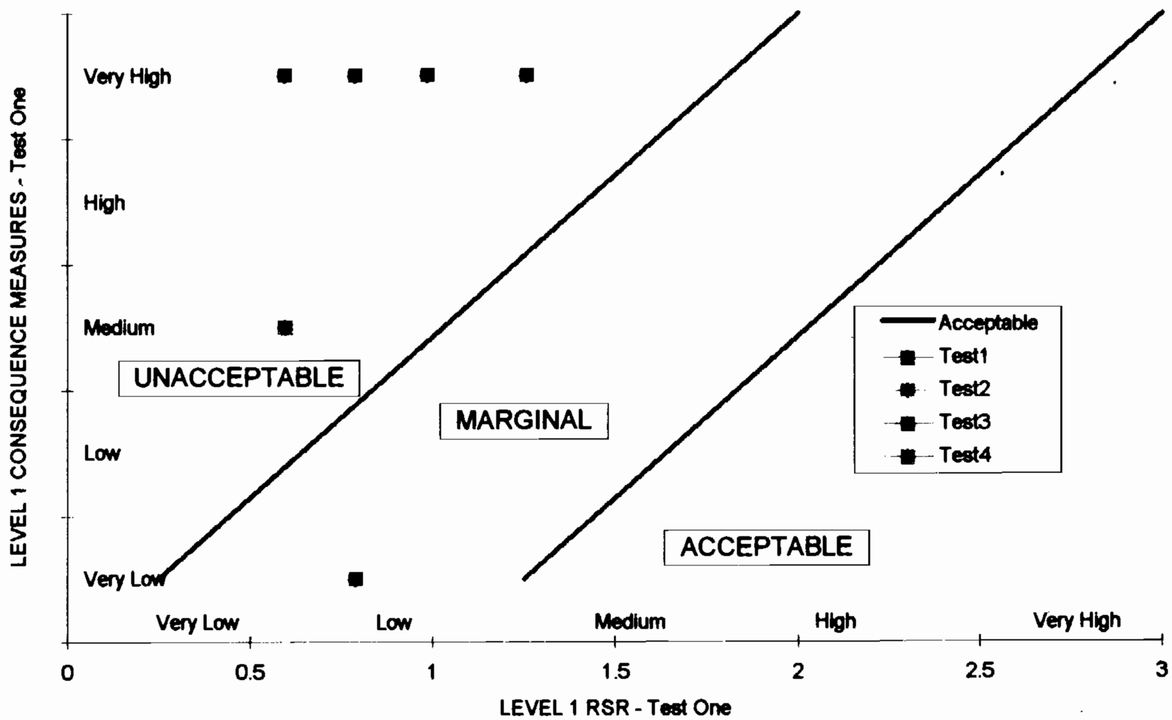


Coeff. of Variation = 6.27%.
Vmax | Hmax = 124.00 miles/hr (StdDev = 7.77), at Max Wave Height of 65.0 feet.
EXPECTED MAXIMUM WIND VELOCITY (Vmax) given Hmax - miles/hr
Hmax, feet
Max Wind Velocity vs. Wave Height
Move to Select Data Points
160
140
120
100
80
60
20
30
40
50
60
70
80
90
100
110
120
Done?

L2I1 - Manual Input (ULSLEA)

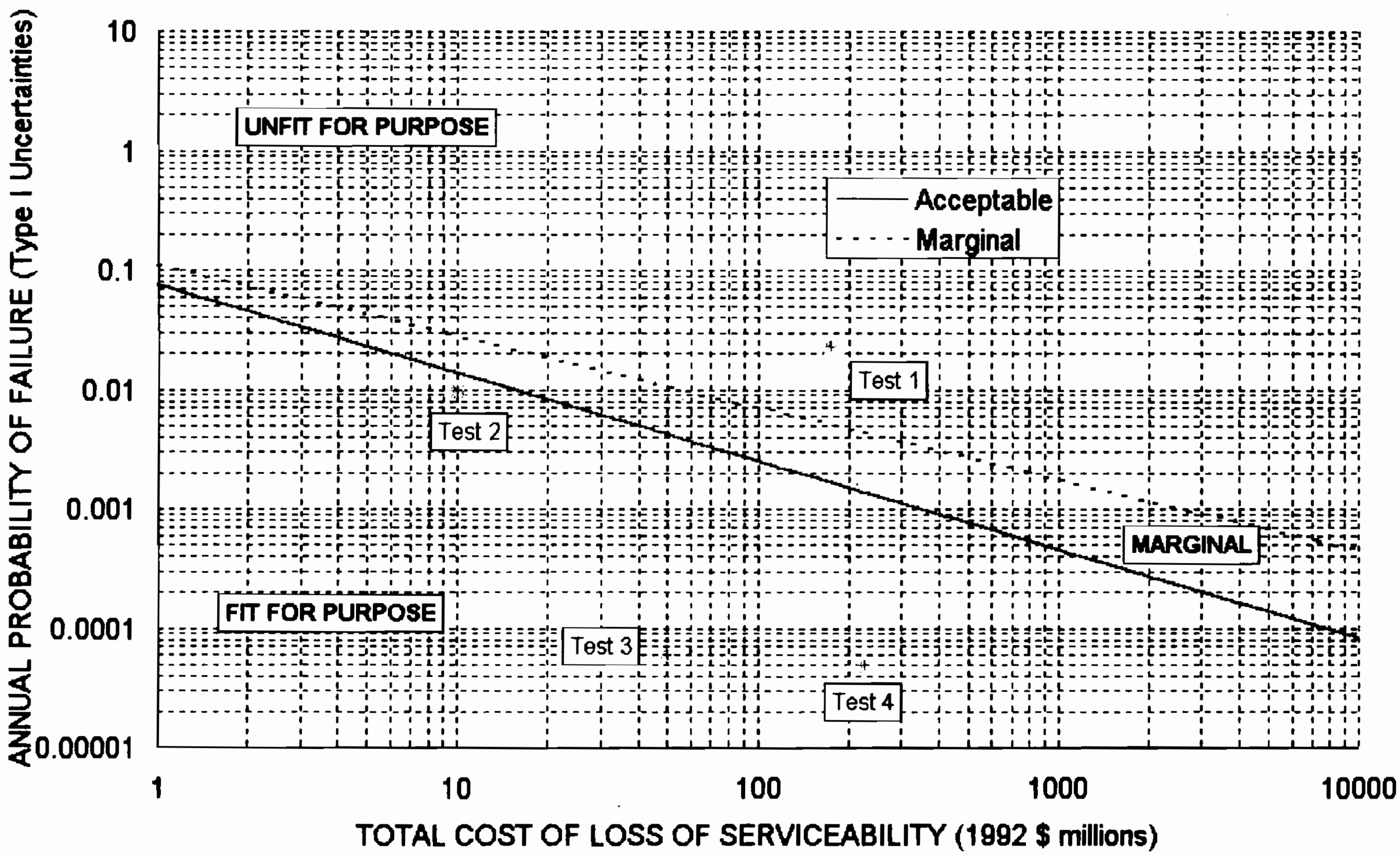


L1Risk1_Fleet1 Results



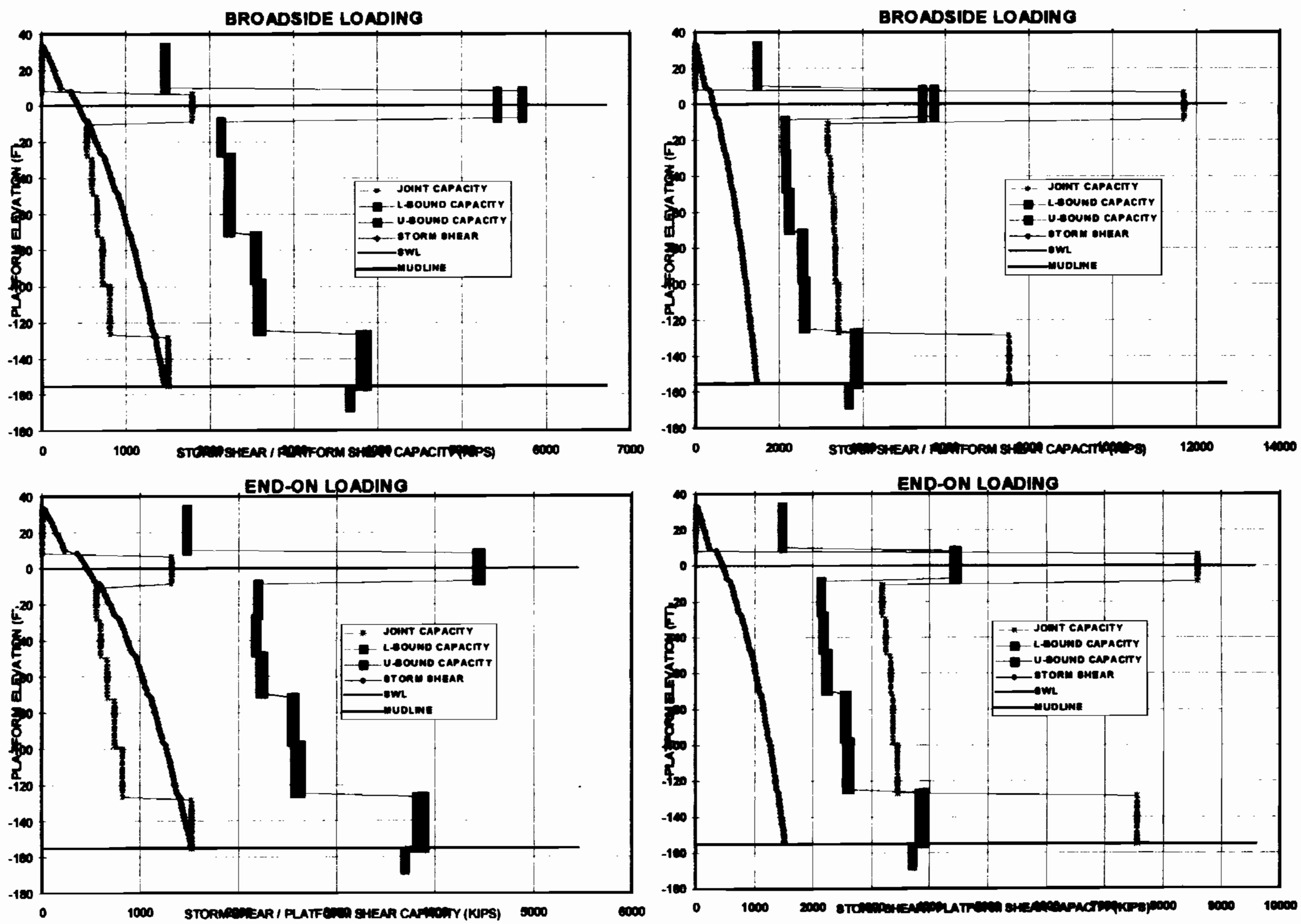
STANDARDS - Acceptable: C=2.571*RSR-2.7125; Marginal: C=2.571*RSR-0.14275. Standards are fixed for this evaluation type. Create a new evaluation type if other standards are desired.

L2Risk1_Fleet1 Results



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

L2RSR1 vs L2RSR2 (ULSLEA 2.0 vs 2.1)



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

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

Next Meeting Date: JUNE 1996