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Teaching of an Ocean Engineering Capstone Design Course*

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The Ocean Engineering Program at Texas A&M University offers a required capstone design course entitled 'Design of Ocean Engineering Facilities'. For one semester senior ocean engineering students focus on designing an ocean engineering facility in a project engineering environment similar to that found in industry or government. A faculty member and professional engineer from industry have jointly taught his course. The integration of industry input into the course is extremely valuable, and this unique approach has been quite successful. The class organization, project selection and summary of two projects are discussed. The 1989 project addressed the design of a deep water production riser, and the 1992 project was concerned with the design of a floating production system. The students were organized into groups to further define the problem, develop and analyze alternative solutions, conduct economic analysis, and consider safety and environmental concerns. Students gave oral presentations at a professional society meeting and to industry and faculty representatives at the course conclusion.

INTRODUCTION

THE SENIOR capstone design course, 'Design of Ocean Engineering Facilities' is offered once a year by the Ocean Engineering Program at Texas A&M University. As many as 30 senior ocean engineering students enroll each Spring Semester. Coordination of the course and supervision of class activities is the responsibility of the assigned faculty member. The four credit hour course meets a total of seven hours per week. One hour is for lecture and the remaining hours are two 3-h laboratory sessions. The course has a dedicated personal computer, drafting table and meeting rooms for project group discussions. The computer has a word-processor, spreadsheet, computer-aided design and other necessary software installed for completing the selected design project.

In 1988 the Offshore Technology Research Center (OTRC) was established as a National Science Foundation Engineering Research Center at Texas A&M University and the University of Texas at Austin. The center has an educational component that has assisted in providing industrial participation in the design project.

All students enrolled in the design course are seniors and must have completed the prerequisite courses entitled 'Dynamics of Offshore Structures' and/or 'Basic Coastal Engineering' that also require fundamental engineering science prerequisites of fluid mechanics, structural mechanics, computer methods and water wave mechanics. Therefore, the students are academically prepared to undertake the design of a major offshore or coastal engineering facility.

Table 1 shows an example course syllabus for Spring Semester 1992 that includes lectures on the design process from the selected textbook [1]. The grading distribution shows the student's performance is based upon participation, written reports and oral presenatations. Similar syllabuses and procedures have been used during the past four years.

COURSE DESCRIPTION AND OBJECTIVE

The catalog description is 'Design of structures, equipment and systems for the ocean; environmental, logistical and reliability requirements. Complete design process followed through a group design project; delineation of alternatives, constraints, economics and environmental consequences included to strengthen real-life problem solving skills.' The overall objective of the course is to bring together the students with knowledge and analytical skills developed after approximately 3.5 years in the Ocean Engineering curriculum and have them apply what they have learned to a real world ocean engineering design problem.

INDUSTRIAL PARTICIPATION

The OTRC has many industrial sponsors that donate funds to help support the center's activities.

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Table 1. Syllabus for capstone design course entitled 'Design of Ocean Engineering Facilities' (OCEN 407) for Spring Semester 1992

Week	Topic	Assignment
1	Introduction and organization, define design problem	Literature, Text ch. 1
2	Design process, literature search, organize design groups	Text ch. 2 and 3
3	Clarify objectives, functional analysis, specifications, group design of alternate solutions	Text ch. 4–6, progress report due
4	Generating and evaluating alternatives, group design of alternate solutions	Text ch. 7 and 8
5	Improving details, design strategies, group design of alternate solutions	Text ch. 9 and 10, progress report due
6	Ethics and professionalism, group design of alternate solutions	
7	Group design of alternate solutions	
8	Organize and prepare midterm progress report, midterm progress report, individual oral presentations to class	Midterm progress report
9	Organize and practice midterm progress report oral presentation for professional society meeting, oral presentation to Texas Section of Society of Naval Architects and Marine Engineers (SNAME)	Written summary to be given to attendees of SNAME meeting
10	Project final design and group discussions	
11	Project final design and group discussions	Progress report due
12	Project final design and group discussions	
13	Project final design and group discussions	Draft final report due
14	Organize and practice final oral presentation, final oral presentation to Ocean Engineering faculty and industrial representatives	
15	Complete final report	Final report due

Text: Cross, N., *Engineering Design Methods* [1]

Grading distribution:		
	Class attendance and progress reports	25%
	Midterm progress report	25%
	Final report	30%
	Oral presentations	20%

One type of support is called 'in-kind support' which means the sponsor provides services such as ship time, equipment lease or personnel time instead of a cash contribution. It is this in-kind support that has been requested from OTRC to provide the services of an experienced design engineer from industry to assist the faculty member in conducting the design course. The industry person is a visiting lecturer and attends one laboratory session a week, provides industrial data, gives several lectures, arranges for additional industrial speakers, participates in reviewing and grading student reports and presentations, and provides contacts to answer student questions.

In the past four years, the Ocean Engineering design class has completed design projects entitled 'Treasure Viking: Conversion of the Pentagon 82 Semi-submersible to a Floating Production System' [2], 'Design of a J-lay Pipelay Vessel Barge' [3], 'Design of Underwater Hotel (WOTEL)' [4] and 'Preliminary Design of a Deepwater Tension Leg Platform Production Riser' [5]. The visiting lecturers have come from the Houston, Texas area, which is only 145 km from the Texas A&M campus. Thus, the industry lecturer can spend nearly four hours on campus and complete the two hour drive in a day. The industry lecturers for the previously mentioned design projects were Mr Bev Edwards and Mr Edward Liles of Oceaneering Production Systems in 1992, Mr James Hale of Brown & Root in 1991, Mr David Tuturea of Brown & Root in 1990 and Mr Michael Cook of Exxon Production Research in 1989. At the course conclusion the industrial lecturer's time and expenses are computed and then credited as in-kind support from their respective company to the OTRC.

PROJECT SELECTION

1992 project

In the preceding Fall Semester the faculty instructor requested permission from the OTRC administration to contact industry sponsors to locate a possible industry lecturer and solicit some possible design projects from which the student could select. It is desirable to involve the students in the design project selection so that they have a feeling of participation, an obligation to complete and enthusiasm for participating in the selected topic.

As an example, in Fall 1991 Oceaneering Technologies was contacted to determine if they would be interested in participating in a design project related to the design of remotely operated vehicles. Personnel and project commitments did not permit participation in this area, but it was possible for them to participate in the area of offshore production systems. Oceaneering selected Mr Bev Edwards and Mr Ed Liles to serve as the industry lecturers.

The Oceaneering Production Systems group within Oceaneering Technologies provided eight design topics entitled 'Floating Production, Storage and Offloading (FPSO) Facility', 'Single Point Mooring (SPM) System Design Improvement', 'Drill Ship Conversion of Mobile Offloading Production and Storage (MOPS) Facility', 'Marine Offloading Terminal', 'Short Term Well Test Storage System', 'Jackup Mobile Offshore Production Unit with Floating Storage and Offloading Vessel', 'Semi-Submersible Production Unit' and 'Shallow Water Extended Well Test Vessel'.

The students met in December 1991 and ranked the projects according to their interests. The individual student rankings were summed and the project was selected based upon the project with the smallest sum value. As a result, the topic 'Semi-Submersible Production Unit' was selected as the design project that the students would undertake beginning in January of the 1992 Spring Semester. The selection of the design project topic in the previous semester was an important time saver and permitted the students to focus their efforts for the semester on engineering design and not spend the first two weeks choosing a project.

1989 project

Prior to the beginning of the 1989 Spring Semester, the industry lecturer was identified. On the basis of the expertise of the lecturer, the design of an offshore deep water riser was the general topic available to the students. Several possible riser problems were posed, and the students decided to undertake the comparison of different riser materials and to select one material for final design of a deep water tension leg platform. Information was available from a related study [6], and on composite risers [7].

DESIGN PROJECT DEFINITION

1992 project

The industry lecturer described the general problem at the start of the semester to assist the students in the first step of design, which was defining the problem. As an example, the Spring 1992 class selected the design of the conversion of a semi-submersible drilling rig to a floating production system. The lecturer described the basic problem, the vessels available and possible locations. The class selected the semi-submersible 'Treasure Viking' because of its purchase price and location in Galveston, Texas. As a result of the location, the class made a field trip to inspect the 20-year-old vessel and obtain necessary information such as mooring equipment stability characteristics, design drawings, existing equipment, etc. Two locations were selected: one site was in the Green Canyon area of the Gulf of Mexico in 823 m of water and the second was off the coast of South Africa near Mossel Bay in 149 m of water. Thus, the design problem definition was to design the conversion of the 'Treasure Viking' semi-submersible drilling rig to a floating production system with minimum equipment and structural changes for a shallow water site (Mossel Bay) and a deep water site (Gulf of Mexico).

1989 project

Lectures were presented on the subjects of titanium, riser design, composite material analysis, riser tensioners, economics, and the costs of riser material and equipment. After preliminary information was assimilated, the students decided to conduct the preliminary design of a production riser for a tension leg platform that would investigate and compare risers constructed of steel, steel with buoyancy modules, titanium, aluminum and composites. At midterm, the students selected one material and completed the final design for a deep water location in the Gulf of Mexico. The Gulf of Mexico was selected primarily because of availability of environmental data and because it is the likely location for such a design to be realized. A computer simulation was leased from Marine Computation Services, Inc. through Exxon Production Research to analyze the riser motions and loads.

CLASS ORGANIZATION

The Ocean Engineering design class was divided into design groups to complete the design project as illustrated in Table 2. The students and instructors identified design groups, and then the students decided in which groups they preferred to participate with the understanding that some sacrifices would have to be made to fill all the groups equally. For the Spring 1992 design, each student was to participate in one primary design group and at least one secondary group. The primary design groups were hydrodynamic loads, structures, stability and mooring. The secondary groups were environmental data, graphics, economics, installation and logistics, safety and environmental regulations. Four students were in each primary design group and two to six students participated in one or more of the secondary groups.

In the 1989 project the students spent two weeks gathering initial data, choosing the best regulatory code to use and understanding the configuration of risers in the tension leg platform (TLP) system. Each student participated in one of the three initial information groups. The next five weeks were spent designing the riser with different materials, and again each student was involved with one of the riser material design groups. A titanium riser was chosen for final design, and the last seven

Table 2. Organization of students for design projects

1992 Design of Semi-submersible Drilling Rig Conversion to a Floating Production System	
Primary design groups	No. of Students
Hydrodynamic loads	4
Stability	4
Structures	4
Mooring	4
Secondary design groups	
Environmental data	4
Graphics	5
Installation and logistics	6
Economics	2
Safety and environmental regulations	3
Final report editors	2
1989 Preliminary Design of a Production Riser for a Deep Water Tension Leg Platform	
Initial information groups (3 weeks)	
Pressure vessel code	3
Environmental data	3
Riser configuration	3
Riser material design groups (5 weeks)	
Steel only and with buoyancy riser	3
Titanium and aluminum riser	3
Composite riser	3
Riser final design groups (7 weeks)	
Stress joint design	3
Vortex shedding	2
Riser clearance	2
Corrosion and biofouling	2

weeks were spent on the final riser design with the students divided as shown in Table 2 into four groups dealing with stress joint design, vortex shedding, riser clearance, and corrosion and biofouling.

DESIGN CLASS LECTURES

During the first half of the Spring 1992 course, the faculty coordinator spent two hours per week giving lectures on the design process. Lectures were presented on several topics that included the design process and methods, clarifying objectives, functional analysis, generating and evaluating alternatives, improving details, design strategies, and ethics and professionalism. The industry lecturer presented informational lectures during the 3-h laboratory design session once a week. Guest speakers were also invited to discuss critical parts of the design problem. For the 1992 design, lectures were presented on the description of the 'Treasure Viking' mooring analysis, stability calculations, structural changes, riser equipment and characteristics, economics, safety requirements, and installation and logistics requirements.

For the 1989 project, guest lecturers presented seminars on the topics of titanium, composites, production risers, economics of riser design, use of the FREECOM [8] computer simulation, and stress joint design and concepts. The computer simulation was leased from Marine Computation Services Inc., and it was installed on the designated computer for the sole use of the class.

DESIGN PROJECT SUMMARY

1992 project

The 1992 project was to design the conversion of a Pentagon 82 'Treasure Viking' semi-submersible drilling rig (Fig. 1) to a floating production system. A shallow water (149 m) site located 51.4 km south of Mossel Bay, South Africa and a deep water (823 m) site in Green Canyon, Block 205 in the Gulf

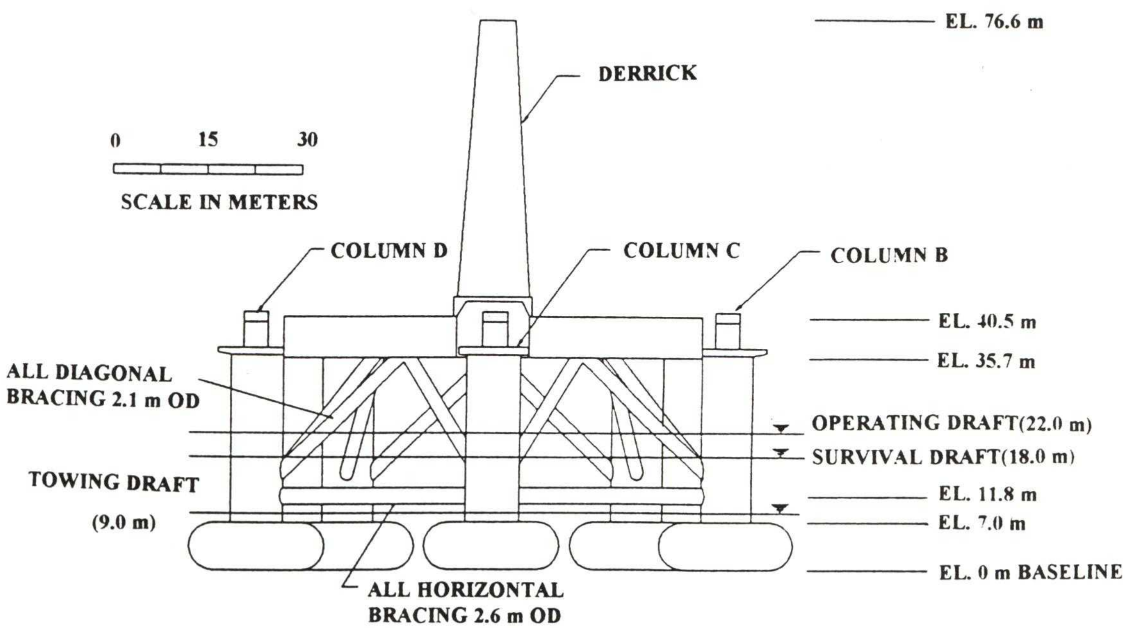

Fig. 1. Front view of the drilling vessel 'Treasure Viking' [2]

of Mexico about 148.2 km south-southwest of Grand Isle, Louisiana were chosen for the operational locations. The design objectives were (i) to evaluate hydrodynamic loads, (ii) to determine optimum location of production equipment in order to minimize degradation of vessel motion characteristics, (iii) to design structural additions to support production equipment and other necessary conversion modifications, (iv) to determine stability and motion characteristics of the converted vessel, (v) to design the mooring system for both sites using existing mooring winches, (vi) to evaluate the conversion cost, and (vii) to satisfy pertinent safety and environmental regulations.

Hydrodynamic loads were evaluated for the environmental conditions associated with the 1, 5, 10 and 100 year storms with the 1 and 10 year storms used in design calculations as the operational and survival conditions. Three design drafts (21.3 m production, 18.3 m survival and 9.1 m towing) and four different loading directions were considered. The hydrodynamic loads were analyzed according to American Petroleum Institute (API) recommended guidelines (API RP 2F P1) [9]. The maximum hydrodynamic loads at both sites were found to occur for the front view (Fig. 1).

Structural design and modifications required the design of a flare boom for the South African site, structural supports for the production equipment and buoys used for the mooring system at the Gulf of Mexico site. The flare boom was designed using a two-dimensional structural analysis program (RISA 2D) according to the American Institute of Steel Construction (AISC) Load and Resistance Factor Design (LRFD) manual [10]. The flare boom design resulted in a 30.5 m boom with an Indair flare tip, and one boom was to be mounted on both columns B and D of the 'Treasure Viking' to control stability and allow for changing wind conditions. The production equipment was to be added as modules on self-contained structural skids and six skids were designed. The buoys were used to support the bulk of the mooring line added for the deep water site so that existing mooring winches could be used and additional flotation such as sponsons need not be added to the vessel. The design called for one spherical buoy for each mooring line for a total of 10 buoys. The overall net buoyancy achieved with the buoy design was 365 kN and a depth capability of 232 m.

The mooring system was required to moor the vessel safely in two environmentally difficult locations, Mossel Bay and Green Canyon, to withstand a 1 year storm operational condition and a 10 year storm survival condition. The mooring analysis was performed according to API Recommended Practices API RP 2P [11] and API RP 2F P1 [9]. The mooring system for both locations consisted of a 10 line symmetric mooring pattern as shown in Fig. 2. At the South Africa site the mooring system included the addition of 7.0 cm diameter wire rope, 7.0 cm chain and ten 249 kN Stevshark anchors. Unfortunately the design changes were not quite sufficient to meet the API specifications and further analysis was needed to investigate the use of a buoy-supported system or increasing the diameter of the wire rope. The Gulf of Mexico design required 8.9 cm diameter wire rope, 9. 5 cm chain, and 409 kN net buoyancy buoy and a 133 kN Stevmud anchor for each mooring line. These changes met the API requirements for the deep water site.

Using the loads provided by the structures, hydrodynamics and mooring groups, the overall vessel stability was evaluated for both the present and converted FPS configurations. After ballasting for all three drafts, the static stability values of the FPS showed a trim vessel that displaced enough water to maintain the desired drafts at both sites. The metacentric heights for the survival and operational drafts were slightly below the minimum metacentric heights but well above the vertical center of gravity. Because buoys were used to support the additional mooring line weight at the Gulf of Mexico site, it was determined that the addition of sponsons for additional buoyancy was not necessary. Dynamic stability calculations showed the 'Treasure Viking' met American Bureau of Ships (ABS) [12, 13] requirements for Mossel Bay, but further analysis was required for Green Canyon.

A project timeline for both the Mossel Bay and Green Canyon sites was divided into eight planning stages; contract negotiations, design engineering, procurement and process package construction, shipment of equipment, installation and refurbishment of equipment, towing, setup and pre-tensioning of the mooring system, and startup. The total project completion time for Mossel Bay was 22 months and for Green Canyon was 19 months. The FPS was checked for safety using codes specified by the American Bureau of Ships [13], the API [14], Safety of Life at Sea [15] and the Environmental Protection Agency [17] and met all requirements.

The economic analysis considered principal costs such as the vessel purchase price, production equipment, mooring equipment, structural modification, renovation and installation expenses, and safety modification, and secondary costs such as construction management, classification, insurance and contingency costs. The production profits were figured using a price of $20 per barrel and production rates of 25,000 barrels per day for Mossel Bay and 40,000 barrels per day for Green Canyon. The total project cost was $31 million for the Mossel Bay location and $130 million for Green Canyon. If the assumption on the price of oil was reasonable, then the Mossel Bay location was recommended as workable for any conceivable project lifetime. The Green Canyon site either needed a more detailed analysis to determine if the cost could be lowered, a higher oil price could be attained, or a longer project life could be used to make the venture commercially viable.

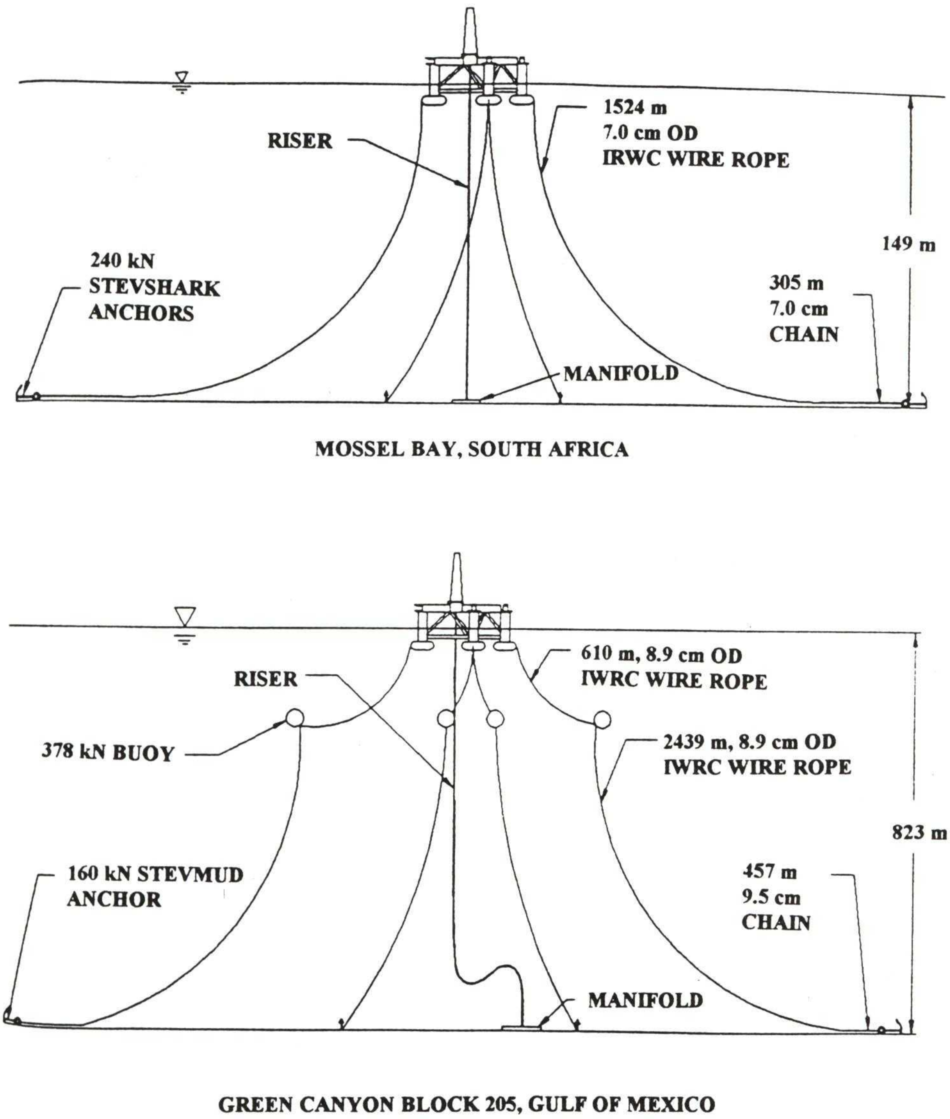

Fig. 2. Mooring configuration for Mossel Bay and Green Canyon sites for 1992 floating production system design [2]

1989 project

The 1989 project was to design a production riser for a deep water tension leg platform located in the Gulf of Mexico. The initial design study consisted of gathering environmental data, understanding the details of a production riser and determining the design codes to use. The American National Steel Institute (ANSI) codes [17] were used for the design of the riser wall thickness. The risers were essentially long cylindrical pressure vessels that must withstand the wellhead pressure, assumed to be 68,948 kN/m^2. Three water depths (457.3, 914.6 and 1829.3 m) were studied for riser materials of steel (HY80), steel with buoyancy (syntactic foam), titanium alloy (6% aluminum and 4% vanadium), aluminum (6061) and composites (carbon and fiberglass fibers). The production riser was a 19.4 cm outside diameter tube with a single inner tube of 8.9 cm outside diameter. All risers used steel connections, and there were 49 risers in the 457.3 and 914.6 m water depths and 64 risers at the 1829.3 m depth. Design environmental conditions were for a 100 year design wave and a loop current. Table 3 summarized the results of five weeks of investigating the use of the different riser materials.

A computer simulation, named FREECOM [8], was available for student use on the design project. This simulation is a frequency domain finite-element analysis which evaluated the riser displacements, angular deflections, bending moments, bending stresses and effective tensions. The riser design was not to exceed a horizontal displacement of 10% of water depth and an angular deflection of 10°. The top tension was assumed to be 1.5 times the riser weight in water. Aluminum was eliminated early because of its low yield strength. The results show that a steel riser was the least expensive and a composite material riser was the most expensive.

As a result of the anticipated decrease in the future cost of titanium when depths of 914.6 – 1829.3 m might be attempted and its novelty as a

Table 3. Comparison of riser materials from 1989 project [6]

Riser types	Water depth (m)	Environment	Top tension (kN)	Weight in water (kN)	Weight in air (kN)	Weight per m in air (N/m)	Riser wall thickess (cm)	Tubing wall thickness (cm)	Max. top angle (deg)	Max. bottom angle (deg)	Max. bottom bending stress (1000 kN/m^2)	Production riser cost ($1000/riser)	Incremental TLP cost ($1000/riser)	Total cost ($1000/riser)	Total cost per m ($/m)
Steel only	457.3	100 year	627	418	454	957	1.765	0.953	3.8	10.4	586	289	226	515	1128
Steel w/buoy.	457.3	100 year	445	369	485	1043	1.765	0.953	4.8	13.8	538	280	180	460	991
Titanium	457.3	100 year	245	165	191	407	1.27	0.533	3.0	10.2	303	723	88	811	1771
Composite	457.3	100 year	302	169	200	426	1.687	0.533	3.5	9.0	186	1002	109	1111	2667
Steel only	457.3	Loop current	627	418	454	957	1.765	0.953	3.7	7.4	421	289	226	515	1128
Steel w/buoy.	457.3	Loop current	445	369	485	1043	1.765	0.953	6.9	11.2	434	280	180	460	991
Titanium	457.3	Loop current	245	165	191	407	1.27	0.533	11.4	11.1	331	723	88	811	1771
Composite	457.3	Loop current	302	169	200	426	1.687	0.533	7.0	7.5	165	1002	128	1130	2713
Steel only	914.6	100 year	1237	823	890	957	1.765	0.953	4.1	9.8	669	461	473	934	1020
Steel w/buoy.	914.6	100 year	778	681	1063	1154	1.765	0.953	3.0	13.5	552	526	298	824	892
Titanium	914.6	100 year	485	325	374	401	1.27	0.533	4.1	9.3	359	1434	185	1619	1768
Composite	914.6	100 year	534	316	391	426	1.687	0.533	7.0	9.5	207	1986	187	2173	2506
Steel only	914.6	Loop current	1237	823	890	957	1.765	0.953	1.7	6.0	400	461	473	934	1020
Steel w/buoy.	914.6	Loop current	778	681	1063	1043	1.765	0.953	4.3	8.5	345	526	298	824	892
Titanium	914.6	Loop current	485	325	374	124	1.27	0.533	6.0	6.5	248	1434	185	1619	1768
Composite	914.6	Loop current	534	316	391	130	1.687	0.533	5.4	6.0	138	1986	304	2290	2526
Steel only	1829.3	100 year	2455	1637	1766	957	1.765	0.953	4.0	9.5	827	802	1389	2191	1194
Steel w/buoy.	1829.3	100 year	1334	1223	2042	1118	1.765	0.953	2.5	14.0	641	1063	750	1813	987
Titanium	1829.3	100 year	965	641	747	407	1.27	0.533	4.3	8.8	414	2856	541	3397	1856
Composite	1829.3	100 year	823	618	783	426	1.687	0.533	4.0	12.0	262	3952	461	4413	2486
Steel only	1829.3	Loop current	2455	1637	1766	957	1.765	0.953	1.0	5.7	503	802	1389	2191	1194
Steel w/buoy.	1829.3	Loop current	1557	1490	1841	1007	1.765	0.953	3.0	15.0	531	868	875	1743	948
Titanium	1829.3	Loop current	965	641	747	407	1.27	0.533	2.6	5.0	262	2856	541	3397	1856
Composite	1829.3	Loop current	823	618	783	426	1.687	0.533	3.8	7.1	165	3952	475	4427	2483

riser material, the titanium riser was selected for final design in a depth of 1829.3 m. The depth selection was based on the desire to study risers for depths greater than that of current offshore platforms. The most severe design condition was the 100 year Gulf of Mexico hurricane. The design analysis of the stress joint produced a 6.1-m-long tapered titanium tube. Investigations showed that vortex shedding would not be a problem. Riser clearance studies using FREECOM indicated a minimum riser spacing of 3 m was adequate. Corrosion and biofouling studies required gaskets and protective coatings at all titanium-to-steel connections and a biofouling coating on each riser to a depth of 45.7 m. Using a Pierson–Moskowitz spectrum with the 100 year storm, the results (Fig. 3) show that the riser stayed within the allowable 10° angular deflection, 10% water depth horizontal offset and below the 510,000 kN/m^2 failure bending stress. The total cost for a single riser was estimated to be $3.55 million and the total 64 riser system was $227 million.

REPORTS

The results of almost everything an engineer does in a work assignment are usually included in a written report. Therefore, report writing was an important part of the design class. Individual

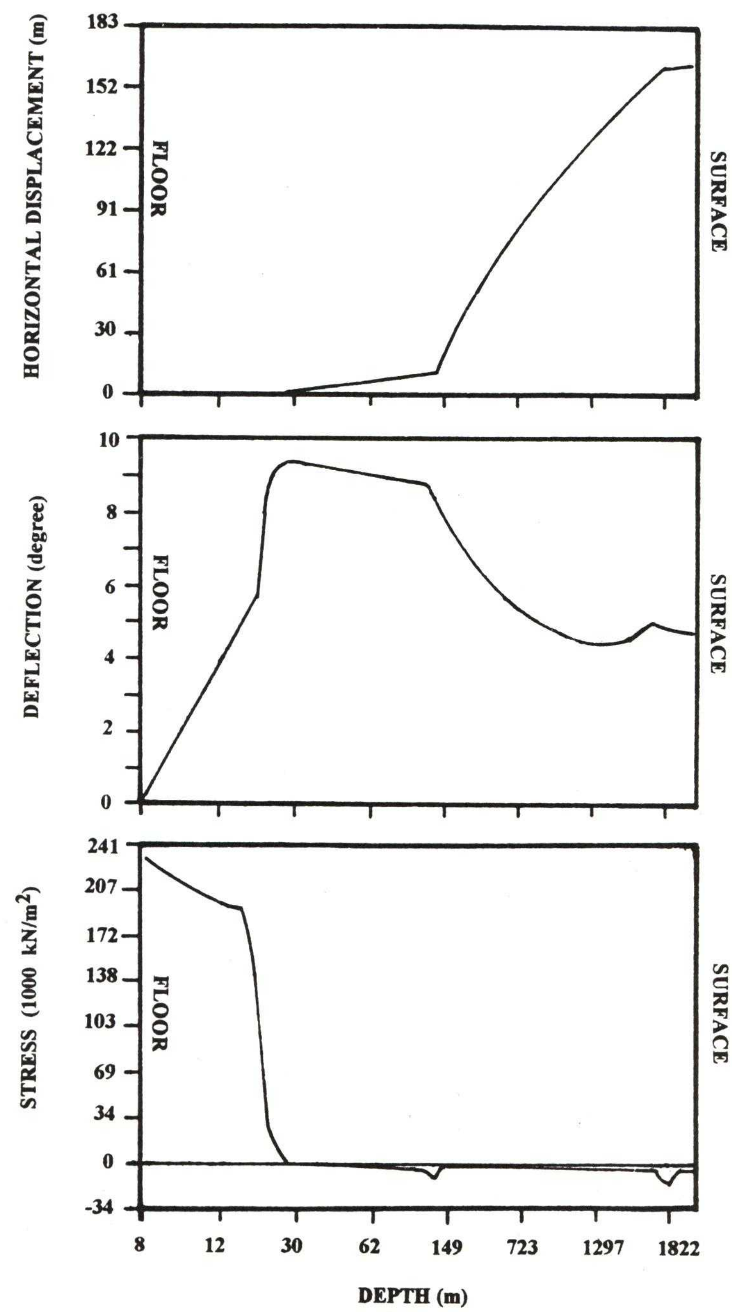

Fig. 3. Angular deflection, horizontal displacement and bending stress results from computer simulation of riser with stress joint in 1829.3 m water depth for a 100 year storm using a Pierson–Moskowitz spectrum [6].

progress reports (one page memorandum) were required at the beginning of the course. The first major report was the midterm progress report that was required from each main design group and some support groups (Environmental Data, Graphics). This midterm report was due at the completion of eight weeks, and it was reviewed and graded for technical correctness, proper spelling and English grammar. After the first eight weeks, two more progress reports were required. A draft final report was due at the end of the 13th week. This report was similar in format to the midterm report, and all groups were required to submit a report for their respective group. Each group report was a chapter in the final report. To complete the final report, two students volunteered to act as report editors and provide a format and guidelines for the final report that was assembled using word-processing software (WordPerfect) and the dedicated personal computer. Each group submitted their report chapter on a floppy disk for final assembly by the editors. The editors were responsible for coordinating and writing of the introduction, summary, abstract and acknowledgements. Each group was also assigned an appendix for sample calculations and useful information not included in the main report. The draft report was reviewed by the editors and instructors, and their comments were incorporated in the final report that was completed the week following the final class period. Finally, the students were encouraged to condense their final report into a short paper and submit it to a design competition. Condensed versions of the 1989 [5] and 1992 [2] reports were submitted to the American Society of Mechanical Engineering's Ocean Engineering Division design competition. Recently, the 1992 project won the 'Best Student Design Project' award.

ORAL PRESENTATION

Oral presentations are frequently required of engineers. Therefore it is important for student engineers to be introduced to this important function. For the 1992 and 1989 design classes, as well as those in other years, all students were required to prepare and give presentations at midterm on their progress report and at the final presentation. Students orally reported to the class frequently during class consultations with the instructors. Although this process was rather time consuming and perhaps inefficient, it is an extremely important experience for the students in expressing themselves orally before their peers. Students presented final oral presentations to the Ocean Engineering Program faculty and industry representatives. In addition, selected students presented the midterm progress report to a joint meeting of the Texas A&M Student Section and Texas Section of the Society of Naval Architects and Marine Engineers. Consequently, all students were given ample exposure to oral presentations and answering questions about their work. The instructors critiqued and graded both presentations.

CONCLUSIONS

A unique method for involving practicing design engineers in the conduct of the Ocean Engineering Program capstone design course has been very successful. Industry involvement was facilitated through the use of in-kind support from the OTRC at Texas A&M University. Perhaps similar approaches at other universities could use personnel services of senior design engineers as lecturers in capstone design courses as a donation to the university. This concept has been very successful for the past four years in Texas A&M's Ocean Engineering Program capstone design course. A commitment of one day a week by industry personnel gave much better continuity to the course than the previous procedures of an occasional visit and attendance at the final presentation. Presentations at meetings of local professional societies such as Texas Section of the Society of Naval Architects and Marine Engineers gave the students exposure to and feedback from practitioners.

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