Pre-Conference Workshop on
Very Large Floating Structures
(7 PDUs accredited by PE Board, Singapore)

25th September 2007, Tuesday, 9:00am to 5:00pm
EA-02-11, Faculty of Engineering, National University of Singapore

This one-day workshop is conducted by

Prof. Wang Chien Ming
National University of Singapore

A/Prof. Tomoaki Utsunomiya
Kyoto University

Prof. Masahiko Fujikubo
Hiroshima University

Prof. Shigeru Ueda
Tottori University

Prof. Emeritus Eiichi Watanabe
Kyoto University

Mr. Henry Han Lei
Hann-Ocean Technology Pte Ltd

Supported By
Introduction to VLFS
Prof. Wang Chien Ming, National University of Singapore

In this lecture, structural and civil engineers are introduced to the world of very large floating structures (VLFS) that have been gradually appearing in the waters off developed coastal cities and countries with long coastlines. Their presence is largely due to a severe shortage of land and the sky-rocketing land costs in recent times. After providing a description of a VLFS and highlighting its advantages (under certain conditions) over the traditional land reclamation in creating space from the sea, possible applications of VLFS in Singapore will be presented. The input design data, hydroelastic analysis and design considerations for very large floating structures (in particular a super-large floating container terminal) are discussed, albeit in the most basic forms.

Wave Properties and Hydroelastic Analysis of VLFS
A/Prof. Tomoaki Utsunomiya, Kyoto University

A typical Very Large Floating Structure (VLFS) has large horizontal dimensions ranging from several hundreds meters to several kilometers. On the other hand, the depth of the VLFS is only several meters. For example, the Mega-float Phase 2 model has a length of 1,000m, a width of 121m and a depth of 3m. Given such a small depth to length ratio, the VLFS would behave almost like an elastic plate when it is subjected to wave actions. For accurately assessing the dynamic response of VLFS, hydroelastic analysis must be employed. In this lecture, wave properties and basic assumptions for linear hydroelastic analysis is firstly introduced. Then, fundamental concepts for hydroelastic analysis of VLFS will be given. Both semi-analytical approaches and fully-numerical approaches will be presented. Several numerical examples will be presented, together with the applicability and the limitation of the method.

Structural Analysis and Design of VLFS
Prof. Masahiko Fujikubo, Hiroshima University

The objective of structural design is to develop a structure that fulfills serviceability and safety requirements in a cost-effective manner. For a novel structure like VLFS, the structural design needs a first-principle approach that is based on a rational structural response analysis and explicit design criteria. In this lecture, the linear and nonlinear structural analysis methods for the design of VLFS are presented, based on the experience gained from the construction of the pontoon-type Mega-float project in Japan. First, a structural design flow, typical of VLFS, and the design limit states specified in the Technical Guidelines of Mega-Float, are explained to clarify the role of linear and nonlinear structural analyses at various stages of the structural design. Structural modeling techniques developed for the hydroelastic response analysis of pontoon-type VLFS and an effective method for predicting the local stress response using a multi-step approach are explained next. Regarding nonlinear structural analysis, example analyses of structural damage due to airplane collision are presented. Finally, a simplified method of progressive collapse analysis of a pontoon-type VLFS is presented as an effective tool for overall collapse analysis of VLFS.

Analysis and Design of Station Keeping Systems for VLFS
Prof. Shigeru Ueda, Tottori University

Floating structures are utilized in various locations such as deep waters, shallow water with a soft foundation, well sheltered calm sea basin and so on. Among many components in the design of floating structures, mooring system is one of the key components of the floating structure to meet the function of the facility. For the purpose for the utilization of offshore space, floating structure has to be kept within the allowable displacements. This is so called station keeping and this is completely different function of to a floating vessel which freely moves in carrying goods from one port to another. Recently, the so-called buckling type rubber fenders were used for the mooring systems of floating oil stockpiling reservoir in Japan. As for the load deflection characteristics, the reaction force increases almost in proportion to the deformation of the rubber fender, by up to about 20% of strain. However, over that strain the reaction force does not increase and remains almost steady. A large size floating structure is subjected to steady load from wind, current, and wave drifting force, and fluctuating loads from waves and wind. The principle of design of fender mooring system is that the fender deflection against the steady load shall be less than about 10% strain and the deflection due to the motions of floating structure by the action of waves and wind shall be less than or within the deflection in the steady reaction range. Usually, the design is done by use of numerical simulations. However, it takes many trials until the determination.

Anti-Corrosion Systems and Maintenance of VLFS
Prof. Eiichi Watanabe, Kyoto University

Infrastructures are deteriorating daily. The administrators, nevertheless, are finding ever increasing difficulty in securing the necessary budget for repair. Thus, it becomes necessary to provide basic maintenance plans accountable using the concept of life cycle cost (LCC). For this purpose, the Asset Management System (AMS) will serve as a powerful tool in providing the necessary information for the decision making on when and how the repair work should be carried out. Recently there has been remarkable progress in analyzing the electro-chemical corrosion forming process and in improving the durability of structures since they are now required to be designed to survive for 100 years or more considering the LCC within the framework of the performance-based design. Results of exposure tests are now being made available and discussed more often together with the appearance of new advanced structural materials. There are various methods of corrosion protection available including organic lining, inorganic lining, petrolatum lining, paint coating, and cathodic protection. Comparative studies showed that the use of heavy-duty saltwater resistant stainless steel in addition to titanium is strongly recommended for attaining the best LCC. The corrosion protection methods by paint coatings and titanium-clad steels for steel structures that are built in the coastal areas of Japan will also be presented. It has been found that the most severe corrosions occur at the splash zone or at the zone immediately below the Mean Low Water Level. Based on a long 20-year corrosion exposure test conducted on a rolled H carbon steel member, one obtains information on how to predict the LCC considering the corrosion rate due to deteriorating properties of paint coatings including Polyurethane resin and Fluorine resin.
The construction of large floating platforms requires joining multiple pontoons together. This lecture illustrates key practical issues and design challenges of joining modular platforms/pontoons in rough seas. Five fundamental requirements for an ideal pontoon connector design are established and defined as self-alignment, impact attenuation, rigid engagement, self-tensioning and optimal strength. Nine relevant patents on pontoon connector designs are reviewed and compared to the 5 requirements. An innovative design concept is introduced, which consists of two patents namely Fender Connector (Patent No. WO2004/024555A1 / SG109504 / U.S.7063036) and Frictional Locking Connector (Patent No. PCT/SG2006/000008). This design integrates the five functional requirements into one compact connector. The engineering process from concept generation, model testing to prototyping and sea trials are presented. The advantages and benefits of the connector are illustrated. Various floating platform connector developments and its potential applications are discussed.

**Speakers’ Profiles**

**Prof. Wang Chien Ming** is Professor of Civil Engineering at the National University of Singapore. Recently, Prof. Wang has been appointed as the Deputy Head for the Engineering Science Programme, NUS Faculty of Engineering. Prof. Wang is a Chartered Structural Engineer, a Fellow of the Institution of Engineers Singapore and a Fellow of the Institution of Structural Engineers (U.K.). He is presently the Chairman of the IStructE Singapore Division. His research interests are in the areas of structural stability, vibration, optimization, plated structures and Mega-Floats. He is the author or co-author of over 300 scientific publications, reviewer of many international journals in mechanics, editor of several conference proceedings such as the proceedings on optimization techniques and applications and on computational mechanics and special issues of journals and co-editor of two volumes on Analysis and Design of Plated Structures. He is an Editor-in-Chief of the International Journal of Structural Stability and Dynamics and an Editorial Board Member of Engineering Structures and the Journal of Computational Structural Engineering. Moreover, he has co-authored three books “Vibration of Mindlin Plates”, “Shear Deformable Beams and Plates: Relationships with Classical Solutions” and “Exact Solutions for Buckling of Structural Members”.

**A/Prof. Tomoaki Utsunomiya** is an Associate Professor of Civil and Earth Resources Engineering at Kyoto University, Japan and has undertaken education and research in the areas of Offshore Structures including Very Large Floating Structures (VLFS) and Floating Bridges. He has published about 170 papers and books in these areas. His main research interests include hydroelastic analysis of Very Large Floating Structure. Part of his major contributions in this area are: “An eigenfunction expansion-matching method for analyzing the wave-induced responses of an elastic floating plate”, Applied Ocean Research, 17 (1995); “Wave response analysis of a box-like VLFS close to a breakwater”, Proc. 17th OMAE (1998); and "Fast multipole method for wave diffraction/radiation problems and its applications to VLFS", Int J Offshore Polar Eng, 16 (2006).

**Prof. Masahiko Fujikubo** is a professor at the Division of Structural Engineering, Department of Social and Environmental Engineering, Hiroshima University. He graduated from Osaka University in 1979, and received his M.Sc. in 1981 and Ph.D in 1988 from Osaka University. His research areas are the ultimate strength and structural reliability of ships and offshore structures, and nonlinear structural analysis. He stayed in the Norwegian University of Science and Technology from 1988 to 1989 to do research on the assessment of ductile fracture of offshore tubular structures. He was engaged in the Mega-Float project in Japan from its initial phase as a technical advisor for structural design and analysis. He published a textbook "Structural Design of Very Large Floating Structure" from Seizando (in Japanese) in 2004. He is now a Director of Japan Society of Naval Architects and Ocean Engineers (JASNAOE), a Member of ISSC2009 Technical Committee “Ultimate Strength” and an Editorial Board Member of Journal of Marine Science and Technology.

**Prof. Shigeru Ueda** graduated from Kyoto University in 1967, received his M.Sc. in 1969 and Dr. Eng. In 1985 from Kyoto University. Then, he joined the Ministry of Transport (MOT) and engaged in the design of container berth in Port of Kobe. He moved to the Port and Harbour Research Institute MOT, and did research work on design of offshore structures. Major works include berthing and mooring of ships, motions and moorings of floating structures, design of pile type offshore structures, earthquake resistant design and reliability design of port and harbour structures. He stayed in HRS Wallingford from 1975 to 1976 and studied ship motions and analysis. He moved to Tottori University in 1994 and continues with the aforementioned research studies as well as teaches Structural Mechanics, Probability and Statistics, Dynamic Response Analysis and Offshore Structural Engineering. He is a Fellow Member of Japan Society of Civil Engineers, Professional Engineer (Civil Engineering) and Executive Professional Civil Engineer (JSCE Infra Structure Design)
Prof. Eiichi Watanabe is a Professor Emeritus, Kyoto University and the Chairperson of Board of Directors of Foundation of Osaka Regional Planning Institute. He graduated from Kyoto University in 1964, received his 1st M. Sc. in 1966, from Kyoto University, 2nd M. Sc. in 1968 and Ph. D in 1969 from Iowa State University as a Fulbright grantee and Dr. Eng. from Kyoto University. Professor Watanabe served as a vice president of JSCE from 2004 to 2005 and is serving as a vice president of IABMAS, member of board of directors of ISSC and Chairmen of Bridge Asset Management for Aomori Prefecture and City of Osaka. He is a member of the European Academy of Sciences. His research interests are in the areas of steel structures, buckling, earthquake resistant design, reliability, maintenance and durability of steel bridges, corrugated steel webs, steel cables, creep and relaxation of cables, offshore structures, and floating bridges. He has written over 440 scientific publications besides with about 30 books including Structural Mechanics I and II, Maruzen, 1999 and 2000, respectively (in Japanese), Encyclopedia of Bridges, Blue Backs, Kohdansha, 1991 (in Japanese), editor of Theoretical and Applied Mechanics 1996, Northholland, 1997 and Theoretical and Applied Mechanics, Vol. 50, Science Council of Japan, 2001.

Mr. Henry HAN Lei is Founder and Managing Director of Hann-Ocean Technology Pte Ltd in Singapore. Mr. Han started his professional career as a Naval Architect in Marine Design & Research Institute of China (MARIC) after his graduation from South China University of Technology (SCUT) in 1986, where he obtained his B.Sc. degree in Naval Architecture & Ocean Engineering. In 1992, he came to Singapore and worked with Conan Wu & Associates, Naval Architects. Since 1994 till July 2005, Mr. Han had had been employed as a Senior Engineer and later as Project Manager by Defence Science & Technology Agency (DSTA), providing technical advice for marine platform designs, and leading in many naval project managements. Mr. Han developed many innovative solutions/designs for the Republic Singapore Navy and won numerous awards on innovations during his career with DSTA, including Eureka Award 2003 in International Exposition of Innovation and Quality Circles. He is the inventor of Han’s Fender Connector and Han’s Frictional Locking Connector resolving the key challenges in joining large floating platforms in rough seas. His first pontoon connector design has been implemented successfully in a military joined floating platform. He established Hann-Ocean Technology in 2005 with the aim to further develop the military technology for commercial applications. Hann-Ocean has successfully developed a novel All-in-One Multifunctional Rigid Pontoon Connector in its first year. Mr. Han also received his M.Sc degree in Smart Product Design from Nanyang Technological University. Mr. Han now still serves as a regular technical consultant for DSTA.

Registration Details

Registration Fees (Course registration fees include course materials, refreshments and lunch)

Participants from Singapore: SGD250.00 + Prevailing GST
Overseas participants: SGD250.00 (GST Exempted)

For enquiries, please call Ms Lilian CHOONG at Tel: 6516 5113. Alternatively you can drop an email at engcll@nus.edu.sg

To register, mail or fax the completed registration form to:

Professional Activities Centre
NUS Faculty of Engineering
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Singapore 117576
Fax: (65) 6874 5097

Payment: Payment is required prior to the workshop. Crossed cheques should be made payable to “National University of Singapore”.

Discount: A 10% discount will be given for companies/organizations sending 3 or more participants for the workshop. NUS Alumni will also enjoy the 10% discount off the registration fees.

Refunds and Cancellations: A 50% refund will be given for withdrawals (received in writing) ten working days before the commencement of the workshop. No refunds will be made thereafter. However, a replacement will be accepted upon prior arrangement at no extra cost. Please inform us of the changes, if any, by fax.

The Organizer reserves the right to cancel the workshop and fully refund the participants, should unforeseen circumstances warrant it. Every effort will be made to inform participants of any changes.
Registration Form

WORKSHOP ON VERY LARGE FLOATING STRUCTURES
25th September 2007, Faculty of Engineering, NUS

Registration Fees:
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Overseas participants: SGD250.00 (GST Exempted)
* Course registration fees include course materials, refreshments and lunches

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Closing Date: Please send in your registration form together with your payment by 18th September 2007, Tuesday