NUS National University of Singapore | Centre for Offshore Research and Engineering Faculty of Engineering

Centre for Offshore Research and Engineering (CORE)

at Maritime Institute @ NUS

Y. K. Chow
Director, Maritime Institute @ NUS
Executive Director, CORE

Y.S. Choo
Director (Research), CORE

Mission and Key Objectives

NUS National University of Singapore | Centre for Offshore Research and Engineering Faculty of Engineering

Mission

To be a leading Centre in research & development, and education & manpower training for the advancement of the offshore and maritime industry.

Key Objectives

- To develop strategic research and development programmes that result in knowledge generation and intellectual property creation
- To develop education programmes and manpower training for Singapore's offshore and maritime industry
- To actively promote R&D collaboration with industry, A*STAR research institutes and tertiary institutions to transform Singapore into an offshore and maritime hub of global significance

Professorships

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- **Keppel Professorship**
  - Prof Torgeir Moan, NTNU (Dec 2002 - Dec 2006)
  - Prof Andrew Palmer
- **Lloyd's Register Educational Trust Professorship**
  - Prof Peter Marshall, formerly Shell (Mar 2007 - Mar 2009)
  - Prof Choo Yoo Sang
- **Maritime Technology Professorship (MPA)**
  - Prof Rodney Eatock Taylor, Oxford University
  - Prof Paul Taylor, Oxford University
  - Prof John Dempsey, Clarkson University
  - Dr John Halkyard, formerly Technip
- **EDB Subsea Engineering Professorships Programme**
  - Dr Bil Loth, WD Loth and Company

Major Research Programmes

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- **Offshore Technology Research Programme (A*STAR, MPA)**

15 projects including smart sensing; re-assessment, retrofitting, and repair of offshore structures; intelligent deepwater mooring systems; LNG sloshing; subsea processing; AUV; methane hydrates; pipeline-soil interaction; jack-up foundations; plate anchors; torpedo anchors

- **Multiphase Flow Analysis for Downhole Oil & Gas Equipment (A*STAR)**

7 projects addressing constitutive and numerical modeling of multiphase flow, and multiphase flow processes and issues concerning flow assurance; heavy oil production and downhole equipment design

- **Materials Innovation for Marine & Offshore Industry (A*STAR)**

6 projects covering mainly design and analysis of composite risers and joints; fatigue, durability and impact survivability of composite risers; study on novel composite materials for risers

JIP on Static and Fatigue Strength of Grouted Tubular Joints

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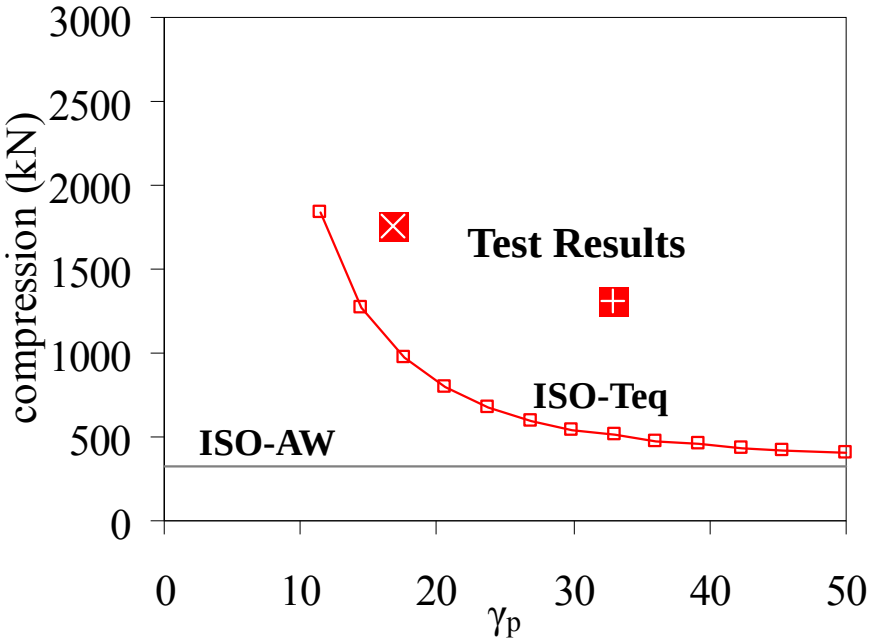

Project Sponsors: American Bureau of Shipping, ClassNK, Densit, Lloyd's Register, McDermott International, Petronas Carigali, Tata Steel

Results: Large-scale laboratory tests demonstrate that the presence of in-filled grout changes significantly the joint stiffness and failure mode. Numerical analyses able to capture the observed joint behavior. Current ISO recommendations significantly under-predict joint strength.

Research scope and details for Phase 2 of JIP being finalised.

InSafe Joint Industry Project

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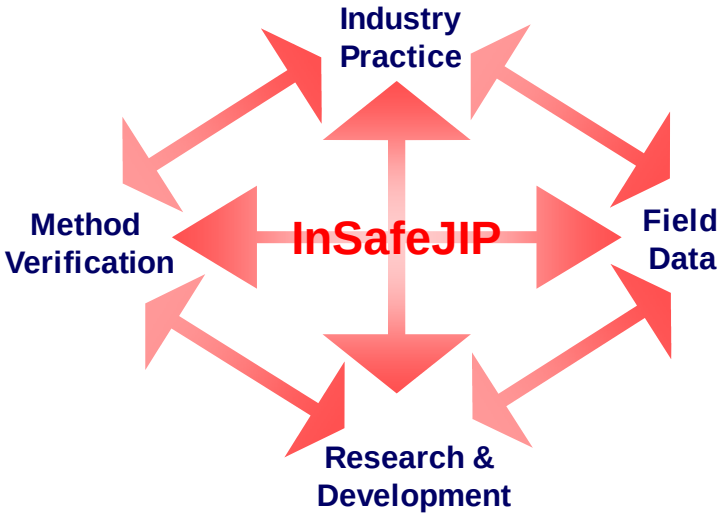
IMPROVED GUIDELINES FOR THE PREDICTION OF GEOTECHNICAL PERFORMANCE OF SPUDCAN FOUNDATIONS DURING INSTALLATION AND REMOVAL OF JACK-UP UNITS

Work Scope

- Site investigation & lab testing
- Spudcan bearing capacity predictions; punch-through
- Spudcan operation related issues



Project Team

RPS Energy

University of Oxford

NUS National University of Singapore

The University of Western Australia

Project Sponsors

American Bureau of Shipping	GEO-Danish Geotechnical Institute	Noble Drilling
Braemar Falconer	GL Noble Denton	Premier Oil & Gas Services
ConocoPhillips	Global Maritime	Premium Drilling/COSL
DONG Energy	HSE UK	Shell UK Limited
ENSCO International	Keppel Offshore & Marine	Transocean (Global Santa Fe)
ExxonMobil	Maersk Drilling	
Fugro Singapore	Matthews Daniel	

Joint Industry Projects (JIPs)

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JIP on Improved Partial Joint Penetration (PJP-plus) Welded Tubular Joints

Objective: To examine the fatigue performance of a new type of welding details (PJP+) for critical tubular joints in offshore platforms subjected to cyclic actions.

Project Sponsors:

ABS, HGG, McDermott, Nippon Steel Engineering

JIP on Spudcan-Pile Interaction

Objective: *To carry out c*entrifuge model tests and large displacement Finite Element simulations to study the mechanism of spudcan-pile interaction and propose rational design methodology.

Project Sponsors*:*

ABS, ExxonMobil, Shell, Total, Keppel Offshore & Marine

JIP on Spudcan-Footprint Remediation

Objective: To investigate the effectiveness of various mitigation measures through centrifuge physical modeling and advanced numerical simulations.

Project Sponsors:

ABS, ConocoPhillips, ExxonMobil, Keppel Offshore & Marine, Fugro, GL Noble Denton, Maersk Drilling, MPA Singapore

Some Challenges in Deepwater Technology

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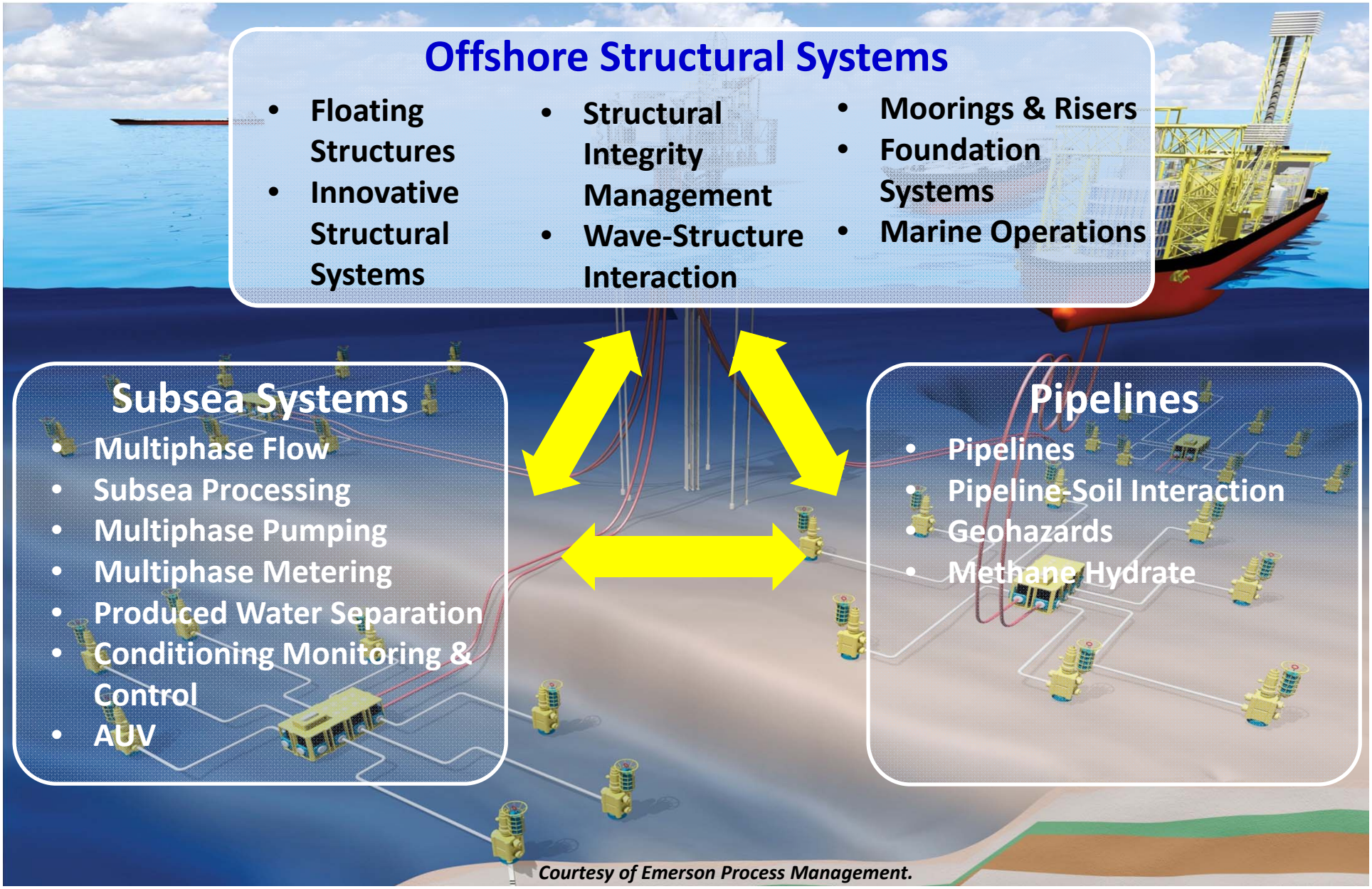


Offshore Structural Systems

- Floating Structures
- Innovative Structural Systems
- Structural Integrity Management
- Wave-Structure Interaction
- Moorings & Risers
- Foundation Systems
- Marine Operations

Subsea Systems

- Multiphase Flow
- Subsea Processing
- Multiphase Pumping
- Multiphase Metering
- Produced Water Separation
- Conditioning Monitoring & Control
- AUV

Pipelines

- Pipelines
- Pipeline-Soil Interaction
- Geohazards
- Methane Hydrate

Courtesy of Emerson Process Management.

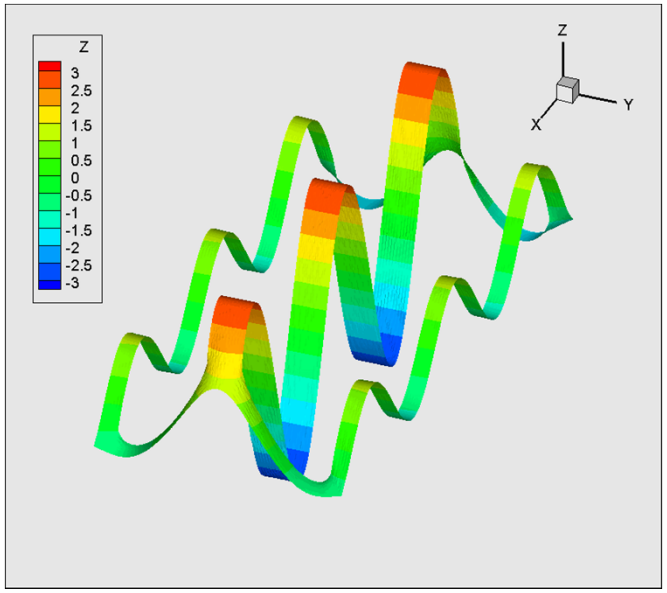
Coupled Response of Side-by-Side Operations

Source: seabreezes.co.im

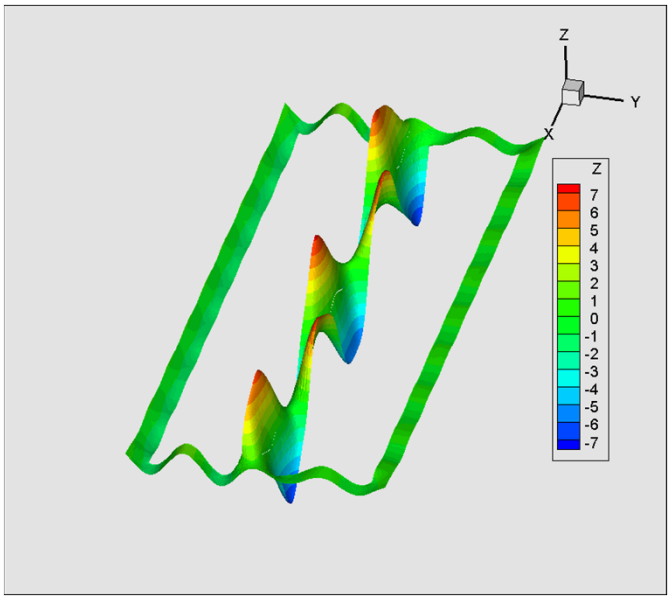
Motivation: Concerns for floating systems during side-by-side operations which can result in highly nonlinear response

Approach: DIFFRACT and OpenFOAM development

Example: Free Surface Resonance in narrow gap for FPSO/FLNG and tanker operations



Surface Resonance in Gap for Head Sea



Surface Resonance in Gap for Beam Sea

Innovative Structural Systems

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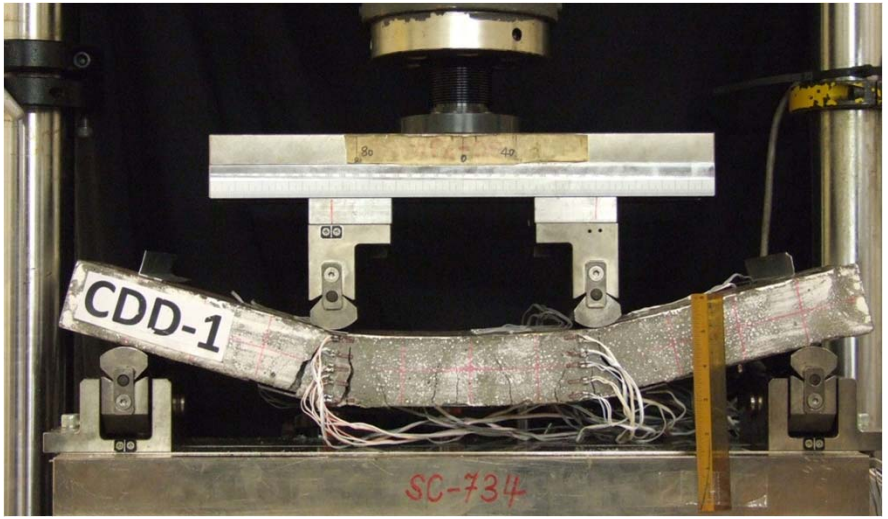
Motivation: Structural weight and strength important for floating structures

Approach: Maximise structural performance through innovative schemes (e.g. different concrete/grout , J-hooks, interface texturing)

Example: **Integrated Steel-Concrete-Steel System Through Laser Welding**



Type of beam	Ultimate Load kN
Plain Grout	2.6
Grout with top + bottom plates	3.8
Integrated SCS CSD-1	24.7
Integrated SCS CDD-1	36

Results: Highly ductile behaviour (CDD-1) with ultimate strength **1300%** higher than plain grout specimen.

Possible Applications: double-hull side shells or bottom, impact barrier, fire & blast wall

Structural Integrity Management (SIM) of Offshore Systems

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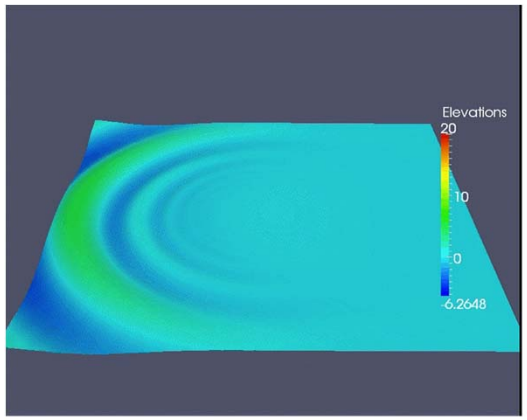
Motivation: Structural/Asset integrity is critical for safe operations of fixed and floating offshore systems.

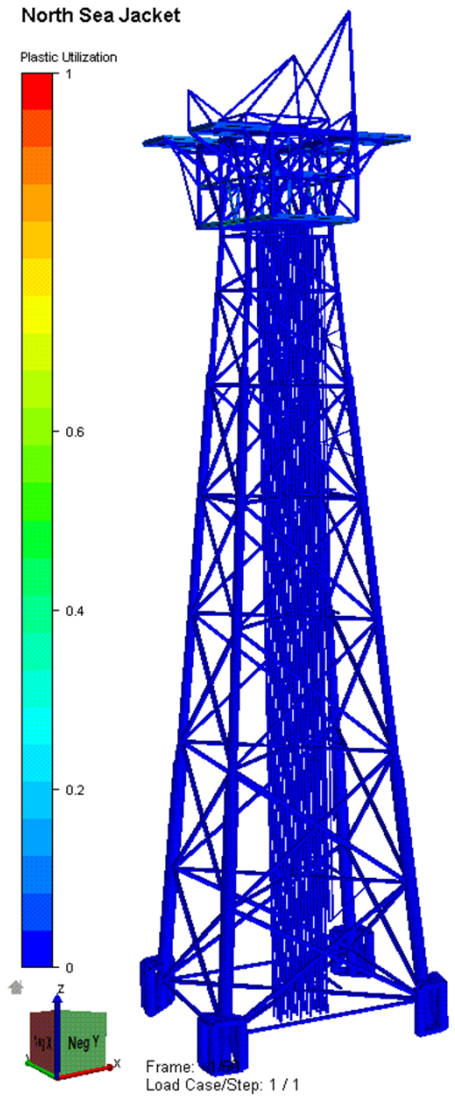
Progress: Systems approach on effects of extreme environmental events on structural and foundation responses.

Example: **Re-assessment of offshore platforms**



Extreme wave representation

SIM Related R&D in CORE: Structural health monitoring, fibre optic- and laser-based sensing, fatigue & fracture, strength enhancement



Pushover analysis

Effects of Current Blockage on Offshore Structures

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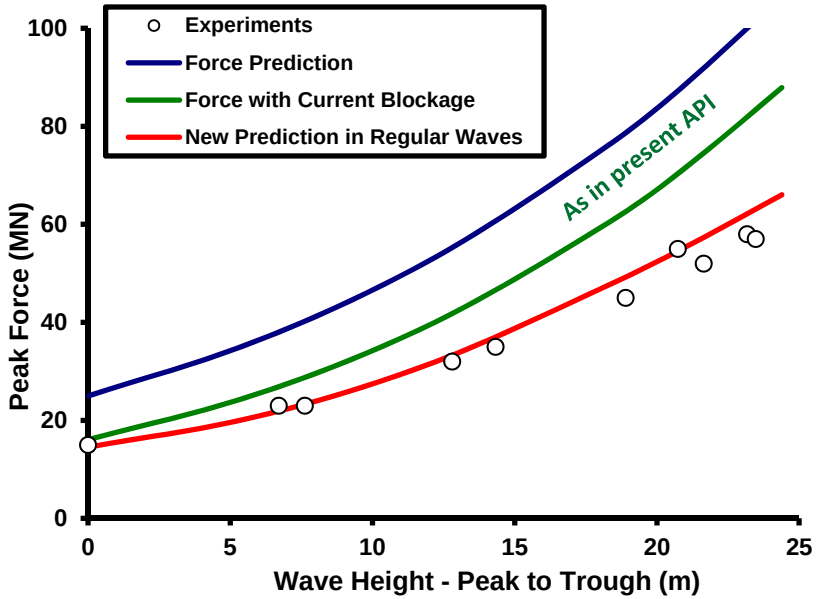
***Motivation**:*

Improved prediction of wave and current loadings on compliant towers

- partly in response to BP Macondo accident, push for dry tree solutions
- forces and responses are over-predicted using conventional approach

Re-analysis of tank tests from Allender & Petrauskas - Chevron (OTC 1987), 2.5m/s current + regular waves

Design approach for compliant towers: loads resisted by combination of dynamics + strength



Findings:

Current only → blockage

Wave + Current → extra blockage

Offshore Riser Arrays

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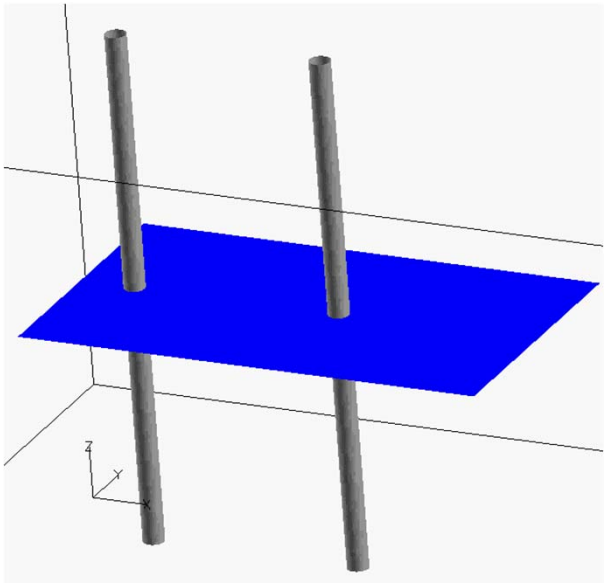
Objective

Accurate and efficient numerical modeling of vortex induced vibration (VIV) suppression devices for riser arrays at high Reynolds number:

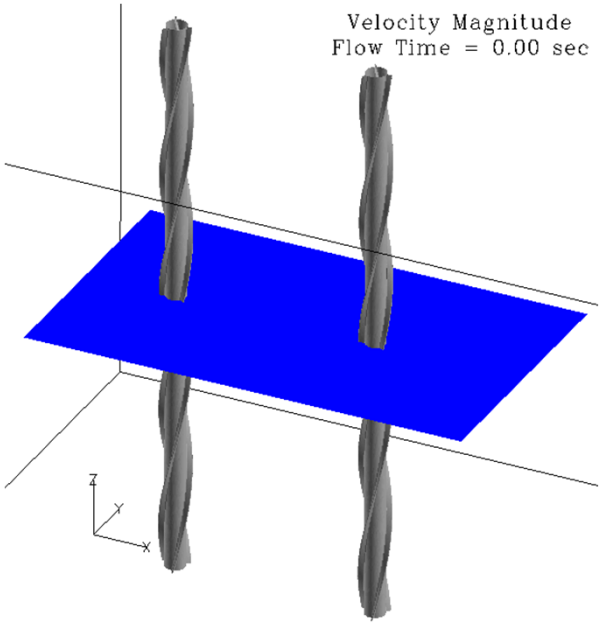
- Determine mutual interactions of risers
- Find elegant and effective means to suppress VIV



Research Methodology

Nonlinear Fluid-Structure Interaction

- Novel iterative staggered procedure
- Strong inertial-coupling effects for long risers at mass ratio m* ≈ O(1)



Fatigue Analysis and Life Prediction of Composite Risers

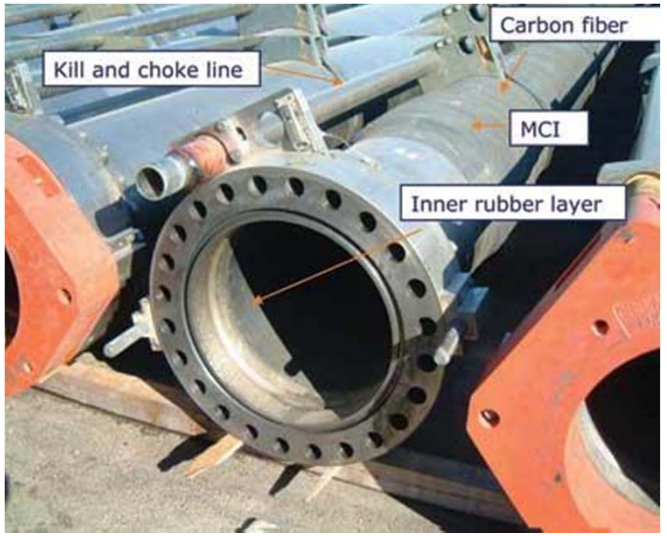
NUS National University of Singapore
Centre for Offshore Research and Engineering
Faculty of Engineering

Objective

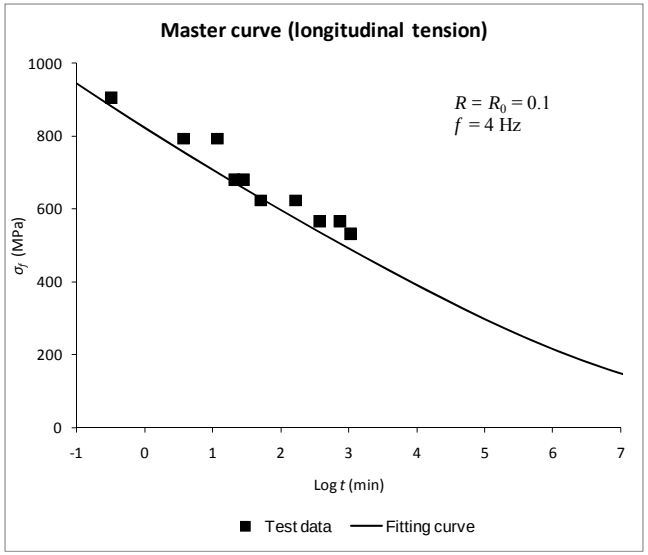
To investigate the long-term behavior and life of composite risers under cyclic fatigue loadings in seawater environment.

Research Methodology

- Fatigue tests of composite materials used in risers under different stress ratios;
- Fatigue model based on master curves and Puck's criterion for long-term and cyclic loading conditions;
- Damage mechanisms to account for damage accumulation during fatigue loadings;
- Seawater environment to be considered in the fatigue analysis.



Composite riser (joint)



Fatigue master curve

Plate Anchors for Permanent Mooring in Deepwater

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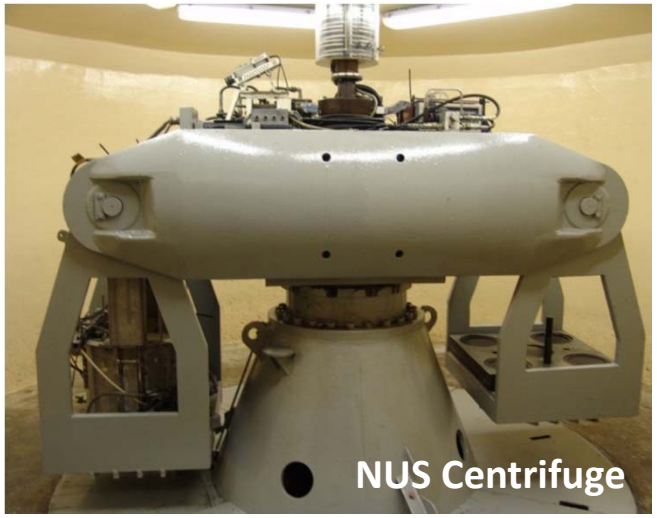
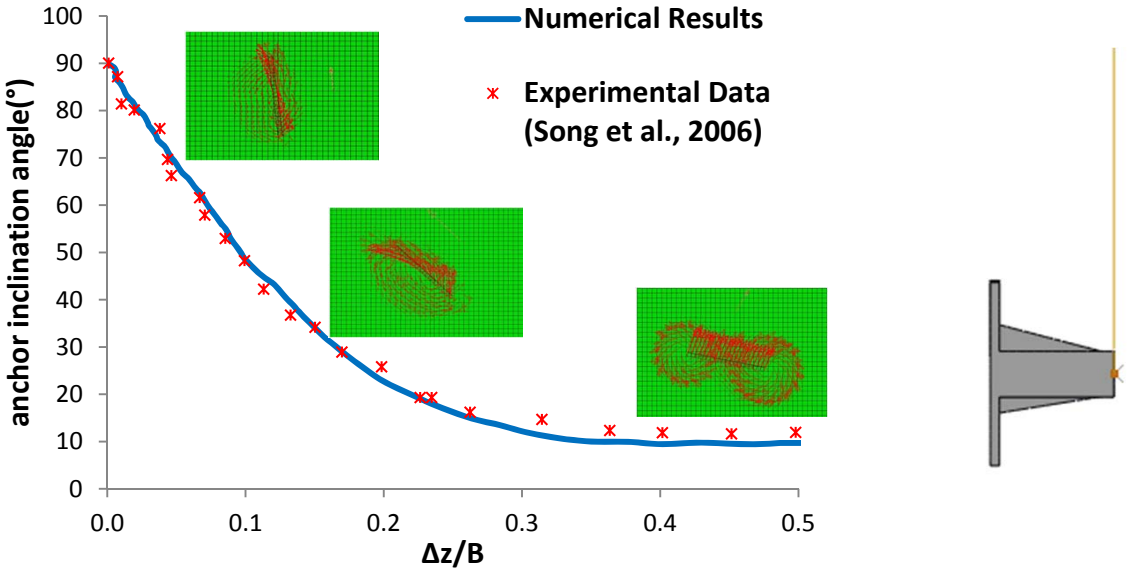
Methodology :

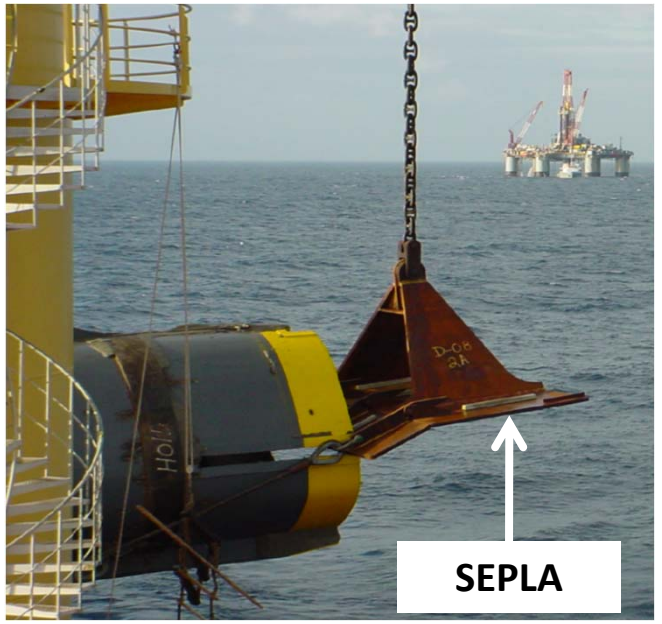
- Geotechnical centrifuge experiments
- Large displacement finite element analysis

Key considerations:

- Loss of embedment during keying reduces anchor capacity due to shallower embedment in weaker soil
- Soil remoulding during keying will further degrade anchor capacity
- Long term capacity of plate anchor







Source: ATP Oil and Gas Corporation

Deepwater Dynamically Installed Anchors

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Centre for Offshore Research and Engineering
Faculty of Engineering

Objective

To improve the current design methodology for dynamically installed anchors by focusing on quantification of design unknowns and installation uncertainties.

Source: Araujo, J. B. d., R. D. Machado and C. J. d. M. Junior, OMAE2004-51201.

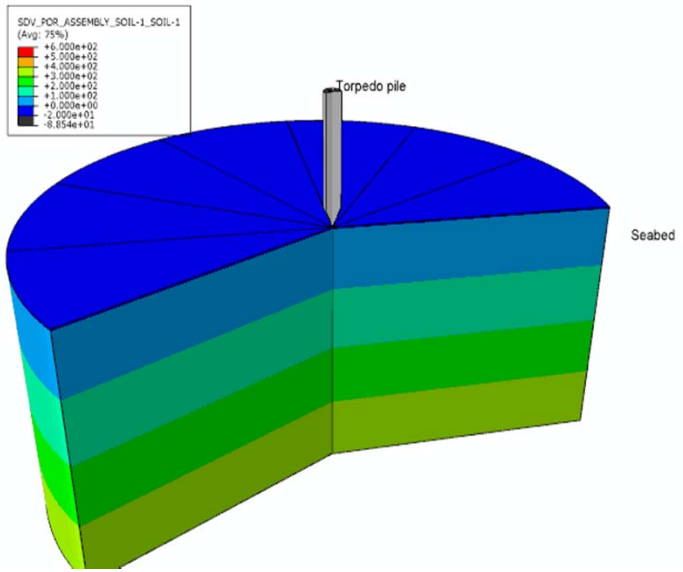
Research Methodology

Anchor - Current Interaction

- Computational Fluid Dynamics Simulations

Anchor - Soil Interaction

- Physical modelling using geotechnical centrifuge
- Large displacement finite element simulations



Simulation of Floatover Operations

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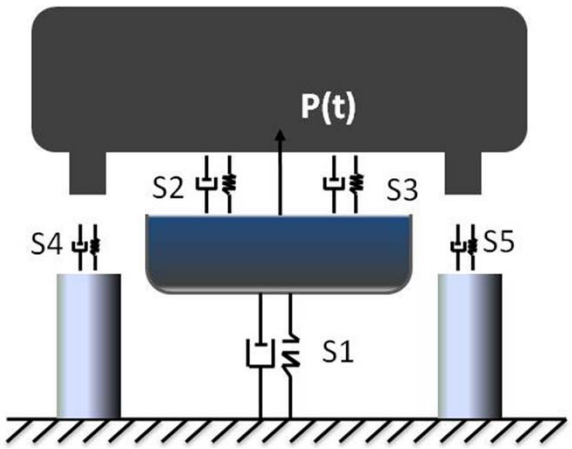
Motivation: Floatover operations increasingly important for offshore/near-shore integration of offshore systems

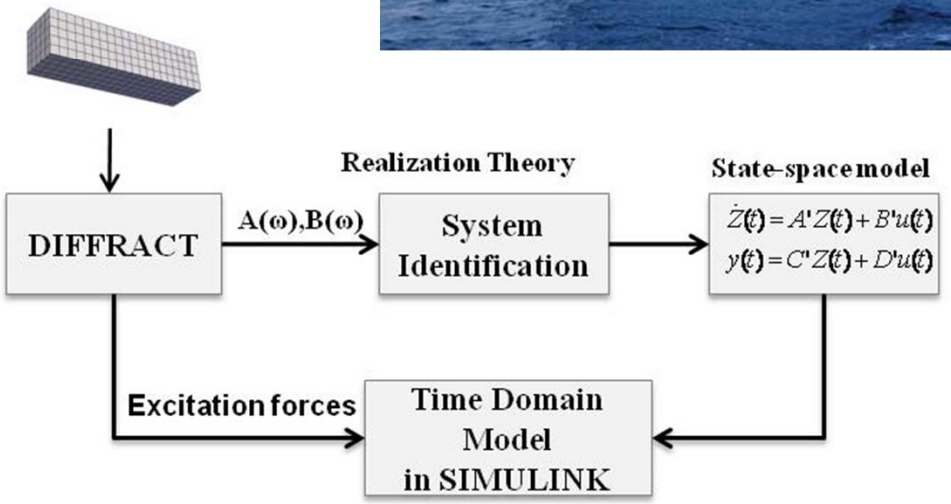
Progress: Time domain simulations including impact being developed

Floatover Installation for offshore platform
(Courtesy: McDermott)

Floatover Installation for Kikeh Spar
(Courtesy: Technip)



Representation for impact analysis



Time domain floatover simulation integrated with DIFFRACT

Thank you