Ice Ridge Loads on Floating Offshore Structures

François Pétrié – OCEANIDE
Lee Hedd – OCEANIC
Jean-Marc Cholley – TOTAL
Reference: CITEPH-27-2009

Duration: 3 years (2009-2011)

Papers: OTC-22050, OTC-22099 (ATC 2011) & OTC-23758 (ATC 2012)
OCEANIDE

Founded in 1986, located south-east of France

Providing engineering & basin model testing services to O&G Companies/Contractors for offshore and coastal developments

Operating 3 tests facilities including the BGO FIRST deep basin

MARINE OPERATIONS

BP / Aker : Clair Ridge jacket launching

SEA KEEPING

TOTAL / HOE : MOHO-NORD TLP Transportation

SUBSEA

MURPHY / SBM : Kikeh offloading line (GAP)
OCEANIC

Founded in 1993, located St John’s (Canada)

Provides contract research into the performance of marine systems in their environments. Specializing in hydrodynamics and arctic and cold region environments.

Working with Memorial University & National Research Council Canada’s Institute, offering facilities and scientific support.

ICE MODEL EXPERIMENTS

SEAKEEPING

CONSULTING / NUMERICAL SIMULATION

Maneuvering of a PSV in ice

Motion studies for a Semi

Flowlines over an Articulated Tug and Barge
A FEW DEFINITIONS – 1 of 2

RIDGE: structure made from broken ice blocks, formed by compression and shear forces at edges of large ice floes. Up to 80m x 20m size.

Ridges often represent the ultimate design load state for structures operating in ice, but their effect on structures is not well known.
A FEW DEFINITIONS – 2 of 2

MIZ (Marginal Ice Zone): transition between free sea and ice-pack

It is accepted that waves damp out in MIZ, but the relationship between the amount of wave damping with ice concentration and distance into the ice field is not fully understood. Wave conditions shall be known in MIZ for safe operations and design purpose.

Drilling platform "Vidar Viking" in the foreground. Icebreakers in the background smashed the drifting sea ice in order to keep the position of the drilling platform stable.

A : Ice covered sea
B : Marginal Ice Zone
C : Open sea
SCOPE OF WORK – 1 of 3

To analyze wave propagation at Marginal Ice Zone (MIZ)

Â Investigate the effect of ice concentration, distance into the ice field, wave height ... on the wave damping, using scaled model tests
Â Compare to existing analytical models and evaluate their accuracy
SCOPE OF WORK – 2 of 3

To enhance the prediction of ice ridge loads on offshore structures

- Investigate the effect of parameters such as ridge size, bow shape, mooring stiffness... using scaled model tests
- Compare the results with existing analytical formulas
- Evaluate the robustness of numerical simulations
SCOPE OF WORK – 3 of 3

To deliver an ‘handbook of best practice’ for the assessment of ice loads on offshore structures using model tests

Although it is likely that the approaches recommended in ISO19906 are conservative when it comes to estimating the magnitude of the loads for these types of structure, it is possible that these loads are too conservative, resulting in excessive structural weight and cost.

Alternative assessments to the calculation method are required. To ensure that the structure being properly assessed, ISO19906 makes some recommendations on the use of model scale experiments for predicting loads on an offshore structure in ice covered water.

They are very broad and cover a wide range of experiment methods and ice conditions. The purpose of this task is to recommend, in detail, methods for assessing the loads on floating, moored structures, using model experiments at a reduced scale in a refrigerated ice tank.
Wave propagation in MIZ

Model tests performed in BGO FIRST basin with ice floes modeled using:
- PVC for bending stiffness
- EPDM + steel for density adjustment

Main findings are:
- Exponential decrease of wave height with number of floes is confirmed
- Influence of wave period on this decrease is quantified (MIZ = low pass filter)
- Much more damping is found than with existing analytical models

Results will be implemented in HYCOM (Fram Strait, Barents Sea) and METAREA (Beaufort Sea) weather forecasting systems through CITEPH-64-2012 project, in collaboration with a Norwegian and a Canadian institute.
Ridge loads on floating structures

Model tests performed in NRC Ice Basin

**SPAR**
- Unconsolidated Ridge, upright and 8 degree tilt
- Cone only, speed variation
- Consolidated Ridge, upright and 8 degree tilt

**FPU**
- Two bow shapes
- Mooring stiffness variation
- Drift speed variation
- Consolidation

**NUMERICAL SIMULATIONS**
- SPAR and FPU in unconsolidated ridge

Numerical simulation of a SPAR in ice ridge

SPAR model in ice ridge

FPU model in ice ridge
Ice ridge loads on floating structures

**Large effect:**
- Ridge depth
- Consolidation
- Ice density

**Some effect:**
- Mooring stiffness

**Little effect:**
- Drift speed
- Parent ice sheet thickness
- Length of ridge
Produced a guide for the practical application of model experiments in the analysis of offshore structures in ice;

- Facility design and specifications
- Modeling offshore structure
- Modeling ice features
- Scaling of ice properties
FEEDBACK

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Â· Develop their expertise / new products
Â· Create new synergies with others companies
Â· Demonstrate their capabilities thanks to publishing

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François Pétrié (OCEANIDE) : fpetrie@oceanide.net
Lee Hedd (OCEANIC) : hedd.lee@oceaniccorp.com
Jean-Marc Cholley (TOTAL) : jean-marc.cholley@total.com