The Pencil Buoy Method
Installation of Subsea Structures without Offshore Crane Vessel

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AKER MARINE CONTRACTORS (AMC)

35 years experience worldwide:

- Subsea SURF: Structures, umbilicals, risers & flow-lines
- Floater installation and mooring system
- Topsides transportation and floatover
- Field abandonment
AGENDA

- Pencil Buoy Method Overview
- Shallow Water Pre-Rigging
- Main Padeye Design
- Full Scale Measurements
- Conclusion
THE PENCIL BUOY METHOD

- AMC Patented - Submerged transportation and installation
- Inshore pre-rigging
- Submerged tow - unrestricted seasonal storm
- Lowering to seabed on site
ANIMATION

The Pencil Buoy Method
SHALLOW WATER PRE-RIGG

- Start tow - structure connected to vessel winch wire
- Minimize rigging length to ensure as small module draft as possible
- Ensure safe clearance between lifting gear and vessel propeller/rudder
- Present template example:
  approx. 40 meters
ADVANTAGES – PENCIL BUOY METHOD

- No need for large deck space
- No crane required offshore
- Avoid pendulum motions in air
- Avoid slamming loads
PENCIL BUOY DIMENSIONS

- Carrying capacity: 250 tonnes
- Weight: 55 tonnes
- Height: 29.5 meters
- Diameter: 4.5 meters

- Pencil Buoy with carrying capacity of 150 tonnes exists
- Carrying capacity beyond 350 tonnes is developed
PADEYE IMPROVEMENTS

- Fatigue challenges ⇒ Redesign
- Circular vs. triangular shaped opening
- Flexible connection
- Lower stresses at fatigue sensitive areas
- Robust fatigue performance
THE LANGELED CASE

- Dry weight: 325 tonnes
- Submerged weight: 195 tonnes
- Dimensions: 19.7 x 6.0 x 5.8 meters
- Towing draft: 80 meters
COMPARISON OF STRESSES

Sea State

Hydrodynamic Analyses
  Force Time Series
  FE Model
  Theoretical Stress Time Series

Full Scale Measurements
  Actual Stress Time Series
ANALYSIS OVERVIEW

- Sea States
- Hydrodynamic Analyses: Padeye Forces
- FE Model: Stresses at Critical Locations
- ULS Code Check
- ULS Stress Check
- Rain Flow Counting
- Fracture Mechanics
- S-N Curve
- Fatigue Damage
COMPARISON – DYNAMIC STRESS

Analysed Results

Measured Results

#3 - Analysed Dynamic Stress corresponding to Gauge 1

#3 - Measured Dynamic Stress from Gauge 1
COMPARISON

Standard Deviation of Dynamic Stress - Sea State 1

Standard Deviation of Dynamic Stress - Sea State 2

Standard Deviation of Dynamic Stress - Sea State 3

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Pencil Buoy Method

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DISCUSSION OF LANGELED CASE

Sources of Inaccuracy

- Visually observation of wave data
- Strain gauges – position and corresponding stresses
- Computer tools accuracy

Conclusion

- Measured and analysed results compares well
- Reliable analysis methodology established
- Padeye inspections continued
CONCLUSION OF LANGELED CASE

- Measured and analysed results compares well
- Reliable analysis methodology established
- Padeye inspections continues
A SAFE AND RELIABLE SOLUTION

- The Pencil Buoy method is thoroughly tested
- Easily generalized to shallow pre-rigging locations
- Reduced cost due to vessel type
- Submerged tow – unrestricted
- Analysis strategy is verified
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