Case Study – Airgap Calculations

DNV GL Offshore Technical Seminar

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Case Study Rigs

- H-3 design from early 70’s
- H-6e design from 2005

Both rigs designed according to principle in DNV GL-OS-C103

- In the ULS condition, positive air gap should in general be ensured for waves with a $10^{-2}$ annual probability of exceedance
Air-gap on early rigs - Freeboard on H-3’s

- The H-3 has a survival freeboard of 18.3 m
- Based on experience from the ODECO rigs
- Model test 1972
  - Showed large clearance
  - Evaluated to be appropriate freeboard
- Air-gap analyses early 80’s
  - Large air-gap margin
  - No diffraction or LF roll/pitch considerations

- Will still show positive air-gap under guidelines in DNVGL-OTG-13
- All of the 37 Aker H-3 rigs operated in 30-40 years without accidents from horizontal deck impact
Freeboard on Aker H-6e

- Designed in 2005 - 2006
- Based on Aker H-3, H-3.2, H-4.2 designs
- Designed for 1.5 m clearance to waves in ULS conditions
- Deck elevation based on
  - Extensive analysis
  - Model testing
- Designed according to DNV 2005 revisions
- Airgap analysis inline with DNVGL-OTG-13
Airgap analysis

- Panel model of the hull
- Morison model
- Mass matrix
- Loading conditions – VCG
- Airgap grid/points

- Analysis program
  - Linear radiation/diffraction analysis
  - 6 DOF motions
  - Linear surface elevation
  - Post processing
RAOs and damping

- Damping
  - Stochastic linearization
  - Governing seastates
  - Heave RAO

- Validation and Verification of analysis model
  - Convergence testing
  - Sensitivity analysis
  - Model test
Environmental conditions

- Contour line method
  - DNVGL North Atlantic conditions
  - Site specific conditions

- Wave spectra
  - Jonswap
  - Torsethaugen

- Short crested sea / Long crested sea
Factors to include

- Wave asymmetry
- Static heel
- Low frequent roll/pitch
- Wave current interaction
- Spatial statistics
- Extreme estimate – probability level
Presentation of results

- **Airgap**: Difference in elevation between the bottom of the deck or some other relevant part of the structure and the mean water level. **Instantaneous airgap** includes the presence of waves and corresponding wave induced response of the structure.

- **Wave upwelling**: sum of waves and wave induced response of the structure. Airgap = Deck elevation – wave upwelling.
Post processing

- Wave frequent upwelling =
  - Linear surface elevation combined with wave asymmetry
  - + wave frequent motions

- Dynamic upwelling =
  - Wave frequent upwelling + low frequent effects

- Total upwelling =
  - Dynamic upwelling + static effects

- Statistics of total upwelling, 90% fractile
- Surface elevation plot for complete grid
Surface Elevation RAOs

- “Strange” results for periods <8-10s
- Increased diffraction effect for H-6 seen for several locations, not only close to column
- For both: higher uncertainty for very short period sea-states
  - Small impact on governing sea-state @ Hs=17.3

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Model Test Verification

- Important to compare apples-to-apples
  - Model of the model (mass, mooring, static angles from test)
  - Numerical wave spectrum in correlation analyses if shape different than target
  - Challenging if crest elevations deviate noticeably from design basis

- Calibrate model-of-model appropriately and perform design analyses with calibration results applied in design model
  - Mainly damping level and asymmetry factor

- Slamming measurements
  - Model test normally not direct input to design, slamming measurements is an exception
  - Challenging if noticeable difference between model-of-model and design model
Interpretation of Results - Deck or Column

- Not always straightforward to define split between deck and column
- Continued columns should not be considered as deck
- May matter for definition of negative air-gap
**Operation draft**

- Generally required to maintain positive air-gap in operational draft, unless sufficient structural and positioning capacity can be demonstrated.

**SDIR (Norwegian Maritime Authority) letter to owners with Norwegian flagged rigs, 28 Sept. 2016**

_Dokumentasjon av air gap i operasjonstilstand_

Negativt air gap i operasjonstilstanden kan føre til alvorlig brønnhendelse ved at innretningen settes ut av posisjon. Sjøfartsdirektoratet oppfordrer derfor rederiet til å også utarbeide ny dokumentasjon for operasjonstilstanden med samme metode som nevnt over, for å fastsette ved hvilke værforhold innretningen skal gå fra operasjons- til sikkerhetstilstand, jf. § 10.1.1.2 i byggeforskriften. **Operasjonstilstanden skal alltid ha positivt air gap, med mindre en kan bevise tilstrekkelig struktur- og posisjoneringskapasitet.**

- For a rig with positive air-gap @ survival draft
  - Operational criteria → Positive air-gap

- For a rig with negative air-gap @ survival draft
  - Criteria can be more flexible as structure is required to withstand negative air-gap
  - How much negative allowed?
  - Is station keeping a challenge?
Thank you!
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