Numerical design concept for submerged, axially loaded grouted connections

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Outline

• Introduction

• Large scale tests

• Numerical design concept

• Summary
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Grouted connections - general

Introduction
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Introduction
Grouted connection of jacket support structure

Introduction

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Grouted connection of tripile support structure

Introduction

- Partly submerged ambient conditions
- Axially loaded plus bending
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Laboratory tests under dry ambient conditions

Large scale tests

Current guidelines based on laboratory tests under dry ambient conditions!

ULS (FLS)

Failure mechanism:

• Compression strut failure
• (Locally crushed grout)
Laboratory tests under submerged ambient conditions

Large scale tests

Current guidelines based on laboratory tests under dry ambient conditions!

ULS?  
FLS?
Failure under submerged ambient conditions

Increase of cyclic load

- $F(t) = 0$
- $F(t) > 0$
- $F(t) >> 0$

Initial

Bond loss

Local crushing

Flush out

Gap + Water ingress

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Limit state for numerical concept

Large scale tests

Load cycles / load stage

Stable  Incremental degradation  Progressive degradation

Limit state

$u_{rel}$ [mm]

$u_{rel} \approx -25$ mm

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Finite element model

Numerical design concept

- Rotational symmetry
  → reduced FE-model (CAX4)
- Local crushing of grout
  → Depiction of shear keys
- Stress analysis at shear key interface
  → Very fine mesh
Finite element model

Numerical design concept

- Displacement controlled simulation (by reference point)
- Modelled tubes -> exclude influence boundary conditions
- Grout: nonlinear (CDP)  Steel: linear elastic

Interaction: Surface-to-surface
- Hard contact (normal direction)
  - Penalty $\mu=0.4$ (tangential direction) according to Lotsberg (2013) and Fehling (1990)
Numerical design concept

Flowchart

Input of global load simulation
Comparison laboratory test and FE-simulation

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Design concept for submerged axially loaded grouted connections

Conditions of use

- Submerged ambient conditions
  - different failure mechanism
- Predominantly axial loading

Requirements for FE-model

- 2D rotational symmetric FE-model
  - Depiction of shear keys
  - Nonlinear material (e.g. Concrete Damaged Plasticity)
  - Highly discretized mesh
- Local stress analysis of grout material according to ModelCode 2010
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