Dynamic installation of a slip joint connection

Experimental set up and results

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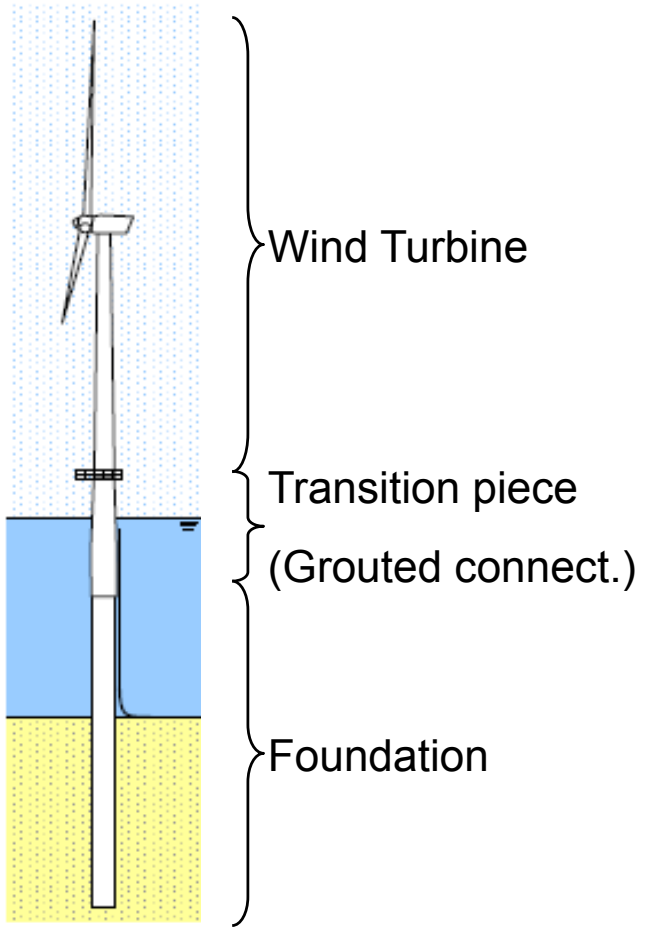
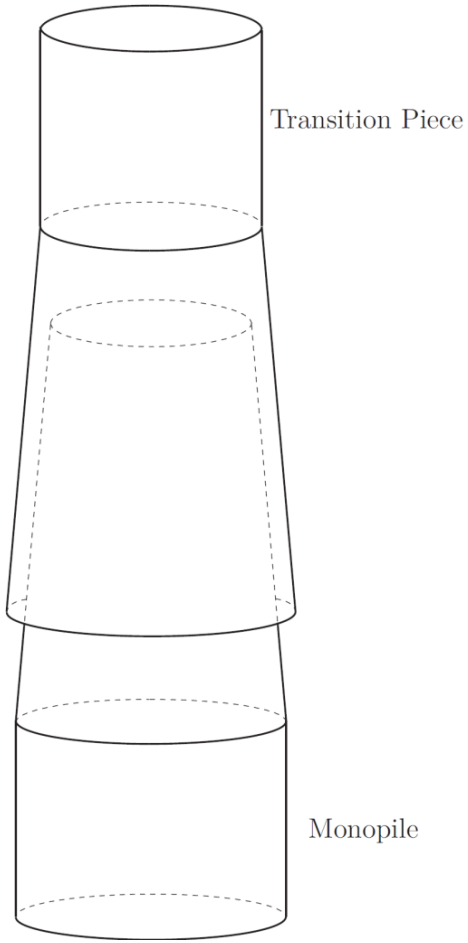
Introduction

- Alternatives for grouted connection are being investigated.
- JIP DNV suggests a conical grouted connection.
- Why use grout again?



Slip Joint Connection

- No layer of grout
- Steel to steel connection
- Friction based
- Not a new idea:
  - Used Onshore
  - Windmaster turbines



[Van der Tempel & Schipholt ,2003]

Slip joint - Opportunities for the industry

- Smaller diameter causes 14% weight reduction of the TP
  - Considering PAWF current dimensions.
  - 1.5% weight reduction on park level.
- No grout:
  - Faster installation.
  - No grout costs, for PAWF +/- 1 mill[1].
- Experience in alternatives.
- Reduction of risk in the future.
- Opportunity for the monopile to go into deeper water.
- More?

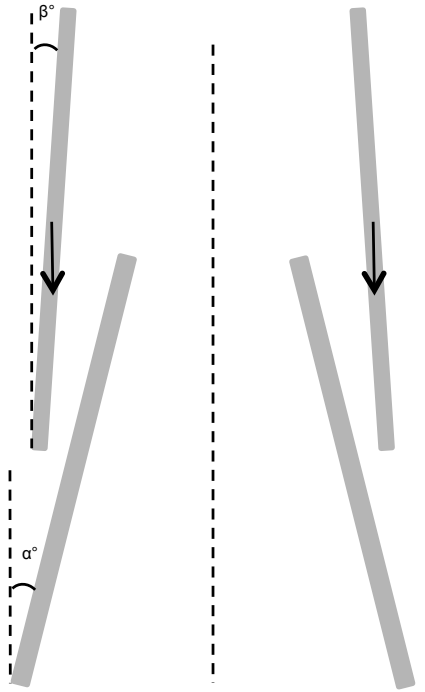
[1] Based on numbers provided by Van Oord

Slip joint project

- Van Oord, WMC and TU Delft work together with the goal to realize certification of the slip joint
- TU Delft focus :
  - Installation offshore
    - Practical goal: Show that a slip joint can be installed by "shaking"
    - Approach:
      - Create simplified models to predict behaviour during installation
      - Perform scale test of the dynamic installation of a slip joint connection
  - (Numerical model of the slip joint (Dr. E. Lourens))
- All results have been promising and stimulate to proceed with the project

Experimental set up & test

- Dimensions based on the OC3 project
  - D_{mp}=6m, t=60mm
  - Cone angle TP 1° and MP 1.05°
  - Scaled 1:10



- Measuring
  - Settlement
  - Strains (axial and circumferential)
  - Accelerations (three directions)

Experimental set up

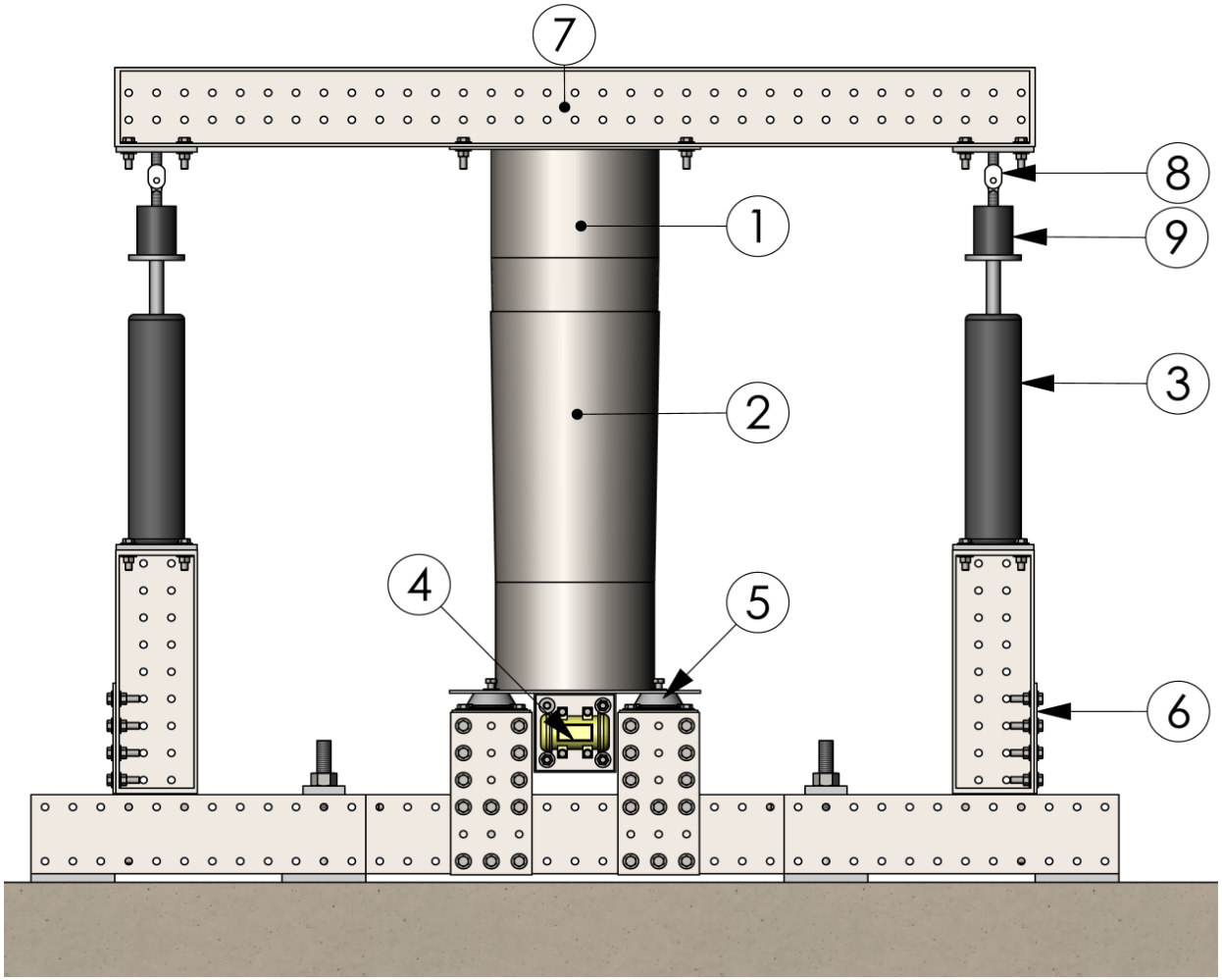
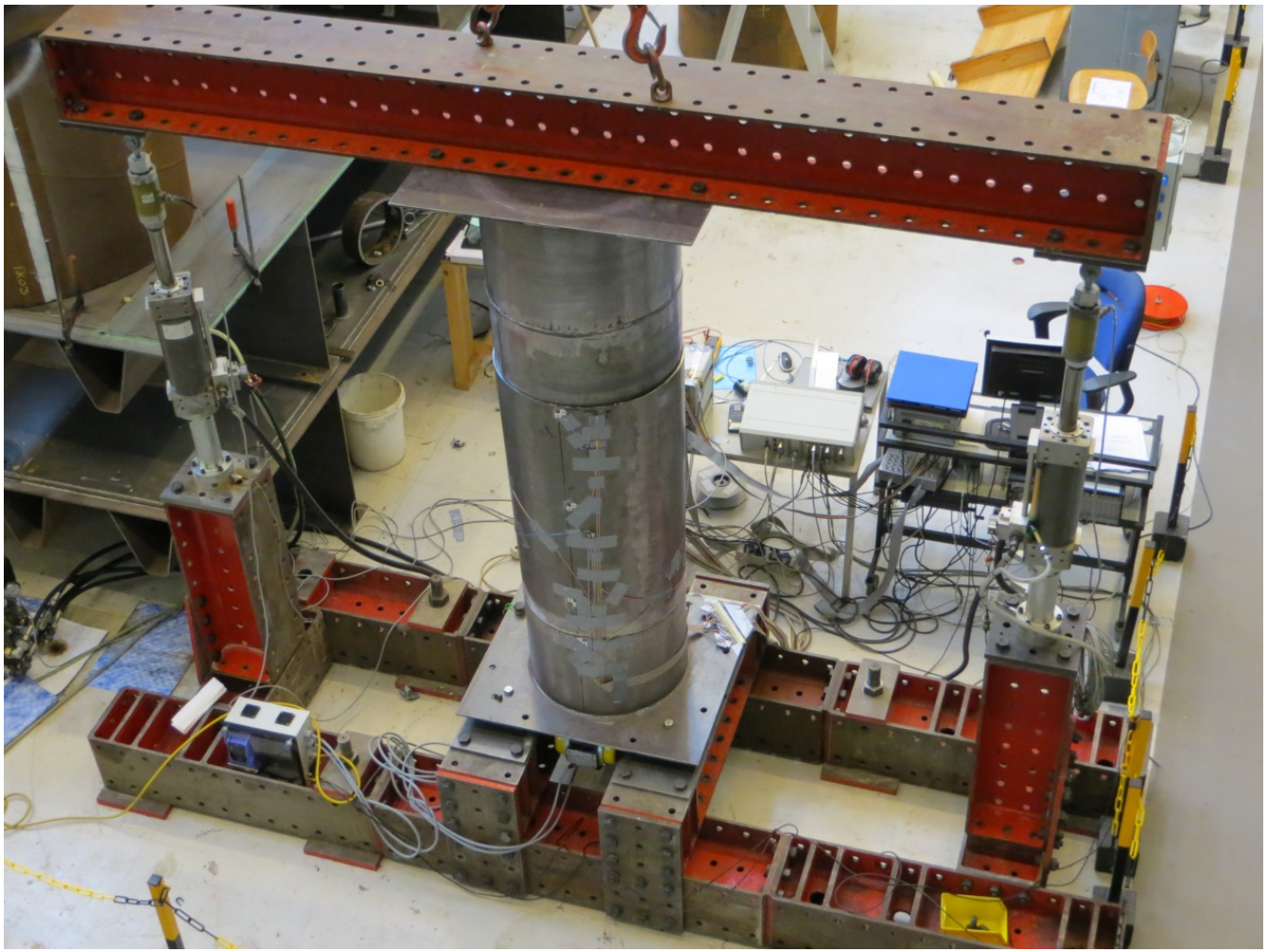


Figure made by Koen Herrmans, Msc 2013

1) Monopile
2) Transition Piece
3) Hydraulic Jack
4) Vibration Block
5) Machine Mounts
6) Tower Mounting Plate
7) Load Beam
8) Hinge
9) Load Cell

Experimental set up



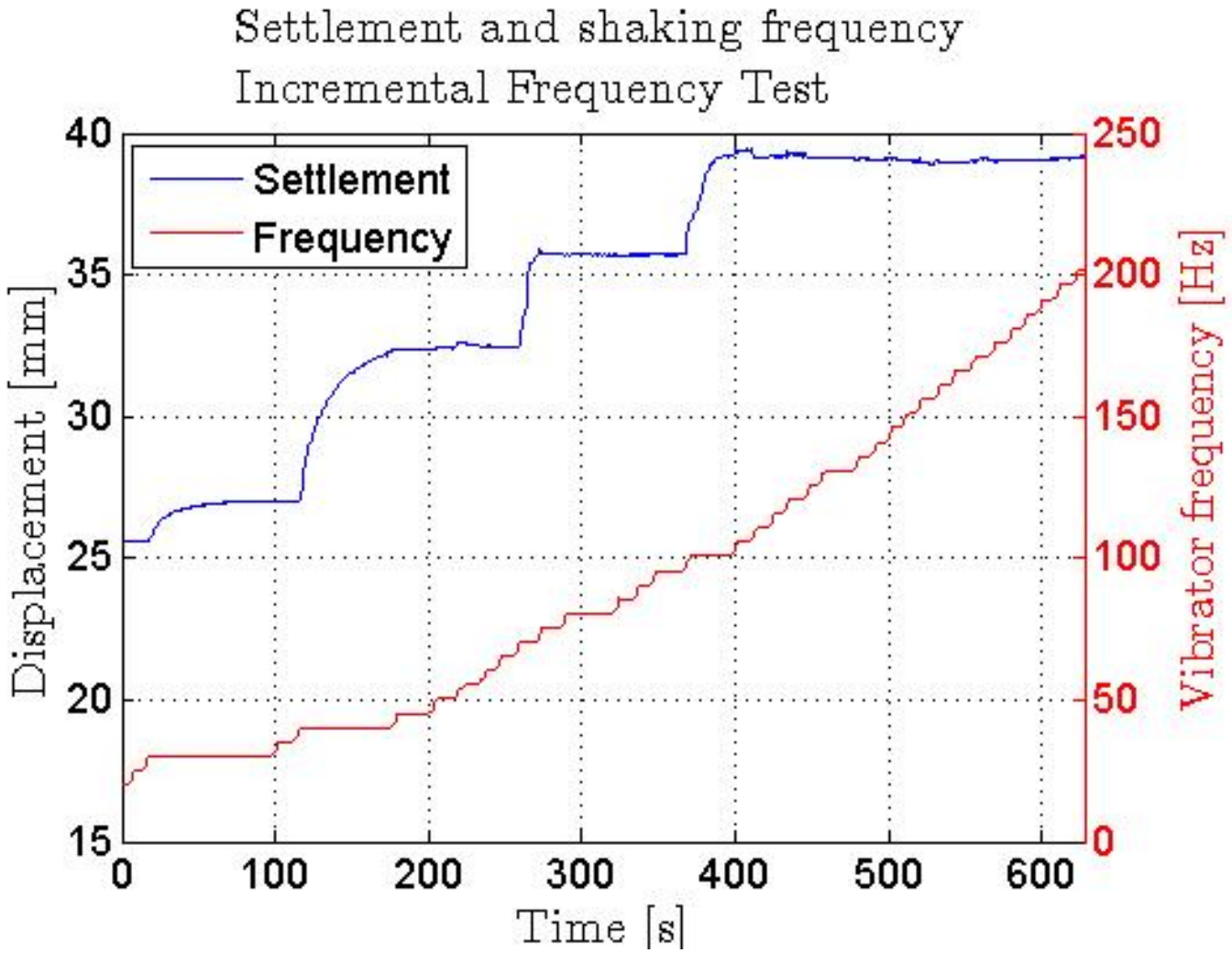
Dynamic installation

- Settlement under self weight with shaker on top

Full scale weight	Axial force	10.6 MN
Scaled	Axial force	10 kN

- Shaker in steps of 5 Hz from 0-200 Hz

Results dynamic installation



Concluding

- Slip joint has potential as alternative to the traditional grouted connection.
- Results of Van Oord, WMC and TU Delft are promising and stimulate to proceed with the project
- Installation of the slip joint is possible by shaking with specific frequencies.

- Future work will focus on:
  - Modal experiments to identify mechanics during settlement.

Thank you for your attention!

Questions?