

Experimental evaluation of backfill around monopiles

Søren Peder Hyldal Sørensen
Department of Civil Engineering
Aalborg University
sphs@civil.aau.dk

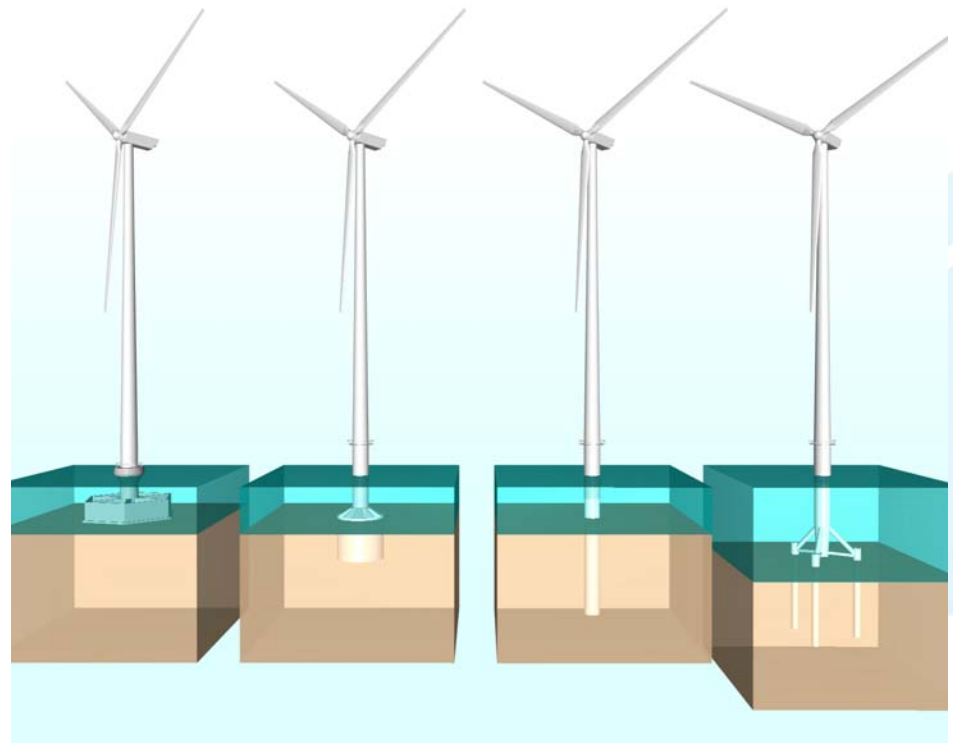
Outline

- Introduction
 - Foundations for offshore wind turbines
 - Scour and backfill phenomena
- Large scale tests on backfill at GWK, Hannover
 - Test procedure
 - Time scale of backfill
 - Relative density of backfilled soil material
- Concluding remarks

Foundations for offshore wind turbines

Several types of foundation

Focus: Monopile foundation



Foundations for offshore wind turbines

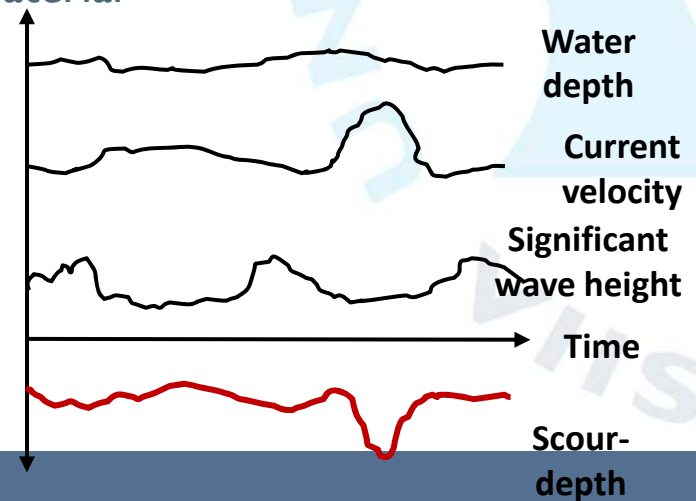
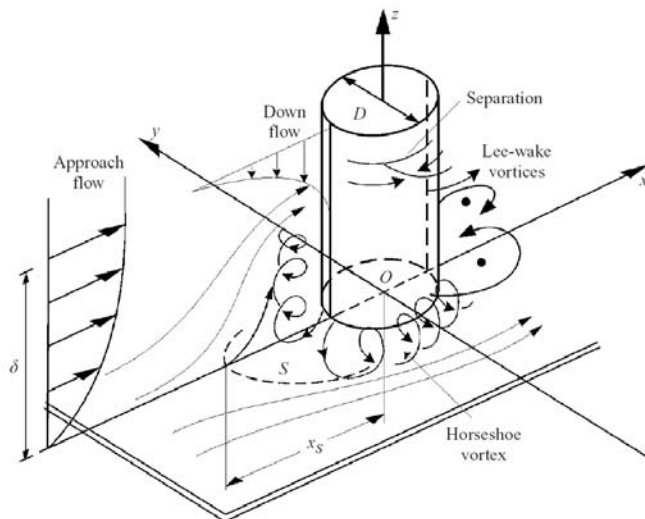
Monopile foundations:

- Steel piles
- Tubular shape
- $D = 4-6$ m
- $L = 20-25$ m



Scour and backfilling phenomena

- Erosion occur around monopiles causing scour holes
The equilibrium depth depends on the sea conditions
 - Current leads to large scour holes – up to $1.3D$
 - Waves leads to small scour holes
- Changing sea conditions leads to changes in the scour depth
- Little knowledge regarding the backfilling process and of the strength/stiffness of the backfilled soil material



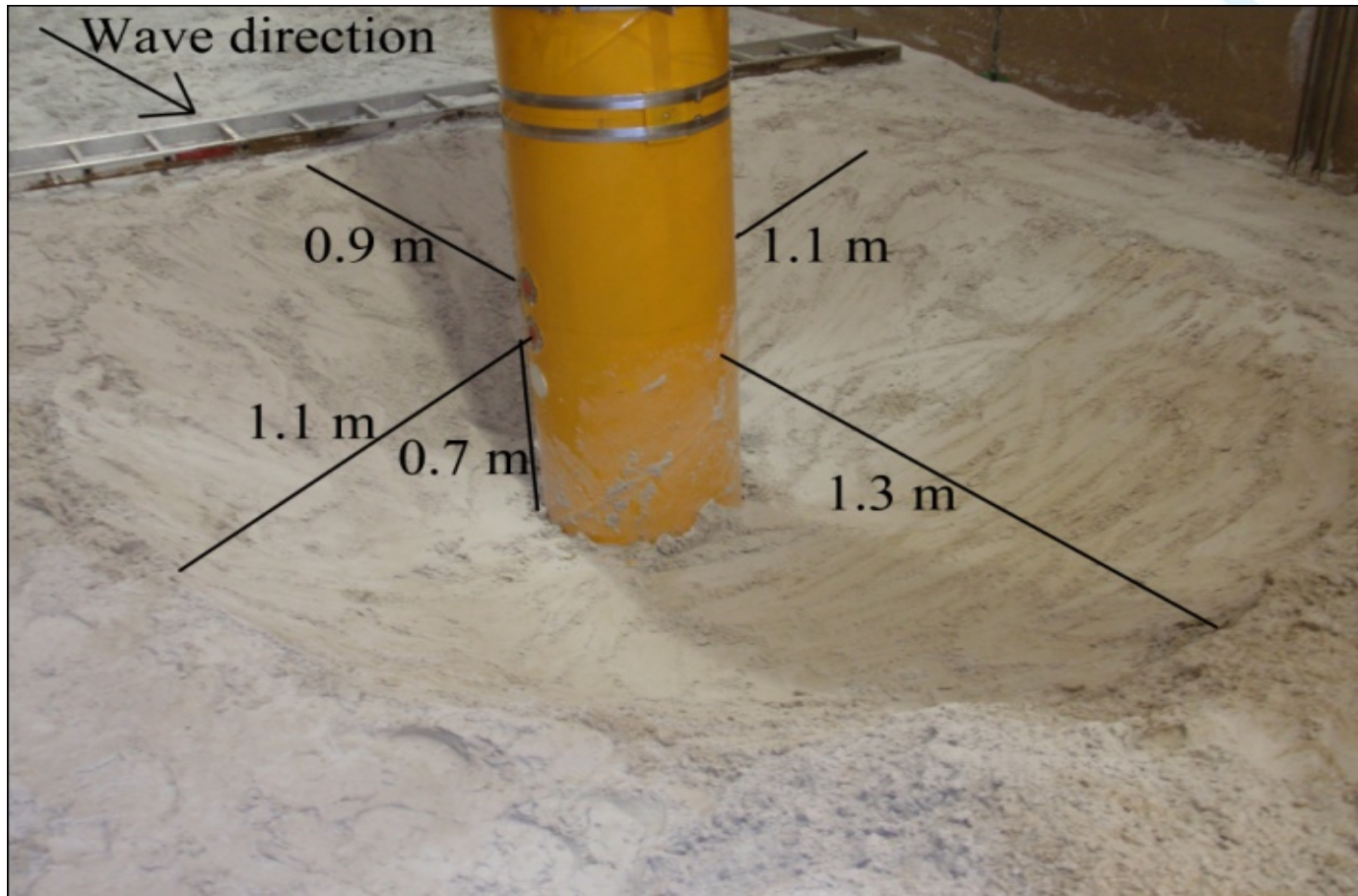
Large-scale test on backfill at GWK, Hannover

Purpose of test:

- To investigate the time scale of backfill
- To determine the relative density of backfilled soil material



Test procedure – preparation of scour hole



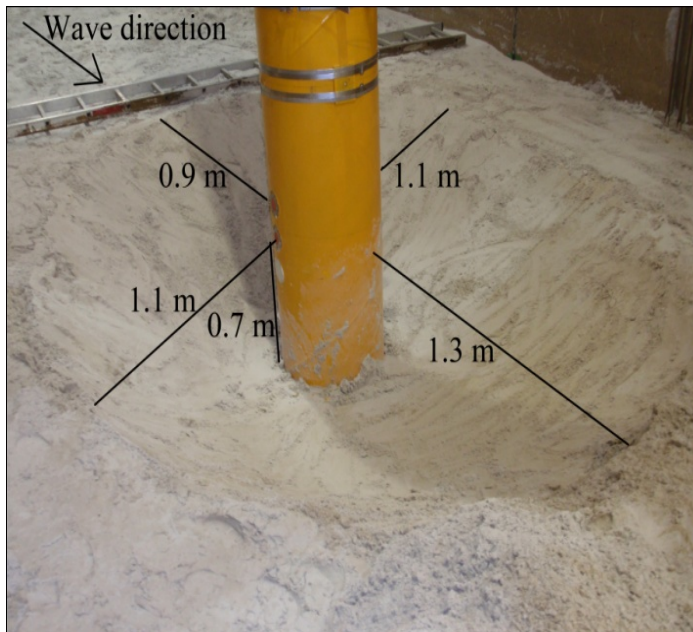
Test procedure – filling in water



Test procedure – Running of waves



Test procedure – Drainage of water



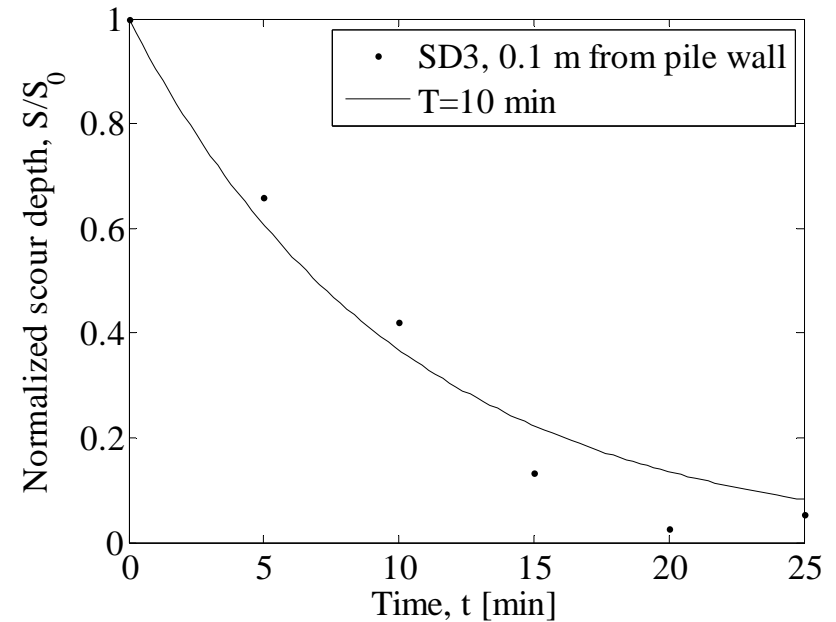
Test procedure – taking soil samples and cone penetration tests



Results – Time scale of backfill

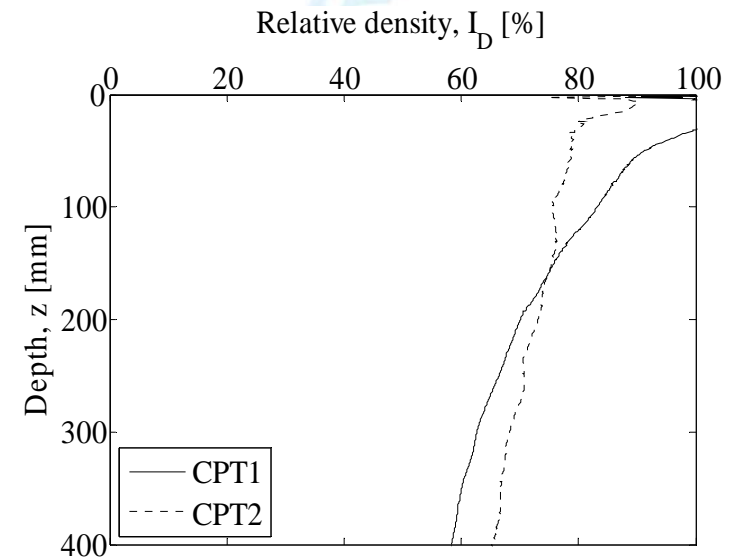
Time scale of backfill:

$$S = S_{\infty} + (S_0 - S_{\infty}) \cdot \exp(-t / T)$$



Results – Relative density of backfilled soil material

Soil sample	Relative density, I_D
1	70 %
2	85 %
3	90 %
4	80 %
5	76 %



Concluding remarks

- Very small time scale for the backfilling process
- Relative densities of 60-80 % - High stiffness and strength of the sand material
- A less conservative design of the foundation is possible:
 - Reduction in wall thickness – Less steel needed
- Further reseach needed
 - Variation of relative density with time
 - Relative density for other sea conditions, and soil conditions