Understanding and Assessing Scour Development at Offshore Structures

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Abstract

Scour around a marine structure is the removal of sediment such as silt and sand, which can result in the formation of scour holes and may compromise the integrity of the structure. A great amount of research has been undertaken in laboratory facilities to measure scour development at vertical piles, in unidirectional flow conditions. This has given scientists and engineers a broad understanding of the mechanisms for the development of scour at a marine structure.

Conditions in the laboratory can never fully mimic the conditions present in the real-world leading to uncertainties about the scouring process. Considerable research has also been carried out, outside of the laboratory and this has helped to fill in some of the gaps however the field data analysed tends to be snapshots of what is going, which again leads to uncertainties.

A powerful tool in scour analysis, monitoring and prevention is an online system which provides continuous measurements over an area around a marine structure. This type of system, will provide a continuous picture of what is going on at the seabed and consequently act as an early warning system for the integrity of the marine structure.

Scour In the Laboratory

Hydrodynamic Field

The change in a flow pattern with the addition of a marine structure will result in one or more of the following (Whitehouse, 1998; Whitehouse *et al.,* 2011):

- Flow Contraction
- Horseshoe Vortex formation in front of the structure
- Lee-wake vortices behind the structure
- Reflection and diffraction of waves
- Wave breaking
- Turbulence generation
- Pressure differentials in the soil leading to liquefaction.

For a circular pile, the principal features of scour (shown in *Fig. 1*) have been heavily researched and are well defined in Figure 1:

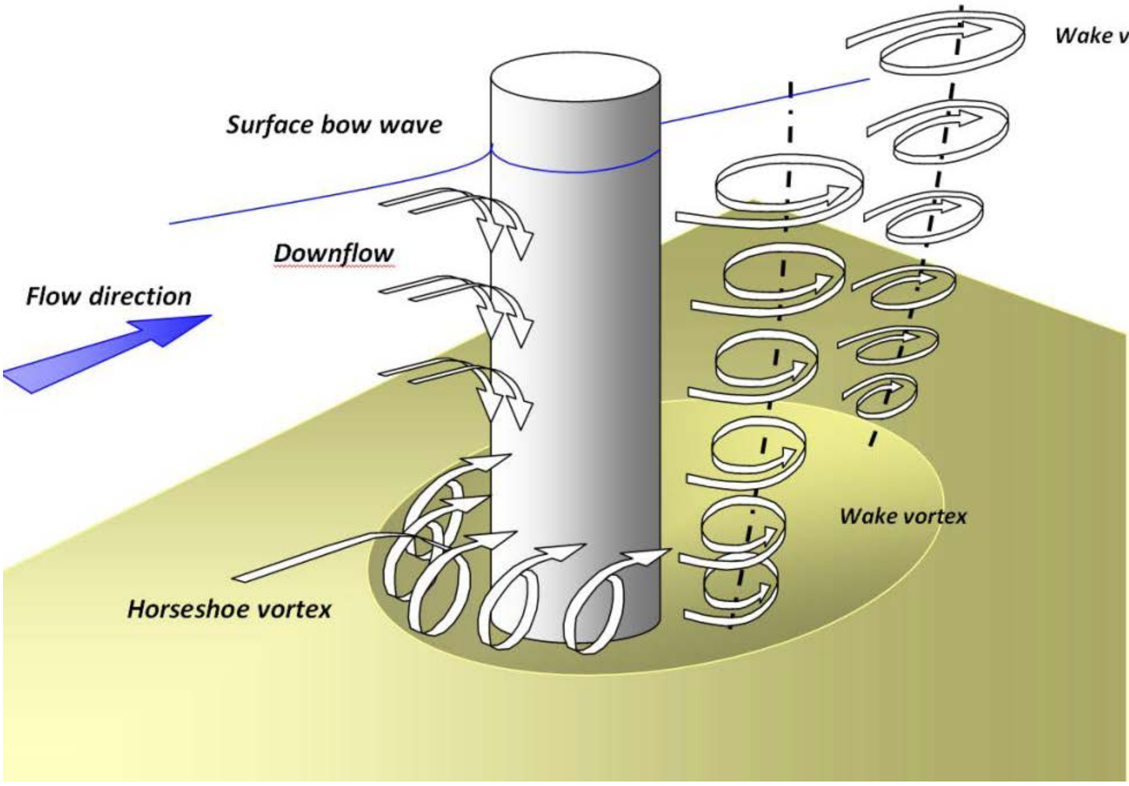

Figure 1: Key hydraulic processes acting at a pile to cause scour

Source: Whitehouse et al., 2011

Marine Bed Composition

Experiments have been carried out researching the effects of different sediment classes. If sand is taken as the benchmark case then in general terms the erodibility is expected to decrease for coarser and finer soils, although muds and clays may be quite variable in their response depending on their cohesion and stiffness (Fig. 2).

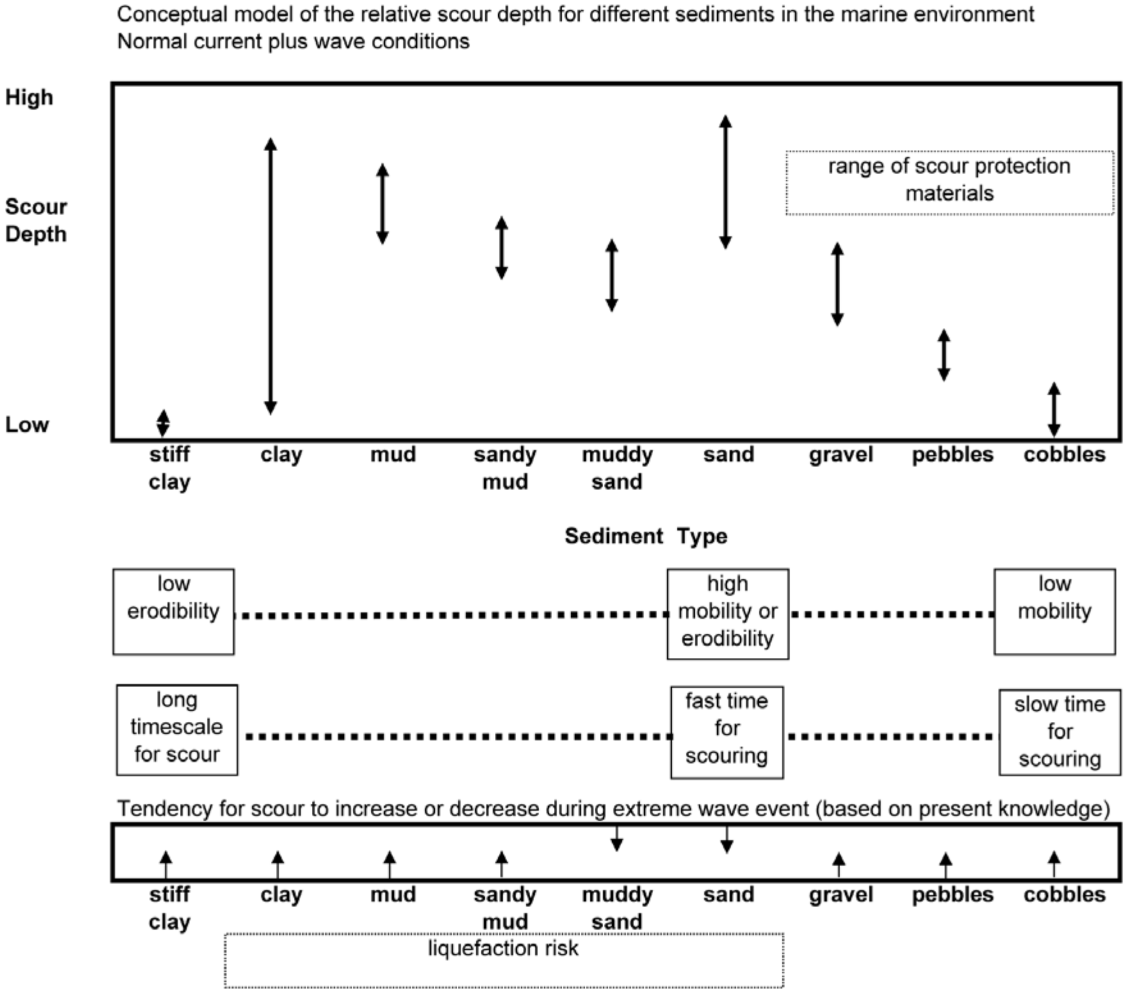

Figure 2: Conceptual model of the relative scour depth for different sediments

Source: Whitehouse, 2006

Scour In the Marine Environment

Outside of the laboratory, marine soils are rarely found to be uniform in structure and can be multi-modal in their grading as well as exhibiting a varying amount of cohesion. This, coupled with the high rate of variability found in currents and waves, makes assessing the extent of scouring in these real soils, far more complex and the methods available for assessment more limited.

Scour Analysis Techniques

Historically, there have been a wide variety of techniques used to routinely monitor scour at a marine structure: Visually, using divers or ROVs, and through acoustic methods such as Multibeam Echo Sounders or SONAR devices (Fig. 3).

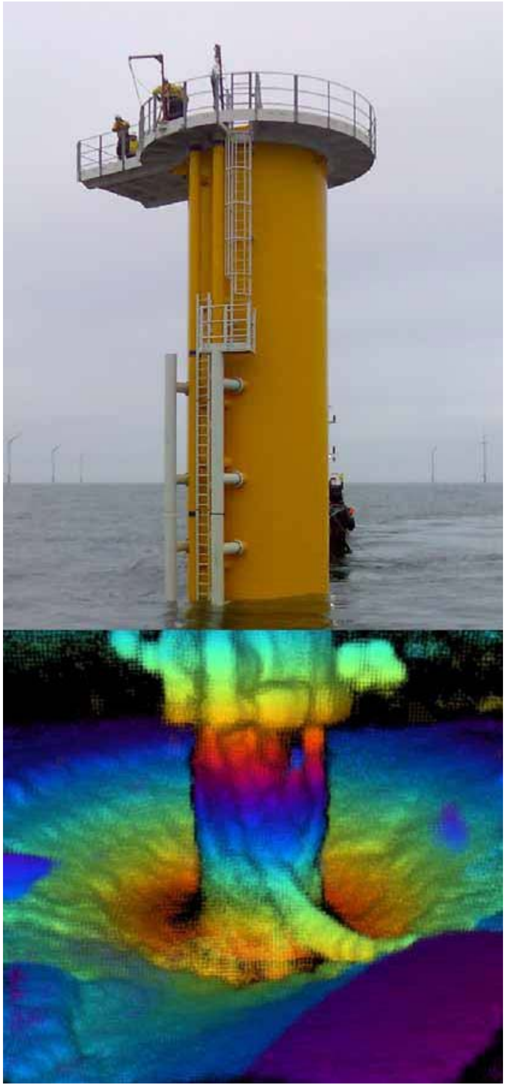

Figure 3: Image courtesy of CodaOctopus using their Echoscope® real-time 3D sonar – Snap-shot of scour at a marine structure

Time Scale of Scour Development

With current data sets from various SONAR instruments, a general growth in scour can be seen in many cases, over a period of time. However, these datasets are snapshots of a point in time, so caution should be taken if inferring a general reduction in scour depth as this may just be a function of the prevailing conditions rather than a general trend.

Recent studies by Harris et al (2010) suggest that the scour depth can vary significantly under combined current and wave conditions through time (Fig. 4).

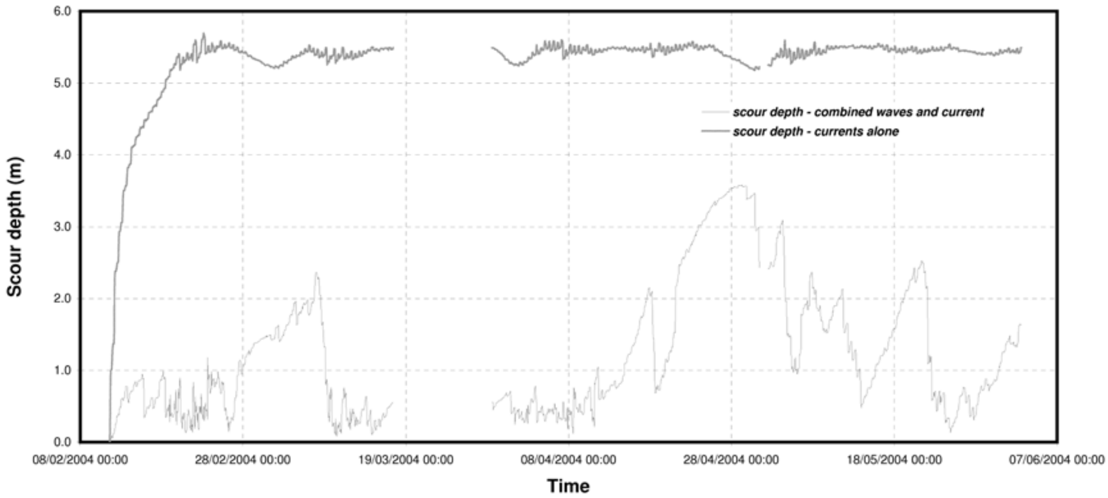

Figure 4: Results from a model at prototype scale. Validation of this kind of detailed modelling requires continuous time-series data of environmental conditions and scour depths at the foundation

Source: Harris et al., 2010

Guidance on Scour

DNV (Det Norske Veritas) and Germanischer Lloyd are two of the independent organisations responsible for certification of offshore structures. In conjunction with the existing regulatory regime they help to ensure an appropriate level of safety and reliability through offshore classification, thus providing assurance that requirements laid down in applicable rules and regulations are met during all phases of the asset’s design, construction and operation.

As of 2011, DNV guidance for scour at an offshore structure was based mostly upon published results from scale laboratory studies. This means that the need for scour protection at an offshore structure relies heavily on research carried out in waves or unidirectional steady flow conditions, simplified sediments and simplified geometry. This gives rise to uncertainty about potential scour depth at marine structures, which means uncertainty about the need for scour protection.

Conclusion

After extended consultation with leading experts in the field of scour analysis, Nortek's online scour monitor (Fig. 5) seems to fill in a lot of the blanks relating to scour development at a marine structure. In conjunction with metocean measurements it will improve scour calculations, by giving continuous feedback of scour development, and therefore help in removing a lot of the uncertainties associated with modelling and snapshot data. This in turn will improve realism within engineering/FEED calculations, which should help improve installation time and potentially save a lot of money when it comes to working out the need for and the best approach to scour protection. The Nortek Scour Monitor will act as an early warning system and provides invaluable information for modellers and project operators alike, trying to assess scour formation and whether scour protection is required.

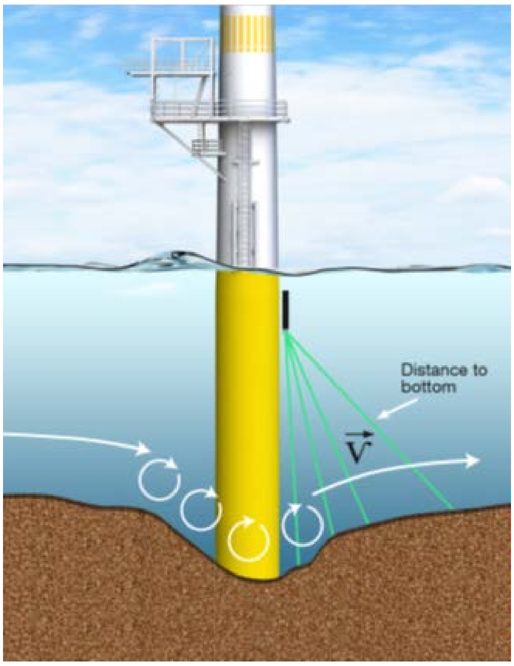

Figure 5: Nortek scour monitor attached to a pile. Providing an on-line real-time picture of temporal scour development. Changes in seabed levels adjacent to the structure are measured and real-time data can be displayed at base. Scour and subsequent depositional events which might happen during storm periods can thus be identified and fully quantified

Figure 6: Nortek Scour Monitor

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