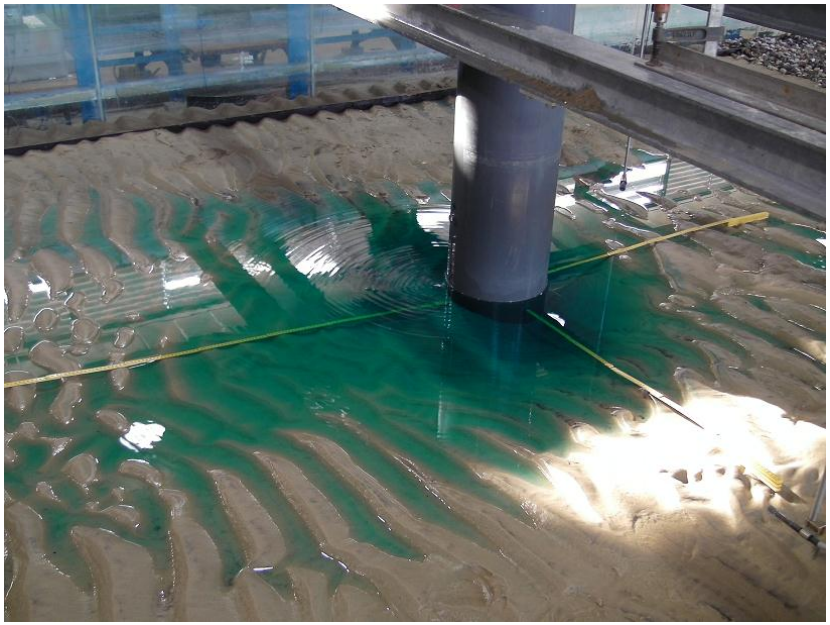
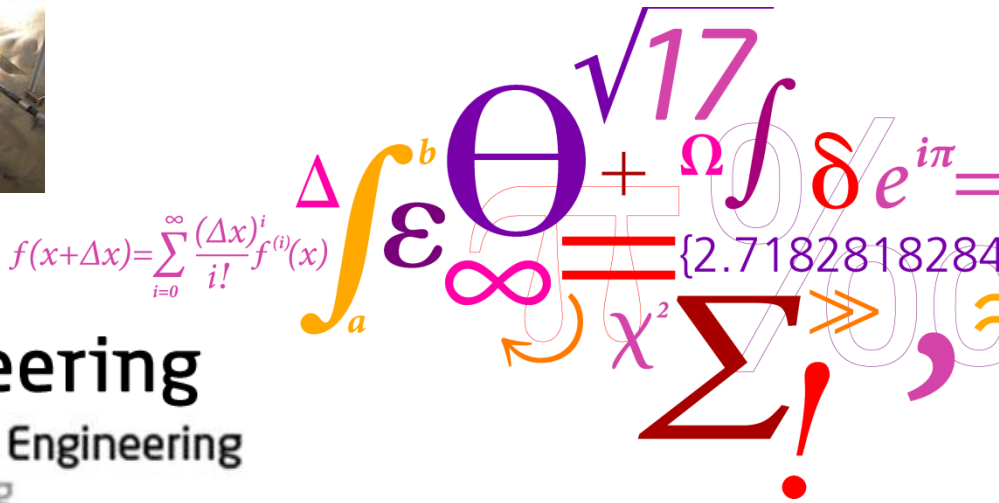
Time scale of scour around a pile in combined waves and current

Seabed Wind Farm Interaction (SBWI)
Statkraft Ocean Energy Research Program (SOERP)
Future Marine Structures (FMK)

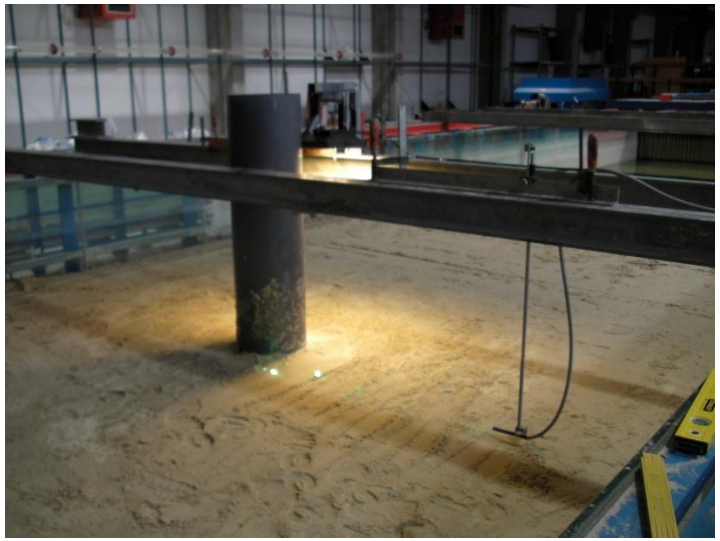


Thor Ugelvig Petersen
B. Mutlu Sumer
Jørgen Fredsøe



DTU Mechanical Engineering
Fluid Mechanics, Coastal and Maritime Engineering
Department of Mechanical Engineering

Agenda

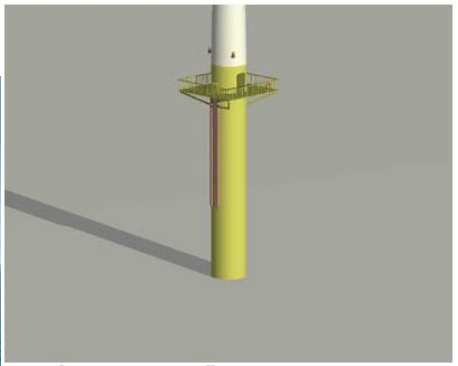


- Opening
- Description of the scour process
- Test conditions
- Results and discussion
    - Scour Depth
    - Time scale of the scour process
- Main conclusions

Motivation

In regards to offshore wind turbine (OWT) foundations the evolving of scour and backfilling over time has implications for following aspects:

- Maximum loading and structural strength
- Fatigue life and Eigen frequency
- Foundation depth

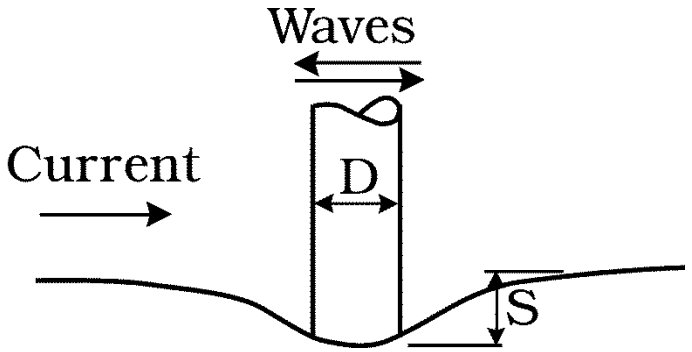


(photo from http://www.nordschleswiger.dk/;
http://www.unc.edu/spotlight/harnessing-the-wind

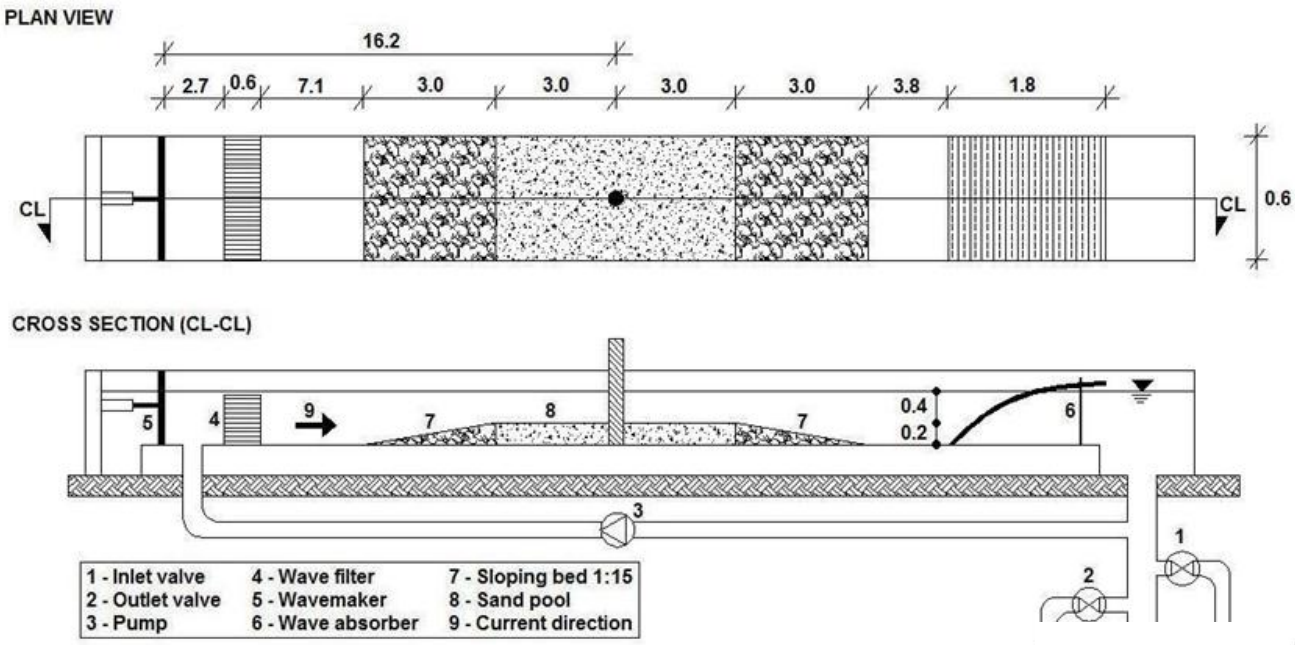
Motivation (2)

• Scour characteristics in a flow environment where waves and current are present concurrently.

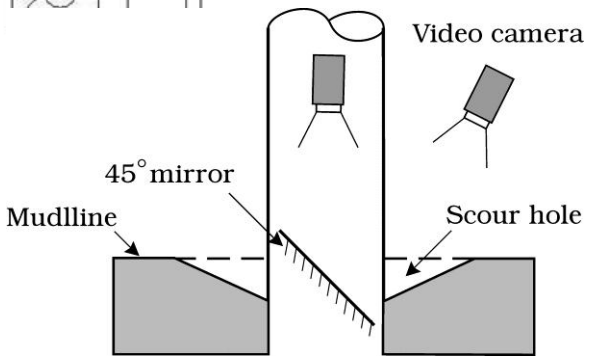
•What is the time development of the scour depth?



Experimental setup and Test conditions



Sketch of the flume. Dimensions are given in meters [m].



- Wave and Current flume (0.6 m wide)
- Pile diameter: 4 and 7.5 cm
- Sand size: d_{50} = 0.17 mm

Governing parameters

- Scour depth

$$S_0 = f(KC, U_{cw})$$

- Time scale of scour

$$T^* = f(KC, U_{cw}, \theta)$$

$$KC = \frac{U_m T_p}{D} \qquad U_{cw} = \left(\frac{U_c}{U_c + U_m}\right)$$

$$\theta = \frac{U_f{}^2}{g(s-1)d_{50}}$$

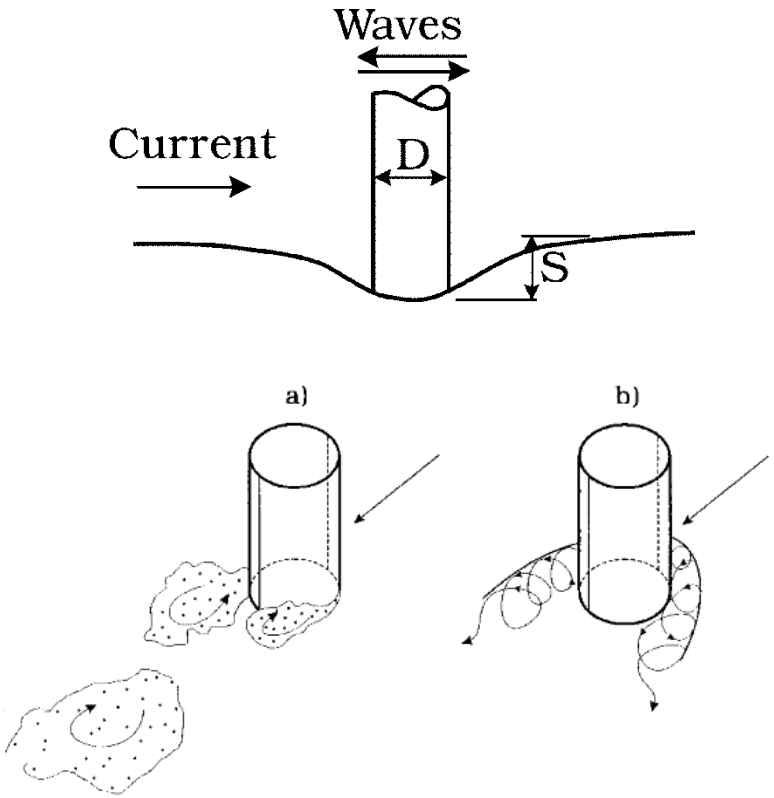
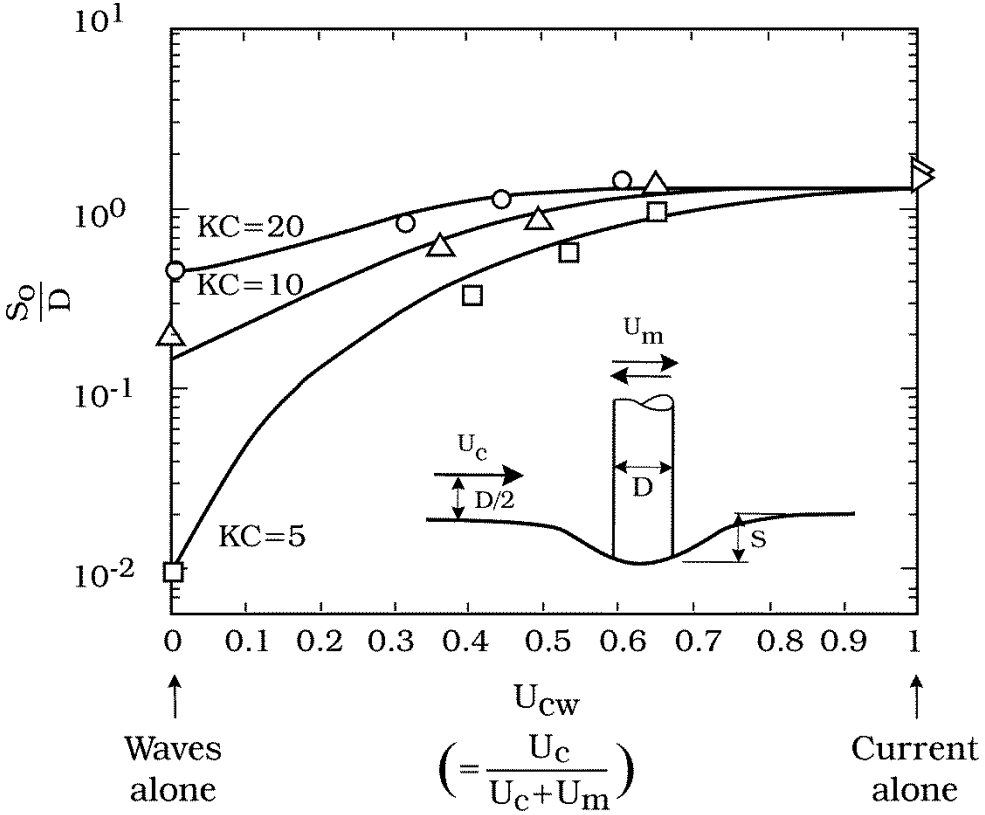


Figure from Sumer and Fredsøe (2001)

Scour depth around a pile in combined waves and current



$$\frac{S}{D} = \frac{S_c}{D}\left[1 - exp\{-A\,(KC - B)\}\right]; \qquad KC \geq 4$$

$$A = 0.03 + \frac{3}{4}\,U_{cw}^{2.6}$$

$$B = 6\,exp(-4.7\,U_{cw})$$

Sumer and Fredsøe (2002)

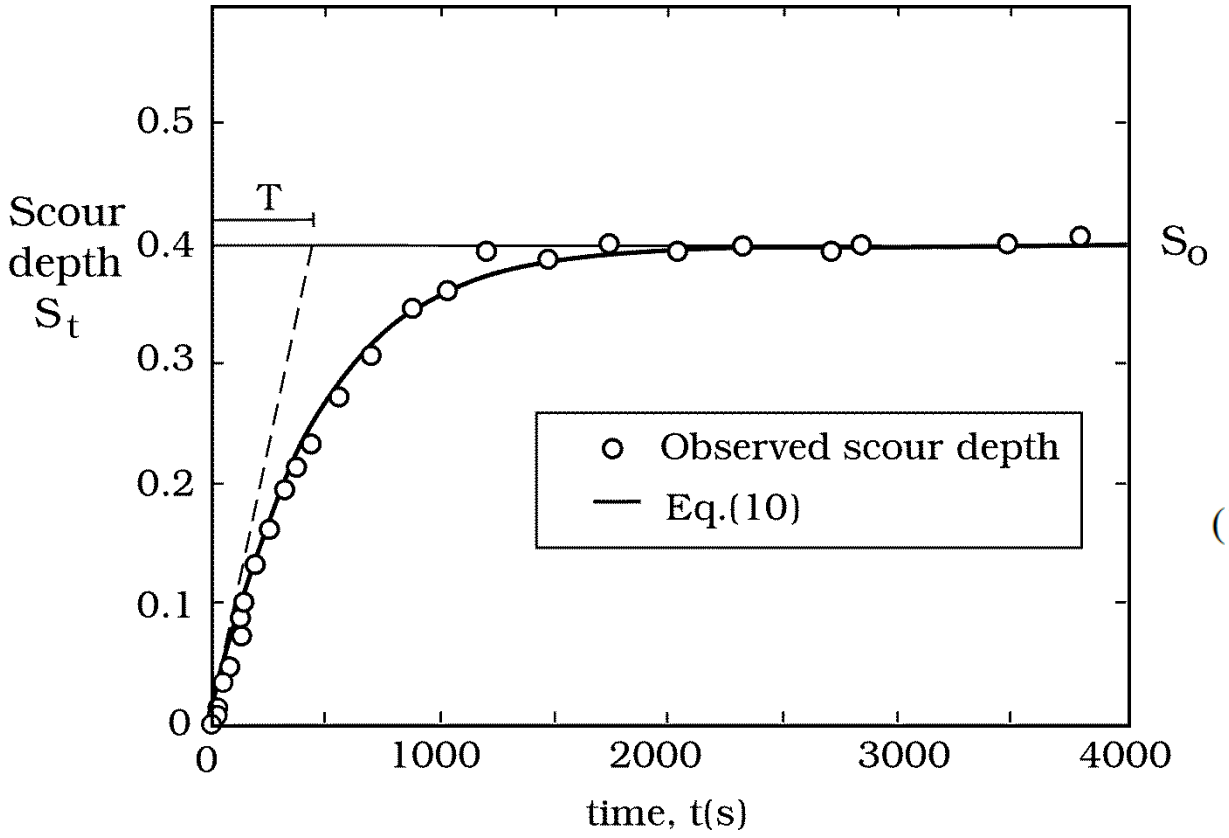
$$\frac{S}{D} = 1.3\{1 - exp[-0.03(KC - 6)]\}; \quad KC \geq 6$$

Sumer et al. (1992a)

S/D = 1.3 with $\sigma_{S/D} = 0.7$

Sumer and Fredsøe (2002)

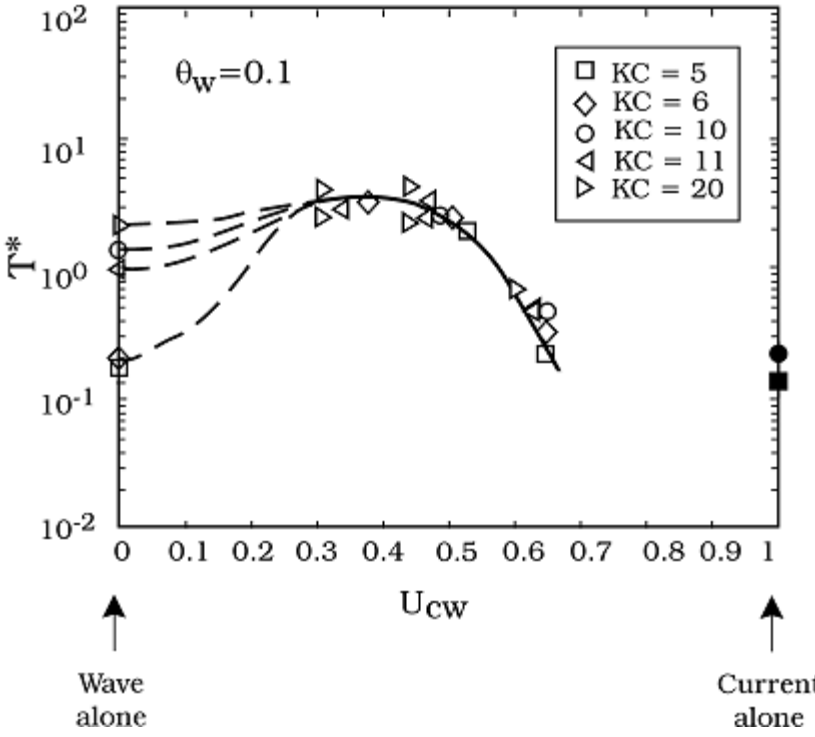
Time development of scour



$$(10)\quad S_t = S_0\left(1 - exp\left(-\frac{t}{T}\right)\right)$$

Observed time development of scour depth in combined current and waves. Live bed ($\theta > \theta_c$). KC = 4, U_{cw}= 0.47, θ_w = 0.15, S_0/D= 0.4, T = 445.

Time scale of scour around a pile in combined waves and current

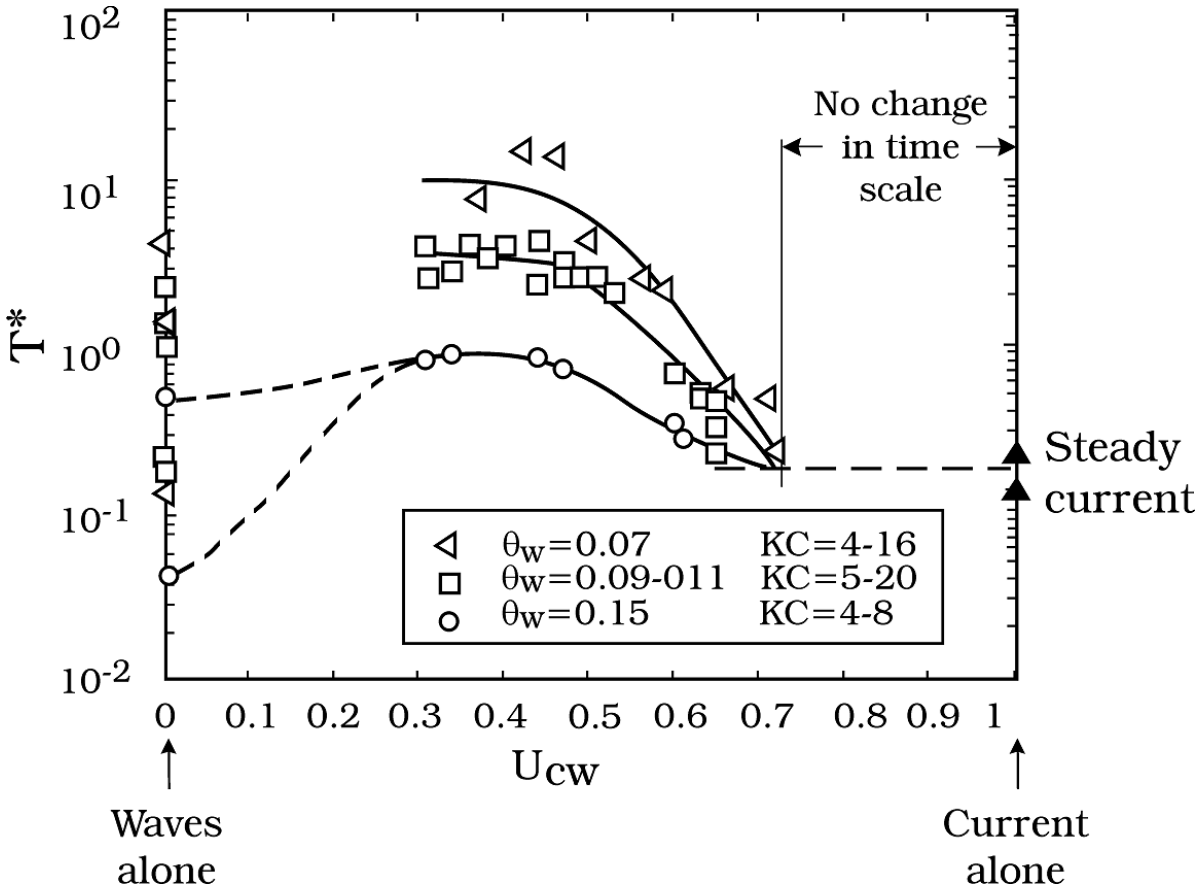


$$T = \frac{D^2}{\left(g(s-1)d_{50}^3\right)^{1/2}} T^*$$

$$T^* = 10^{-6}\left(\frac{KC}{\theta}\right)^3$$

$$T^* = \frac{1}{2000}\frac{\delta}{D}\theta^{-2.2}$$

Time scale of scour around a pile in combined waves and current



Time scale of scour around a pile in combined waves and current

The time scale of scour in combined waves and current is governed by three parameters, namely U_{cw}, KC and θ_w. The present study indicate that:

1. The time scale of scour T increases significantly when even a slight current is superimposing on a wave.

2. The KC dependence of the time scale T is mainly observed for low values of U_{cw} in the wave dominated regime. For U_{cw} values larger than 0.4 no clear KC dependency was observed.

3. The time scale decreases with increasing θ_w over the entire range of U_{cw}.

References

Sumer, B. M., Christiansen, N., Fredsøe, J. (1992a). “Time Scale of Scour around a vertical pile.” Proc., 2nd Int. Offshore and Polar Engineering Conference, International Society of Offshore and Polar Engineers, San Fransisco, California, Vol. 3, 308-315.

Sumer, B.M. and Fredsøe, J. (2002): The Mechanics of Scour in the Marine Environment. World Scientific, New Jersey, Singapore, London, Hong Kong.

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