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

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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

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

- 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

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

\[ KC = \frac{U_m T_p}{D} \quad U_{cw} = \left( \frac{U_c}{U_c + U_m} \right) \]

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

Figure from Sumer and Fredsøe (2001)
Scour depth around a pile in combined waves and current

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

\[
A = 0.03 + \frac{3}{4} U_{cw}^{2.6}
\]

\[
B = 6 \exp(-4.7 U_{cw})
\]

Sumer and Fredsøe (2002)

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

Sumer et al. (1992a)

\[
S/D = 1.3 \text{ with } \sigma_{S/D} = 0.7
\]

Sumer and Fredsøe (2002)
Time development of scour

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

$$S_t = S_0 \left(1 - \exp \left(-\frac{t}{T}\right)\right)$$
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\[ T^* = 10^{-6} \left( \frac{K_C}{\theta} \right)^3 \]

\[ T^* = \frac{1}{2000} \frac{\delta}{D} \theta^{-2.2} \]
Time scale of scour around a pile in combined waves and current

![Graph showing the time scale of scour around a pile in combined waves and current. The graph plots $T^*$ against $U_{cw}$, with different symbols and lines representing different wave angles ($\theta_w$) and current coefficients (KC). No change in time scale is indicated.]
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 $\theta_w$. 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 $\theta_w$ over the entire range of $U_{cw}$. 
References

