M3 Scour Analysis & Protection

08/17/2016

Exceptional service in the national interest

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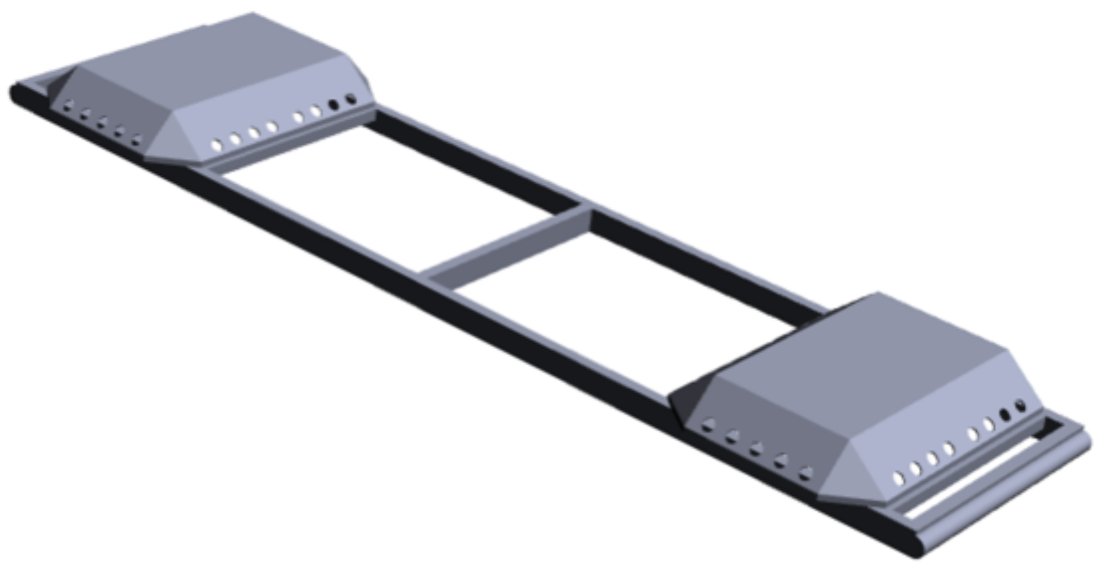

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Wave case #4

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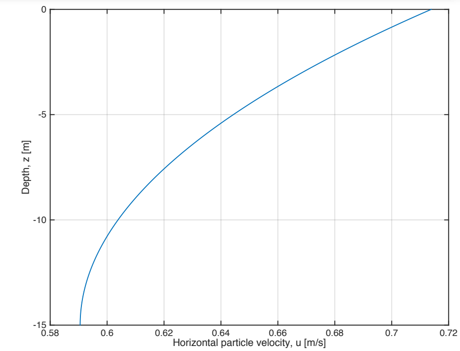
$$h = 15\,\text{m}$$
$$H = 1.66\,\text{m}$$
$$T_w = 13\,\text{s}$$

$$\text{Ursell}: \frac{H\lambda^3}{h^3} \approx 10$$

Linear waves OK

$$\text{max orbital velocity: } U_m = \frac{\pi H}{T_w}\frac{\cosh\left(k\left(z+h\right)\right)}{\sinh\left(kh\right)}$$
$$\approx 0.6\,\text{m/s}$$

Tuba/Alice gave Um = 0.4 m/s



$$\theta = \frac{U_{fm}^2}{g\left(s-1\right)d} = \frac{\frac{fw}{2}U_m^2}{g\left(s-1\right)d}$$
$$\approx 0.2$$
$$\theta > \theta_{cr}$$
$$\theta_{cr} \approx 0.05$$

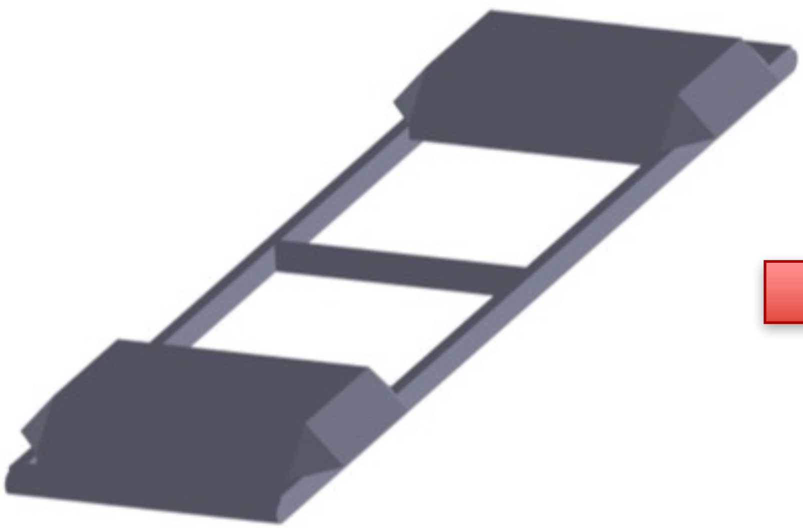
$$fw = 0.035\left(\frac{2\pi U_m^2 T_w}{\nu}\right)^{-0.16}$$

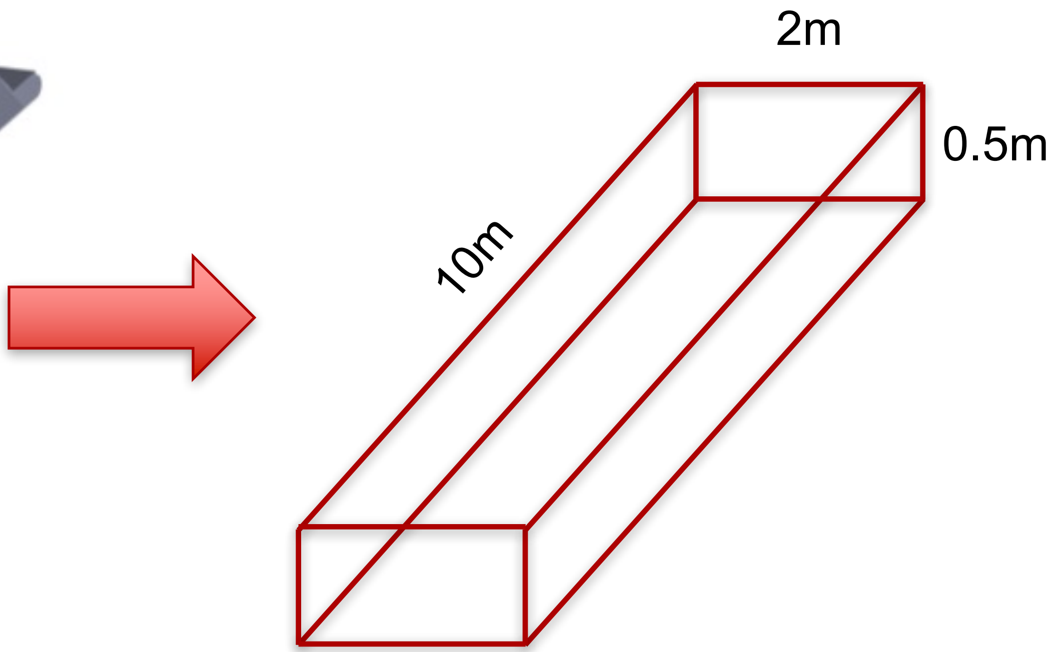
Fredsoe and Deigaard (1992)

"live-bed"

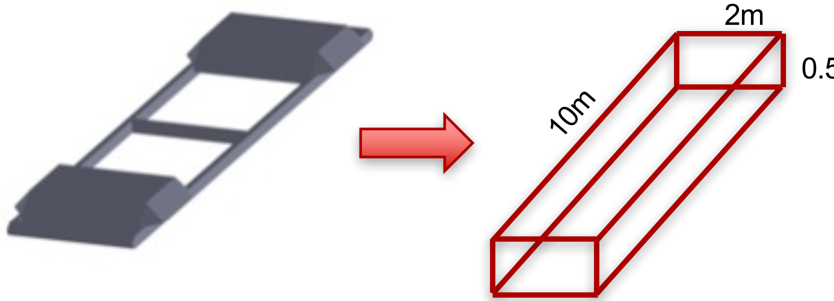
Global Scour

Device acts as one compound obstruction





Global Scour (cont.)



$$2 < D < 10$$

$$\lambda = 150$$

$$D/\lambda \sim O(0.01)$$

$$D/\lambda > O(0.1), \qquad \text{Large-pile}$$

$$D/\lambda < O(0.1), \qquad \text{Slender-pile}$$

(separated flow)

Device as a whole acts a "slender-pile"

Global Scour – "slender pile"

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max scour

char. dim.

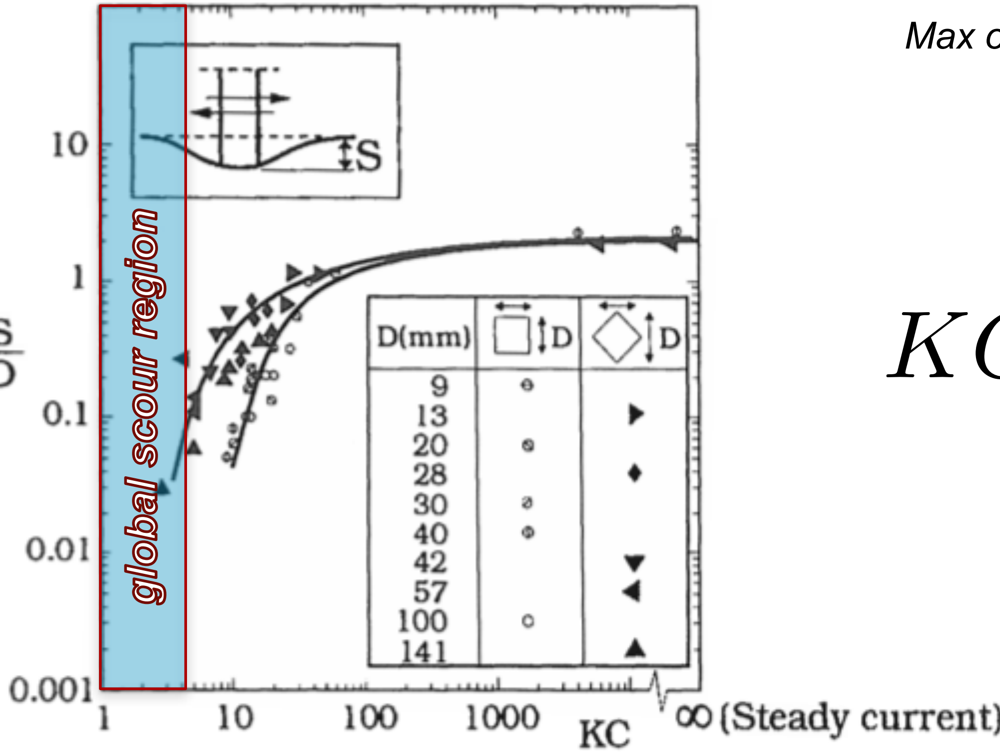


Figure 3.36: Equilibrium scour depth. Square pile. Live bed ($\theta > \theta_{cr}$). Sumer et al. (1993).

Max orbital velocity

Wave period

$$KC = \frac{U_m T_w}{D}$$

Characteristic dimension

Global scour should be negligible in this regime

finite height of M3 device further reduces global scour likelihood

Global Scour – "large pile"

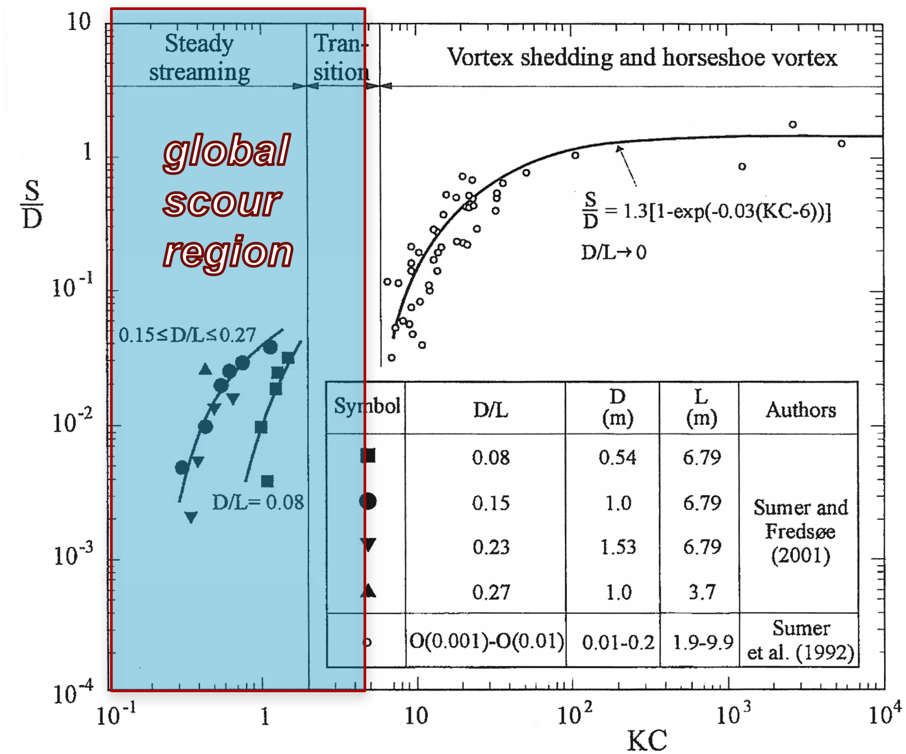


Figure 6.21: Maximum scour depth at the *periphery* of the pile base. Live bed. Sumer and Fredsøe (2001).

Max orbital velocity *Wave period*

$$KC = \frac{U_m T_w}{D}$$

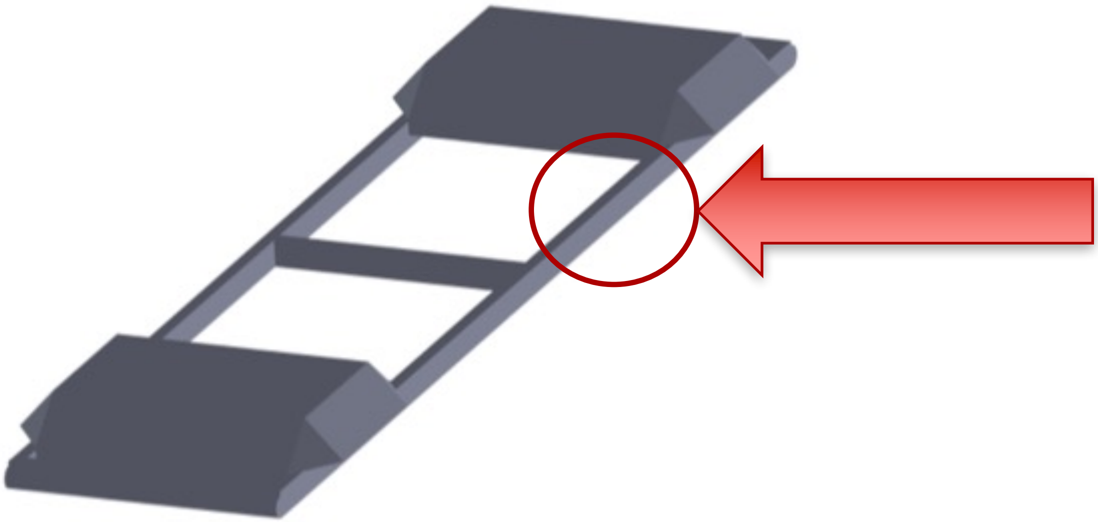
Characteristic dimension

Global scour should be negligible in "large-pile" regime

finite height of M3 device further reduces global scour likelihood

Local Scour

Analyze cross members using empirical relations for subsea pipes



Local scour

member diameter (~0.2m)

$$S_{pipe} = 0.1D\sqrt{KC}$$
$$\approx 0.12\,\mathrm{m}$$

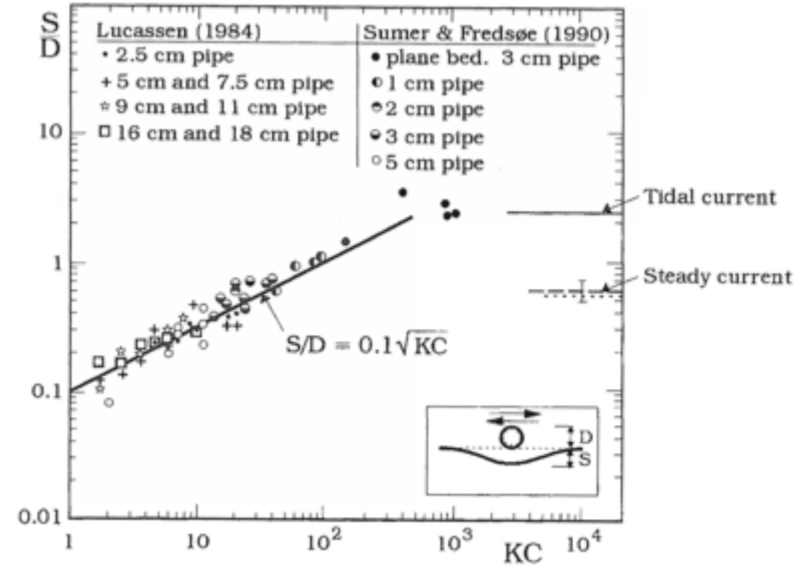
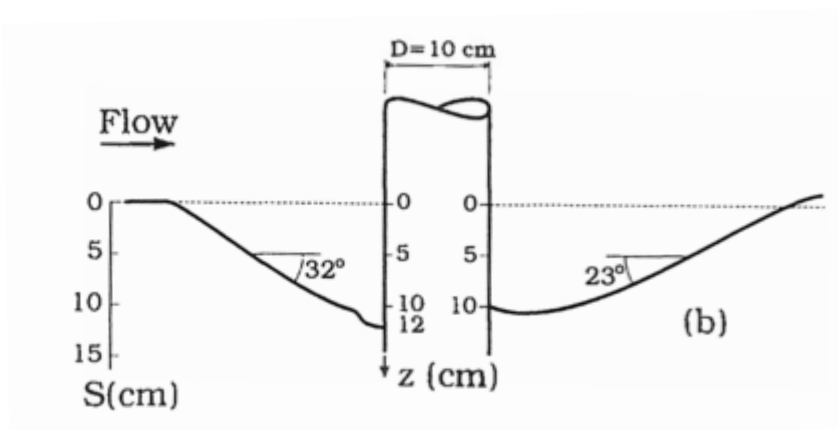


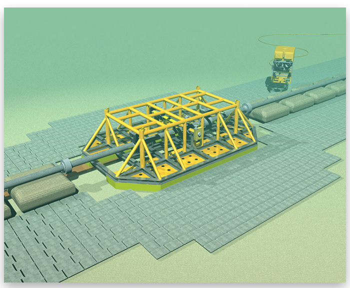
Figure 2.23: Equilibrium scour depth. Wave. Live bed ($\theta > \theta_{cr}$). Sumer and Fredsøe (1990).

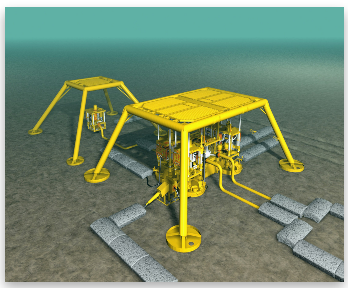


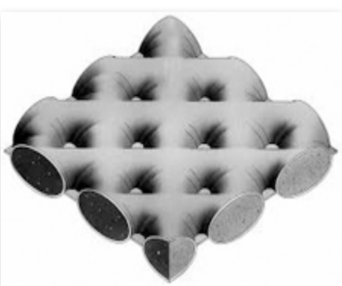
$$R_{scour} = \frac{S}{\tan(23°)}$$
$$\approx 0.3\,\mathrm{m}$$

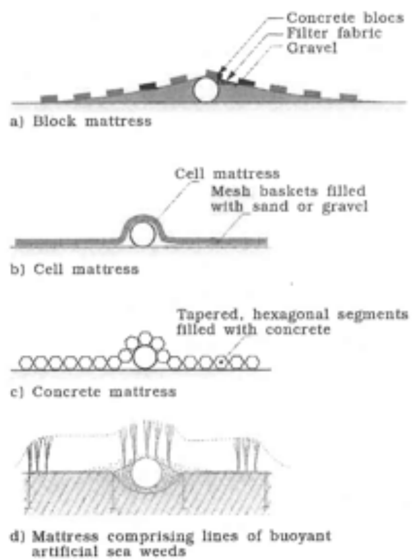
Proposed process

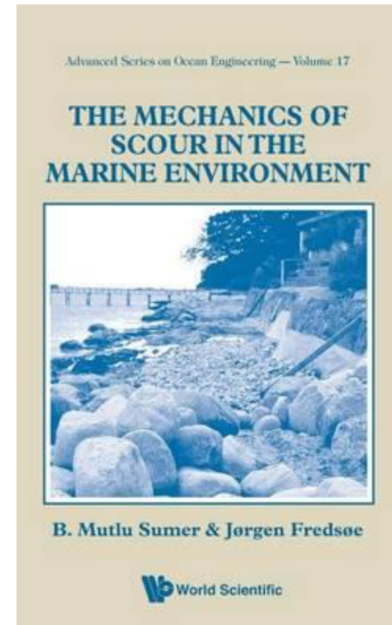
1. CFD and empirical analysis to predict shear stress and scour respectively
2. Correlate CFD and empirical analysis
3. Deform CFD seabed based on scaled shear stress map
4. Confirm scour extents
5. Scour protection mattress











Sumer, B. Mutlu, and Jørgen Fredsøe. *The mechanics of scour in the marine environment*. World Scientific, 2002.