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Publication date:
2020

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
Sui, T., Staunstrup , L. H., Carstensen, S., & Fuhrman, D. R. (2020). *A New Rational Model for the Current-Induced Three Dimensional Scour Beneath Submerged Pipelines*. Abstract from Virtual International Conference on Coastal Engineering (VICCE 2020).

A NEW RATIONAL MODEL FOR THE CURRENT-INDUCED THREE DIMENSIONAL SCOUR BENEATH SUBMERGED PIPELINES

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Marine pipelines are commonly used to transport water, sewage, gas, oil etc. Scour beneath a pipeline in this context will lead to free spanning regions (and potentially vortex-induced vibration), increasing structural fatigue, thus being a big concern to coastal engineers and scientists.

In this study, new experiments involving the three-dimensional current-induced live-bed scour beneath submerged horizontal pipelines are presented, spanning larger Shields parameter (θ up to 0.16) and pipe-to-sediment diameter ratio (D/d up to 444) than previous studies. The scour and span shoulder migration process are recorded with digital cameras which are placed at the rear of the cylinder pipe (Fig. 1a). Specific emphasis is on gaining a better understanding of, and ability to predict, the span migration velocity during the initial and subsequent development of such a scour hole. Consistent with previous experimental observations (Cheng et al., 2009), both a primary (faster) and secondary (slower) span migration are observed. Process visualization of suspended sediment patterns are in line with prior speculation that this transition coincides with reduced local bed shear stress amplifications as the scour hole both deepens and widens.

Dimensional analysis and physical insight are combined, leading to a new rational model for predicting the span migration velocity in both live-bed and clear-water regimes, with predictions naturally coinciding at the limit of far field incipient motion conditions (Fig. 1b, and Fig. 1c). In both regimes the data cluster as predicted, and fitted closed-form expressions are provided for predicting the span migration velocity. The rational approach likewise includes a new and simple criterion for the transition from primary to secondary migration in the live-bed regime (Fig. 1d). In the clear-water regime, the model incorporates primary dependence on the ratio of the Shields parameter to its critical value, resolving apparent contradictions with a previous study (Wu and Chiew, 2012) which suggests that the depth-based Froude number is the most important governing parameter. The developed rational model (Fig. 1b-d) can be used to quantitatively predict all known major features of the span migration velocity in the early stages of the three-dimensional (live-bed and clear-water) scour beneath submerged pipelines induced by perpendicular flow, and can hence be regarded as the first complete model for this evolution.

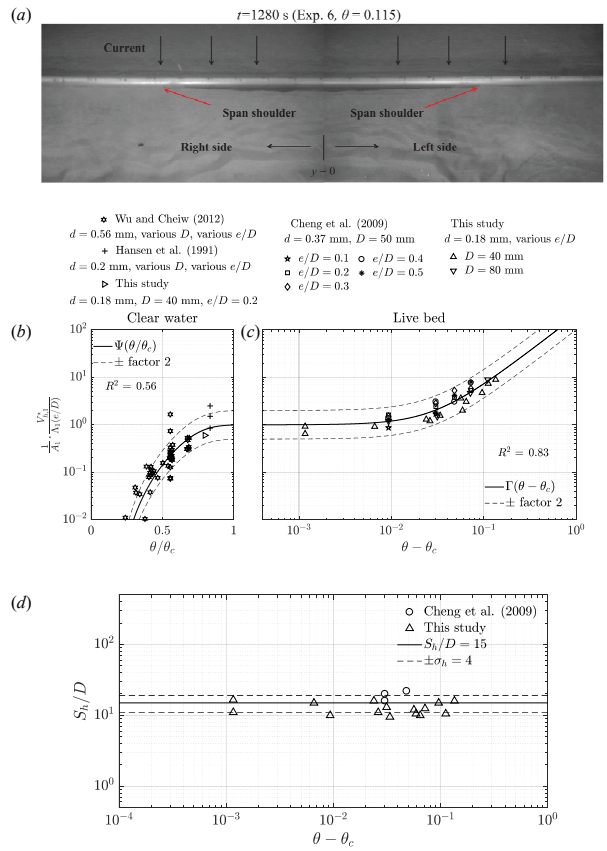

Figure 1 - (a) Snapshots from video recording from one example experiments; Comparison of predicted (full lines) and measured (markers) primary span shoulder migration velocity (b) in the clear-water regime (left side) and (c) in the live-bed regime (right side) (Note that these naturally coincide where $\theta = \theta_c$); and (d) the measured span extent S_h/D where transition from primary to secondary span migration velocity occurs.

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