

SCOUR INDUCED SPAN SHOULDER MIGRATION AROUND SUBMARINE PIPELINE WITH WAVE AND CURRENT LOADING

Titi Sui, Hohai University, ttsui@hhu.edu.cn
 Qi Yang, Hohai University, yangqi@hhu.edu.cn
 Chi Zhang, Hohai University, zhangchi@hhu.edu.cn
 Jinhai Zheng, Hohai University, jhzheng@hhu.edu.cn
 David R. Fuhrman, Technical University of Denmark, drfh@dtu.dk

INTRODUCTION

Submarine pipelines play a pivotal role in the transportation of crucial natural resources like gas, oil, and water across extensive distances beneath the seabed. When these pipelines are deployed in a marine environment, they alter the local flow patterns in the vicinity of the pipeline compared to the undisturbed seabed in the far field. This flow alteration can result in scour, characterized by an increased local sediment transport capacity (Sumer and Fredsøe, 2002). Such scour propagation has the potential to induce sagging, vortex-induced vibrations, and fatigue failures of the pipeline. While prior research has primarily focused on 2D scour, where scour propagates vertically, it is important to acknowledge that scour can manifest not only vertically but also horizontally along the length of the pipeline, giving rise to what is referred to as three-dimensional scour around the pipeline. This three-dimensional scour can create free spans beneath the pipeline, consequently elevating the stresses on the pipeline within the span. Coastal engineers have expressed substantial concern about the velocity at which the span shoulder migrates due to its implications for predicting pipeline stability. A recent study by Sui et al. (2021) explored the migration of the span shoulder beneath the pipeline solely under the influence of current. The study proposed a comprehensive model for predicting the migration rate in both clear water and live bed scour regimes. This research expands upon the previous study by analyzing span shoulder migration in the context of three-dimensional scour beneath submerged horizontal pipelines. It particularly focuses on enhancing our comprehension and predictive capability of span migration velocity under conditions involving both waves and currents.

RESULTS AND DISCUSSION

To quantify the impact of waves on span shoulder migration velocity, the dimensionless strength ratio of current to wave (denoted as m) was employed. It is worth noting that m varies between 0 and 1, where $m=1$ signifies pure current conditions and $m=0$ denotes pure wave conditions. The analysis reveals a notable "pump effect" of waves, leading to a fluctuating migration velocity pattern with an increasing in m (see Figure 1). This implies that considering wave components in predominantly current-driven scenarios results in a reduction of span migration velocity. Taking into account the m dependence, a rational model is developed in the present work for predicting the span migration velocity under combined wave and current conditions, following a similar framework as in Sui et al. (2021). Figure 2 illustrates that the data closely clusters around the

model's predicted values with deviations typically within a factor of 2. The dependence of non-dimensional velocity on the Shields parameter was observed to follow a power law with an exponent of 3/2, consistent with the numerous sediment transport rate predictions. The coefficient of determination (R^2) for predictions made using the present model is $R^2=0.74$, marking a substantial improvement when compared to previous formulas (e.g., around 0.44 as reported by Cheng et al., 2014, not depicted in the current figures). Furthermore, it can be concluded that the Shields parameter (θ) exerts a dominant influence on span migration velocity in three-dimensional scour around pipelines, both under pure current conditions (Sui et al., 2021) and in the combined wave and current scenarios discussed herein.

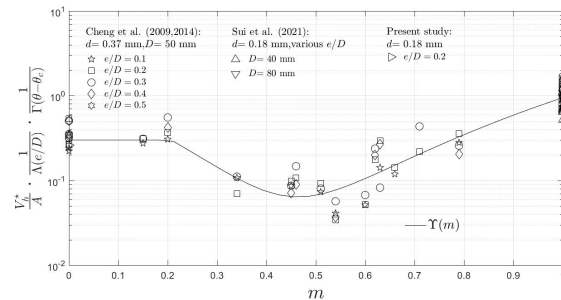


Figure 1 - The m dependence on the span shoulder migration velocity

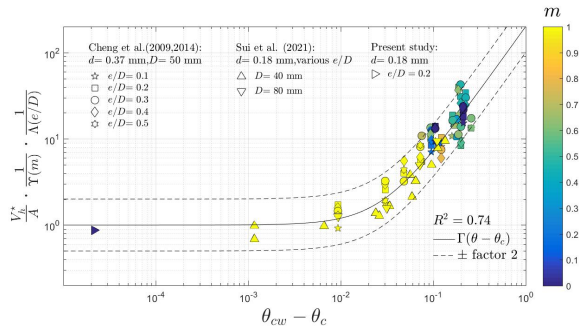


Figure 2 - Model prediction of the span shoulder migration velocity below a pipeline with wave plus current conditions.

REFERENCES

- [1] Sumer, B. M., Fredsøe, J., 2002. The Mechanics of Scour in the Marine Environment. World Scientific, Singapore.
- [2] Cheng, L., Yeow, K., Zang, Z., Li, F., 2014. 3D scour below pipelines under waves and combined waves and currents. Coast. Eng. 83, 137-149.
- [3] Sui, T., Staunstrup, L.H., Carstensen, S., Fuhrman, D.R., 2021. Span shoulder migration in three-dimensional current-induced scour beneath submerged pipelines, 103776 Coast. Eng. 164, 1-22.