Time Scale for Wave/Current Scour Below Pipelines

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ABSTRACT

A nondimensional formula has been developed for the time scale of the scour process below a marine pipeline, based on the presently available data. The main part of the data originates from ISVA. Both the current case and the pure-wave case are considered. The results indicate that the nondimensional time scale is proportional to the -5/3 power of the Shields parameter. In the study, the time scale of scour, involving a change in the wave climate, has also been investigated. The results indicate that the time scale is governed by the Shields parameter plus the two Keulegan-Carpenter numbers corresponding to the waves before and after the change takes place.

FULLY DEVELOPED STAGE OF SCOUR PROCESS


The purpose of the present study is to investigate the time scale of the scour process. The study covers also the transitional scour processes involving changes in wave climate.

INTRODUCTION

When a pipeline is laid on an originally plane bed, scour will take place below the pipeline due to the action of waves and current, where the scour process will eventually attain a fully developed stage.

The scour depth corresponding to this fully developed stage has been studied quite extensively for steady currents — Kjeldsen et al. (1973), Bijker and Leeuwestein (1984) and Mao (1986), among others, for a fixed pipe, and Sumer et al. (1988) and Kristiansen (1988) for a vibrating pipe.

The data indicate that the dependence on the Shields parameter is quite weak (when the scour takes place on a live bed), while the dependence on the relative roughness and Reynolds number is insignificant. See Sumer and Fredsøe (1990), which collected the data from Kjeldsen et al. (1973), Lucassen (1984), Mao (1986) and Kristiansen (1988). For all practical purposes, the following relation can be used as the design equation, to predict the equilibrium scour depth in steady currents:

\[ S_o / D = 0.6 \pm 0.1 \]

NOMENCLATURE

- \( d \) : sand size
- \( D \) : pipe diameter
- \( f \) : friction factor
- \( f_w \) : wave frequency
- \( g \) : acceleration due to gravity
- \( K_C \) : Keulegan-Carpenter number (Eq. 2)
- \( K_{C_{final}} \) : KC number following change in wave climate
- \( K_{C_{initial}} \) : KC number prior to change in wave climate
- \( s \) : specific gravity of sediment
- \( S \) : scour depth
- \( S_o \) : equilibrium scour depth
- \( t \) : time
- \( T \) : time scale of scour process
- \( T^* \) : nondimensional time scale of scour process (Eq. 6)
- \( T_w \) : wave period
- \( U \) : flow velocity
- \( U_f \) : bed shear velocity
- \( U_m \) : maximum outer flow velocity in waves
- \( U_{fm} \) : maximum bed shear velocity in waves
- \( v \) : kinematic viscosity
- \( \theta \) : Shields parameter (Eq. 1)
- \( \theta_{final} \) : Shields parameter following change in wave climate
- \( \theta_{initial} \) : Shields parameter prior to change in wave climate

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