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Self-Burial of Pipelines at Span Shoulders

B.M. Sumer* and J. Fredsøe

Technical University of Denmark, Institute of Hydrodynamics and Hydraulic Engineering, Lyngby, Denmark

ABSTRACT

The process of self-burial of pipelines at span shoulders has been investigated experimentally in the laboratory in steady currents. Only the noncohesive sediment bed is considered. A rigid cylinder has been used as the pipe model. In all the tests, the experimental conditions were arranged such that the pipe is supported by a sand ridge in the middle. When the length of this supporting ridge is decreased to a critical value, the pipe begins to sink in the sand due to soil failure. The scour, the sinking and, at a later stage, the backfilling processes were monitored by video in plane and side views simultaneously. A simple formula adopted from soil mechanics regarding the bearing capacity of soil was found to give a satisfactory result in relation to the sinking of the pipe at the span shoulder.

NOMENCLATURE

A : Bearing area
B : Half-width of equivalent rectangular footing (Fig. 7)
D : Pipe diameter
D_f : Depth of equivalent rectangular footing (Fig. 7)
d_{50} : Sand size
e : Sinking of pipe in soil at span shoulder
F_L : Lift force on pipe
g : Acceleration due to gravity
h : Flow depth
ℓ : Length of pipe-supporting span shoulder
N_γ, N_q : Bearing capacity factors
Q : Bearing capacity load
Re : Reynolds number, $Re = VD/\nu$
s : Specific gravity of sand grains (particle specific gravity), $s = \gamma_s/\gamma \cong 2.65$
s_P : Specific gravity of pipe, $s_P = \gamma_{pipe}/\gamma$
s_γ, s_q : Shape factors in bearing capacity formula
t : Time
U_f : Bed friction velocity, $U_f = \sqrt{\tau_o/\rho}$
V : Flow velocity at level of pipe axis
W : Weight of pipe
γ : Specific weight of water
γ_{pipe} : Specific weight of pipe
γ_s : Specific weight of sand grains
γ' : Specific weight of soil (sand) in water. ($\gamma/\gamma \cong 1.8 - 1 = 0.8$ in the present study)
θ : Shields parameter
ν : Kinematic viscosity
τ_0 : Bed shear stress

INTRODUCTION

It is known that pipelines laid on the seabed may bury themselves. The self-burial of pipelines occurs both in the free-span areas and at span shoulders.

In the former, when the scour hole below the pipe is sufficiently long the pipe begins to sag in the scour hole. By the time the pipe reaches the bottom of the scour hole, the scour stops and the back-filling process starts, and subsequently the pipeline may be covered by sand and presumably be self-buried. This type of self-burial process has been investigated fairly extensively in the past (Leeuwestein et al., 1985; Fredsøe et al., 1988; and Gökçe and Günbak, 1991).

Regarding the second type of self-burial of pipelines, namely the self-burial at span shoulders, the development of this process is closely related to the three-dimensional scour which occurs underneath the pipe in the area where the free span joins the span shoulder.

In contrast to the effort directed towards the understanding of the self-burial process in the free-span areas, the self-burial process at the span shoulders seems not to have attracted much attention. To the authors' knowledge, no systematic investigation of the subject has been undertaken until now.

The purpose of the present work is to get an understanding of this self-burial process in the case of a noncohesive sediment bed and in steady currents.

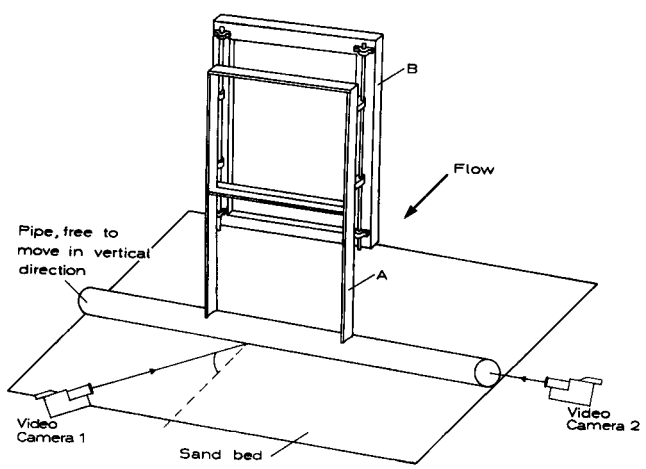

Fig. 1 Test setup

*ISOPE Member.
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KEY WORDS: Bearing capacity, general shear failure, pipelines, pipeline spans, self-burial, soil mechanics, span shoulders.