

Occurrence of Spanning of a Submarine Pipeline with Initial Embedment

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ABSTRACT

For better understanding the mechanism of the occurrence of pipeline span for a pipeline with initial embedment, physical and numerical methods are adopted in this study. Experimental observations show that there often exist three characteristic phases in the process of the partially embedded pipeline being suspended: (a) local scour around pipe; (b) onset of soil erosion beneath pipe; and (c) complete suspension of pipe. The effects of local scour on the onset of soil erosion beneath the pipe are much less than those of soil seepage failure induced by the pressure drop. Based on the above observations and analyses, the mechanism of the occurrence of pipeline spanning is analyzed numerically in view of soil seepage failure. In the numerical analyses, the current-induced pressure along the soil surface in the vicinity of the pipe (i.e. the pressure drop) is firstly obtained by solving the N-S equations, thereafter the seepage flow in the soil is calculated with the obtained pressure drop as the boundary conditions along the soil surface. Numerical results indicate that the seepage failure (or piping) may occur at the exit of the seepage path when the pressure gradient gets larger than the critical value. The numerical treatment provides a practical tool for evaluating the potentials for the occurrence of pipe span due to the soil seepage failure.

KEY WORDS: Submarine Pipeline; Pipe span; Currents; Sands; Seepage failure

INTRODUCTION

When a submarine pipeline is laid upon seafloor, there always exists some embedment into the soil. In severe ocean environments, the soil beneath the pipeline may be scoured, and the pipeline will thereby be suspended above the seafloor. The occurrence of pipeline span is proven to bring much potential for vortex-induced vibrations of pipelines. Therefore, to efficiently avoid the occurrence of pipeline span is highly desired in the pipeline engineering.

As illustrated in Fig.1, for an initially partially embedded pipeline under the influence of ocean currents, vortices may be induced in both upstream side and downstream side of the pipeline, and the resulting

pressure drop would further induce seepage flow within the seabed. The soil scouring beneath the pipe is a coupling process between vortices around the pipeline and seepage within the soil.

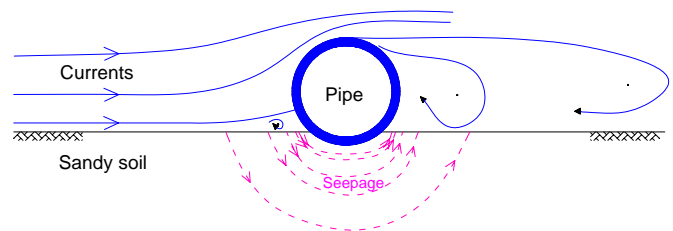


Fig. 1 Illustration of currents induced seepage flow beneath a partially embedded pipe (not in scale)

The mechanism for the occurrence of the spanning of a submarine pipeline with some initial embedment into the seafloor has attracted much attention from numerous researchers. Mao (1986) has described the vortices formed at front and at the rear of the pipe, and discussed the correlations of seepage flow with the onset of scour beneath the pipe. Based on the further experiments, Chiew (1990) concluded that piping is the dominant cause of the initiation of scour beneath the pipeline in currents. Sumer and Fredsoe (1991) conducted experiments to determine the critical condition in the case of wave loading, and expressed it in terms of Keulegan-Carpenter number (KC) and the initial embedment-to-diameter ratio (e_0/D). Sumer et al. (2001) studied the onset of scour below pipelines and the self-burial in both waves and currents. Their experimental results indicated that the excessive seepage flow and the resulting piping are the major factor for the onset of scour below the pipeline. The criterion for onset of scour was given in Sumer and Fredsoe (2002). Besides the aforementioned experiments, numerical method was recently also adopted for simulation of this physical phenomenon, such as the work by Liang and Cheng (2005), Yang et al. (2005) etc.

In this paper, for a better understanding of the mechanism of scour beneath a submarine pipeline, the whole process of the occurrence of