Displacement and Inner Force Analysis of Spanned Pipeline Based on the Interaction between Pipe and Soil

Xianfan Cao Yanlong Qin
CNPC Research Institute of Engineering Technology Department
Tanggu, Tianjin, China

ABSTRACT:

The pipelines buried in soil may become spanned under the scouring action of wave and current. Based on the project in which the pipelines laid among the artificial island No.1, No.3 and the platform No.1, Nan Pu oil field, the study of the displacements and the inner force of spanned pipelines is performed, in which the interaction between pipe and soil is taken into consideration. The buried pipeline is regarded as Winkler beam. The load on spanned pipeline includes two types: the uniform load and the concentrated load, induced by pipe gravity, transported medium gravity, wave, current and so on. Hence, in this paper the responses of the spanned and the buried pipeline, including the displacement and inner force, are studied and the analytic solution of them is obtained. At last, the method is validated and used to calculate the displacements and the inner force of spanned pipeline in Nan Pu oil field under a working condition.

KEY WORDS: pipeline; displacement; inner force; interaction between pipe and soil; pipeline; Winkler beam; spanned.

INTRODUCTION

With the exploration of oil field in the sea, a large member of pipelines is laid all over the world. The pipelines buried in soil may become spanned when they are scoured by wave and current (Sumer, Whitehouse and Torum, 2001). It is of important interest to study the displacement and the inner force of spanned pipelines for it can be used to guide the safety maintenance of pipelines. If the boundary of spanned pipeline is considered to be fixed or hinged, the calculation is easy to deal with. However the results based on them are of little accuracy. If the complicated mechanics property of soil is considered (Ose, Yong, Nystrom and Damsleth, 1999), it is difficult to calculate the responses of spanned pipeline. According to the Winkler model (Hetenyi, 1946; ShuHeng, 2005; Wang, 2008), the beam-supporting soil is modeled as a series of closely spaced, mutually independent, linear elastic vertical springs, which provide resistance in direct proportion to the deflection of the beam. The Winkler model is applicable for the soil with less shear strength, such as clay, silt. In this pipe, the study of displacements and inner forces of pipelines is performed based on the Winkler model in which the spanned pipeline is subjected to the uniform load and the concentrated load. The buried pipeline is considered as Winkler beam which is laid on the infinite half space. By using the deformation compatibility condition, the displacements and inner forces of the spanned and the buried pipeline are obtained.

MATHEMATICAL MODELS

In general, the load to which the spanned pipeline is subjected includes pipe gravity, transported medium gravity, wave and current, which can be regarded as uniform load along the axis of the pipeline when the pipeline are buried in soil horizontally. For pipe in pipe, there are many spacers connecting outer pipe and inner pipe, which are spaced equably. The forces acting on the outer pipe, which are induced by the inner pipe gravity and transported medium gravity, can be considered as concentrated loads. Hence, there are two types of load that spanned pipeline are subjected to: the uniform load and the concentrated loads. In this paper, the displacement and the inner force of the spanned pipeline under this two types of load are studied. The sketch of spanned pipeline is shown in Fig.1, the middle part is suspended and the two sides of pipe are buried. For small deformations, the displacement of pipeline can be obtained by superposition of that obtained under two types of load. The relationship is shown in Fig. 1, Fig. 2 and Fig. 3.

Fig. 1 The sketch of spanned pipeline under the concentrated load and the uniform load

Fig. 2 The spanned pipeline under the concentrated load