Axial and Lateral Sliding of Pipe on Simulated Seabed Soft Soil

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Abstract: Deep-water oil pipelines rest on very soft seabed and are susceptible to axial and lateral movement of pipelines due to cyclic thermal and pressure changes and lateral buckling due to thermal expansion under operating conditions. Hence, several physical models have been designed and constructed at the CIGMAT Laboratory to investigate the pipe movement onsoft soil seabed.

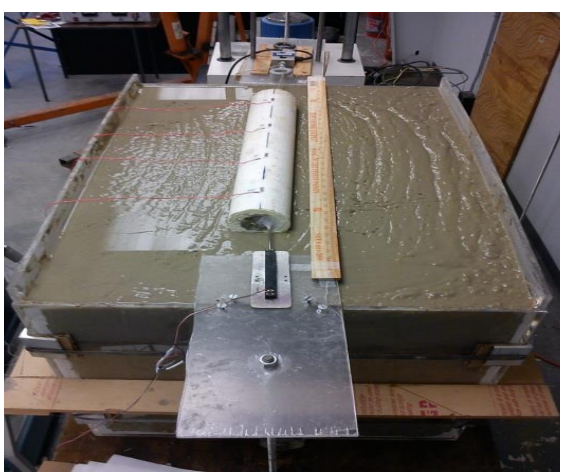
1. Introduction.

The axial and lateral soil resistances depend on several factors. Most of these factors have a wide range of uncertainties. In general, these resistances strongly relate to the installation methods, pipeline weight history, and pipeline displacement magnitudes. There are several models used to predict the lateral resistance of the pipeline (G.M. Wantland, et al., 1979), (J.M. Schotman, 1987), (Harald Brennodden, 1992)and (S. Mebarkia, 2006)). In general, the lateral resistance is the product of lateral bearing capacity factor (formation of berms), average shear strength, and pipeline embedment. However, the axial resistance is the product of an adhesion (friction) factor, soil shear strength, and pipeline embedment. The adhesion (friction) factor depends on the magnitude of the shear strength (Guideline for the Seismic Design of Oil and Gas Pipeline Systems –ASME). Based on the testing condition, frictional factors of 0.1 to 1.5 have been reported by different authors (D.J. White, et al., 2011).

2. Objective

The main focus of this study was to investigate the pipe-soil interaction using model tests. After developing the soft clay with undrained shear strength of 15 psf to represent the seabed, the specific objective of this study was as following:

(1) Determine the axial and lateral friction-displacement relationship for plastic pipe on the soft soil seabed. Plastic pipe was selected to represent the coated deep-water pipelines.


(a)


(b)

Figure 1. Test models: (a) Axial loading (b) Lateral

3. Materials and Methods

Model test, with dimension of 3 ft. length 2 ft. width. and 3 ft. depth was used to simulate the pipe interaction with the soft clay soil representing the seabed (Figure 1). The thickness of the soft soil profile used in this study was 1 ft., about 3 times the diameter of the pipe. The resistance to pipe sliding on the soft soil was monitored using a load cell. The pipe displacement and excess pore pressured were monitored using linear variable displacement transducer (LVDT) and pore pressure transducers.

4. Result and Discussion

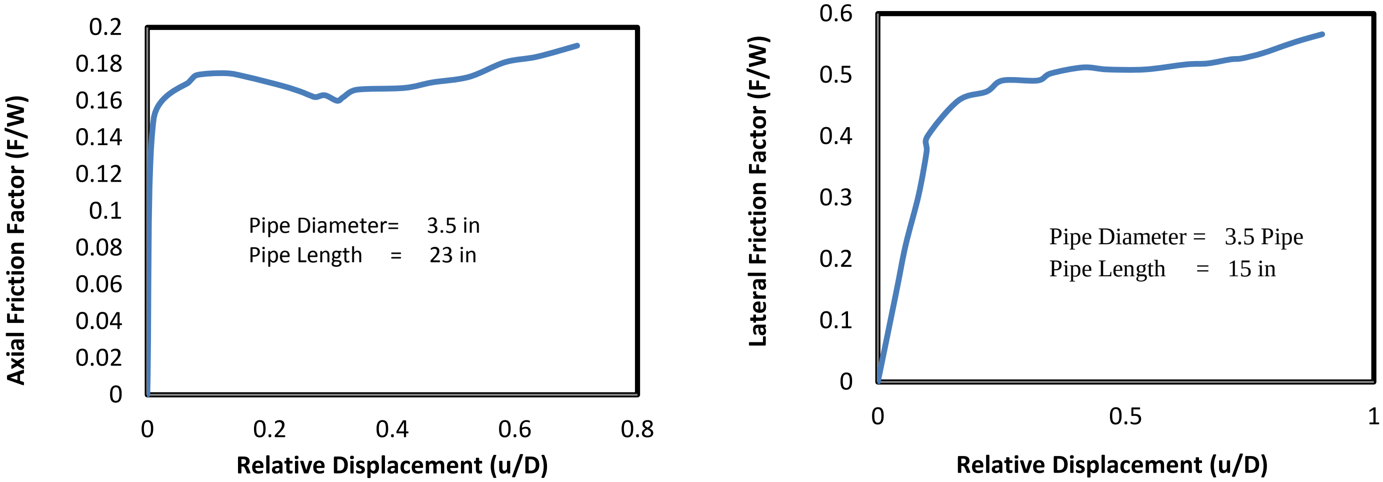


Figure 2. Friction Factor; (a) Axial Friction Factor (b) Lateral Friction Factor

In this study friction factor is defined as the resisting force divided by the vertical load (weight) and the displacement was normalized with the diameter of the pipe. Maximum axial resistance was reached with relative displacement of 0.15 (Fig.1) and maximum lateral resistance was reached with relative displacement of 0.4 as shown in Fig.2

5. Conclusion

Maximum axial and lateral resistances were reached after relatively short movement of the pipe. The average lateral friction was about three times higher than that of the axial friction for same rate of displacement. The frictional factors are within the reported numbers in the literature.

5. Acknowledgement

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6. Reference

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