Behavior of Flexible Pipe with Sand Backfill

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Abstract

An experimental study, on interaction between soil backfill and flexible plastic pipes was performed in a soil box, which represents the trench condition. Earth pressure transducers, strain gages, and deflectometer were used to determine the stress distribution, hoop strain distribution, and deflection of flexible pipe in the soil box. The sand was used as backfill material which had a maximum and minimum dry density of 112 lb/ft^3, and 98 lb/ft^3 respectively. Tests were performed at a relative density of 65%. Surface stress was applied up to 70 psi. Measurements were taken during backfilling and when surface pressure was applied. Earth pressure, hoop strain, and sidewall friction are analyzed and discussed.

1. Introduction

In major cities, pipes are laid in trenches and then backfilled with various materials. It is important to determine the stress, and strain behavior of flexible pipes on the buried pipe in the trench condition. In order to simulate the trench condition, soil box was used in this study. The stress, and strain in the pipe may be significantly influenced by the interface friction angle between backfill and walls, properties of pipe, backfill material, soil box dimension, and surface loading.

2. Objective

The overall objective of this study was to study of the performance of flexible plastic pipes during sand backfill placement and surface loadings under trench condition and model the response of buried pipes using numerical analysis.

3. Testing program

To simulate the buried flexible pipe in a trench, a soil box was used in this study. The soil box was fabricated and a flexible PVC pipe of SDR 55 was installed in soil box as shown in Fig. 1. Commecially available sand was used for backfilling and surface static pressure of 70 psi and was applied for the two months. The pipe-backfill system was instrumented to read the circumferential strains in the pipe wall, soil pressure exerted against the pipe at the crown, spring-line and invert, and pressure on the soil surface.

4. FEM Analysis

Finite element analysis program "PLAXIS" was used to study the interaction of PVC pipe with the backfill soil in the soil box. The cross-trench condition was analyzed as plane strain condition. Six circular segment elements were used to represent the PVC pipe. Fifteen node plane strain triangular elements were used to model the backfill. Five node beam elements were used to represent the soil-steel box interface. A vertically free and horizontally fixed boundary was used for soil box sidewalls.

4. Results

The variation of vertical earth stress and hoop pipe strain with applied surface stress is shown with FEM analysis in Fig. 2, 3 and 4.

Figure 1. Principal Elements of Soil Box

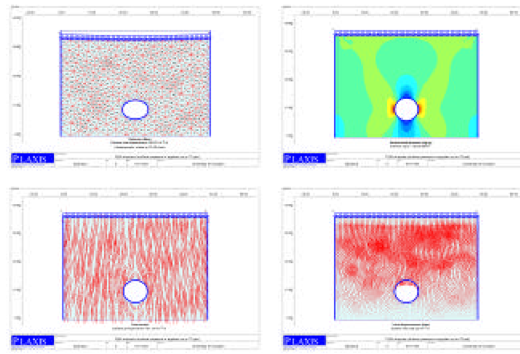

Figure 2. FEM Analysis for Vertical Earth Stress

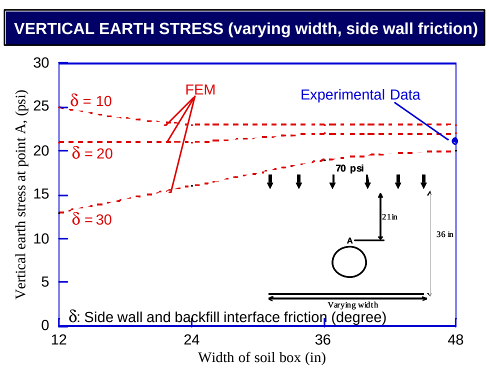

Figure 3. Vertical Earth Stress (Experiment and FEM)

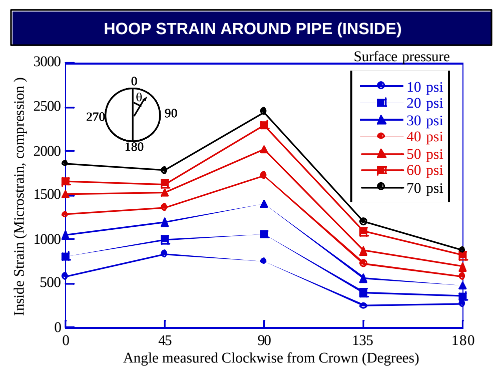

Figure 4. Hoop Strain Around Pipe (Inside of Pipe)

5. Conclusions

The vertical stress distribution obtained from the experimental results agreed with the finite element analysis prediction. Pipe properties, soil box dimension, side wall and soil interface friction angle played an important rule in the stress development in the flexible pipe. Compressive strain were developed in the pipe wall when surface load was applied.

6. Acknowledgments

This work was supported by CIGMAT under grants from the City of Houston, Houston, Texas, and Texas Department of Transportation.

Cho, Sungro (2003). "Behavior of Flexible Plastic Pipes with Flowable Backfill in Trench Conditions" Ph.D. dissertation, Cullen College of Engineering, University of Houston, Houston, Texas.