Verification of Stress Distribution in A Soil Box

Sungro Cho and C. Vipulanandan

CIGMAT- Department of Civil and Environmental Engineering
University of Houston, Houston, Texas 77204-4003
Phone: 713-743-4291(O); E-mail: sungrocho@yahoo.com

Abstract

Soil pressure transducers were used to determine the stress distribution in the backfill in a “soil box”. The soil box represents the trench condition in the ground. The sand used as backfill material 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 70%. Surface stress was applied up to 50 psi. The vertical and horizontal earth pressures were measured at various depths using the soil pressure transducers. The validity of the theoretical solution based on Janssen’s analysis was compared to experimental results.

1. Introduction

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

2. Objective

The overall objective of this study was to determine the stress distribution in the soil box by direct measurement and comparing it to a theoretical solution.

3. Testing program

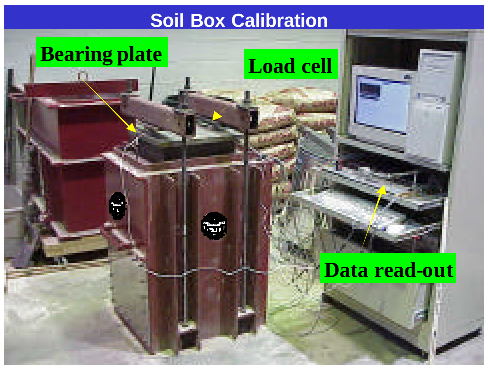
A self loading steel soil box was designed for simulating earth pressure with a width of 24 inches, breath of 20 inches, and a height of 36 inches (Fig.1). The specially developed soil pressure transducers were diaphragm strain gage types 3.5 inches in diameter and 1 inch thick (Fig.2). These transducers, sensitive from 0.5 to 1 psi pressure (nonlinear calibration behavior), were used to measure the vertical and horizontal soil pressure using sand classified as SP (USCS). The sand was deposited uniformly into the soil box by dropping 3 ft from a bucket achieving a relative density of 70%. The surface load was applied using a rigid plate and the load was measured using load cells. The theoretical solution (Van Horn, 1963) for vertical stress at a depth z below the surface in a box of width b and breath l, interface friction angle between backfill and walls of f, subjected to an applied surface pressure of q, can be estimated by following equation.

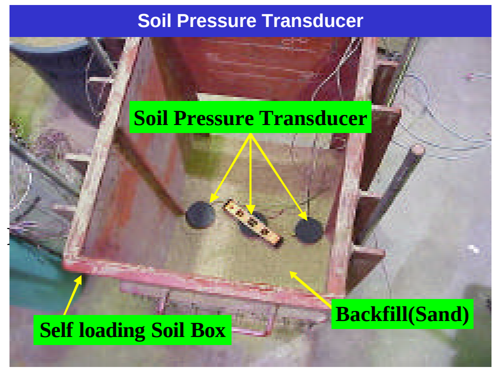
$$s_v = \frac{Lg}{2k_r \tan f}\left[1 - \exp(-2k_r \tan f \frac{2z}{L})\right] + q\exp(-2k_r \tan f \frac{2z}{L}), \text{ where, } L = \frac{bl}{(b+l)}$$

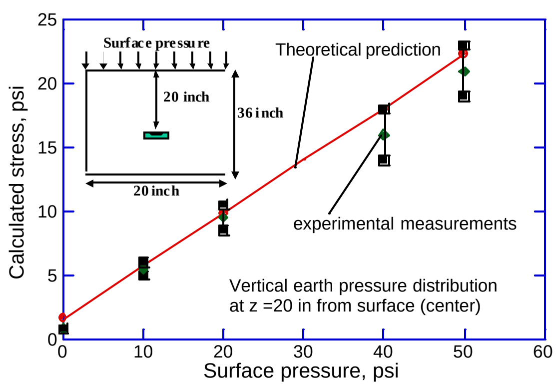
g = Unit weight of soil, k_r = the ratio between horizontal and vertical pressure

4. Results

The variation of vertical stress with applied surface stress is shown in Fig. 3 and Fig. 4. The theoretical prediction was obtained with an interface friction angle between backfill and walls of 20°.







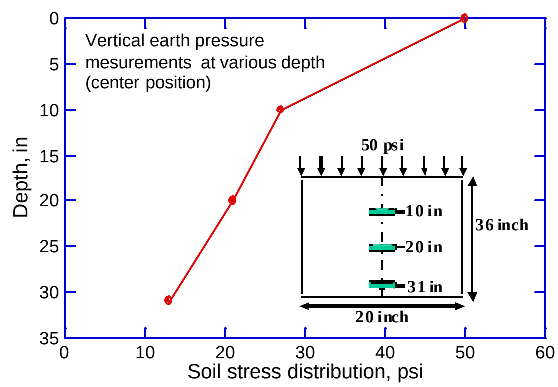


Fig.3. Vertical stress distribution (z=20 in)

Fig. 4. Vertical stress distribution at varying depth

5. Conclusions

The vertical stress distribution obtained from the experimental results agreed with the theoretical prediction.

6. Acknowledgments

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

7. References

1) Bulson, P.S. (1985), "Buried Structure: Static and Dynamic Strength", Chanpman and Hall, UK.

Van Horn, A.D. (1963), "A Study of Loads on Underground Structures", part III, Iowa Engineering Experiment Station.