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Laboratory tests of small-diameter HDPE pipes buried in reinforced sand under repeated-load

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Abstract

This paper describes laboratory tests on small-diameter high-density polyethylene (HDPE) pipes buried in reinforced sand subjected to repeated loads to simulate the vehicle loads. The amplitude of applied stress was 5.5 kg/cm^2 in all tests. Deformation of the pipe was recorded at eight points on the circumference of the tested pipes to measure the radial deformations of the pipe. Also, settlement of the soil surface was measured throughout the test for up to 1000 cycles of loading. These values increased rapidly during the initial loading cycles; thereafter the rate of deformation reduced significantly as the number of cycles increased. The variables examined in the testing program include relative density of the sand, number of reinforced layers, and embedment depth of the pipe. The influence of various reinforced layers at relative densities of 42%, 57%, and 72% in different embedded depths of 1.5–3 times of pipe diameter were investigated. The results show that the percent vertical diameter change (ΔD) and settlement of soil surface (SSS) can be reduced up to 56% and 65% for ΔD and SSS, respectively, by using geogrid reinforcement, and increase the safety of embedded pipes. Also, the efficiency of reinforcement was decreased by increasing the number of reinforcement, the relative density of soil and the embedded depth of the pipe. The influence of the first cycle was also found to be one of the main behavioral characteristics of buried pipes under repeated loads. The ratio of deformation of the pipe from the first cycle to the last cycle changes from 0.5 to 0.9 in different tests. It should be noted that only one type of pipe, one type of geogrid, and one type of sand are used in laboratory tests.

Keyword: Laboratory test; Soil reinforcement; Repeated loads; Buried flexible pipe; Percent vertical diameter change; Soil surface settlement

1. Introduction

The safety of buried pipes, as one of the most important urban facilities, under different loading conditions depends highly on the safe design and performance of these buried structures. This cannot be achieved unless their actual behavior is well understood and their design is considered. Considerable research on the behavior of pipes embedded in unreinforced soil under various loading conditions has been carried out using small-scale physical models or full-scale models. The work was originally carried out by Marston and Anderson (1913) and a theory for calculating diameter change was used by Spangler (1941). Rogers et al. (1995, 1996) investigated the influence of the installation procedure on the subsequent performance of a buried flexible pipe. The results of tests examining four different installation conditions indicated that the pipe wall strain data correlated well with pipe displacement and the pipe wall displacement profile can be predicted from strain measurements with care. Brachman et al. (2000) designed a laboratory facility for evaluating the performance of small-diameter pipes when buried under deep and extensive overburden material. They reported that reducing boundary friction to less than 5° and limiting the boundary deformation to less than 1 mm at a vertical surcharge of 1000 kPa provide a good idealization of field condition for a deeply buried pipe. Faragher et al. (2000) carried out a full-scale controlled field test to investigate the behavior of embedded flexible pipes under repeated loadings in real installation conditions. It was observed that the vertical

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