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Analysis of repeated-load laboratory tests on buried plastic pipes in sand

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ABSTRACT

This paper describes a laboratory model test carried out on high-density polyethylene (HDPE), small diameter pipes buried in trenches, which subjected to repeated loadings to simulate the vehicle loads. Deformation of the pipe was recorded at eight points on the circumference of the tested pipes to measure the radial deformations and detect cross-sectional pipe profiles. Also settlement of the soil surface during the test up to 1000 cycles of loadings was recorded, until its value become stable or the excessive settlement was happened. The parameters varied in the testing program include height of buried depth, relative density of the sand and intensity of stress on the soil surface. The influence of various repeated loads (with magnitude of 250, 400 and 550 kPa) at relative densities of 42%, 57% and 72% in different embedded depth of 1.5–3 times of pipe diameter were investigated. Based on the results, in medium and dense sand relative density, the pipe embedded in depth of 3.0D and 2.0D, respectively, mostly remained undamaged (the maximum value of VDS is less than 5%) and increased the safety of buried pipes under different magnitude of repeated loads. The records of the pipe deformation and settlement of the soil surface due to the repeated loads have been compared in different conditions. These values increase rapidly during the initial loading cycles by a rate decreasing significantly as the number of cycles increase. 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 pipe at first cycle to last cycle changes from 0.60 to 0.85 in different tests. Finally for the obtained results, a non-linear power model has been developed to estimate the vertical diametral strain of buried pipe and settlement of the soil surface based on the model test data. It should be noted that only one type of pipe and one type of sand are used in laboratory tests.

1. Introduction

Many researchers have investigated the structural response of buried flexible pipes, ducts and culverts under different loading for more than 80 years. The original work was carried out by Marston and Anderson [1], and a theory for calculating diametral change, was used by Spangler [2]. Rogers et al. [3,4] investigated the influence of the installation procedure on the subsequent performance of 100–375 mm diameter flexible pipe. The results of test 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. [5] 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. [6,7] carried out a full-scale controlled field test to investigate the behavior of embedded flexible plastic pipes in a range 600–1050 mm diameter, under repeated loading in real installation conditions. It was observed that the vertical deformation of pipe increased rapidly during initial loading cycles while the rate of deformation reducing markedly as further cycles of loading were applied. Mir Mohammad Hosseini and Moghaddas Tafreshi [8] conducted laboratory work on 100 mm diameter thin steel pipes subjected to repeated loads up to 100 kPa. They found that the soil density and the pipe embedded depth would be the most important factors affecting the soil–pipe interaction. Mogahaddas Tafreshi and Khalaj [9] performed an experimental study on 110 mm diameter HDPE pipe to investigate the behavior of pipes buried in geogrid reinforced sand when subjected to repeated loads up to 550 kPa. They reported that the use of geogrid reinforcement can significantly reduce the vertical diameter change of pipe and settlement of the soil surface. Arockiasamy et al. [10] performed field tests on polyethylene, PVC and metal large diameter pipes subjected to highway design truck loading, followed by numerical simulations using finite element

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