ABSTRACT

Concrete pipes serve as an effective underground infrastructure lines especially as sewer lines, culvers or conduits. Today, it is well known that besides the pipe material, the installation types have a great effect on the performance of the pipe-soil system.

The present study deals with the experimental and theoretical investigations of buried concrete pipes. Concrete pipes are buried in loose and dense conditions of gravelly sand soil and subjected to different surface loadings to study the effects of the backfill cover, compaction, trench width and bedding types on the pipe.

A full-scale experimental testing program was undertaken to perform tests on 19 typical precast unreinforced concrete pipes with 300 mm internal diameter tested in a laboratory soil box test facility set up for this study. Three loading platforms are used namely, uniform loading platform, strip loading platform and patch loading platform. The wheel load was simulated through patch loading platform which have dimensions of 254 mm *508 mm (10 in * 20 in), which is used by AASHTO to model the wheel load of a HS20 truck.

The pipe-soil systems were loaded up to pipes collapse. Pipes were instrumented with strain gauges to measure circumferential strains, in addition to LVDTs and dial gauges, for measurements of the pipe vertical deflections and settlement of the loading platforms.

Theoretical analyses were performed using both of Burns & Richard analytical solution and finite-element method (CANDE software). In finite element analysis the soil-structure interaction analysis of buried pipe is typically conducted within two dimensions, assuming the buried pipe and surrounding soil are in a plane strain condition.

The test results further indicated that flexure governed the buried pipe behavior. Flexural cracks formed slightly before the ultimate load.

It was found that the behavior of the buried pipe was strongly influenced by backfilling methods. In case of uniform loading and according to the collapse loads of pipes with 60cm backfill cover; the installation quality in case of dense backfill in comparison with very loose backfill can increase the strength of pipe-soil system to approximately 50% as an upper limit.

The highest bedding factor obtained was 4.53 for concrete bedding with dense backfill and lowest bedding factor is 1.26 for uncompacted backfill and compacted soil bedding.

A 70% of the pipe strength that was gained through using the traditional concrete bedding of indirect design method could be considerably achieved through controlled installation using backfill of dense compaction granular material.

The concrete pipe with good quality installation and cover of 60 cm demonstrated a large capacity to resist extreme loads that reached nearly two times AASHTO heavy design loading, HS-20.

A comparison of soil backfill, between a loose and dense compaction, showed that the dense backfill improve largely the pipe installation and then the strength of pipe-soil system. Also bedding material with low compaction effort cause considerable reduction in induced stresses.

It is found that as trench width be narrower to the pipe diameter; its resistance to the vertical loading is more effective due to the reduction in the soil load that reached to the pipe crown which finally increases the soil-pipe system strength.