Abstract

It is generally accepted that high density polyethylene pipe (HDPE) performs well under live loads with shallow cover, provided the backfill is well compacted. Although industry standards require carefully compacted backfill, poor inspection and/or faulty construction may result in soils that provide inadequate restraint at the springlines of the pipes thereby causing failure. The objectives of this study were: 1) to experimentally define a lower limit of compaction under which the pipes perform satisfactorily, 2) to quantify the increase in soil support as compaction effort increases, 3) to evaluate pipe response for loads applied near the ends of the buried pipes, 4) to determine minimum depths of cover for a variety of pipes and soil conditions by analytically expanding the experimental results through the use of the finite element program CANDE.

The test procedures used here are conservative especially for low-density fills loaded to high contact stresses. The failures observed in these tests were the combined effect of soil bearing capacity at the soil surface and localized wall bending of the pipes. Under a pavement system, the pipes' performance would be expected to be considerably better. With those caveats, the following conclusions are drawn from this study.

Glacial till compacted to 50% and 80% provides insufficient support; pipe failure occurs at surface contact stresses lower than those induced by highway trucks. On the other hand, sand backfill compacted to more than 110 pcf (17.3 kN/m^3) is satisfactory. The failure mode for all pipes with all backfills is localized wall bending.

At moderate tire pressures, i.e. contact stresses, deflections are reduced significantly when backfill density is increased from about 50 pcf (7.9 kN/m^3) to 90 pcf (14.1 kN/m^3). Above that unit weight, little improvement in the soil-pipe system is observed.

Although pipe stiffness may vary as much as 16%, analyses show that backfill density is more important than pipe stiffness in controlling both deflections at low pipe stresses and at the ultimate capacity of the soil-pipe system. The rate of increase in ultimate strength of the system increases nearly linearly with increasing backfill density.

When loads equivalent to moderate tire pressures are applied near the ends of the pipes, pipe deflections are slighly higher than when loaded at the center. Except for low density glacial till, the deflections near the ends are not excessive and the pipes perform satisfactorily. For contact stresses near the upper limit of truck tire pressures and when loaded near the end, pipes fail with localized wall bending.

For flowable fill backfill, the ultimate capacity of the pipes is nearly doubled and at the upper limit of highway truck tire pressures, deflections are negligible.

All pipe specimens tested at ambient laboratory room temperatures satisfied AASHTO minimum pipe stiffness requirements at 5% deflection. However, nearly all specimens tested at elevated pipe surface temperatures, approximately 122°F (50°C), failed to meet these requirements. Some HDPE pipe installations may not meet AASHTO minimum pipe stiffness requirements when installed in the summer months (i.e. if pipe surface temperatures are allowed to attain temperatures similar to those tested here). Heating of any portion of the pipe circumference reduced the load carrying capacity of specimens.

The minimum soil cover depths, determined from the CANDE analysis, are controlled by the 5% deflection criterion. The minimum soil cover height is 12 in. (305 mm). Pipes with the poor silt and clay backfills with less than 85% compaction require a minimum soil cover height of 24 in. (610 mm). For the sand at 80% compaction, the A36 HDPE pipe with the lowest moment of inertia requires a minimum of 24 in. (610 mm) soil cover. The C48 HDPE pipe with the largest moment of inertia and all other pipes require a 12 in. (305 mm) minimum soil cover.