Discussions and Closures

Discussion of “Laboratory Study on Geosynthetic Protection of Buried Steel-Reinforced HDPE Pipes from Static Loading” by Ryan Corey, Jie Han, Deep K. Khatri, and Robert L. Parsons

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Over the last 3 decades the academic geotechnical engineering community has been involved in conducting laboratory and full-scale testing on geosynthetics to study the benefits of using these materials for the protection of shallow buried pipes. Such testing is based on the concept that the stiffness of this material itself and the resulting stiffness of soils with geosynthetic inclusions would be beneficial in relieving the stresses to which the pipes may be subjected when buried at shallow depths (and subjected to traffic, construction, and permanent loads). Noteable previous studies on the benefits of geosynthetics was conducted at Carleton University, Ottawa, in 1983 and 1987 under the direction of Professor Gunther Bauer, who reported the results of full-scale laboratory tests investigating the use of geogrid geosynthetic under static and repeated load conditions in controlling settlement (Bauer 1984). More recently, Bueno et al. (2005) reported preliminary results on a novel construction method to reduce vertical stresses on buried pipes. This research effort done on both small-scale and large-scale facilities showed that the vertical stresses acting on top of the pipe can be significantly reduced by the use of geosynthetic reinforcement. Factors influencing the design are the length and location of geosynthetic in relation to the top of the structure soil type, soil density, and stiffness of the geosynthetic inclusion. Additional research efforts have been made since that time by other researchers as noted by the authors of the original paper.

According to the authors of the original paper, a shortcoming of the tests conducted so far has been that the tests were undertaken on small-diameter pipes with no test on a pipe diameter exceeding 425 mm. Also, the previous tests focused on pipe deflection and soil settlement with limited instrumentation. The original paper is considered an expansion of the previous studies using a larger-diameter pipe with instrumentation that monitor the longitudinal strains in the geosynthetic and the strains within the pipe, as well as the deformations of the pipe and ground surface.

The writer offers a few comments on the original paper and findings. The authors of the original paper have presented the results of the experimental program in a series of graphs (Figs. 5–13) which depict various aspects of behavior of the soil and pipe, and strains in the geogrid and pipe under the applied stresses. Figs. 5 and 6 depict the deformation of the soil surface (loading plate settlement) and vertical deflection of the underlying pipe for both unreinforced and geogrid-reinforced situations as outlined in the experimental program in Fig. 1 and Table 2. The findings of the original paper in relation to the results obtained are somewhat at variance with what has been deduced by the writer from Figs. 1 and 5–13. For example, at the same applied vertical pressure of 345 kPa for the sand base section, the writer has deduced that the percent of vertical deflection of the pipe in the unreinforced sand configuration over the surface settlement of the plate should be around 10% rather than 14%, while the percent of vertical deflection of the pipe over the surface settlement in the reinforced sand case should be 14% rather than 10% as noted by the authors of the original paper. These results would therefore indicate that the geogrid reinforcement has contributed to a reduction of the vertical deflection of the pipe. However, it would appear that there is a bit of confusion in understanding the results presented and some of the conclusions drawn by the authors of the original paper, as a result of the authors of the original paper not including and identifying clearly the results of all the tests indicated in Table 2 and Figs. 5 and 6.

In the case of the aggregate base, however, for the same applied pressure of 345 kPa, the results are approximately the same as shown by the authors of the original paper which would indicate that a greater benefit may be attributed to the larger resulting stiffness of the aggregate base course with the inclusion of the geogrid reinforcement in the aggregate base along with the geogrid reinforcement in the sand over the crown of the pipe. This situation is also true for all applied stresses on the pipe below the aggregate base section up to the 552-kPa applied limit stress to the aggregate base. In comparing the reduction in surface settlement in the case of the unreinforced sand base under the 345-kPa applied stress, the reduction in plate/surface settlement resulting from the geogrid-reinforced inclusion inside the pipe trench is determined by the writer to be around 25% of the unreinforced sand base the same as was reported in the original paper. The results in Fig. 5 also show that the surface settlements of the sand base are much larger than those of the aggregate base for applied stresses up to the limit stress of 345 kPa of the sand base, which is also in keeping with the findings of the original paper.

Fig. 6 also shows that the vertical deflections of the pipe below the sand base are slightly larger than those below the aggregate base for all stresses up to the limit stress of the sand of 345 kPa. From these results one can infer that the geogrid inclusion above the crown may be too short to act as a tension member, and should be as least as long as the geogrid in the aggregate base section. Also, the stiffness of the sand base is insufficient to aid in reducing the stress on the pipe despite that the stiffness and strength of the sand base would be expected to improve with increased surface settlement up to the limit stress of the sand. As noted by Bauer (1994) the use of more than one layer of geogrid geosynthetic of similar length reduces considerably the pressure transmitted to the underlying pipe, while the use of nonwoven geotextile geosynthetic of varying rigidities over a buried pipe using the so-called Geovala approach developed by Bueno et al. (2005) showed smaller vertical stresses than those measured in the conventional installation, thereby demonstrating the importance of geosynthetic reinforcement in reducing applied stresses on buried pipes.

Figs. 7 and 8 depict the results of the earth pressures measured at the crown of the pipe under various magnitudes of applied vertical pressure for reinforced and unreinforced sand and aggregate conditions, and compared them with earth pressures above the pipe crown due to the currently accepted AASHTO live load distribution. Figs. 7 and 8 depict a loading and unloading sequence of applied pressure, for both the unreinforced and reinforced conditions. As noted by the authors of the original paper, the reduction in deflection at the crown for both the sand and aggregate backfill was about a 10% reduction of pressure on the pipe crown with the inclusion of geogrids under the maximum limit pressures for the
sand base section as well as the maximum limit pressure for the aggregate base section. Somewhat similar crown pressures were obtained for both sand and aggregate base sections up to the maximum limit pressure of the sand base section. Figs. 7 and 8 also show that beyond a crown pressure of 10 kPa recorded for both the sand and aggregate base resulting from the pressure due to self weight of soil above the crown, the crown pressures increased almost in a linear fashion to the maximum limit pressures of the sand and aggregate bases. This information would be of value in selection of nonsteel reinforced high-density polyethylene (HDPE) pipes commonly used as buried conduits.

It is presumed that the sand and aggregate limit pressures were determined from triaxial tests. However, no details of this testing have been provided for any of these materials. The stiffness of the materials can be determined from the load settlement curves as shown in Fig. 5 in which the sand material displays generally a smaller stiffness than the base coarse aggregates as would be expected. However, the geogrid being absent from the sand base course does not allow the evaluation of the behavior of the reinforced sand base in comparison with that of the reinforced aggregate base.

It would have been of both academic and practical interest if the authors of the original paper had undertaken an experiment with a similar length of the upper geogrid in the sand base at the same location as used in the aggregate base section. The findings would have allowed the determination of the effect of this inclusion on the surface settlement and pipe vertical deflection, and also allowed for comparison with the results of tests on the aggregate base section. Furthermore, this would have demonstrated what effect the type and physical characteristics of these base course materials would have on the surface settlement, and vertical pipe deflection behavior.

References
