Trenchless Technology Center Newsletter

D E C E M B E R 2 0 1 2

Evaluating Friction Coefficients Associated with Installation of Thermoplastic Pipes Using HDD

Horizontal directional drilling (HDD) is a trenchless construction method used for the installation of pipelines and conduits beneath natural and manmade obstacles and across environmentally sensitive areas. An accurate pull-load prediction during HDD installation is an important aspect of proper design and successful installation, and it is particularly true in the case of thermoplastic pipes. Over-estimating the anticipated pull load could result in the need to install a heavier wall and/or a larger diameter pipe, increasing construction costs. Underestimation of pull loads could result in tensile stresses that exceed permissible levels and, in extreme cases, lead to permanent deformation and ultimately rapture of the pipe product in the borehole.

There are several parameters that contribute the minimum force required to advance a pipe product within the bore including pipe length and weight, surface friction, borehole frication, drilling fluid drag, and bore path geometry. In the case of long drives of large diameter thermoplastic pipes, borehole frication could account for the lion share of the pull force, particularly if a ballast installation approach is not used. The laboratory testing program reported herein was commenced to quantify friction coefficient values in the case of a thermoplastic pipe subjected to various levels of normal loads for various combinations of soil materials and drilling fluid compositions. The design of the experiment included several common soil materials (sand, silty-sand, clay and silty-clay), a range of drilling fluid products and additives (bentonite-based fluid for sandy soils; polymer based drilling fluid for clayey soils) and two pipe diameters (6 in. and 8 in.).

Experimental Set-up

The experiment consisted of two different custom built set-ups. The first set-up was used to prepare the soil beds (with and without drilling fluid filter cake), while the second setup was utilized to pull the pipe product atop soil bed, while applying a predetermined normal load to pipe and measuring the friction coefficient between the pipe product and soil substrate. The set-up used for the preparation of the soil bed is shown in Figure 1. A 6-in. square, 2-in. tall steel box was filled with soil in three lifts with each lift compacted using a 5-lbf hammer. A Plexiglas guide was used to shape the surface of the soil surface to obtain a curved surface one and a half times the diameter of pipe product.

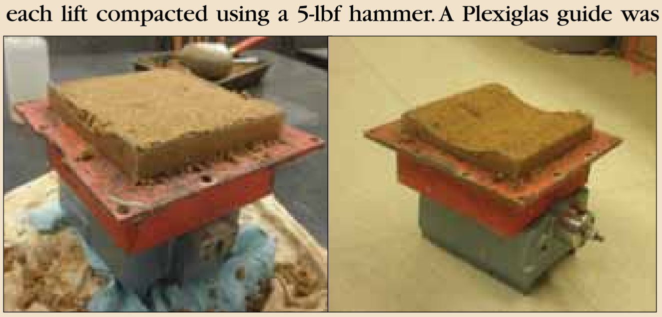

Figure 1: Plexiglass guide (left) and shaped soil surface (right)

The soil box was then covered and bolted with a steel lid through which drilling fluid was injected under a pressure of 30 psi over a 10-minute period, enabling filtration through the porous soil medium and subsequently, the development of a filter cake on the soil surface, thus, mimicking the process taking place in the borehole during an actual HDD operation.

Next, the lid was removed and the soil bed with the deposited filter cake was placed on the second set-up, a modified direct shear test machine. The pipe was placed on the soil bed, and a 200-lbf load cell was connected to it rear end. Two linear variable displacement transducers (LVDT) were deployed to register the linear displacement of the pipe and box, respectively. The box was pulled at a rate of 1.2 mm/min, and the restrained load cell at the rear end of the pipe recorded the friction force (see Figure 2).

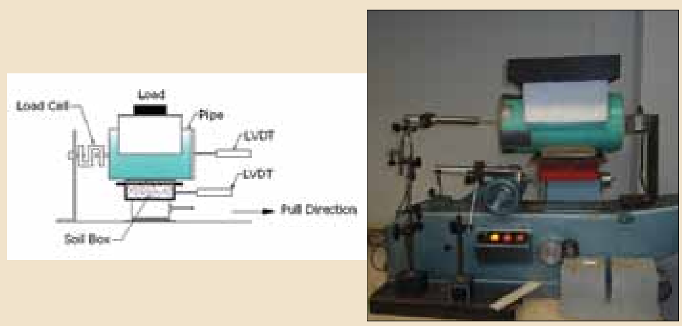

Figure 2: Second set-up – schematic (left) and actual (right)

Experimental Results

Figure 3 shows friction force developed between the sand bed and an 8-in. thermoplastic pipe with and without drilling fluid filter cake. The steep portion of the curve indicates static friction between the pipe and bare-soil (or filter-cake); the point at which the curve level-out indicates force level required to initiate motion (i.e., mobilize the pipe); the horizontal portion of the curve reflects the dynamic friction between the pipe and the soil substrate.

Figure 4 displays the maximum friction forces for sand and clay for cases where filter cake was present and in the absence of such a filter cake. In the case of sandy soils, the force required to mobilize the pipe in cases where the filter cake was absence was found to be up to 50 percent higher compared to the same scenarios where proper filter cake was present. Also, the axial force needed to mobilize the pipe increases with the level of normal force applied to the pipe. In the case of clayey soil, the reduction in pulling force due to the presence of drilling fluids was found to range between 13 percent and 33 percent.

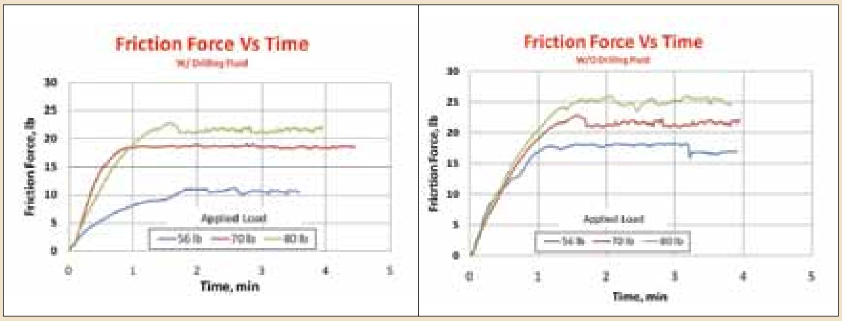

Figure 3: Friction Force between 8 in. pipe and sandy soil with (left) and without drilling fluid (right)

The experiment was repeated for a 6-in. diameter thermoplastic pipe. The axial force required to mobilize the pipe when in contact with a predominantly sandy soil increased by 20 percent to 35 percent when drilling fluids were not used. The increase in the required axial force in the case of clayey soils was 10 percent to 32 percent, depending on the magnitude of the normal force (i.e., buoyancy uplift force due to the presence of slurry in the borehole).

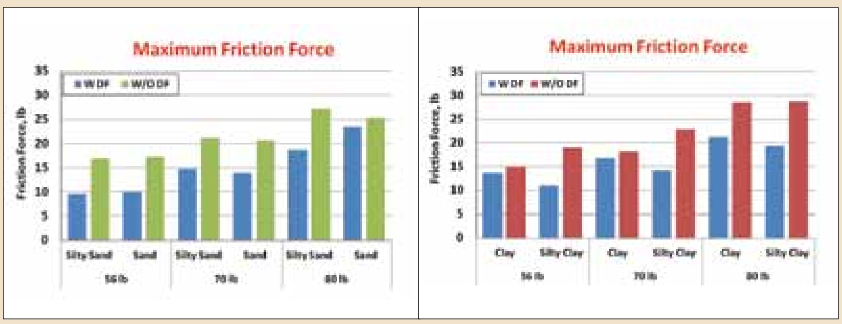

Figure 4: Friction Force between 8-in. pipe with sandy soil (left) and with clay soil (right)

Summary

The presence of a filter cake resulted in friction coefficient values for sand and silty-sand to reduce from 0.33 and 0.36, to 0.23 and 0.24, respectively. In the case of clay and silty-clay, friction values dropped from 0.29 and 0.39 without filter cake, to 0.25 and 0.27, respectively, due to the presence of a properly deposited filter cake. Thus, the utilization of proper drilling fluid mixtures allows smaller rigs to pull thermoplastic pipes over substantially longer distances without over-stressing the pipe product, thus improving the overall cost effectiveness of such projects and reducing construction-related risks.

Industry Advisory Board Meeting Holds Annual Meeting

The TTC hosted its annual Industry Advisory Board meeting in Ruston, La., on the campus of Louisiana Tech University from Oct. 24-26. The kick-off started with a buffet dinner at the Historic Fire Station in downtown Ruston, including a delicious Croatian barbeque provided by Dr. Neven Simicevic. More than 60 participants, including IAB members, TTC staff, faculty, and students, took part in 15 technical presentations in addition to lab demonstrations held throughout the event.

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