Engineering
UPDATE©

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500 FT. ASSEMBLY PLATFORM ON CONCRETE PIERS HEAVES

Shortly after construction, a new manufacturing plant was having trouble controlling the tolerances on the production machinery. The plant engineer finally deduced that the foundation on which the 500 ft. long assemblage track was supported was moving. He suspected that the foundation was settling differentially downward. Settlement was apparently the foremost concern in design. A differential deflection of the assembly track equipment supported by the foundation of a mere 0.04 in. was considered unacceptable.

Due to the tight tolerance required for the production machinery, a massive foundation system consisting of concrete drilled piers was installed in the ground to minimize settlement. The foundation constructed to support the assemblage track consisted of 102, 5-6 ft. diameter, belled, reinforced concrete cassions installed about 25 ft. deep. The large diameter belled cassions were needed to insure that the compression of the pier itself and supporting ground from the manufacturing load would be minimized. The tops of the cassions were structurally connected by a 3.5 ft. thick, 25 ft. wide, and 500 ft. long reinforced concrete cap. A plan and cross-section showing this foundation system is shown in Figure 1.

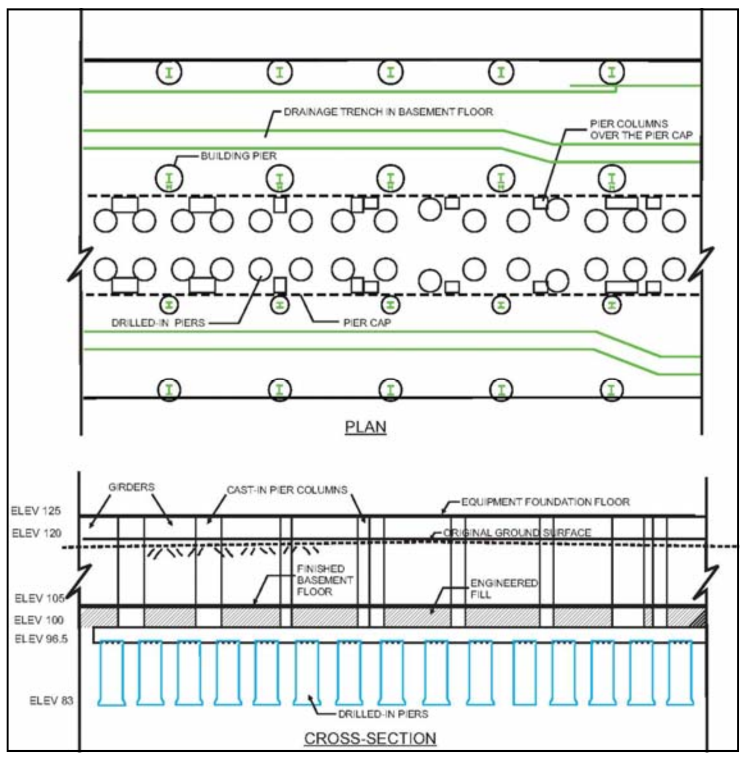

FIGURE 1 PLAN AND CROSS-SECTION OF THE FOUNDATION FOR THE ASSEMBLAGE TRACK IN THE MANUFACTURING PLANT

However, it was later discovered from level surveying that the concrete pier foundation was in fact moving upward, not settling. A plot of the differential upward movement along the assemblage track over about 8 years is shown in Figure 2. Figure 2 shows there has been a fairly constant rate of upward movement over the monitoring period of about 0.25 in/yr. The potential for ground swell from moisture absorption was also considered in the design but was underestimated. The ground swell potential was primarily based on testing of the more shallow, less dense, soil-like materials which had higher moisture contents.

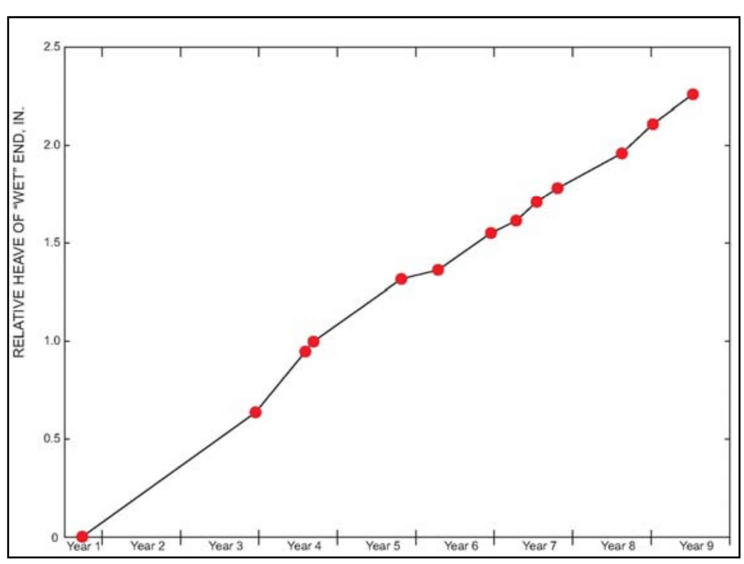

FIGURE 2 PLOT OF THE UPWARD MOVEMENT OF THE MACHINE ASSEMBLAGE TRACK OVER TIME

The main factors in underestimating the potential of the subsurface to lift up the assemblage track and this massive foundation system, were related to two underappreciated conditions. The first condition was the swell potential of the subsurface materials. The pier foundation was found to be socketed into a weathered profile of highly plastic claystone, and as such, had greater heave potential with depth as it generally became more compact (or denser) and drier. These claystone conditions were non-optimum given that part of the manufacturing process resulted in disposing of the processing water onto the basement floor on one side of the assemblage track (the wet end). This processing water would flood the basement floor and seep into the subgrade. Consequently, the subsurface claystone materials were constantly exposed to processing water which became perched in the sandy engineered fill (see Figure 3).

The other important factor which was underappreciated was the ability of the perched process water to be absorbed to depths well below the bottom of the belled cassions. This is also illustrated in Figure 3. As this water was being absorbed down to the wetting front, the claystone materials swelled upwards in spite of the significant download foundation loads. Based on in-ground measurements, upward movement was detected to depths of about 6-7 ft. below the pier bottoms at the wet end of the assemblage track (or a depth of about 31 ft.). Under these site conditions, combined with results of swelling tests performed at depth, downward movement of the wetting front (or greater depths of moisture penetration) would be expected. Historically, even deeper wetting fronts have been reported at sites with similar rock conditions. It should be noted that use of the term "active zone" would be a misnomer in this case as the surface was not subjected to evapotranspiration.

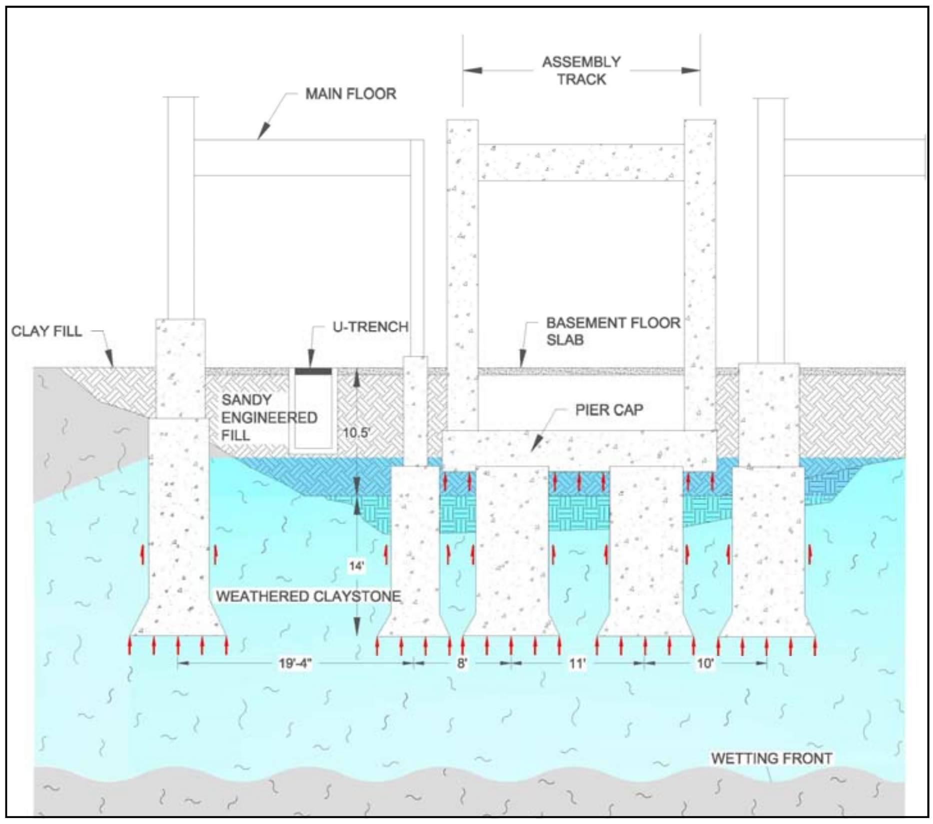

FIGURE 3 ILLUSTRATION OF THE DOWNWARD ABSORPTION AND WETTING FRONT IN THE SUBSURFACE CLAYSTONE MATERIALS

LESSONS LEARNED

This project site was initially poorly investigated and analyzed. If swell tests were run on the lower foundation materials it should have at once become apparent that the swell potential and the depth of the wetting zone for the subsurface claystone materials were much greater. Because site conditions result in a "closed system" (i.e. no surface evapotranspiration), the depth of moisture penetration would be much greater than typically expected and thus deeper heaved conditions would exist. As a result, greater address of the heave potential was required. Misidentifying building foundation heave conditions can present difficult remediation options. They are better addressed before construction and thus worth a more expert design evaluation.

Other Engineering UPDATES of Interest:

UPDATE 13: Foundation Recommendations Result in Unnecessary Large Cost

UPDATE 8: Geotechnical Investigation of Building Damage

UPDATE 29: Hangar Slab Assessment for Poor, As-Built Subbase/Subgrade Conditions

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FOR MORE INFORMATION: There is a significant amount of additional information that is available on the above subject. For more information, please contact MEA at the address listed below.

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