Engineering
UPDATE©
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INVESTIGATION OF A ROADWAY FAILURE

A town in Missouri located on the banks of the Mississippi River demanded the construction of an earthen levee to protect itself from the floodwaters of the river. This required the construction of an asphalt bypass road for an existing state highway, as the proposed levee construction cuts across the highway into the adjacent limestone bluff.

The contractor followed the design guidelines and took the care generally practiced in the field while constructing the bypass. There were rains and high river stages during the process of construction. The subgrade fill was compacted to required density. The engineers were satisfied with compaction test results and approved for asphalt paving. As soon as the paving started the subgrade started pumping. The asphalt truck became stuck, and had to be pulled out with a dozer. The asphalt paving was stopped when the asphalt trucks got stuck and created deep ruts. At this stage the engineers thought that the best remediation was to remove and replace the bypass. Even though the replaced bypass held up during second paving, the subgrade still pumped and the asphalt cracked and settled. Additional asphalt was used to bridge the subgrade and achieve the design lines and grades.

An investigation was called upon to analyze the difficulties encountered during the construction of the bypass. The site was inspected and documented and subsurface conditions were mapped and sampled. Detailed assessment of road conditions and associated plans and specifications were done to determine the cause(s) of construction difficulties.

Forensic testing was conducted on the representative samples collected from the field. Based on the laboratory results the soils used for road fill and natural deposits were reclassified. These soils exhibited unusual characteristics for a silty or clayey soil. In moist conditions, the soils appeared sandy as the individual soil grains appeared to aggregate. Also the soils exhibited unusual compaction properties.

It was discovered from the laboratory testing that there was a dramatic decrease in soil strength when the fill or subgrade soil was compacted at wetter allowable moisture contents or when the soil compacted to specifications became exposed to moisture (see Figure 1). Therefore, the decline in the performance of the bypass road is linked to the moisture-induced softening of previously compacted embankment subgrade soils. It was found that the exposure to moisture was exacerbated by the upward movement of groundwater given the geologic setting. The results of laboratory testing explained how the fill and subgrade prepared to the plans and specifications resulted in the

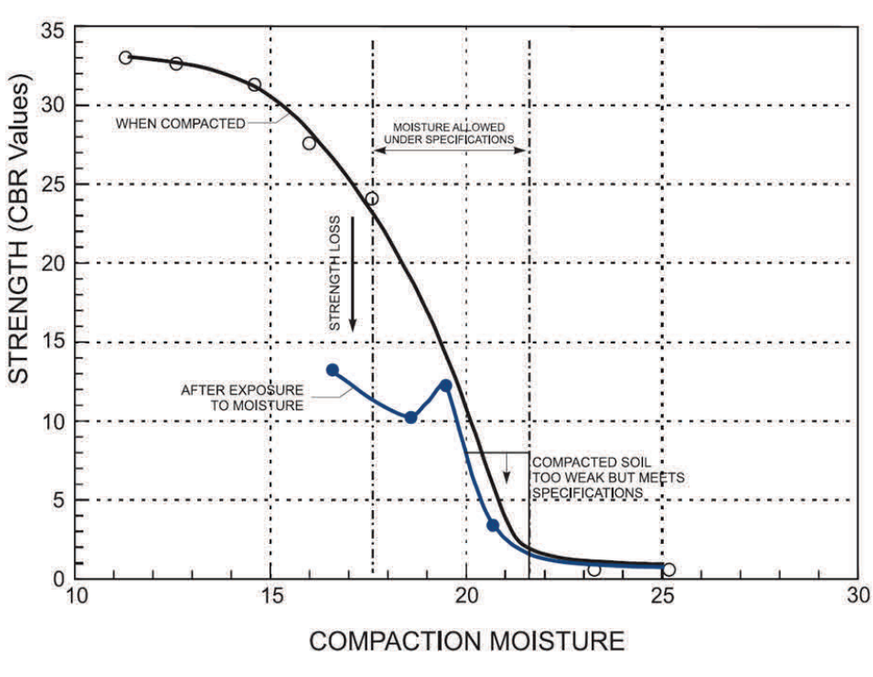

FIGURE 1 SOIL COMPACTED TO SPECIFICATIONS BECOMES TOO WEAK AT ALLOWABLE MOISTURE CONTENTS OR WHEN EXPOSED TO MOISTURE

road failure realized in the field. Although the compacted roadway foundation was prepared under the engineer's approval it was too unstable for the installation of the asphalt pavement when exposed to moisture.

During construction a number of observations were made of upward migration of groundwater, surface springs, and artesian conditions. However, the pre-construction groundwater levels at the site were considerably lower. An analysis of the hydrogeologic conditions helped in unraveling the story behind this moisture softening of the compacted subgrade and fill. The bluff which is adjacent to the site is made of solutioned limestone and acted as a groundwater recharge area (see Figure 2). During heavy rains, the groundwater levels rose in the bluffs which in turn caused a rise in the hydraulic head in the sand layers lying underneath the silts/silty fine sands in the foundation and embankment. The plastic lean clays and fat clays below the foundation subgrade appear discontinuous and did not provide an impermeable barrier for the upward movement of the groundwater. Also the silty embankment and foundation soils are conducive to significant capillary rise and are extremely vulnerable to pumping action which brings the freewater to surface in response to traffic loads.

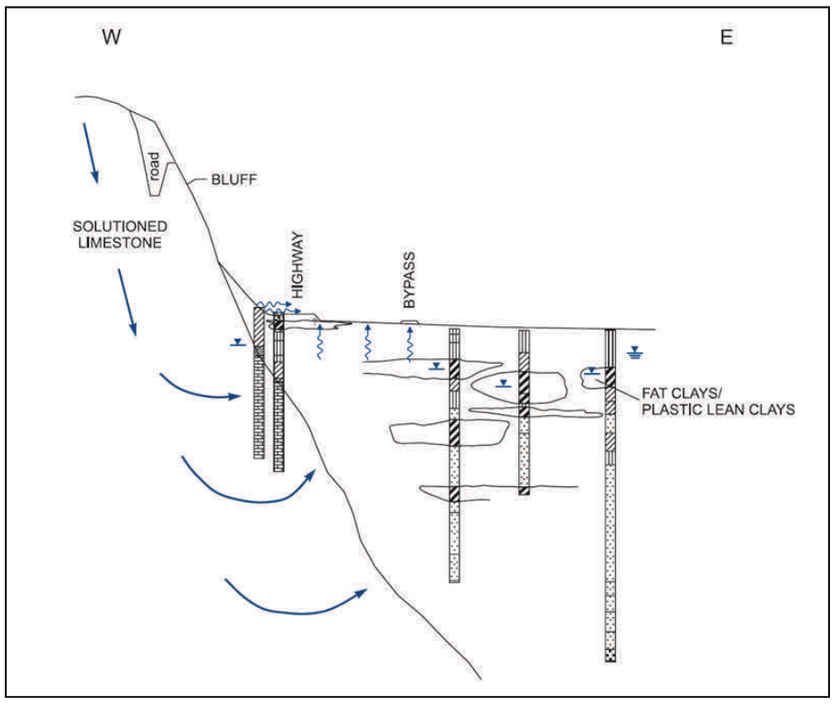

FIGURE 2 HYDROGEOLOGIC PROFILE OF THE SITE

The results of this testing combined with the geologic setting explained how the fill and subgrade prepared to the plans and specifications resulted in the road failure realized in the field. Although the compacted roadway foundation was prepared under the engineer's approval it was too unstable for the installation of the asphalt pavement when exposed to moisture. The asphalt crumbled because of the unstable fill and subgrade as the roadbed was too soft to support necessary construction traffic.

Other Engineering UPDATES of Interest:

UPDATE 7: Soil Provides Poor Road Construction Support

UPDATE 15: Asphalt Quality Investigation

UPDATE 20: Investigation of Pavement Performance

ABOUT MEA: Marino Engineering Associates, Inc. focuses on engineering research, practice and expert evaluations and is licensed in 24 states in the U.S. Our projects primarily have an emphasis on Geotechnical Engineering, however, we also have significant experience in projects involving transportation, subsidence engineering, laboratory testing, training, and geophysical exploration. Gennaro G. Marino, Ph.D., P.E., D.GE is president and principal engineer of Marino Engineering Associates, Inc., and has been a licensed professional engineer since 1984. To obtain additional information on MEA, one can also visit our website at www.meacorporation.com.

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

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