

MARCH 2008 MEETING

Wednesday, March 12, 2008

TECHNICAL PROGRAM

Underground Vault Failure Investigation and Repair

Speaker: [Eric Green, P.E.](#), Green Engineering Consulting

PRESENTATION SUMMARY

To an audience of about 35, Eric Green, P.E., President of Green Engineering Consulting, a graduate of Texas A&M University and the Massachusetts Institute of Technology, and a licensed professional engineer presented a forensic case history entitled, "Underground Vault Failure Investigation and Repair".

The project Mr. Green discussed was the failure of a 230' x 360' underground pump vault designed to hold raw sewage on its way to a sewage treatment plant. It was opined that the failure resulted from external hydrostatic loads, that resulted in a large crack in the 5-foot thick mat slab that formed the base of the pump vault. The presentation discussed the design, failure, the failure analysis, and the repair to this failure. The failure occurred during commissioning, i.e., before construction was complete.



Mr. Green detailed that the design of the vault was essentially a concrete box that was constructed below ground level, with the bottom of the vault founded approximately 90 ft. below grade. The failure of the mat occurred prior to the plant becoming operational, and the first signs of failure were reported as a loud popping sound followed by the vault and surrounding area filling with water. The source of groundwater was never determined, and no evidence of groundwater was present during the original geotechnical investigation or the excavations during the mat and wall construction.

The design calculations assumed a hydrostatic head of 195 pcf at 90 ft., well in excess of the 82 pcf needed if the water table were to occur at grade level, which it nearly did. However gross errors were found in the structural design calculations, which were opined to have been the cause of numerous undersigned structural elements. The structural design calculations were believed to be limited to only seven pages of hand calculations. No errors were found in the geotechnical design or the construction.

Once the vault became accessible, it was determined that the main leak initiated in the mat of the vault, and numerous fractures and cracks occurred in the mat and surrounding upper structure. Also vertical offsets were observed in the mat, especially adjacent to a drain trench, that paralleled one of the outer walls, where the mat thickness necked down from 5 ft. to 3.5 ft.

Next Mr. Green discussed the different alternatives of repair to restore the structural integrity of the vault and the repair option that was implemented. Fortunately, the leak (from the outside inward) kept the vault from popping out of the ground as it only had a 0.5 safety factor against uplift when empty. After dewatering was implemented, this allowed a repair that included adding dozens of precast concrete compression struts at several levels of the 90-foot high walls, added 3 to 4 ft. of concrete thickness to the existing perimeter walls that were as thick as 8 ft. at the base, and reinforcing the mat with over a hundred rock anchors on a 25 ft. grid to resist future hydrostatic heave.

No one was hurt in the failure or the repair operation. The forensic investigation and repair lasted 21 months and cost an additional \$45 million over the original \$80 million construction cost. No lawsuit was filed as the E & O insurance carrier willingly handed over a check in the amount of the \$250,000 insurance policy. The civil engineer of record, who was also the prime contractor for the project, is in federal prison on bribery charges connected with the project.

For a summary of Mr. Green's June 2006 FPA presentation, [click here](#)