Investigation and Rehabilitation of Bridge Abutment MSE Wall Instability

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OVERVIEW

This presentation will address the investigation, analysis, rehabilitation and eight year performance monitoring of a formerly unstable Mechanically Stabilized Earth (MSE) retaining wall. The wall varied up to 27 feet (8.23 m) in height and utilized steel bar mat in the reinforced zone. It had a long history of slowly leaning out and road maintenance crews routinely added asphalt over the years to fill in the "dip at the end of the bridge". The abutment wall was part of an overpass bridge for a highway in a large metropolitan city in north central Texas. The bridge was critical for emergency vehicles to access an adjacent hospital district.

Forensic Examination

Very little information was available for review regarding design of the wall. Initial evaluations generally consisted of: visual observations and measurements of wall and pavement displacements along with associated distress, review of available construction plans, drilling and laboratory testing, test pit excavations to determine reinforcement details, engineering analysis of field, laboratory and survey data to determine the potential for future damaging movements and recommendations for remediation of those movements.

CAUSATION

Early settlement of the bridge approach slab was determined to be a function of minor compression of foundation soils and embankment fill. Continued settlement was attributed to creeping pullout failure from inadequate passive resistance of the uniform, fine silty sand backfill to the horizontal bars of the mat reinforcement as the wall progressively tilted (see Figure 1).

SOLUTION

The next efforts generally consisted of: selection of a cost effective remedial method that allowed the bridge to remain open. The chosen solution consisted of injections of sodium silicate, in a permeation chemical grout method, to improve passive resistance of the reinforced zone. A qualified contractor was chosen and determination of in-place stiffness of wall backfill in a test section before and after injections was performed. Computer modeling was performed to determine the minimum amount of grouting necessary to increase the long term Factor of Safety (FS) to acceptable limits. Determination of a permeation grouting program including materials, methods and injection hole spacing was finalized to develop a safe and long term solution.

Statistical analysis was used to determine distinct trends in comparing pre and post grouting in-place stiffness. On this project, Deep Dynamic Cone Penetration (DDCP) test probes located further than 27 inches (68.6 cm) away from a grout hole revealed significant deterioration in after-grouting stiffness. Closer spacing of the DDCP probings found uniform resistance and approximately 3.5 times improvement in stiffness to pre grouting values. Computer modeling resulted in a grid pullout FS exceeding 1.5 at all locations and determined the dimensions of the recommended grouting zone.

REMEDIATION

Detailed construction plans and specifications for permeation grouting of the MSE sand backfill zone with sodium silicate chemical grout were developed and the injection operations were monitored. Post grouting DDCP was monitored to meet acceptance criteria. Numerous construction details were specified and built to return the site to conventional ride ability after grouting. Survey monitoring of the wall occurred more frequently during the evaluation and remediation periods. Monitoring was terminated after approximately eight years of satisfactory wall and pavement performance.

LESSONS LEARNED

As a designer, always consider long term compatibility of reinforcement and retained soil materials used to construct infrastructure. Caution should be taken when relying upon specifications developed by others in a relatively new geo system. Material compatibility was critical in determining this remedial solution.