Project Summary

Texas Department of Transportation

0-5179: Deep Mixing Technology for Mitigation of Pavement Roughness

Background

Expansive soils are well known for their cyclic shrink-swell volume change behavior due to seasonal related moisture changes. Non-uniform soil movements from the soils in active depth zones cause distress to pavement structures resting on them. These soil movements result in uneven pavement surface and eventual cracking in all directions, thus leading to pavement roughness problems. This distress causes discomfort to travelers and it also leads to rehabilitation of the effected pavements costing millions of dollars of repairs annually. There have been several research efforts from TxDOT to prevent or mitigate swell/shrinkage related subgrade problems. In this project, researchers explored a novel ground improvement technique to stabilize expansive subsoils extending to considerable depths.

The deep soil mixing (DSM) technique involves the auger mixing of in-situ soil with chemical binders in wet form and this method has resulted in uniform DSM columns. These columns embedded with geogrids have proven to be successful in reducing settlements and enhancing strengths of very soft to soft clays, organic soils, and loose sands.

What the Researchers Did

In this research, an attempt was made for the first time to study the effectiveness of the DSM technique in minimizing swell-shrink behavior of expansive subsoils up to considerable depths by conducting both comprehensive laboratory mix design and field pilot scale studies. This study considered both lime and cement binders in combination and solely at three water-binder ratios for stabilization of two soil types of moderate and highly expansive soils in laboratory studies. Analyzing the laboratory test results, the best performing stabilizer was selected and then used in the construction of two pilot scale test sections.

Two DSM treated composite sections were designed and constructed, along with two control sections, at two project site locations. Two different area treatment ratios, 25% and 35%, were adopted for moderate and high expansive soil sites, respectively.

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The DSM treatment at both sites was performed up to depths of 10 to 12 feet. Quality assessment studies were also conducted, following the construction of test sections, through laboratory tests on wet grab samples from the field, non-destructive testing (downhole and SASW tests) in the field, and mineralogical studies on the field samples.

The data from field instrumentation was collected for well over two years and then analyzed to evaluate the effectiveness of DSM treatment in minimizing swell/shrink behavior of expansive subsoils. This was achieved by comparing lateral soil movements, vertical surface movements and swell pressures (vertical and lateral) of DSM treated sections to those from control sections with seasonal moisture variations.

What They Found

Non-destructive testing techniques indicate that average stiffness of these areas is more when compared to those from the untreated areas. The maximum soil movements and swell pressures recorded in both DSM treated and untreated sections in the present research were tabulated. Vertical soil movements in composite DSM treated areas showed considerably lesser values than those monitored in untreated soil sections. Lateral soil movements recorded inside DSM columns are negligible and around the columns are considerably smaller than those recorded in the untreated sections.

Reductions in surface and lateral subsoil movements in DSM treated sections were attributed to the improvement achieved through the DSM technique, indicating effectiveness of DSM in minimizing the expansive subsoil movements. Swell pressures recorded in treated sections are considerably lower than those determined on untreated soils from laboratory tests. The maximum swell pressures (both lateral and vertical) recorded at both treated sections are in the range of 1 to 4.5 psi indicating that treated sections can be best characterized as those with very low swelling nature. Also, analytical model calculations based on the composite section analysis yielded good agreement with field data.

What This Means

DSM area treatments of low (25%) and medium (35%) ratios showed substantial potential in minimizing subsoil movements and swell pressures. These improvements in expansive soil behavior will reduce distress to the overlying pavements and thereby potentially decrease maintenance costs. A step by step procedure to design DSM columns to mitigate expansive soil movements to targeted heave values was developed for future usage.

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