

Designing Pavements for Long Term Stability in Expansive Clays

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INTRODUCTION

Expansive clays cause millions of dollars in damage annually to our nation's highways, roads and city streets. A section of Oklahoma Interstate 35 in southern Carter County, (Figure 1), originally constructed in 1968, began to deteriorate soon after completion due to the movement of the heavy clay soils on which it was constructed. The original pavement section consisted of 9 inches of plain jointed P.C. concrete on a base of 4 inches of fine aggregate bituminous base, F.A.B.B. The subgrade was treated with hydrated lime to a depth of 6 inches.

The project lies within the Ardmore Basin which extends from a mile south of the Carter-Love county line through Ardmore to the south edge of the Arbuckle Mountains. Geologically, the rock units in this area are tilted (dip) at angles approaching vertical, with dip angles of 70 to 80 degrees being common. (Figure 1) The Springer and Goddard shale formations present here are thousands of feet thick and due to their tilted nature, have weathered much more deeply than the more typical flat-lying rock formations present in most of Oklahoma. These formations produce the highly weathered, highly plastic clay soils, that reach depths of 18 feet, along this portion of the I-35 alignment.

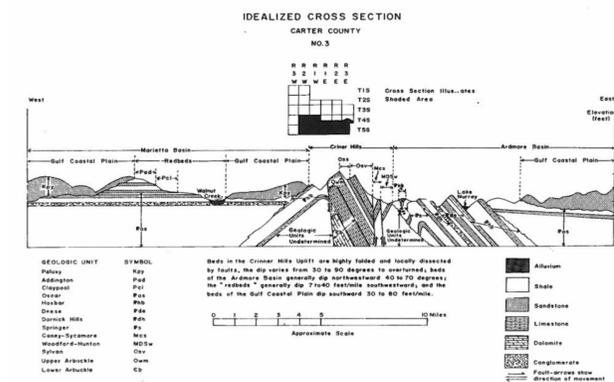


FIGURE 1 - Geologic Cross Section of Southern Carter County

PROJECT HISTORY

Soon after the 1968 completion of this section of Interstate 35, the cyclic wetting and drying of the heavy clay soils began to cause undulations in the pavement. This led to cracks forming in the pavement panels along with a deteriorated ride quality. Pavement panels were repaired or replaced and asphalt overlays were placed in an attempt to restore the ride to the pavement. Through the following years, additional asphalt overlays were placed in order to maintain an acceptable ride quality for the pavement. By 2002, the thickness of the asphalt overlays had reached up to 14 inches. In spite of numerous panel repairs and overlays, the pavement continued to suffer the effects of the heaving clay soils. Maintenance costs continued to increase. Presented with these mounting costs, the decision was made to reconstruct the pavement. Recognizing the severity of the problem soils and their effects on the pavement, an extensive soils and geologic investigation was undertaken in order to design a new pavement section that would withstand the detrimental effects of these heavy clay soils

NEW PROJECT DEVELOPMENT

The soils investigation exposed extensive deposits of deep, active clays and numerous locations of shallow groundwater seepage throughout the length of the project. The soils tests revealed clays having plasticity indices ranging to the mid 60's. Further analysis of the data indicated an active zone of up to 18 feet in depth. The active zone refers to the upper stratum of the soil profile which exhibits the majority of the shrinking and swelling. This zone undergoes frequent fluctuations in moisture content as affected by climatic cycles. Given the depth of this active zone, it became apparent that more extensive measures than the typical 8 to 12 inches of lime stabilization would be needed to find a solution to this problem.

Various options were evaluated as potential solutions to providing a stable subgrade for the proposed highway. These options included replacing the top 6 feet of the subgrade with a more select soil, or with crushed quarry stone. Further evaluation of these options revealed them to be either cost prohibitive or difficult to construct due to the lack of select soils near the project site.

Further research and literature reviews led to the option of using a moisture barrier to control the swelling clays. The theory behind using a moisture barrier was that if one could control moisture content within the active zone of the soil profile, there would be minimal expansion or contraction within that zone regardless of the extremes in the climatic cycles. A review of several case histories detailed good success in the use of geomembranes or heavy plastic sheeting placed in vertical trenches along the pavement shoulder. The concept of the vertical moisture barrier was to encapsulate the upper portion of the soil profile such that fluctuations in moisture content would be kept to a minimum. The key was to place the barrier deep enough to maintain this constant, uniform moisture content within the active zone. Theoretically this depth needs to be at least 2/3 to 3/4 the depth of the active zone of the soil profile for the barrier to be effective.

The presence of fiber optic lines and high pressure gas lines along with several shallow drainage structures made placement of a continuous, vertical moisture barrier impractical. Given these restrictions the decision was made to place a horizontal moisture barrier on top of the subgrade across the grading section of the new roadway.

PAVEMENT DESIGN

This section of I-35 carries an ADT of 40,000 vehicles with 30% trucks. It is part of a major trucking corridor for the southern United States. Given the high volume of trucks and the problem subgrade soils, continuously reinforced concrete was chosen as the new pavement. CRCP was chosen because it is widely regarded as having the best performance on heavy clay soils. The CRCP would be 12 inches thick with a steel content of 0.73%. The mix design required a minimum cement content of 564 lb/CY and a minimum 28 day compressive strength of 3000 psi. It would be placed on a 4 inch thick drainage layer of open graded Portland cement concrete and have a base course of 8 inches of crushed stone. The moisture barrier would be placed on top of lime stabilized subgrade beneath the layer of crushed stone.

The barrier material would need to have a high tear and puncture resistance to withstand the placement and compaction of the crushed aggregate base layer. A thorough search located a material that met the requirements. It was a coated, reinforced geomembrane, made from a HDPE (High Density Polyethylene) reinforcement geotextile that is coated on both sides with a LDPE (Low Density Polyethylene). It is typically used as a water storage liner. Field tests confirmed that the material had the puncture and tear resistance required to withstand the construction traffic loads. The design required the membrane to extend across the entire 70 ft. grading section plus an additional 20 feet beyond each side making a total width of 110 feet. In the project extents requiring pipe underdrain to intercept groundwater seepage, the membrane was extended to the bottom of the pipe underdrain trench. Our belief was that in placing the membrane an additional 20 feet beyond each side of the grading section, it would achieve the same effectiveness as the deep vertical moisture barrier placed along the pavement shoulder (Figure 2).

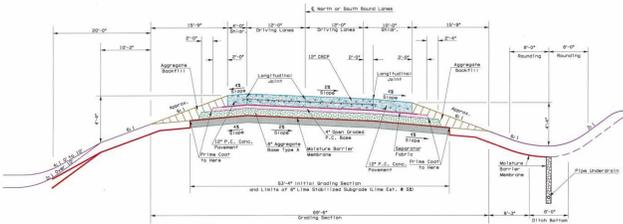


Figure 2 – Typical Section of the Reconstructed Pavement

The design was finalized and the project was let out for bid. The project was awarded in August 2006 and completed in 2008. Figures 3 through 9 show the sequence of removing the old pavement and reconstruction of the new section.



Figure 3 - Removal of the old pavement: note the thickness of the overlay and the condition of the old concrete pavement



Figure 4 - Lime Stabilization operations



Figure 5 – Moisture barrier placed across the grading section



Figure 6 – Spreading the crushed aggregate across the membrane



Figure 7 – Compacting the open graded base layer



Figure 8 – Tying the steel reinforcement



Figure 9 – The completed project.

REFERENCES

Additional information and the complete list of references can be found in the full article.