Foundations on Expansive Soils : Geotechnical View

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Building foundations on expansive soil occur every day in Harris County, Fort Bend County, Galveston County, Brazoria County, and Montgomery County. Beaumont clays are moderately to very highly expansive and their expansive characteristics can adversely affect foundation performance. Is there a foundation system that can remove all risk of movements associated with expansive soils? What triggers foundation movements?

This presentation will explore the types of foundations and floor systems that are used the Houston area. Discussions of design methods and factors affecting movement will be discussed. Practical solutions for reducing potential for movement will be offered.

Four foundation systems are commonly used in the Houston area. They include 1.) stiffened slab, 2.) shallow individual foundation, 3) drilled piers, and 4) pile foundations. Determination of which foundation system is appropriate is a function of loads, soil conditions, and economics. Are the risks for movement removed or improved by choosing one foundation type versus another? The answer is "no". Stiffened slabs are used both in nonexpansive and expansive environments. Stiffened slab design considers anticipated movement and is based on average moisture conditions being present throughout the life of the structure. The Post Tensioning Institute method is the most common design method used in the Houston area. Design parameters include clay mineral percentage, edge moisture variation distance, and depth of constant soil suction. Shallow foundations, drilled piers, and pile foundations each are used in nonexpansive and expansive environments. Floor slabs may be structurally supported or may supported on grade. Structurally supported slabs effectively mitigate the potential risks associated with the presence of expansive soils provided sufficient void space -- typically about 4 in. to 6 in. -- is provided. A grade-supported floor always has risks for potential movement. To accommodate a grade-support floor, earthwork to develop a buffer of clay having less expansive potential is commonly undertaken. The buffer thickness is selected considering plasticity characteristic of the natural soils and proposed fill, moisture conditions of natural soil, and whether the buffer will be constructed as a cut, fill or combination of cut and fill. Buffer thickness is selected to result in 1 in. or less of anticipated movement during the structure life. What is the trigger for movement? Water � its absence or its presence. Soil in a "wet" moisture condition has lower propensity for movement than soils in a dry moisture condition. Theoretically, if the moisture content of the foundation soils remained the same over the structure life, no movement would develop. Why does moisture balance not occur? Two reasons: climatic factors and non-climatic factors.

Houston's average climate conditions are based on cycles of wet and dry weather. During periods of dry weather, shrinkage of soil along foundation edges occurs. During periods of wet weather, swelling of soils along foundation edges occur. Depending upon the moisture conditions during construction, the effects of climatic conditions may have significant or little impact on foundation performance.

Non-climatic factors are perhaps the biggest contributors to foundation movements. These factors often are beyond the control of the design team as these factors often contribute to distress after the structure has been completed and in service for some period. These factors include landscaping, below-slab utilities, and drainage. Landscaping often is designed for aesthetic reasons with its effects on long-term structure performance not considered. Trees greatly affect moisture balance. Not only existing trees and newly planted trees but also former trees that were removed to accommodate construction. Trees, particularly fast-growing varieties, have substantial water requirements. Sufficient water is initially obtained from the soil, rainfall infiltration, and from irrigation watering. However, as the tree becomes larger, its water requirement quickly outpaces the amount of moisture that can be provided by immediate soils or irrigation watering. With sporadic rainfall, water must come from other sources. What effects do former trees have on foundation performance? The trees resulted in drier moisture conditions in a lateral and vertical direction from the tree. These soils do not immediately return to moisture equilibrium; therefore, as moisture becomes available, swell occurs. When numerous trees have been removed to accommodate construction, a structurally supported floor system should be used in conjunction with the foundations or a stiffened slab should be considered. Irrigation systems can be highly effective in maintaining moisture balance. However, undetected leaks and overuse frequently are contributors to foundation movement.

Below-grade utility leaks are perhaps one of the largest factors for adverse foundation performance. Frequently, the distress occurs before the leak is identified. Leaking utilities often are bedded and backfilled in sand. The sand is a conduit for moisture to reach the underlying or surrounding clays.

Drainage also is a significant contributor to distress. Roof drains ultimately discharge water immediately adjacent to the foundation because splash blocks are removed, rotated, or misaligned. Discharge of roof drains to below-grade storm sewer is more effective and less detrimental then surface discharge. Inadequate drainage, away from the foundation through below-grade storm pipes, often occurs in residential developments. Accumulated rain and irrigation water also contribute Site grade frequently is modified by additional landscaping placed after construction or modifications to address "low" spots that hold water.

In conclusion, foundations constructed on expansive clays can perform satisfactorily provided that good design, good construction, and good maintenance are implemented. The performance of foundations on expansive soil is not solely a function of engineering design and construction. When distress occurs, several contributing factors often are identified. Rarely is one factor the sole reason for distress.

If you have any questions, please contact **Dr. C.Vipulanandan**

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