DECEMBER 2010 MEETING

Wednesday, December 8, 2010

TECHNICAL PROGRAM

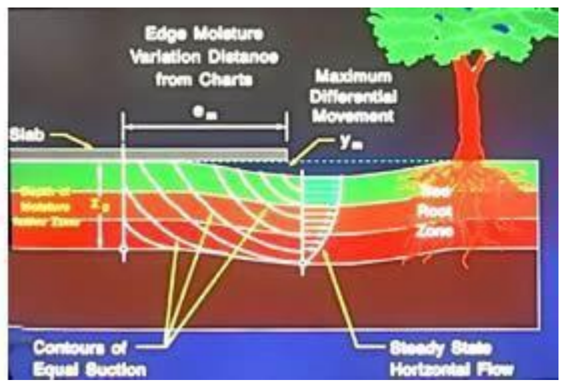
Effects of Trees on Foundations

Speaker: Professor Robert L. Lytton, Ph.D., P.E., D.GE, with Texas A&M University, Bryan, TX, Tel. 979-845-9964

Dr. Lytton is an Honorary FPA Life Member, Professor of Civil Engineering in the Zachry Civil Engineering Department of the Texas A&M University, and a Licensed Professional Engineer in Texas with a Ph.D. in Civil Engineering from the University of Texas (1967). He is internationally famous for his work in the study of expansive soils on foundations, giving presentations on the subject worldwide. He has selflessly presented to this forum at least 8 times in the last 10 years and has also presented in past FPA seminars.

PRESENTATION SUMMARY

To an audience of about 120 at the HESS Club, Dr. Lytton presented "Effects of Trees on Foundations". Dr. Lytton provided new technical data on trees and their effects on the soils supporting foundations. Dr. Lytton integrated this new information into existing understandings of soil mechanics and foundations.



Dr Lytton opened his presentation with an overview of trees and their effects on soils and the surrounding environment. Tree characteristics were discussed at length, including what they need to survive (water, air and nutrients), root zones, water uptake and utilization, and the effect these factors have on the surrounding soils. Roots have an uncanny ability to grow into moist areas but according to Dr. Lytton root barriers are extremely effective at inhibiting root growth.

Dr. Lytton described how a tree's flexible hairlike root fibers are able to propagate in hard clays: the root fiber extracts water from the moister clay in front of it, causing a shrinkage crack to appear. It is this shrinkage crack space that the root fiber can then grow into, in search of more moisture ahead, and so on. He said this action creates clay soils that are about 100 times more pervious than the moisture inactive zone below.

Dr. Lytton also pointed out that the effect of these factors varies between the different types of soils. Additionally, different trees have different shaped root balls and different water demands. The root ball has also been proven too faroutreach the drip zone of the tree. Some trees are better able to draw moisture from the soil in drought conditions andtherefore have a more dramatic effect on soil moisture changes. It was interesting to note that often the shape of the root ball mimics the shape of the crown, depending on the tree species, soil type, climatic conditions and surroundingcompetition. E.G., conifers do not fight hard for moisture as compared to other tree species and so they do grow well in clay soils.

All these factors affect the active moisture zone of the soils. The moisture activity zone is that depth of soil that must be considered when designing the depth, type and strength of the foundation including drilled piers. Realworld soil sampling at existing healthy trees shows that suction (pF) extends down to the depth of root fibers. Measurements around a medium sized Post Oak tree in Central Texas indicated root fibers as deep as 15 feet.

In addition to slab on ground foundations, Dr. Lytton discussed the effects of tree induced moisture changes on soils surrounding and supporting drilled piers. The factors affecting the design of drilled piers included the moisture active zone, Zm, the required anchor length, La, of the shaft below the active zone, the need to account for unsymmetrical bending due to lateral forces from swelling soils and the need for tensile reinforcing. Since many of the forces acting on piers occur in all directions and induce compression, tension and moment, these forces require the designer to extend the pier bottom below the soil active zone, and to account for shaft uplift tensile forces and lateral forces due to wet-dry variances on opposite sides of the pier which in turn induce moment in the pier.

Dr. Lytton gave an example of the foregoing where the suction along the pier shaft varied from pF 4.5 (wilting point) to pF 2.5 (higher than field capacity) because a nearby tree had been removed. This situation created a differential horizontal pressure on the pier of over 10 KSF, which was 4 times the vertical pressure and enough to cause passive earth pressure on the pier shaft.

Dr. Lytton also presented case histories, with photos, where drilled and underreamed cast-in-place piers were excavated and proven to have lifted as much as 4 inches because the skin friction from the swelling upper movement active soil was inadequately resisted by passive skin friction below the movement active zone. He also showed a case study by Dr. O'Neill at UH where the skin friction of a test pier at the NGES-UH site measured more than 8 PSI (1.2 KSF) in the moisture active zone.

Some good points made by Dr. Lytton were:

- The moisture active zone is dictated by site conditions, ***not*** regional conditions.
- The moisture active zone can vary substantially when trees are present.
- The moisture active zone can vary based on the type of tree present since different trees have different root ball shapes and depths.
- The geotechnical engineer should ***always*** log the root fibers since the depth of the shrinkage cracks are created by roots.
- The depth of the moisture active zone depends on the depth of the shrinkage crack zone.
- The depth of the ***movement*** active zone, needed to compute Ym, will ***always*** be less than the depth of the ***moisture*** active zone.
- Soil movement does ***not*** form a uniform pressure on foundations.
- Root barriers work because they are moisture barriers in that they stop the propensity for root propagation in that direction.
- Water, which has surface tension, has a measurable tensile strength which is between 3000 and 3600 PSI, or about 5.3 pF suction pressure.

In summary the science of trees and soils is very complex, and the designers must take all factors into account to ensure good performance of the foundation.

To download Dr. Lytton's slide presentation, click here

To read summaries of previous FPA presentations by Dr. Lytton, please click:
December 2009 - Contrasting Design Approaches for Slabs-on-Ground and Raised Floor Foundations on Expansive Soils
December 2008 - How to use the PTI-3rd Edition to Design Foundations in Houston
December 2007 - Design of Structures to Resist the Pressures and Movements of Expansive Soils
December 2006 - Revisitation of Expansive Soils
December 2004 - Case Studies of Residential Foundation Movements in Southern Houston Area
August 2003 - How to Run Soil Suction Tests

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