Expansive Soils

Due to their potential to provide nonuniform support at the base of a concrete pavement structure, expansive soils must be properly addressed during the design phase.

Expansive soils are soils that significantly change volume with changes in moisture content. Control of expansive subgrade materials to ensure uniform support through wet and dry seasons is a key consideration to the long-term performance of concrete pavement structures. Therefore, if an expansive soil is present in the confines of a new roadway project, the expansive potential of the subgrade must be evaluated and accounted for during the design phase. Expansive soils can be mitigated by compacting the subgrade at the proper moisture content, selectively grading the subgrade material and/or chemically modifying the subgrade. More on this topic is available in ACPA's **EB204P**, "*Subgrades and Subbases for Concrete Pavements*."

Index Tests and Field Variable Impacts

Expansive soils that may swell enough to cause pavement problems are generally clays falling into the AASHTO A-6 or A-7 groups, or classified as CH, MH, or OH by the Unified Classification System, and with a Plasticity Index greater than about 25 by ASTM D4318. Several simple tests provide indices that serve as useful guides to identify approximate volume-change potential of soils. Table 1 shows the approximate relationship between several of these tests and their potential for expansion.

Because the percent expansion data listed in Table 1 represent the change from a dry to a saturated condition, much less expansion will occur in the field since such extreme moisture variation will not take place and the subgrade will have been compacted to the appropriate density.

Experience shows that the volume changes of clays with a medium or low degree of expansion (Plasticity Index below 25) are not a significant concern for concrete pavements, especially if selective grading operations such as cross-hauling and blending of soil types minimize or eliminate abrupt changes in soil character along the alignment.

However, experience also shows that uncontrolled shrinking and swelling of expansive soils can lead to increased stresses in a concrete pavement due to non-uniform support, which accelerates pavement degradation and negatively impacts pavement smoothness. Although changes in soil moisture content are inevitable over the life of a pavement, expansive soils can be effectively addressed through proper compaction, selective grading, and/or chemical modification.

The volume change that may occur with a potentially expansive soil depends upon several factors, including:

- *Climate* — the degree of moisture variation that will take place in the subgrade throughout the year or from year to year. It is generally true that a pavement will protect the grade to some degree and reduce the degree of moisture variation in an underlying subgrade as long as the soil is not capable of drawing moisture from below through capillary action.
- *Surcharge* — the effect of the weight of the soil, subbase, and pavement above the expansive soil; tests indicate that soil swell can be reduced by surcharge loads.
- Moisture and density conditions of the expansive soil at the time of paving.

Knowledge of the interrelationship of these factors leads to the selection of economical and effective control methods.

Table 1. Relation of Soil Index Properties and Probably Volume Changes for Highly Plastic Soils

Data from Index Tests[1]			Estimation of probable expansion,[2] percent total volume change (dry to saturated condition)	Degree of Expansion
Colloid Content (percent minus 0.00004 in. (0.001 mm)) (ASTM D422)	Plasticity Index (ASTM D4318)	Shrinkage Limit Percent (ASTM D427)		
> 28	> 35	> 11	> 30	Very High
20 - 31	24 - 41	7 - 12	20 - 30	High
13 - 23	15 - 28	10 - 16	10 - 20	Medium
< 15	< 8	< 15	< 10	Low

[1] All three index tests should be considered in estimating expansive properties.

[2] Based on a vertical loading of 1.0 psi (0.007 MPa). For higher loadings the amount of expansion is reduced, depending on the load and on the clay characteristics.

Alternate Expansion Tests

Alternative expansion test procedures such as ASTM D4546, ASTM D4829, Caltrans Test Method No. 3548 (CALTRANS 1978) and soil suction tests (AASHTO T273 or ASTM D3152) are especially suitable for evaluating the volume change of subgrade soils. Some of the important factors determined by these tests, which are not indicated by simple index tests, are:

- The effects of compaction, moisture and density on soil swell characteristics.
- The effect of surcharge loads.
- The expansion for the total sample gradation rather than only for a finer gradation fraction of the soil.

Proper Compaction

Proper compaction of the subgrade at the appropriate moisture content is typically the most economical means of mitigating problems associated with expansive soils. To reduce volume changes of highly expansive soils, it is critical to compact them at 1 to 3 percent above optimum moisture content (AASHTO T99). Research has shown that compacting expansive soils at moisture contents exceeding AASHTO T99 optimum will produce a subgrade that absorbs less water, provides slightly higher strength, and will not expand or swell as much as if the soils were compacted dry of optimum moisture at the time of preparation.

To illustrate the effect of moisture content on soil swell, Figure 1 shows that the expansion for an A-6 soil is reduced when it is compacted slightly wet of AASHTO T99 optimum when compared to the high expansion obtained when compacted dry of AASHTO T180, even with the extra compaction effort required for AASHTO T180.

Selective Grading

If expansive soils are not the predominant soil type along the roadway alignment, selective grading (includes blending and cross hauling) might be the most cost-effective method of treatment. Selective grading operations also may be adequate for controlling the shrink and swell potential when the profile grade can be designed to keep expansive soils out of the top of the subgrade.

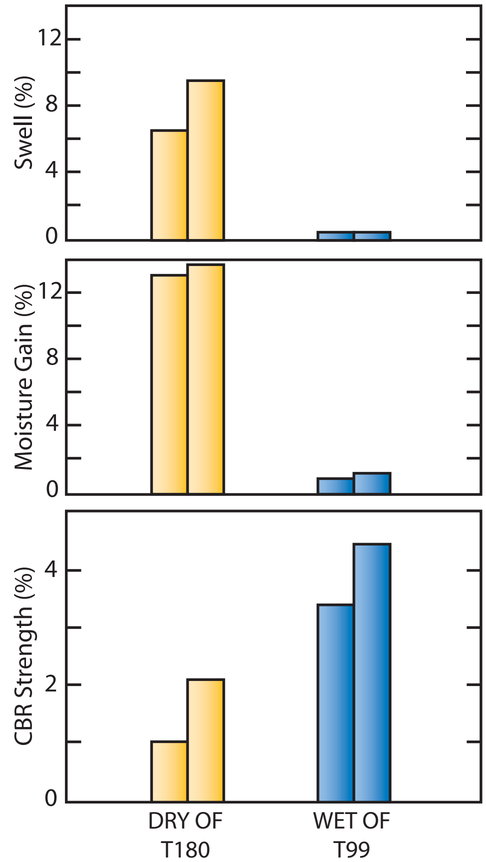

Figure 1. Strength, moisture gain and swell of soil compacted dry of AASHTO T180 and wet of AASHTO T99 optimum moistures.

Chemical Modification

When the subgrade soils consist primarily of expansive clays and it is not economical to import non-expansive soils, chemical modification is the preferred technique. Soils can be modified with lime, portland cement, cement kiln dust (CKD), Class C fly ash or Class F fly ash in conjunction with lime. Modification provides a positive means to control the shrink-swell potential of a soil. In addition, modified subgrade soils provide an ideal working platform, and the time savings associated with subgrade modification can prove to be more economical than selective grading operations on some projects.

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