Unstabilized (Granular) Subbases

Properly engineered unstabilized subbases can provide a very economical and reliable means of preventing pumping in concrete pavement structures.

The most common subbase for applications such as streets, roadways and highways is an unstabilized subbase. Limiting the percent of fines passing the No. 200 (75 µm) sieve is of utmost importance to creating an unstabilized subbase that will resist pumping. Because this is the key criterion in selecting a durable unstabilized subbase, many different materials and gradations can be used. Unstabilized subbases are best controlled during construction using a compaction requirement, with a typical compaction requirement being 95 percent of AASHTO T99. The minimum unstabilized subbase thickness is typically 4 in. (100 mm). More on this topic is available in ACPA's **EB204P**, "*Subgrades and Subbases for Concrete Pavements*."

Introduction

Unstabilized subbases (Figure 1), also known as granular subbases, are the most common type of subbase for applications such as streets, roadways and highways. A wide variety of soils and aggregates make excellent constituents for unstabilized subbases. The types of materials that have been used successfully include crushed stone, bank run sand-gravels, sands, recycled crushed concrete, soil-stabilized gravels, bottom ash, crushed or granulated slag, and local materials such as crushed wine waste and sand-shell mixtures. Any number of combinations of all these materials could potentially be used.

Unstabilized subbases have long been the most common type of subbase, but they fell out of favor with some highway agencies at a time when jointed reinforced concrete (JRC) pavements and undowelled (plain) concrete pavements were the norm. Both of these pavement designs were subject to deterioration by pumping and faulting — at the cracks that occurred by design between dowelled joints in JRC pavements and at each transverse joint in plain undowelled pavements. The faulting, corner cracking and roughness that developed on the pavements designed in this era are primarily attributable to a lack of positive joint (or crack in the case of JRC pavements) load transfer and the unanticipated increase in truck traffic experienced on the road network, and not due to any general negative characteristic of unstabilized subbases.

Since the 1980's, however, the practice of dowelling transverse joints has become the norm for plain concrete pavements and the use of JRC pavement designs for roadways or highways has fallen out of favor. Thus, unstabilized subbases have once again become a preferred subbase for most highway agencies.

When designed and constructed properly, unstabilized subbases make an outstanding support layer for concrete pavements for all types of roadways and highways. Their primary advantage is their relatively low cost when compared to stabilized subbases.

Figure 1. Grading of an unstabilized subbase.

Material Requirements

As a minimum, an unstabilized subbase material must meet the requirements of AASHTO M147 (alternatively, AASHTO M155 might be used if pumping is of significant concern). The following factors generally define materials that make a good unstabilized subbase:

- Maximum particle size of no more than one third the subbase thickness.
- Less than 15% passing the No. 200 (75 µm) sieve.
- Plasticity Index of 6 or less.
- Liquid limit of 25 or less.
- Los Angeles abrasion resistance (AASHTO T96 or ASTM C131) of 50% or less.
- Target permeability of about 150 ft/day (45 m/day), but no more than 350 ft/day (107 m/day), in laboratory tests.

The principal criterion for creating a good unstabilized subbase is to limit the amount of fines passing the No. 200 (75 µm) sieve. If there are too many fines, the unstabilized subbase may hold water more readily and will be prone to erosion, pumping and frost action. If the local climate and soil dictates that it is necessary to prevent damage by frost action, it is better to use materials at or near the minimum fines content defined by the material specification.

Soft aggregate materials also are not satisfactory for unstabilized subbases because additional fines may be created under the abrasion or crushing action of compaction equipment and construction traffic. These fines will decrease uniformity in the layer and may contribute to frost action and other problems.

Gradation

Although a wide range of materials (and gradations) have performed well as unstabilized subbases under concrete pavements, it is important for the subbase to have a reasonably constant gradation that allows compaction equipment to produce the uniform and stable support that is essential for excellent pavement performance. As with the subgrade, any abrupt changes in the character of a subbase can lead to reduced performance of a concrete pavement.

Quality Control

Project specifications should clearly identify the grading option(s) for any specific project, or allow the contractor to select an unstabilized subbase source that complies with the gradings in AASHTO M147 that also meets the specifier's criteria (such as percentage passing the No. 200 (75 µm) sieve). An effective way to ensure gradation control is to allow reasonably wide latitude in the selection of an unstabilized subbase from gradation limits known to be satisfactory.

Prior to construction, the contractor should submit a target gradation that fits within the specified gradation band. For quality control, plus and minus tolerances should be established from the submitted target gradation. Typical job control tolerances from the target gradation are:

- ±10% for materials 1 in. (25 mm) and larger.
- ±8% for materials between 1 in. and No. 4 (25 mm and 4.75 mm).
- ±5% for materials No. 4 (4.75 mm) and smaller.

Consolidation

Unstabilized subbases are best controlled during construction using compaction or density requirements.

Granular materials are subject to some consolidation from the action of heavy traffic once a pavement is placed into service. Thorough compaction of the unstabilized subbase will minimize post-construction consolidation, keeping it within a tolerable range.

Research results document the need for a high degree of compaction for unstabilized subbases with heavy-duty pavements, as shown in Figure 2. The research shows that as few as 50,000 load repetitions can produce excessive consolidation where densities are very low (less than 85 percent). According to the research, densities approaching 95 percent of AASHTO T99 density will prevent detrimental consolidation of a dense-graded granular (unstabilized) subbase.

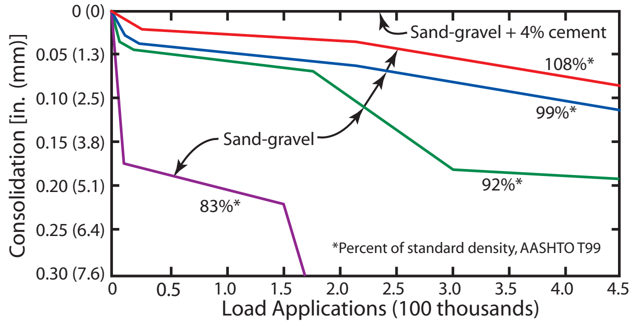

Figure 2. Subbase consolidation under repetitive loading.

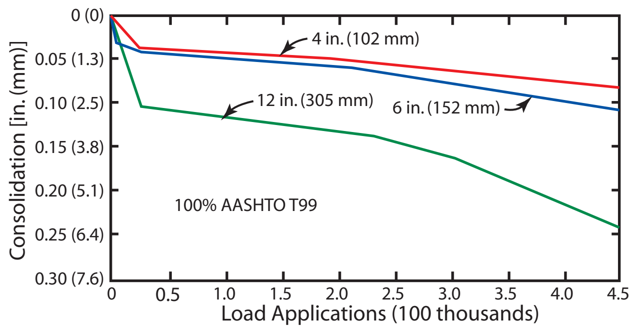

Figure 3. Influence of unstabilized subbase thickness on consolidation.

Thickness and Secondary Consolidation

Since the primary purpose of a subbase is to prevent pumping, it is neither necessary nor economical to use a thick subbase in an attempt to increase support or elevate the grade with respect to the water table; in fact, if any secondary consolidation occurs the magnitude of this consolidation will increase as the subbase thickness increases (Figure 3).

Experimental projects have shown that a 3 in. (75 mm) thick unstabilized subbase will prevent pumping under very heavy traffic. Similarly, slit-trench excavations made at pavement edges reveal that an unstabilized subbase thickness of just 2 in. (50 mm) can prevent pumping, even on projects that have carried heavy traffic for 10 years or more. But, primarily for constructability purposes, the minimum subbase thickness for unstabilized subbases is 4 in. (100 mm).

References

ACPA, Subgrades and Subbases for Concrete Pavements, EB204P, American Concrete Pavement Association, 2007.

Colley, B. E., and Nowlen, W. J., Performance of Concrete Pavements Under Repetitive Loading, Bulletin D23, Research and Development Laboratories, Portland Cement Association, 1958.