CONCRETE INFORMATION

Concrete Pavements Without Subbases for Light Traffic Facilities

The need for a subbase— a layer of granular material placed on a prepared subgrade— depends on the frequency of heavy truck loadings. While mandatory for major highways, a subbase is seldom required for light-duty concrete pavements.

Performance studies and surveys have shown the conditions for which a subbase is or is not required. With this information, an engineer can analyze these conditions and rationally decide if a subbase layer is essential.

The function of a subbase is to prevent pumping of fine-grained, subgrade soils. Pumping, which leads to the loss of soil material beneath slab edges and joints, occurs when three factors exist in combination: pumpable soils, excess water under the pavement, and *frequent heavy truck loads*.

In the absence of heavy truck traffic, which is the case for many streets, secondary roads, and parking lots, a subbase is not needed. For these pavements, good performance can be obtained by using appropriate subgrade preparation techniques aimed at providing uniform foundation support for the pavement.

Pumping— Studies and Surveys

Pumping is the forceful ejection of a mixture of soil and water from under slab edges and joints. It is caused by frequent slab deflections under heavy wheel loads, and eventually leads to the displacement of enough soil so that slab edges and corners are left unsupported.

Cooperative surveys[1] by state agencies covered more than 2,000 miles of concrete pavements in ten states. These represented a wide range of climates, soils, traffic conditions, and pavements with and without joint load transfer devices. Included were projects carrying as many as 700 axle loads per day of more than 18,000 lb (80 kN) and projects with tractor-semitrailer counts up to 1000 to 2000 per day.

The studies showed that all three factors mentioned above — plastic soils, excess moisture, and heavy loads— must coexist for pumping to occur. It was found that, for the greatest amounts of truck traffic encountered, a layer of subbase material* with low fines content and low plasticity is required to prevent pumping.

The most important conclusion was that a subbase is not needed unless the pavement carries a substantial number of heavy trucks** per day. Similar conclusions are reported from other sources: "In cases where design traffic is less than 1,000,000 18-kip (80 kN) ESAL's, a subbase layer may not be needed." (*1993 AASHTO Design Guide*[2]) "It is agreed that base (subbase) is not required for low-volume roads and streets except where the percentage of heavy vehicles is unusually high." (*NCHRP Synthesis 27*[3])

Structural Effects of Subbases

When not needed to control pumping, an untreated granular subbase does not contribute significantly to the performance and load-carrying capacity of a concrete pavement. Design procedures[2,4] recognize the improvement in foundation strength when a subbase is used, but the effects on the design thickness are small. For example, the 1993 AASHTO Guide[2], which recognizes the viability of pavements without subbases for low volume facilities, credits a subbase with only ¼ in. (6 mm) of slab thickness reduction. Accordingly, it is more economical to invest in the slab rather than try to increase the foundation strength.

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* Subbase material requirements are given in Reference 1.

** In the studies, heavy trucks were defined as those with single axles loads in the range of 14 to 18 kips (60 to 80 kN). This excludes panel and pickup trucks, and other four-tire single units.

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Uniform Subgrade Support is the Key

Compared with other types of paving materials, concrete is by far the most rigid, spreading applied wheel loads over large areas of the subgrade. Vertical deflections are small, and the pressure on the subgrade is very low. As a result, concrete pavements do not require a buildup of foundation support. Far more important is to obtain a condition of uniform support for the pavement that will prevail throughout its service life.

Whether a subbase is used or not, the subgrade must be made reasonably uniform, with no abrupt changes in degree of support and with subgrade soils that are of uniform material and density. Attention to this aspect of pavement construction is often neglected, especially for light-traffic pavements.

Soft spots that show up during construction should be excavated and recompacted with the same type of soil as in the adjacent subgrade. Uniform support cannot be obtained merely by replacing the soft spot with granular material. At cut-fill transitions and other locations where there are abrupt changes in soil conditions, cross-hauling and mixing of soils may be needed.

If soil densities are too low or non-uniform, the surface should be compacted with rollers heavy enough to achieve 95% of AASHTO T99 density. Care should also be taken to ensure that soil moisture content is reasonably uniform; excessively wet or dry spots should be corrected. With proper subgrade preparation, soil volume changes due to frost heave or expansive soils will be reasonably uniform and not cause pavement distress.

Summary

Where frequent heavy truck loads are anticipated, a subbase is needed to prevent pavement pumping. Otherwise a subbase is not essential and does not add significantly to pavement strength. Thus, for light traffic situations, the pavement may be placed directly on a properly prepared subgrade. Achieving uniform subgrade support during construction is the key to adequate pavement performance without the expense of a subbase.

Many details of concrete pavement design and construction beyond the purpose and scope of this information sheet are given in the following ACPA publications:

- Design of Concrete Pavement for City Streets (IS184P)
- Design and Construction of Joints for Concrete Streets (IS061P)
- Building Quality Concrete Parking Areas (PA147P)
- Subgrades and Subbases for Concrete Pavements (TB011P)
- Concrete Pavements for General Aviation Airports (IS202P)

References

1. *Subgrades and Subbases for Concrete Pavements*, American Concrete Pavement Association, TB011P, 1991.
2. *AASHTO Guide for Design of Pavement Structures*, American Association of State Highway and Transportation Officials, revised 1993.
3. *PCC Pavements for Low-Volume Roads and City Streets*, National Cooperative Highway Research Program, Synthesis of Highway Practice 27, Transportation Research Board, 1975.
4. *Thickness Design for Concrete Highway and Street Pavements*, American Concrete Pavement Association, EB109P, 1984.

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