PAVEMENT TECHNOLOGY ADVISORY
- SUBGRADE MODIFICATION AND STABILIZATION -
PTA-D7

INTRODUCTION

Subgrade stability is a function of a soil's strength and its behavior under repeated loading. Both properties significantly influence pavement construction operations and the long-term performance of the pavement. The subgrade should be sufficiently stable to:

1. Prevent excessive rutting and shoving during construction;
2. Provide good support for placement and compaction of pavement layers;
3. Limit pavement rebound deflections to acceptable limits; and
4. Restrict the development of excessive permanent deformation (rutting) in the subgrade during the service life of the pavement.

When the subgrade does not possess these attributes, corrective action in the form of a subgrade treatment is needed.

TREATMENT METHODS

In Illinois, treatment of unsuitable subgrade soils is generally accomplished by modification, stabilization, or removal and replacement. Modification refers to a short-term subgrade treatment that is intended to provide a stable working platform during construction. Stabilization refers to a subgrade treatment intended to provide structural stability for improved long-term performance. Removal and replacement, as the name indicates, involves removal of the unsuitable subgrade soil and replacement with a select material (usually granular backfill).

The choice of a specific treatment depends on many factors, including: soil type; required treatment depth; construction variables (cost, availability, and time); treatment objective (short-term vs. long-term); and project location (urban vs. rural).

The two most commonly prescribed subgrade treatment methods for Illinois Department of Transportation (IDOT) projects are the use of additives (for both modification and stabilization), and removal and replacement. The use of additives is generally the most economical treatment method for rural projects. In urban areas, removal and replacement is often preferred because the use of additives creates dust and environmental concerns. The remainder of this advisory focuses on these two methods. Details on other treatment options can be found in the IDOT Geotechnical Manual, which can be purchased using the form available on the IDOT website (www.dot.il.gov).

USE OF ADDITIVES

Additives are of two types: reactive, such as lime; and self-cementing, such as Portland cement, slag modified Portland cement, and fly ash.

Reactive additives chemically react with the clay fraction in the soil to produce desirable changes in the engineering properties of the soil. Plasticity, workability, shrink-swell potential, and strength of fine-grained soils can generally be improved with the addition of lime.

The degree of improvement depends on such factors as soil type, type and percentage of lime, length of cure, soil temperature and soil moisture conditions at the time of curing. In general, lime does not require a curing period for the treated subgrade to achieve the required stability when used for modification. When used for stabilization, lime requires seven days of curing.

For lime modification, the optimum lime content is the percent lime that provides a minimum immediate bearing value (IBV) of 10 percent (see *PTA-T4*). For lime stabilization, the optimum lime content is the percent lime that results in a stabilized soil strength gain of 50 psi (345 kPa) over the untreated soil, and provides a minimum compressive strength of 100 psi (690 kPa) for subbases, and 150 psi (1035 kPa) for bases. The success of lime modification or stabilization depends on the soil-lime reactivity, which largely depends on the clay fraction in the soil. On the average, 15 to 20 percent clay fraction is necessary to ensure reactivity and provide the required IBV.

In granular soils such as silts, sands, and gravels, the clay fraction is too small and the soil-lime reactivity is too negligible to result in any improvements in the soil properties. In this case, soil treatment with self-cementing additives, such as Portland cement or fly ash, becomes an alternative. Self-cementing additives do not necessarily react with the soil or aggregate, but rather bind the natural materials together, increase strength, and provide some degree of waterproofing.

For modification with self-cementing additives, the performance criterion requiring a minimum IBV of 10 remains the same. For stabilization with Portland cement or slag modified cement, the optimum cement content is that which results in a minimum compressive strength of 500 psi (3450 kPa), without practically affecting the compaction and durability (freeze/thaw and wetting/drying) characteristics of the soil-cement mixture.

IDOT research conducted for Physical Research Report #138 indicated that fly ash can increase both the IBV and compressive strength of certain soils. Fly ash was found to require two to three times the application rate of lime for clayey soils, and may not be economical in such applications. However, fly ash was also found to be effective at strengthening silty and sandy soils that may not adequately react with lime. In these cases, modification with fly ash may provide a lower cost alternative to removal and replacement. Based upon these findings and other research, a new state-wide Bureau of Design and Environment (BDE) Special Provision was developed for Soil Modification, allowing fly ash as an alternative.

For both reactive and self-cementing additives, the laboratory evaluation/mix design procedures outlined in the IDOT Geotechnical Manual should be conducted to determine the "optimum" and economical amount of additive required.

REMOVAL AND REPLACEMENT

Also called “undercut and backfill,” this method is a simple procedure that does not require any specialized equipment. However, unless a suitable backfill material is available near the job site, removal and replacement is generally much more expensive than the use of additives. For this reason, removal and replacement is mostly used in urban areas, where dust and environmental impacts make the use of additives less desirable. Removal and replacement may also be the best option in areas where deep deposits of peat and muck cannot be treated with the use of additives.

For questions about this topic, or for additional information, please contact:

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