## Summary Report 501-5S

# Increased Single-Lift Thicknesses For Unbound Aggregate Base Courses

## Problem Statement

State departments of transportation (DOTs) have used aggregate base courses for many years as an integral structural component of pavements. Specifications prescribe requirements for placement and compaction of aggregate bases in addition to quality requirements for the aggregates. Typically, specifications also limit the lift thickness of unbound aggregate bases.

While advances have been made with regard to the capabilities of compaction equipment, lift thickness limits have generally remained unchanged, and this has raised the question of whether these specifications are too restrictive.

Recent evidence from field studies has shown that maximum lift thicknesses of six to eight inches and less are too restrictive, and an excellent constructed product can be obtained with increased single-lift thicknesses; in particular, thicknesses from 10 to 16 inches have been successfully placed. Furthermore, it is believed that allowing the compaction of thicker lifts could result in considerable savings in time and money on future projects.

## Objectives

International Center for Aggregate Research (ICAR) researchers at the University of Texas at Austin conducted Project ICAR-501, *Increased Single-Lift Thicknesses for Unbound Aggregate Base Courses,* with funds provided by the Aggregates Foundation for Technology, Research, and Education. The objective of this study was to evaluate the feasibility of compacting unbound aggregate base courses in thicker lifts than currently permitted by DOTs and to identify effective test methods that assess the quality of the final compacted base or subbase.

This project constructed and tested full-scale test sections using a variety of material types. Two test pads were constructed in an aggregate quarry in Texas utilizing 12- and 21-inch thick compacted lifts of crushed limestone. Three crushed granite test sections were built as part of a road-widening project in Georgia (13-inch compacted lifts), and two test pads were constructed of uncrushed and partially crushed gravel with loess fines taken from a gravel production facility near Memphis, Tennessee ( 12- and 14.5-inch compacted lifts).

For the Georgia tests, a vibratory sheepsfoot roller with a maximum dynamic force of 56,000 pounds and a vibratory smooth drum roller with a maximum dynamic force of 46,000 pounds were applied. Similar capacity compactors were used in the Texas tests. A vibratory smooth drum roller applying 28,000 pounds centrifugal force was used to successfully compact the 12-inch lifts in the Tennessee test series.

## Findings

Several observations were made based on the in-situ density, water content, shear wave velocity, and plate load test results obtained at the three test sites. ICAR research reports document the stiffness and density results for the Georgia, Texas, and Tennessee test sites and the load testing results from the Texas site.

Nuclear Density Gauge (NDG) results show that density requirements can be met with thick lifts for all four types of materials utilized in these tests. The data confirms that density figures in excess of 100 percent of maximum, as determined by the American Association of State Highway and Transportation Officials (AASHTO) T-180, can be achieved in the field.

For the vibratory rollers used in this study, the vibratory smooth drum and the vibratory sheepsfoot rollers provided similar results and both provided adequate compaction. This was standard equipment.

Uniform moisture content impacts the ability to achieve the required level of compaction, as well as affects the stiffness of the compacted layer. The data reflected the importance of controlling the moisture content of the unbound base during the mixing, transporting, spreading and compaction phases. The seismic technique, spectral analysis of surface waves (SASW), which measures shear wave velocity, offers some advantages or additional benefits relative to NDG testing:

1. it is nonintrusive;
2. any layer thickness can be evaluated;
3. soft layers within the base or subgrade may be detected after construction; and
4. the stiffness, obtained directly from velocity measurements, is a direct measure of how the pavement system will deflect under traffic loads.

It should be noted that the North Carolina and Virginia DOTs now allow 10-inch compacted lift thickness, and the Georgia DOT has approved a contractor's request to place a compacted 12-inch lift, contingent upon the successful construction of a 1000-foot test section.

## Recommendations

On the basis of the results of the DOT survey, laboratory data and successful field tests, the following sections are proposed for inclusion in aggregate base course specifications.

**Description.** The contents of this section pertain to mixing, transporting, placement, and compaction of an aggregate base course on a prepared subgrade or subbase.

**Materials.** Gradation, particle size, angularity, and plasticity standards are addressed elsewhere in the typical specification.

**Equipment.** Mixing may be accomplished by a plant such as a pugmill or by road mixing using a motor grader or rotary mixer. Mechanical spreaders will be utilized to minimize segregation and to control loose lift depth. Suitable vibratory compaction equipment will be employed.

**Mixing and Transporting.** The aggregates and water shall be plant mixed to the range of optimum moisture plus or minus 2% and placed on the roadway to avoid segregation and loss of moisture.

**Subgrade Preparation.** The upper six inches of the subgrade shall be compacted to at least 100% of AASHTO T-99 maximum dry density.

**Spreading.** The material shall be placed to the required thickness and cross section by utilizing an approved mechanical spreader. If the compacted thickness of the base course exceeds 12 inches, the base shall be constructed in two or more layers with a minimum compacted thickness of four inches. At the engineer¹s discretion, the contractor may construct a 500 foot long test section to demonstrate achieving adequate compaction without particle degradation for lift thicknesses in excess of 12 compacted inches. The engineer may allow thicker lifts on the basis of the test section results.

If needed, a motor grader, or other approved equipment, may be used to shape the material prior to compaction.. Similarly, a water truck may be utilized to replace lost moisture. All areas of segregated coarse or fine materials shall be removed or scarified to achieve a well-graded material.

**Compaction.** Immediately following spreading and shaping of the aggregates, the compaction effort will begin and will continue without interruption until the desired level of density is achieved. In the event inclement weather forces the compaction effort to terminate prior to completion, the material will be scarified, brought to proper moisture content, and the layer will be reshaped prior to resuming the compaction operation. Recommended minimum density requirements are as specified by the agency.

**Sampling and Testing.** Existing agency standards for frequency and spacing of elevation and density checks should be utilized.

*The information in this summary is detailed in ICAR research report 501-5,* Increased Single-Lift Thicknesses for Unbound Aggregate Base Courses, *by John J. Allen, Jaime L. Bueno, Michael E. Kalinski, Michael L. Myers, and Kenneth H. Stokoe, II. The contents of this summary do not necessarily reflect the official views of AFTRE or ICAR.*