

Finishing Subbases for Slip-Form Paving

EDWARD L. KAWALA, Paving Bureau, Portland Cement Association

An accurately graded, stable subbase is essential in slip-form paving to provide a smooth pavement slab of proper depth. Finishing subbases for slip-form paving requires different construction techniques than are normally used for pavements with side forms; the subbase must be constructed in advance without the advantage of using previously set paving forms as a guide. Equipment and methods that have been used successfully for finishing subbases are described. Three methods of finishing are commonly used: (a) clipping to "blue tops" with motor graders, (b) fine-grading from an accurately placed reference line, and (c) placing a controlled depth of loose material so that after compaction only minor grade adjustments are required. Both untreated and cement-treated granular subbases are discussed.

●SUBBASES have come into general use for concrete pavements only since World War II. The increased truck traffic during and after the war made it necessary to use subbases to prevent pumping of fine-grained subgrade soils. (Subbases are not required for city streets or for rural pavements carrying less than 300 to 400 heavy axle loads daily in both directions. This is well established by the performance of many miles of such pavements without subbases.)

Subbases perform several functions in the construction process. Where conventionally formed concrete is used, subbases provide a stable base for anchoring the forms and dowel baskets (if used), and an accurate surface on which to place the concrete and thus assure a proper slab thickness. With the advent of slip-form paving, subbase stability has become more important than ever. The subbase must provide a uniformly stable, accurate grade on which to operate the slip-form paver.

One of the most important advantages of the slip-form operation is that smoother concrete pavements can be built; the degree of smoothness depends to a great extent on the stability and accuracy of the subbase. Therefore, it follows that the key to the success of any slip-form operation is a firm, unyielding subbase built to close grade tolerances.

The accuracy of the wheelpaths over which the slip-form crawlers travel influences the smoothness of the pavement surface. The degree of accuracy to which the entire width of subbase beneath the slab is constructed influences the amount of concrete required to build the slab to proper grade. Low grades will cause high concrete overruns and thus higher paving costs; high areas result in thin pavement. Therefore, if the slip-form method of paving is to be used successfully to build a smooth-riding slab with a minimum overrun of concrete, accurate subbase grade control is essential.

The small percentage of fines in present subbases has resulted in materials that often do not have the inherent stability to carry slip-form pavers without displacement. As a result of this instability, the growing scarcity and correspondingly increased cost of such clean subbases, and the excellent performance of concrete pavements with cement-treated subbases in California, many states have turned to stabilized subbases.

Although other types have been used, cement-treated subbases are the most widely used stabilized subbases. Concrete pavements with cement-treated subbases are in service in more than 30 states and Canada. California alone has built well over

1,000 mi of concrete pavement on cement-treated subbase, some 500 mi of which was built with slip-form pavers.

MATERIALS

The accuracy to which a subbase can be graded is influenced by the maximum size of aggregate used. Specifications generally limit the maximum size to 1 in. or less; using this maximum-size aggregate, subbases usually can be finished to within $\frac{1}{4}$ or $\frac{3}{8}$ in. of the grade shown on the plans.

In addition to limiting the maximum size and percentage of fines passing the No. 200 sieve, specifications for untreated subbases usually limit the plasticity index to 6 and the liquid limit to 25.

Where such materials are scarce or expensive, marginal materials available locally can be treated with cement to build acceptable subbases. Granular soils falling into AASHTO Soil Classification Groups A-1, A-2, and A-3 are normally used for cement-treated subbases. These materials may contain up to 35 percent passing the No. 200 sieve and may have plasticity indexes of up to about 12. The use of fine-grained soils for cement-treated subbases for concrete pavements is definitely not recommended.

Generally, in cement-treated subbase construction, enough cement is added to produce a hardened material having a 7-day compressive strength of 300 psi or more. In areas subject to frost action, the hardened material should also meet the Portland Cement Association weight-loss criteria based on the standard AASHTO-ASTM wet-dry, freeze-thaw tests for soil-cement.

CONSTRUCTION PROCEDURES

Mixing

Subbases should be compacted at optimum moisture content. Adding water and mixing of untreated and cement-treated material can be accomplished on the grade using traveling mixing machines. Another method is to process the material in a central mixing plant, haul it to the roadway, and place the moist material in a uniform layer on the subgrade by means of a spreader. Dumping material in piles on the subgrade should not be permitted. Complete discussions of methods used to mix, place, compact, and cure cement-treated subbases are available.

Finishing

The next step in construction involves finishing the subbase to accurate grade and crown. Care must be taken during finishing of the cement-treated subbase to assure that surface moisture lost through evaporation during finishing operations is promptly replaced by a light fog-spray.

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The methods used to finish untreated and cement-treated subbases are identical. However, when finishing cement-treated subbases one additional factor must be taken into consideration—the time element. To gain full advantage of the benefits imparted to the subbase by the addition of portland cement, the cement-treated subbase must be constructed and finished to grade within a time limit set forth in the specifications, usually 6 hr after the addition of moisture to the mixture.

The various finishing methods described here are those that have been used successfully on actual projects. Other methods can be used and, in fact, are continually being developed and improved as contractors gain experience with this type of construction. Development of new equipment specifically for this purpose has greatly simplified subbase grade control.

Three methods of finishing are commonly used: (a) clipping to "blue tops" (grade stakes) with motor graders; (b) fine-grading from an accurately placed reference



Figure 1. String line crew determining amount to be cut or filled and signalling to grader operator.

line; and (c) placing a controlled depth of loose material so that after compaction only minor grade adjustments are required.

For cement-treated subbase construction it is imperative that accurate grade be attained during initial construction. Adjustments in surface grade after the cement-treated subbase has hardened are costly, difficult to make, and are generally not satisfactory.

Method 1.—This procedure involves the use of a motor grader for clipping to grade, with blue tops placed transversely across the roadway as reference points. The blue tops are set at each edge of the subbase and, depending on the crown, at one or more points in a line across the section. A level is used to set the blue tops following completion of initial compaction. The longitudinal interval for setting blue tops is usually 50 ft on tangents and 25 ft on curves. The motor grader clips the section to grade starting at one edge and working toward the other. The grader operator is assisted by one or two stakemen, who observe the existing grade at each blue top and signal to the grader operator the amount to be cut or filled.

An alternate method involves stretching a string line across the section between grade stakes placed outside either edge of the subbase. The line is held taut at a specified elevation marked on the stakes. The amount to be cut or filled is determined by measuring down from the string line to the surface of the subbase, as shown in Figure 1. Usually two or more passes are required to obtain grade. The suitability of this method and the accuracy of grade obtained are greatly influenced by the capability of the grader operator. Grader attachments that permit automatic control of blade slope have been used successfully to finish subbases.

Method 2.—This procedure involves the use of a motor grader working to blue tops or to a string line, or an electronically controlled form-grader working to a string line (Fig. 2) to cut a trench to accurate grade at each edge of the subbase. The cutting edge of the rotor is automatically adjusted by means of a grid sensor riding on an accurately placed string line (Fig. 3). The trench grade should be checked immediately behind the machine (Fig. 4). Some handwork is usually required to correct minor variations in the trench grade. The central portion of the subbase is then cut to grade by means of a subgrade planer traveling in the prepared trenches (Fig. 5). The subbase should be cut slightly high (approximately $\frac{1}{8}$ in.) to allow for a small amount of consolidation during final rolling.



Figure 2. Electronically controlled form-grader cutting trench at edge of subbase.

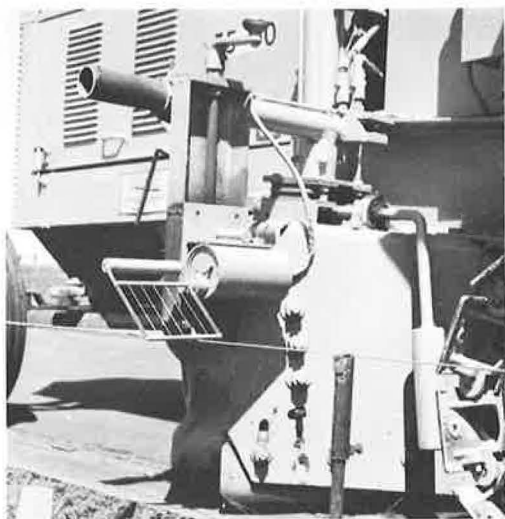


Figure 3. Cutting rotor automatically controlled by sensor riding a string line.

A similar procedure involves the preparation of a trench on one edge of the subbase. An automatic fine-grader, utilizing this trench as a reference for the initial pass, cuts the area adjacent to the trench to grade. The grade established by the first pass of the machine is used as a reference for the next pass. This procedure is repeated until the entire width of subbase is graded.

Automatically controlled fine-graders operating from wires placed along one or both edges of the subbase represent another method of finishing cement-treated subbases. These machines automatically maintain blade height and cross-slope in relation to a selected reference, usually a wire but sometimes an adjacent lane of pavement or graded area. The machines are available in widths of 13 to 30 ft, as pull-type (Fig. 6) or self-propelled (Fig. 7) models on rubber tires, or as self-propelled models on crawlers (Figs. 8 and 9). Because these machines are quite heavy, they require stable support to operate properly.

Method 3.—A somewhat different method for controlling grade involves the placement of the loose material to accurate depth so that after compaction only a minimum amount of grading is required. Most of the subbase work to date utilizing this method has involved a compacted thickness of 4 in.

One technique involves the careful grading of the subgrade and the placing of a uniform depth of moist material. The subgrade acts as a reference plane as the machine places a specific thickness of loose material. The mixture is processed from windrows on the subgrade (Fig. 10). After spreading from the windrows, oscil-



Figure 4. Accuracy of trench grade checked immediately behind form-grader with shop-made level.



Figure 5. Subgrade planer, running in prepared trenches, cutting central portion of subbase to grade.



Figure 6. Cutting blade of pull-type fine-grader controlled by a sensor riding on accurately placed piano wire.



Figure 7. Self-propelled subgrading machine, built by paving contractor, supported on three large wheels in tandem at each corner to provide additional flotation in unstable sands.



Figure 8. Full-width (28-ft) self-propelled subgrader on crawlers, controlled from reference wire.

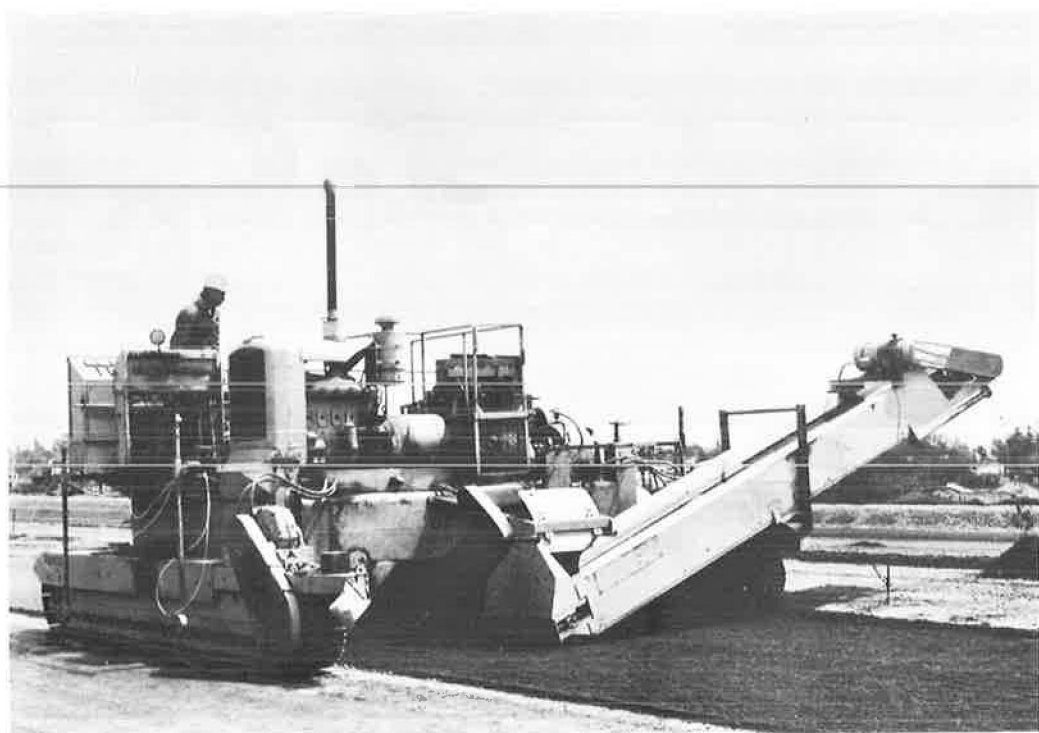


Figure 9. Half-width self-propelled automatic subgrader, controlled from reference wire.



Figure 10. Accurately controlled thickness of loose material placed 28 ft wide by machine.

lating frame-suspended screeds strike off the loose material to grade. A traveling paddle in front of each screed assures sufficient material in front of the screed to prevent low areas. The loose mixture is then compacted with steel-wheel and rubber-tire rollers. A machine somewhat similar in principle but controlled from a reference wire spreads the material from windrows, strikes it off to loose grade with vibrating screeds, and compacts the material with two full-width vibrators (Fig. 11).

Another technique of accurately placing subbase is to use electronically controlled asphalt pavers working off a heavy cord string line (Fig. 12). The screed control system on these pavers provides a means of automatically maintaining grade and slope on the surface of the material being placed with reference to a predetermined grade and slope. Grade is transferred from the string line to the control center by means of a grid sensor. Grade reference for placement of the second lane can be obtained from a sled attachment riding on the surface of the uncompacted mixture placed previously. Pavers have been built to place compacted thicknesses of up to about 8 in. (Fig. 13).

A slip-form paver composed of a combined unit which does everything except mix the concrete, including automatically finishing the subbase to grade, is presently under development (Fig. 14).

Final Compaction and Curing

Immediately after grade is obtained, the subbase is given a final rolling either by a rubber-tire roller or, depending on the type of granular material, a steel-wheel roller followed by a rubber-tire roller. This last rolling knits down any material loosened during finishing.

The final step in finishing cement-treated subbases is the application of the curing material. After rolling, the surface of the cement-treated subbase is given a light



Figure 11. Wire-controlled machine spreading, from windrow, striking off to loose grade, and partially compacting subbase material.

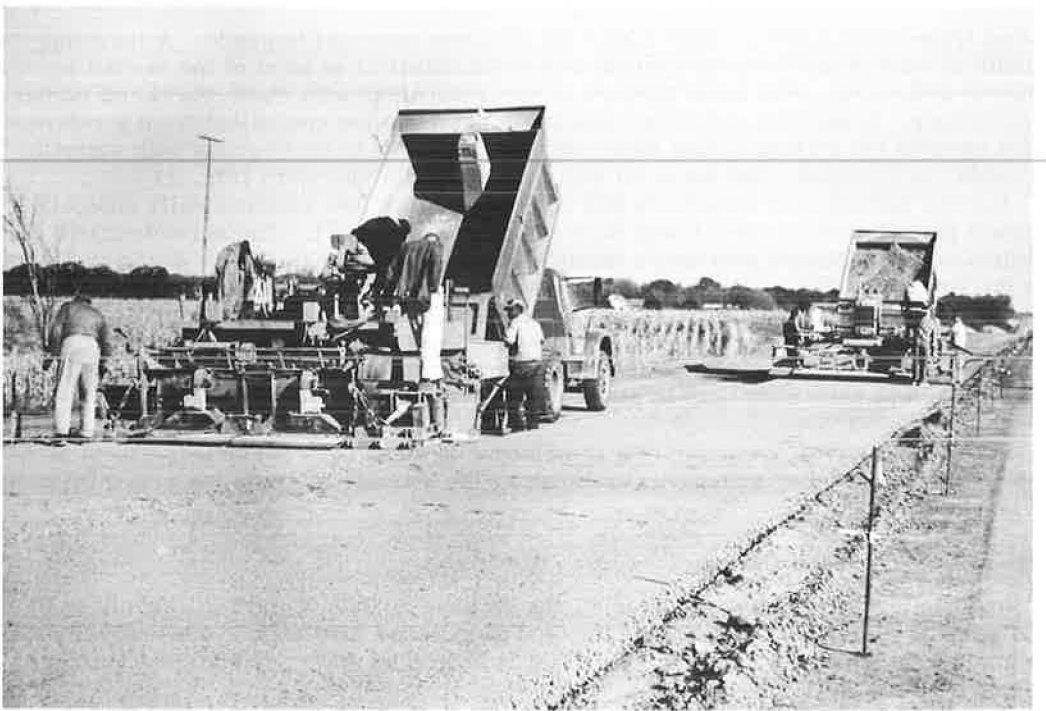


Figure 12. Electronically controlled asphalt pavers placing 4-in. thickness (compacted) on subbase material.

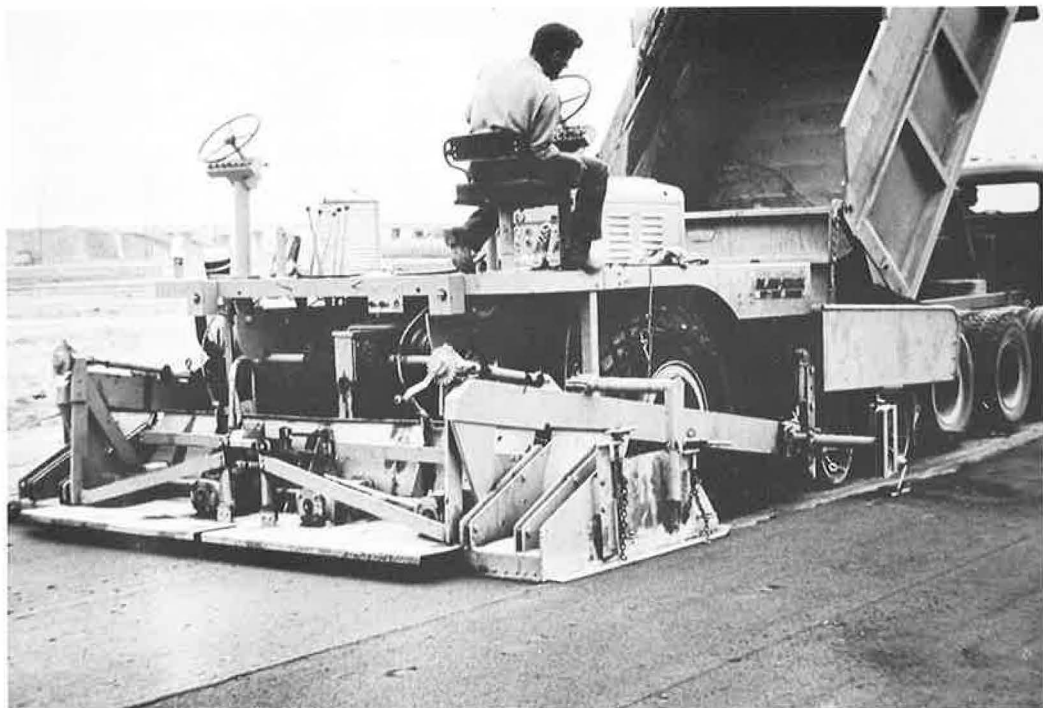


Figure 13. Paver capable of placing and partially compacting thicknesses of cement-treated subbase up to 8 in.



Figure 14. Prototype of combined-unit slip-form paver.

fog application of water. This is usually followed by the application of from 0.15 to 0.25 gal/sq yd of bituminous material for curing.

SUMMARY

A stable, accurately graded subbase is one of the key factors necessary for successful slip-form paving. Methods and equipment have been developed for accurate, rapid grade control. Cement stabilization permits the use of a wide range of granular materials and assures adequate stability of the subbase, regardless of weather conditions. This combination of factors permits mass production of accurately graded subbases and greatly reduces the contractor's downtime due to inclement weather.

Improvement in methods and equipment for finishing subbases will continue. Several manufacturers presently have under development construction equipment that will permit simpler, more accurate subbase grade control.