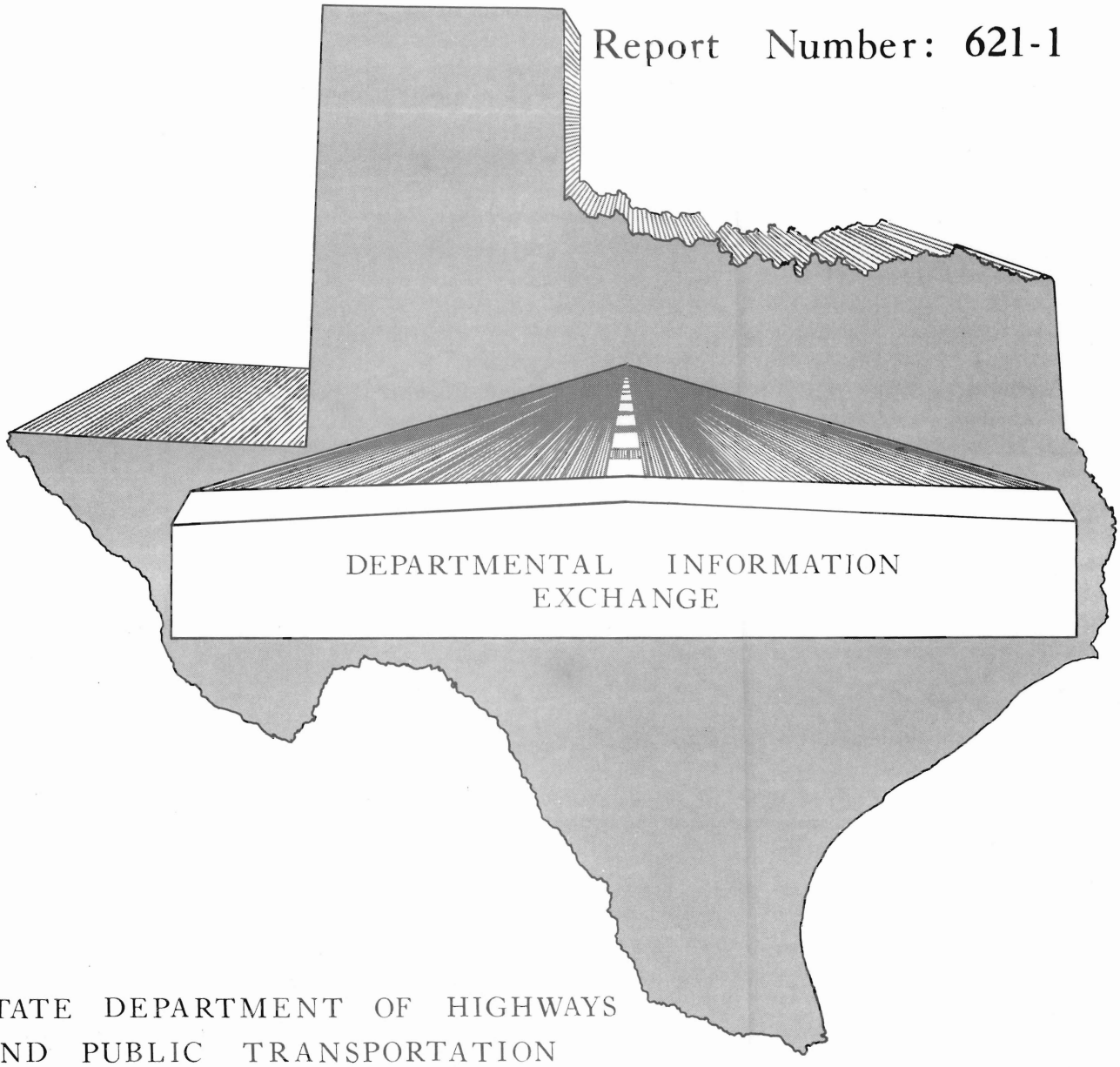
EXPERIMENTAL PROJECTS

CEMENT STACKDUST TREATMENT FOR MATERIALS IN PLACE

Report Number: 621-1



STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

CEMENT STACKDUST TREATMENT

for

MATERIALS IN PLACE

by

Warren N. Dudley
Supervising Resident Engineer

District 20
STATE DEPARTMENT OF HIGHWAYS AND
PUBLIC TRANSPORTATION

Report No. 621-1

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DISCLAIMER STATEMENT

The material contained in this report is experimental in nature and is published for informational purposes only. Any discrepancies with official views or policies of the DHT should be discussed with the appropriate Austin Division prior to implementation of the procedures or results.

ACKNOWLEDGEMENT

The author is grateful for the support of District Engineer, Franklin C. Young who encourages the development of new ideas and materials that aids in engineering economy and for the assistance of Senior Resident Engineer, Clinton Bond who supervised the construction of the test sections. Special recognition is extended to Alpha Cement Company and their employees for their cooperation in making the project possible.

ABSTRACT

This paper is a presentation of the experiences of District 20 of the State Department of Highways and Public Transportation in experimenting with cement stackdust as a stabilizing agent for base and sub-base roadway materials. It includes laboratory test results, roadway use techniques, a proposed Special Specification for use of the material and pictures of typical roadway construction.

CEMENT STACKDUST TREATMENT

for

MATERIALS IN PLACE

Cement stackdust is a by-product produced from the manufacture of portland cement. It is trapped from kiln exhaust by anti pollution devices and stored in dry hoppers. During periods of full cement plant operation approximately 200 tons per day of stackdust is trapped and placed in the storage hopper at the Alpha Portland Cement Company north of Orange, Texas. Included in the cement stackdust that is recovered is finely ground oyster shell and partially burned cement clinker dust. Practically all material recovered from the kiln will pass a 100 mesh sieve. Local contractors have used this by-product material as a construction expedient to stabilize wet subgrade and subbase.

Laboratory investigation indicated that in addition to drying and stabilizing a gain in strength is also experienced. Laboratory results included in Appendix A, prove the value of stackdust stabilization. As shown in the laboratory results a 4.7 triaxial class sandy loam was improved to a high triaxial class I with the addition of 10% cement stackdust. The addition

of 10% stackdust to a triaxial class 2.3 sand shell base material raised the triaxial class to I. The cohesive strength of the base material was increased from 1,440 lb/sq. ft. to 4,464 lb/sq. ft. by adding 10% cement stackdust.

Implementation of laboratory research was accomplished by adding 10% cement stackdust to the sand subbase and sand shell base on a section of FM 105 in Orange County. The highway was being reconstructed by State Forces utilizing cement as a stabilizing agent. The sketches included in Appendix B, show locations where cement stackdust was used as the stabilizer. Laboratory results using the road mixed material reflected results obtained from the laboratory mixed samples.

Cement stackdust stabilization on the test section of FM 105 was accomplished by conventional methods. Field operation using cement stackdust is the same operation as when using hydrated lime or portland cement as a stabilizer. One departure from the usual method was delivering the stackdust in covered dump trucks. The cement plant was nearby and dump trucks were available making this method of delivery workable. The stackdust was dampened as it was loaded into the dump trucks in order to reduce blowing dust. On a subsequent project where cement stackdust was used it was delivered dry by bulk transport trucks and spread on the

roadbed from the transport truck. Pictures depicting construction operations using cement stackdust are included in Appendix C.

The test sections on FM 105 were constructed during March, 1975. One year after construction all test sections are in good condition with no apparent failures. As a result of the experimental work done on this project a recommended specification has been prepared for the use of cement stackdust for future use. The Specification is included in Appendix D.

One advantage gained by the use of cement stackdust is to speed construction in wet areas. Another advantage in using stackdust in lieu of hydrated lime is the cost. Cement stackdust has been purchased for $2.02 per C.Y. Even though laboratory tests indicate 10% stackdust by weight is required to produce results comparable to using 4% hydrated lime the low cost factor off-sets the amount of material required.

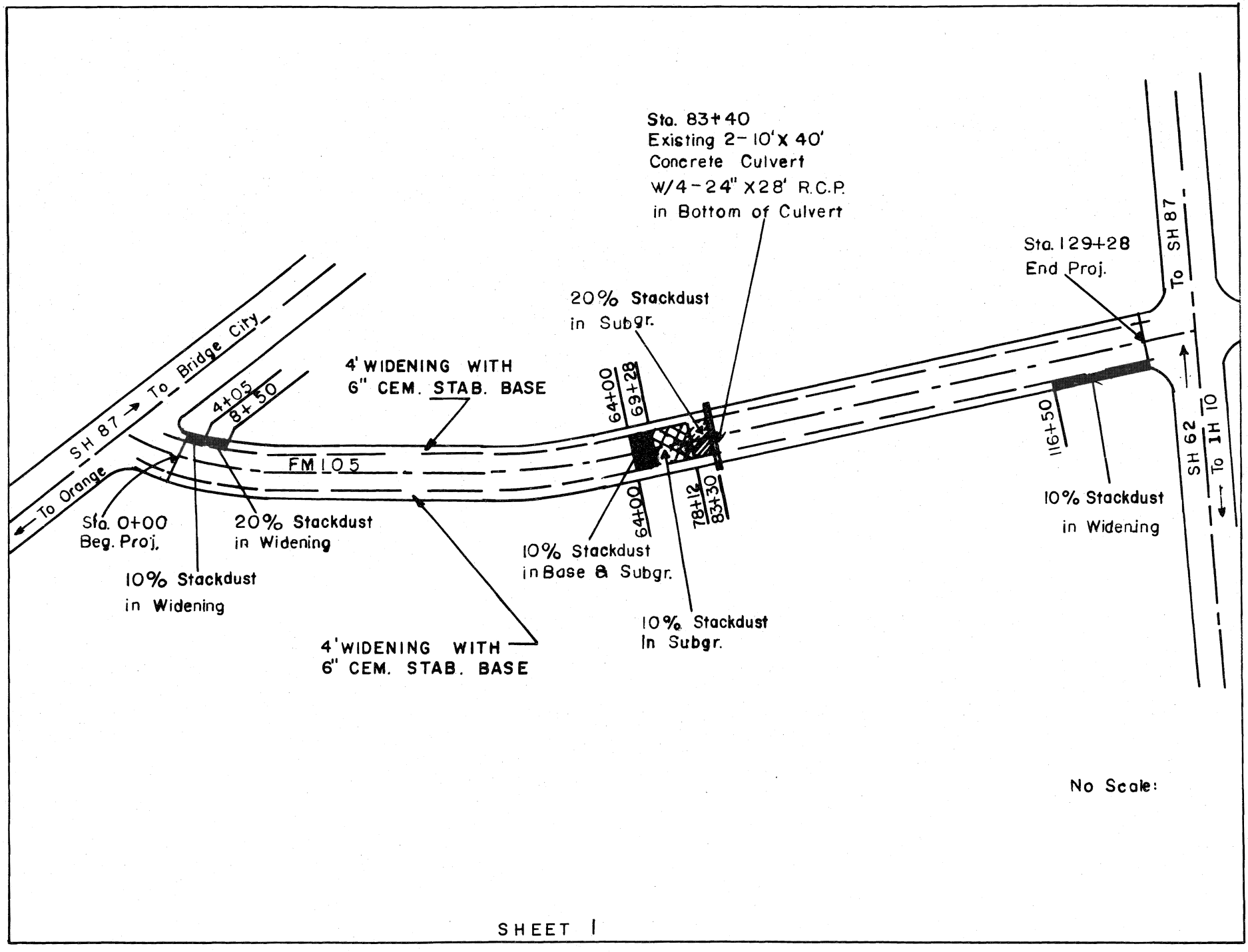
APPENDIX A

SUMMARY SHEET

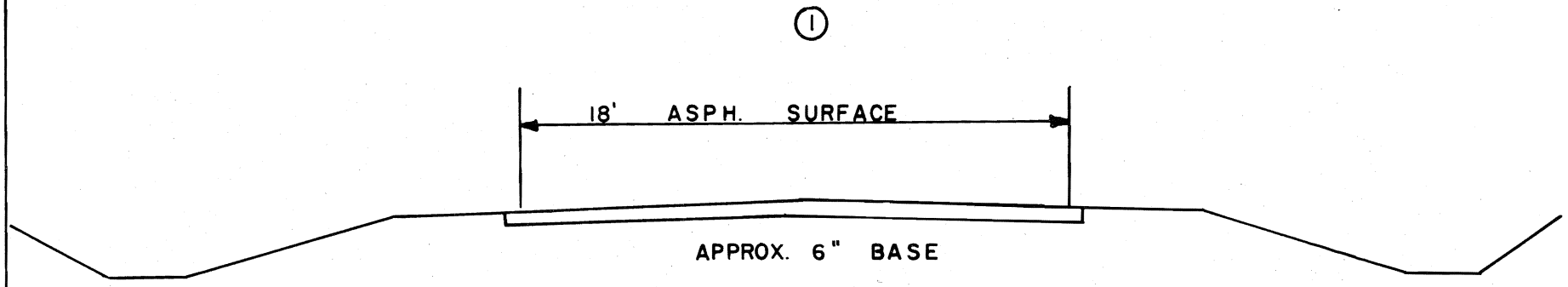
Control: 689-2 County: Orange Highway: F.M. 105 (Between SH-62 & SH-87)

Type of Material & Remarks	Dry Dens. in #/Cu.Ft.	O.M.C. (%)	Moisture Absorbed	Swell (%)	Class of Material	θ	C #/Sq.Ft.
Under Laboratory Control							
Black Sandy Subgrade - Raw Material (75-72)	121.3	7.3	7.3	5.35	4.7	23°-15'	562
Raw Material w/10% Added Stack Dust (75-74)	119.5	10.8	2.3	1.4	1	43°-0'	3,096
Raw Material W/20% Added Stack Dust (75-75)	115.3	11.1	4.5	3.3	1	47°-30'	3,312
Samples Secured from Roadway							
Subgrade Material W/10% Stack Dust Added & Roadway Mixed (75-73)	118.1	12.8	1.4	0.82	1	43°-0'	3,499
Subgrade Material W/20% Stack Dust Added & Roadway Mixed (75-77)	116.9	13.2	2.2	2.10	1	47°-0'	3,024
Under Lab Control							
Raw Sand-Shell Base Material (75-57)	126.9	6.0	1.8	0.62	2.3	49°-30'	1,440
Sand-Shell Base Material W/10% Added Stack Dust (75-59)	122.6	7.9	2.2	0.86	High Class I	47°-15'	4,464
Sample Secured from Roadway							
Sand-Shell Base Material W/10% Added Stack Dust & Roadway Mixed (75-58)	120.5	9.2	1.8	0.92	High Class I	43°-30'	3,096

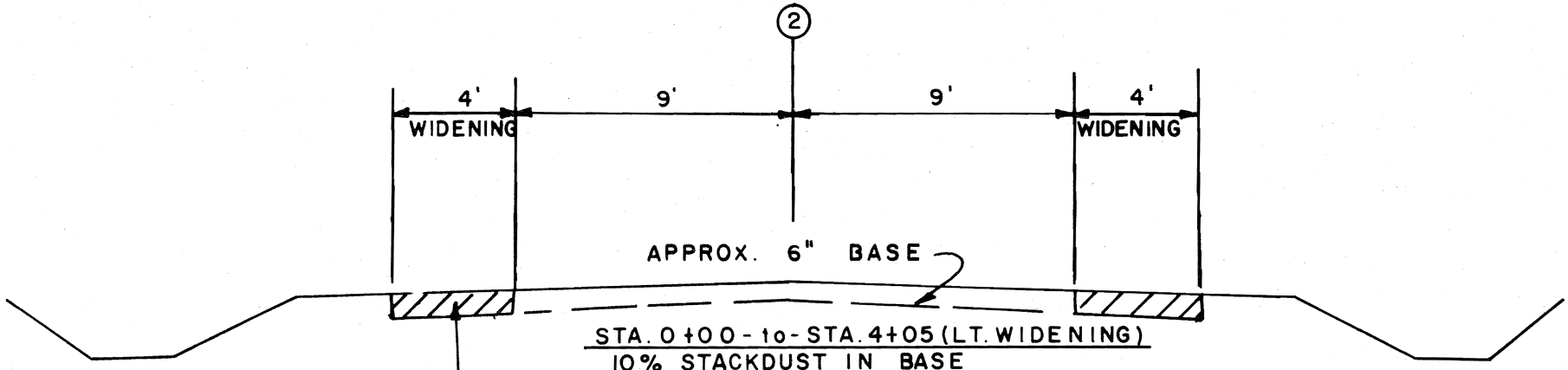
APPENDIX B


Sta. 83+40
Existing 2-10'X 40'
Concrete Culvert
W/4-24" X28' R.C.P.
in Bottom of Culvert
Sta. 129+28
End Proj.
To SH 87
20% Stackdust
in Subgr.
4' WIDENING WITH
6" CEM. STAB. BASE
SH 87
To Bridge City
4+05
8+50
64+00
69+28
FM 105
To Orange
Sta. 0+00
Beg. Proj.
20% Stackdust
in Widening
10% Stackdust
in Widening
64+00
78+12
83+30
10% Stackdust
in Base & Subgr.
10% Stackdust
In Subgr.
4' WIDENING WITH
6" CEM. STAB. BASE
116+50
10% Stackdust
in Widening
SH 62
To IH 10
No Scale:

SHEET 1



ORIGINAL SECTION



USUAL CEM. STAB. BASE IN WIDENING EXCEPT AS SHOWN HEREON (BOTH SIDES)

STA. 0+00 - to - STA. 4+05 (LT. WIDENING)
10% STACKDUST IN BASE

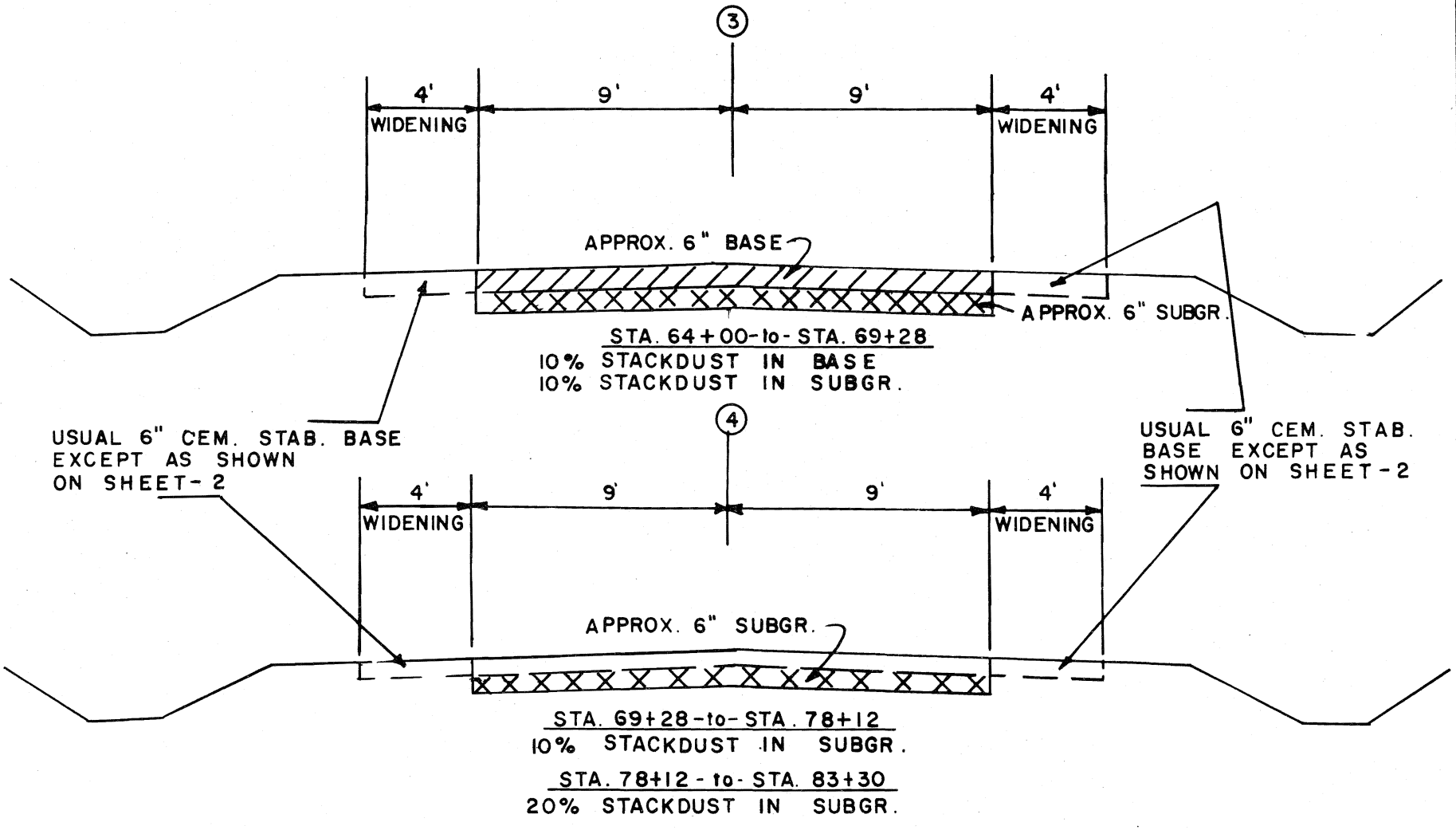
STA. 4+05 - to - STA. 8+50 (LT. WIDENING)
20% STACKDUST IN BASE

STA. 116+50 - to - STA. 129+28 (RT. WIDENING)
10% STACKDUST IN BASE

EXISTING SECTION

FM-105
FROM SH-62 TO SH-87
CONTROL 689-2-
ORANGE COUNTY

5-75



EXISTING SECTIONS

FM-105
FROM SH-62 TO SH-87
CONTROL 689-2-
ORANGE COUNTY

5-75

APPENDIX C

Figure I: Condition of roadway prior to treatment

Figure 2: Scarifying old base and surface

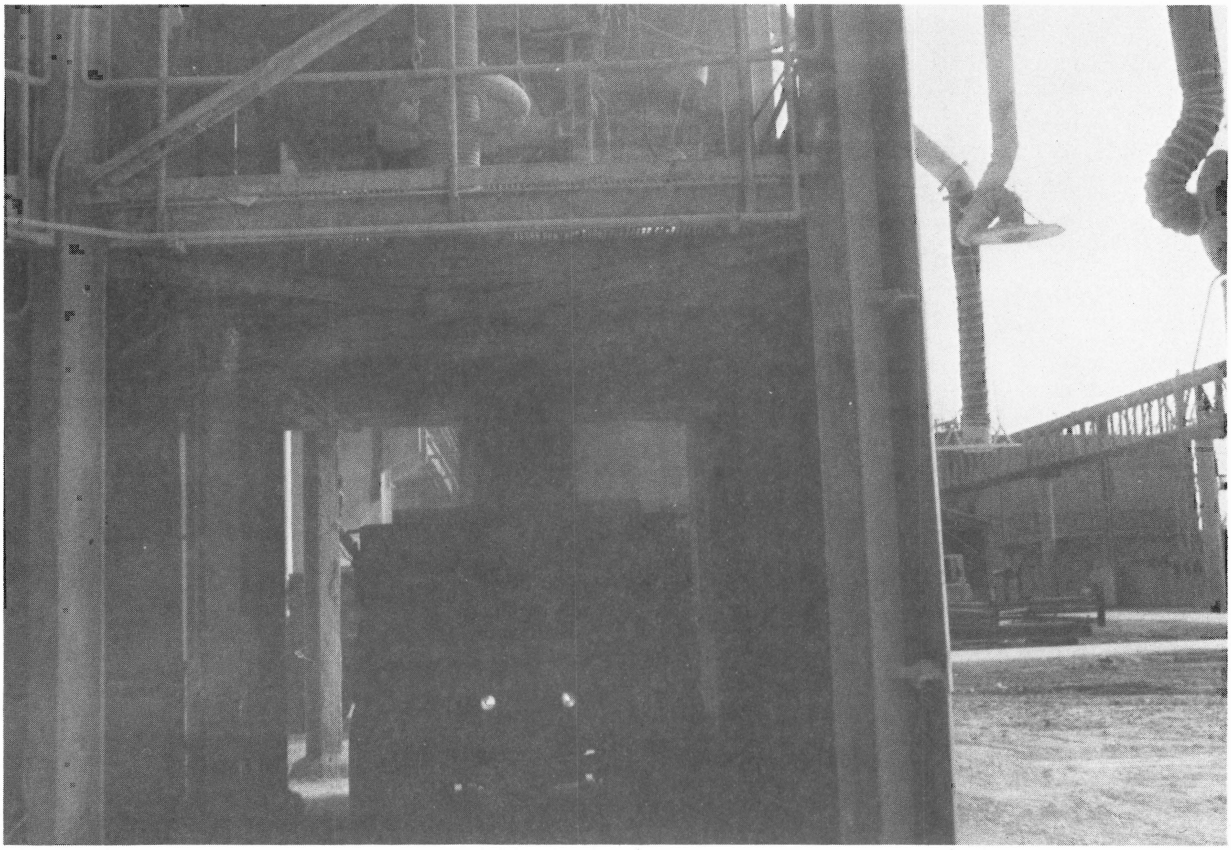


Figure 3: Stackdust being loaded into dump truck from dry hopper

Figure 4: Stackdust being dumped through tailgate spreader

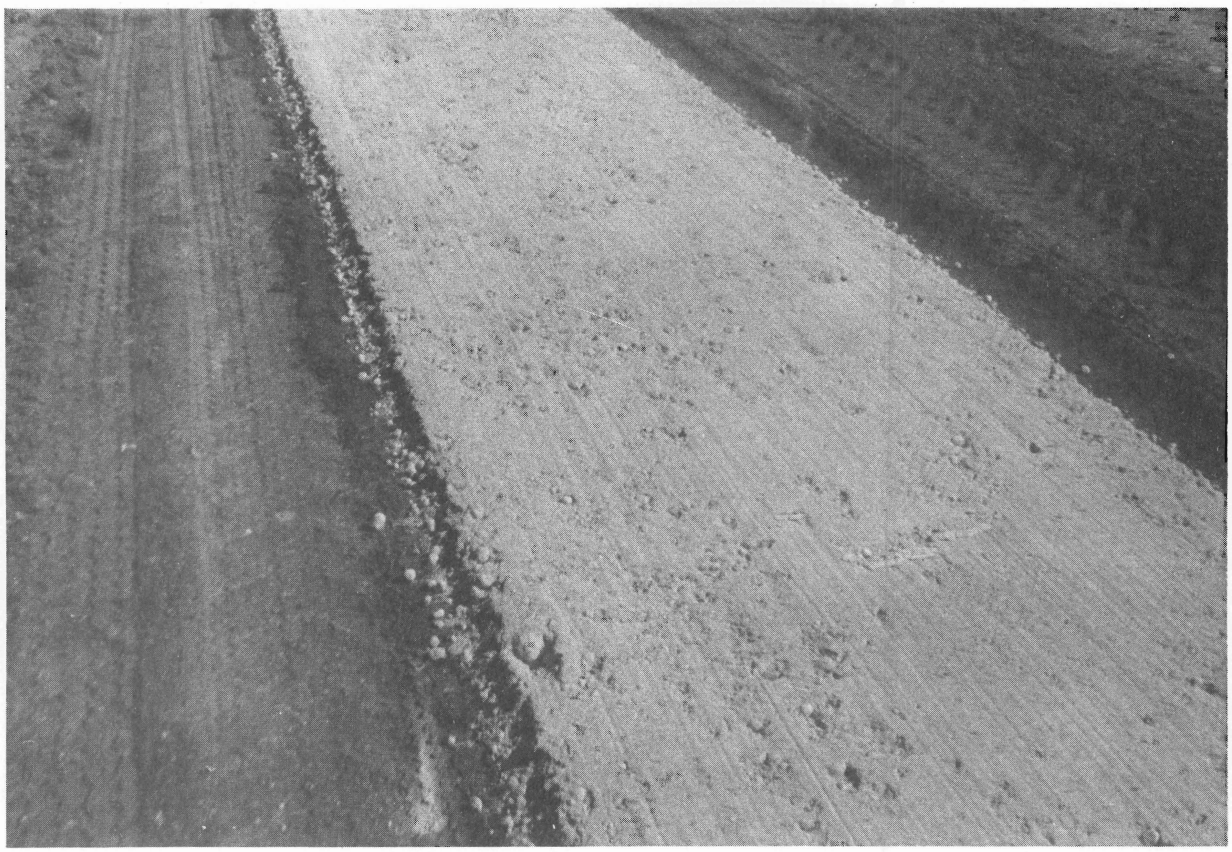


Figure 5: Stackdust in place prior to mixing

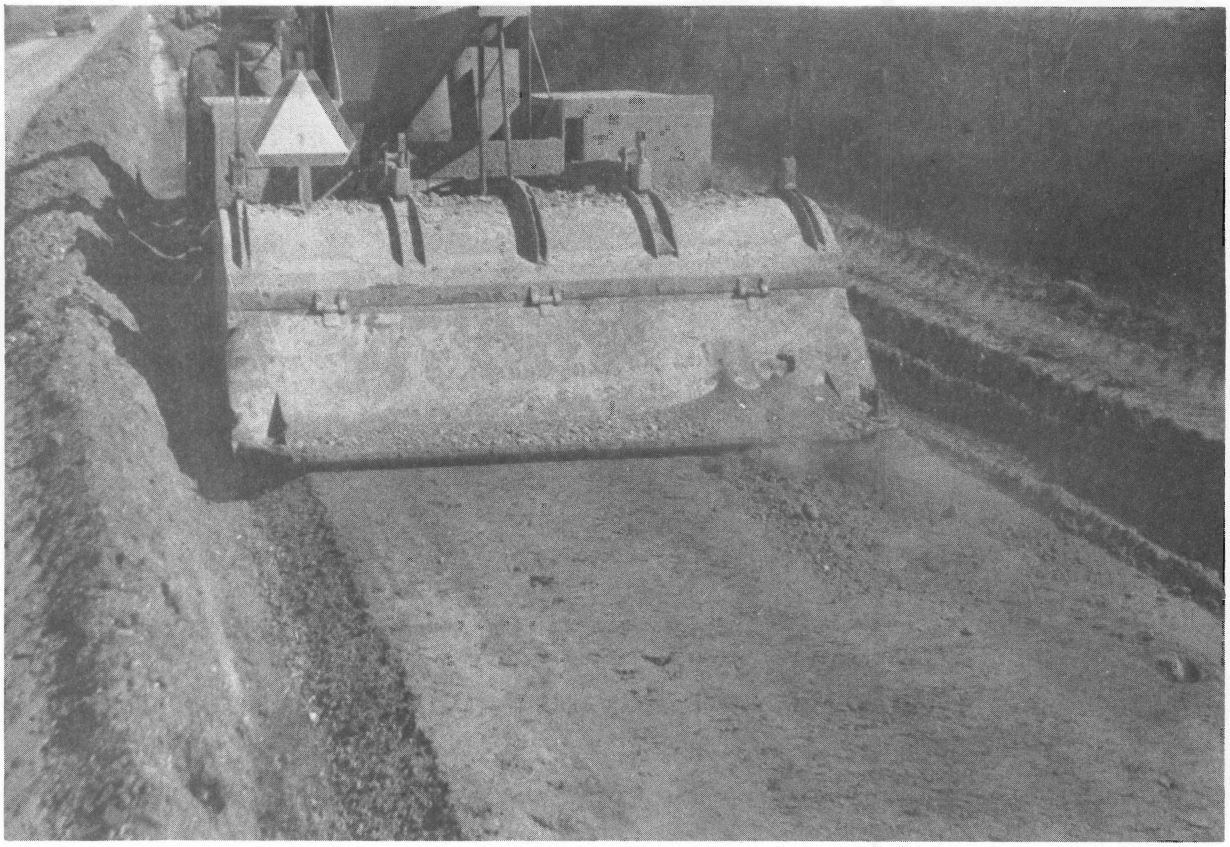


Figure 6: Mixing operation

APPENDIX D

STATE DEPARTMENT OF HIGHWAYS

AND PUBLIC TRANSPORTATION

SPECIAL SPECIFICATION

ITEM

CEMENT STACKDUST TREATMENT

FOR MATERIALS IN PLACE

1. DESCRIPTION:

This item shall consist of treating the subgrade, existing subbase or existing base by the pulverizing, addition of portland cement stackdust, mixing, wetting and compacting the mixed material to the required density. This item applies to natural ground, embankment, or existing pavement structure and shall be constructed as specified herein and in conformity with the typical sections, lines and grades as shown on the plans or as established by the Engineer.

Cement stackdust treatment shall not be mixed or placed when the air temperature is below 40°F and is falling, but may be mixed or placed when the air temperature is above 35°F and is rising, the temperature being taken in the shade and away from artificial heat and with the further provision that cement stackdust treatment shall be mixed or placed only when weather conditions, in the opinion of the Engineer, are suitable.

2. MATERIALS:

(1) Soil. Soil shall consist of approved material free from vegetation or other objectionable matter encountered in the existing roadbed and other acceptable material used in preparation of the roadbed in accordance with this specification.

(2) Cement Stackdust. Cement stackdust shall be a byproduct obtained from the production of portland cement. It shall be recovered from the kiln exhaust and stored in a dry hopper for delivery to the project in covered or sealed vehicles.

When tested in accordance with ASTM Designation C-114, Standard Method for Analysis of Hydraulic Cement, the stackdust shall comply with the following compositional requirements:

Total Calcium content as CaO, percent by weight	Min. 38%
Loss on ignition, percent by weight	Max. 40%

The percent by weight of the residue, when determined in accordance with Test Method Tex-600-J, shall conform to the following requirements:

Retained on the 50 mesh sieve	0-5
Retained on the 100 mesh sieve	0-25
Retained on the 200 mesh sieve	10-50

(3) Water. Water shall be free from substances deleterious to the hardening of the cement stackdust treatment and shall be approved by the Engineer.

(4) Stackdust treatment mixture shall be determined by appropriate Tex Test Methods.

3. EQUIPMENT:

General. Equipment utilized where materials are specified to be measured or proportioned by weight shall conform to the requirements of the Item, "Weighing and Measuring Equipment". Equipment necessary for the proper construction of the work shall be on the project, in first-class working condition, and be approved by the Engineer, both as to type and condition, prior to the start of construction operations. The Contractor shall at all times provide sufficient equipment to enable continuous prosecution of the work and its completion in the required number of working days.

Portland cement stackdust treatment for materials in place may be constructed with any machine or combination of machines and auxiliary equipment that will produce results as outlined in this specification.

Mixing may be accomplished by (1) a multiple-pass traveling mixing plant or (2) a single-pass traveling mixing plant.

The equipment provided by the Contractor shall be operated by experienced and capable workmen and shall be that necessary to provide a cement stackdust treatment meeting the requirements herein specified.

4. CONSTRUCTION METHODS:

(1) General. It is the primary requirement of this specification to secure a completed course of treated material containing a uniform portland cement stackdust mixture free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth and with a smooth surface suitable for placing subsequent courses. It shall be the responsibility of the Contractor to regulate the sequence of his work, to process a sufficient quantity of material to provide full depth as shown on plans, to use the proper amount of portland cement stackdust, maintain the work and rework the courses as necessary to meet the above requirements.

(2) Preparation of Roadbed. Before other construction operations are begun, the roadbed shall be graded and shaped as required to construct the portland cement stackdust treatment for material in place in conformance with the lines, grades, thickness and typical cross section shown on the plans. Unsuitable soil or material shall be removed and replaced with acceptable soil.

The subgrade shall be firm and able to support without displacement the construction equipment and the compaction hereinafter specified. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

(3) Pulverization. The soil shall be so pulverized that, at the completion of moist-mixing, 100 percent by dry weight passes a 1-inch sieve, and a minimum of 80 percent passes a No. 4 sieve, exclusive of gravel or stone retained on these sieves. Old bituminous wearing surface shall be pulverized so that 100 percent will pass a 2-inch sieve.

(4) Application of Cement Stackdust (Roadmix). Portland cement stackdust shall be spread uniformly on the soil at the rate specified on the plans or approved by the Engineer. If a bulk cement stackdust spreader is used, it shall be positioned by string lines or other approved method during spreading to insure a uniform distribution of cement stackdust.

Cement stackdust shall be applied only to such an area that all the operations can be continuous and completed in daylight within 6 hours of such application.

The percentage of moisture in the soil, at the time of cement stackdust application, shall not exceed the quantity that will permit uniform and intimate mixture of soil and cement stackdust during dry mixing operations, and it shall not exceed the specified optimum moisture content for the soil cement stackdust mixture.

No equipment, except that used in spreading and mixing, will be allowed to pass over the freshly spread cement stackdust until it is mixed with the soil.

(5) Mixing and Processing. Unless otherwise shown on the plans, either method (a) or (b) below may be used at the option of the Contractor.

(a) Multiple-Pass Traveling Mixing Plant. After the cement stackdust has been applied it shall be dry-mixed with the soil. Mixing shall continue until the cement stackdust has been sufficiently blended with the soil to prevent the formation of cement stackdust balls when water is applied. Any mixture of soil and cement stackdust that has not been compacted and finished shall not remain undisturbed for more than 30 minutes.

Immediately after the dry mixing of soil and cement stackdust is complete, water as necessary shall be uniformly applied and incorporated into the mixture. Pressurized equipment and supply provided shall be adequate to insure continuous application of the required amount of water to sections being processed within 3 hours of application of the cement stackdust. Proper care shall be exercised to insure proper moisture distribution at all times. After the last increment of water has been added, mixing shall continue until a thorough and uniform mix has been obtained.

(b) Single-Pass Traveling Mixing Plant. After the cement stackdust has been applied it shall be sufficiently dry-mixed with the soil to prevent the formation of cement stackdust balls when water is applied. Unpulverized soil lumps in the soil cement stackdust mixture immediately behind the mixer that are dry will not be allowed. Should this condition prevail, the Contractor shall "pre-wet" the raw soil as necessary to correct this condition.

The mixer shall be provided with means for visibly and accurately gaging the water application. The water shall be applied uniformly through a pressure spray bar.

After cement stackdust is spread, mixing operations shall proceed as follows:

The mixer shall in one continuous operation mix the air-dry soil and cement stackdust full depth, and the required moisture uniformly, thoroughly moist-mix the soil, cement stackdust and water, spread the completed soil cement stackdust mixture evenly over the machine processed width of the subgrade and leave it in a loose condition ready for immediate compaction.

The soil and cement stackdust mixture shall not remain undisturbed, after mixing and before compacting, for more than 30 minutes.

(6) Compaction and Finishing. The material shall be compacted by the "Ordinary Compaction" method unless otherwise shown on the plans. If "Density Control" is required the material shall be compacted to not less than the density shown on the plans. At the start of compaction, the percentage of moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall not be below or more than two percentage points above the specified optimum moisture content and shall be less than that quantity which will cause the soil cement mixture to become unstable during compaction and finishing. When the uncompacted soil cement stackdust misture is wetted by rain so that the average moisture content exceeds the tolerance given at the time of final compaction, the entire section shall be reconstructed in accordance with this specification at the sole expense of the Contractor.

When the "Density Control" method of compaction is indicated on the plans the specified optimum moisture content and density shall be determined in the field by Test Method Tex-114-E or other approved methods, on representative samples of soil cement stackdust mixture obtained from the area being processed.

When the "Ordinary Compaction" method of compaction is indicated on the plans the following procedure shall be used.

Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. The loose mixture then shall be uniformly compacted to the specified density within 2 hours.

After the soil and cement stackdust mixture, excepting the top mulch, is compacted, water shall be uniformly applied as needed and thoroughly mixed in with a spike-tooth harrow or equal. The surface shall then be reshaped to the required lines, grades and cross section and then lightly scarified to loosen any imprint left by the compacting or shaping equipment.

The resulting surface shall be thoroughly rolled with a pneumatic tire roller and "clipped", "skinned" or "tight bladed" by a power grader to a depth of approximately 1/4 inch, removing all loosened soil and cement stackdust from the section. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. If plus No. 4 aggregate is present in the mixture, one complete coverage of the section with the flat wheel roller shall be made immediately after the "clipping" operation. When directed by the Engineer, surface finishing methods may be varied from this procedure provided a dense, uniform surface, free of surface compaction planes, is produced. The moisture content of the surface material must be maintained at its specified optimum during all finishing operations. Surface compaction and finishing shall proceed in such a manner as to produce, in not more than 2 hours, a smooth closely knit surface, free of cracks, ridges or loose material conforming to the crown, grade and line shown on the plans.

5. CURING:

(1) Protection and Cover. After the cement stackdust treated course has been finished as specified herein, the surface shall be protected against rapid drying by either of the following curing methods for a period as shown on plans but in no case less than 3 days or until the surface or subsequent courses are placed:

(a) Maintain in a thorough and continuously moist condition by sprinkling.

(b) Apply an asphalt membrane to the treated course, immediately after same is completed. The quantity and type of asphalt approved for use by the Engineer shall be sufficient to completely cover and seal the total surface of the base and fill all voids. If the Contractor elects to use this method, it shall be his responsibility to protect the asphalt membrane from being picked up by traffic by either sanding or dusting the surface of same. The asphalt membrane may remain in place when the proposed surface or other base courses are placed.

(2) Surface. The surface or other base courses may be applied on the finished base as soon after completion as operations will permit.

6. CONSTRUCTION JOINTS:

At the end of each day's construction a straight transverse construction joint shall be formed by cutting back into the total width of completed work to form a true vertical face free of loose and shattered material.

Cement stackdust treatment for large, wide areas shall be built in a series of parallel lanes of convenient length and width meeting the approval of the Engineer.

7. TRAFFIC:

Completed sections of cement stackdust treated material in place may be opened immediately to local traffic and to construction equipment and to all traffic after the curing period, provided the cement stackdust treated course has hardened sufficiently to prevent marring or distorting the surface by equipment or traffic.

8. MAINTENANCE:

The Contractor shall be required, within the limits of his contract, to maintain the cement stackdust treated course in good condition until all work has been completed and accepted. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the Contractor at his own expense and repeated as often as may be necessary to keep the area continuously intact. Faulty work shall be replaced for the full depth of treatment. It is the intent of this specification that the Contractor construct the plan depth of cement stackdust treatment in one homogeneous mass. The addition of thin stabilized layers will not be permitted in order to provide the minimum specified depth.

9. MEASUREMENT:

The work performed and the material furnished as prescribed by this item will be measured as follows:

Stackdust treatment for materials in place will be measured by the square yard of surface area of completed and accepted work.

Cement stackdust as required will be measured by the cubic yard of material in vehicles as delivered on the road or by the ton of 2000 pounds dry weight as delivered on the road as designated on the plans.

10. PAYMENT:

The work performed and material furnished as prescribed by this item and measured in accordance with the method indicated on the plans and proposal and in accordance with the applicable provisions of "Measurement" above will be paid for at the unit price bid for "Cement Stackdust Treatment (Existing Materials)" and "Cement Stackdust".

The unit prices bid shall each be full compensation for preparing the roadbed; for furnishing all material; for all freight involved; for furnishing scales and labor involved in weighing the material; for pulverizing, applying cement stackdust, water, all processing, mixing, spreading, finishing and curing the cement stackdust treated soil; and for all manipulations, labor, equipment fuels, tools and incidentals necessary to complete the work except as follows:

All earthwork involved in preparation of subgrade, other than that incidental to the specified fine grading, and manipulation necessary to reshape and compact the existing section and to compact the material added, will be measured and paid for in accordance with the provisions governing the pertinent roadway items.

When "Ordinary Compaction" is indicated on the plans, all sprinkling and rolling performed as required will be measured and paid for in accordance with the provisions governing the items of "Sprinkling" and "Rolling" respectively.

When "Density Control" is indicated on the plans, sprinkling and rolling will not be paid for directly, but shall be subsidiary to other bid items, unless otherwise provided on the plans.