EXPERIMENTAL PROJECTS

PLANT MIX SEAL

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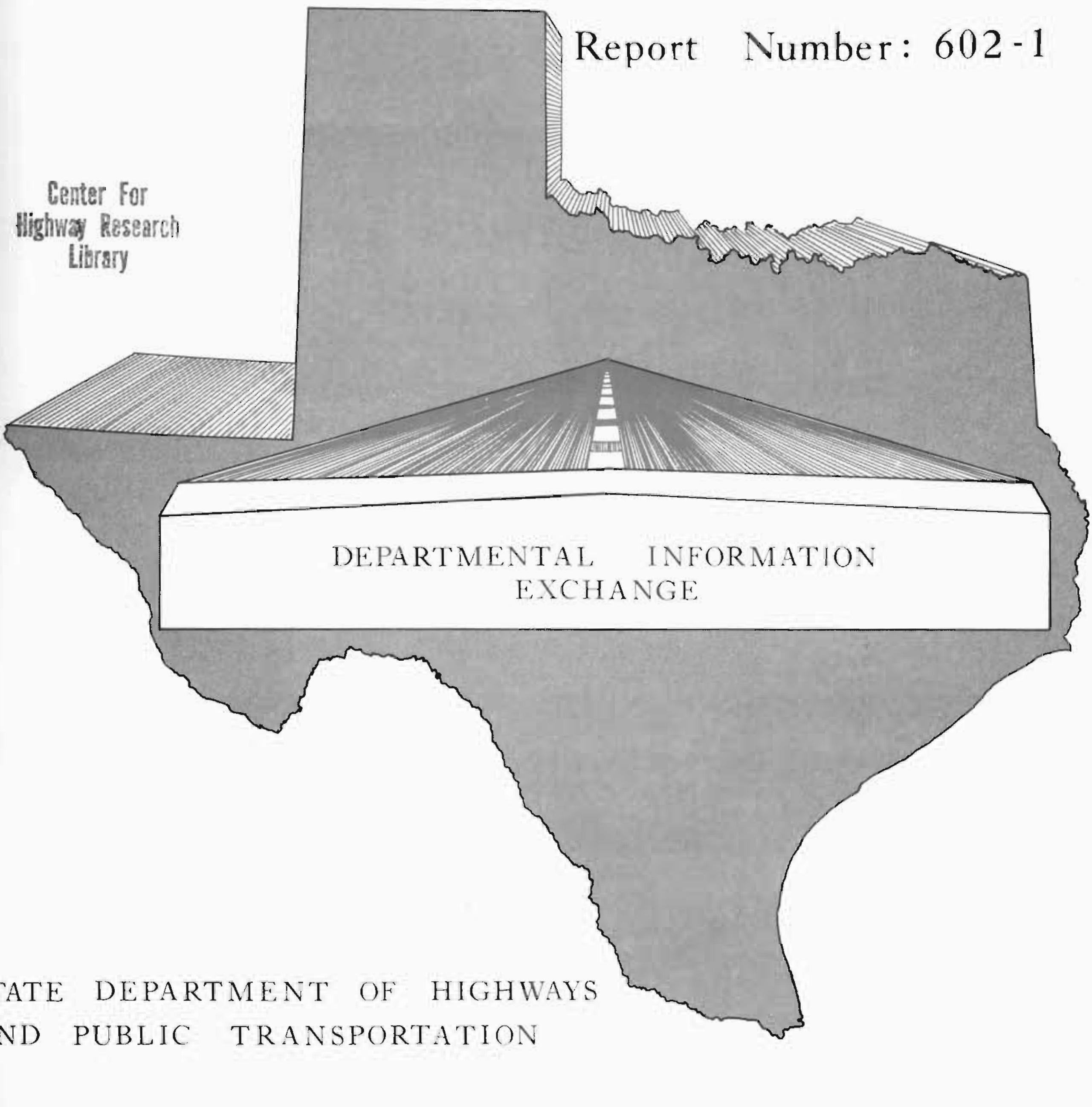

STATE DEPARTMENT OF HIGHWAYS
AND PUBLIC TRANSPORTATION

District 2

Fort Worth, Texas

PLANT MIX SEAL COAT

OR

OPEN GRADE HOT MIX

By

David A. Bass
Laboratory Engr.

And

Joe W. Norwood
Supv. Res. Engr.

Under supervision of
L. F. French
Dist. Design Engr.

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1. INTRODUCTION

In 1972, Administrative personnel with the Texas Highway Department at District 2 became interested in developing an open graded, asphalt stabilized overlay utilizing non-polishing aggregates. The specific objective was to develop a thin lift overlay providing an improved driving surface with a high skid resistance, a relatively low noise factor, and diminished hydroplaning.

2. LABORATORY DESIGN

The District Laboratory Engineer was confronted with having to develop a design for an open graded, asphalt stabilized aggregate mix containing little or no fines, with a paucity of proven design procedures. He immediately initiated the tried and true engineering technique of locating and consulting with associates who had previously confronted a like or similar problem. With this additional information, and from his own experience, the Laboratory Engineer launched his forces into a program of obtaining materials from a variety of sources and mixing these materials in a variety of asphalt and aggregate combinations.

The aggregate gradations chosen for the trial designs conformed substantially with the Texas Highway Department Standard Specifications 302 (Aggregate for Surface Treatments (Class B) and 303 (Aggregate for Surface Treatment (Lightweight) for Grades 4 and 5.

A. Materials:

The aggregates secured for trial designs were Eastland Lightweight, Bridgeport Crushed Limestone, Traprock, Blast Furnace Slag, and Rhyolite. The asphalt selected was an asphalt cement designated as AC-20. Based on experience in designing asphalt stabilized materials, the Laboratory Engineer chose this asphalt due to its hardness characteristics.

B. Procedure:

A predetermined quantity of each aggregate, at 250 degrees F., was mixed with varying amounts of asphalt at 250 degrees F. The resulting trial mixes were evaluated on the basis of aggregate coating, workability, and excessive asphalt, if any. The trials were then made into standard 2" x 4" molds and 3/4" x 6" diameter molds and allowed to cure to determine if they would form a well bonded mass. It was determined that no real conclusions could be drawn from the 4" molded specimens in that they lacked enough cohesion to support the 2" height. The 3/4" x 6" specimens did however give a preview of the road texture. After evaluating these trial batches, the Laboratory Engineer was able to determine that 14.5% by volume appeared to be the minimum amount of asphalt necessary to attain aggregate coverage and workability, and approximately 17.5% by volume the maximum asphalt demand for each aggregate considered. The optimum content appeared to be approximately 16.5% by volume.

The asphalt contents are described as a volumetric percentage of absolute volume of aggregate due to the considerable differences of the specific gravities of the aggregates utilized in the trial designs. The formula used for describing the volumetric percentage is as follows:

$$\frac{\text{Asphalt Content by Weight}}{62.5\ \#/\text{c.f.} \times \text{Sp. Gr. of asphalt}} = \text{Cu. Ft. of Asphalt}$$

$$\frac{\text{Aggregate Content by Weight}}{62.5\ \#/\text{c.f.} \times \text{Sp. Gr. of aggregate}} = \text{Cu. Ft. of Aggregate}$$

Sum of volumes = volume of mix

The corresponding volumetric percentage is the ratio of the material considered to volume of the mix multiplied by 100. This method of describing the quantity of asphalt in the mix enhances quantitative comparisons of asphalt required for the different aggregates and the corresponding economic comparisons for the amount of area overlaid.

3. EXPERIMENTAL SECTION

A. Materials:

Upon completion of the laboratory designs, two aggregates were selected for use on a one-half mile experimental section of IH 820. These two aggregates were Grade 4 Lightweight from TXI Eastland and Grade 4 Crushed Limestone from Gifford Hill & Co. Bridgeport. The gradation requirement was as shown in the 1972 Specifications Item 302 Grade 4 and Item 303, Grade 4.

B. Placement:

The mix for this experimental section was processed by a commercial plant and placed by Texas Highway Department maintenance forces. The District Laboratory Engineer and his personnel supervised the plant operation. The road operation was supervised by the Maintenance Engineer. This mix was processed in conformance with normal Hot Mix procedures and criteria. The placement was performed with an unmodified asphaltic concrete spreading and finishing machine. No rolling was performed on this experimental section. The depth of mat placed was approximately 3/4". During the mixing and placement of the mix the following observations were made:

1. A mat of approximately 3/4" of Grade 4 cover stone could be laid with an asphalt finishing machine.
2. It was absolutely necessary to place a roller on the surface to seat the rock. Most of that area not rolled came up under traffic. (Figure 1).
3. Lightweight aggregates retain some moisture even when dried at high temperatures.

FIGURE 1

FIGURE 2

4. It appeared to be unnecessary to remove all the moisture from the lightweight aggregate. It was better to lower the mixing temperature to less than the boiling point of water. It was found that in very hot mixes with no moisture the asphalt settled to the bottom of the truck. In hot (212°F) mixes with moisture the steam pushed the asphalt to the top of the truck. (Figure 2).

4. DEMONSTRATION PROJECT

A. Objectives:

In Spring of 1973 the Federal Highway Administration and the Texas Highway Department agreed to develop a demonstration project for the improvement of existing pavements with lower than desirable skid values. The specific objective of this project was to use a thin lift, non-polishing aggregate asphalt stabilized overlay providing an improved driving surface with a high skid resistance and a relatively low noise factor. With this objective in mind, the District 2 Administration proposed to use three different non-polishing aggregates on selected sections of the Fort Worth Freeways.

B. Specifications:

Aggregates. One of the three aggregates was stipulated to be a lightweight aggregate, and the other two were to be natural aggregates from separate sources. These three aggregates were to conform to Texas Highway Department Special Specification 3015 as follows:

Retained on 5/8" sieve	0%
Retained on 1/2" sieve	0-2%
Retained on 3/8" sieve	20-35%
Retained on No. 4 sieve	95-100%
Retained on No. 10 sieve	98-100%

In addition to this gradation and the requirements of Item 302 and 303, the mineral aggregate was required to have a "polish value" of not less than 35, when tested in accordance with Test Method Tex-438-A. This test was made on one (1) representative sample of material produced from each source prior to its use. Subsequent tests were to be made only when deemed necessary by the Engineer. The "polish value" test was performed as a quality test for approval of the source and not a job control test.

Asphalt. The asphalt stipulated for use was AC-20 which is a medium hard asphalt cement with a minimum penetration of 55 at 77° F. (100 gr for 5 sec.), and a minimum ductility of 50 at 77° F. (5 cms per min.).

The tack designated was RC-2 which is a cut-back asphalt requiring a penetration range of 110 to 150 at 77° F. (5 cm per min.), and a minimum ductility of 100 cm at 77° F. (5 cm per min.).

C. Materials:

Retaining the material criteria as described, the Texas Highway Department advertised and subsequently let a contract in the summer of 1973 for the placement of an open graded overlay on three Fort Worth Freeways.

Southwestern Contracting Company was the successful bidder and was awarded the contract for the project. The contractor submitted three aggregates; crushed Rhyolite, crushed Dolomitic Limestone, and expanded shale to the Texas Highway Department for approval.

CRUSHED RHYOLITE: This material is produced by Gifford-Hill from their Allamoore Plant near Van Horn, Texas. Rhyolite is an igneous rock and is the extrusive equivalent of granite. It exhibits the same minerals as granite, embedded in an abundant glassy mass which is frequently flow banded. Rhyolite consists mainly of Biotite, Hornblende, Quartz, and alkaline Felspars. Some of the characteristics of Rhyolite are: it has a specific gravity of 2.59. It has a polish value of 36 and has a wear loss approximately 16% when tested by the L.A. Abrasion test, and in this gradation weighed approximately 82 lbs/CF.

<u>CRUSHED DOLOMITIC LIMESTONE</u>: This material is produced by the Trinity Division of General Portland, Inc. at Stringtown, Oklahoma. Dolomitic Limestone is a sedimentary rock which is composed chiefly of calcite and magnesium. The Stringtown material had a loose weight of approximately 86 lbs/cf. It had a polish value of 35, and a wear loss of 14% and a specific gravity of 2.58.

<u>EXPANDED SHALE</u>: The third aggregate submitted was Eastland Lightweight, produced by Texas Industries at Eastland, Texas. The Eastland lightweight had a loose weight of about 53 lbs/cf. It had a polish value of 39 and a wear loss of 21% and a specific gravity of 1.67.

All three of these aggregates submitted were approved for use on the project.

In order to assure equity of cost for all aggregates considered, aggregates were paid for by the cubic yard. Simplification of measuring the volume of aggregate to be paid for was accomplished by converting scale weights to volume as follows:

The surfacing mixture was measured separately by the ton of 2000 pounds of "Asphalt" and by the cubic yard of dry, loose "Aggregate" of the types actually used in the completed and accepted work in accordance with the plans and specifications for the project. The volume of aggregate was calculated from the measured weights of the surfacing mixture by use of the following formula:

$$V = \frac{(w-A)}{27(k)}$$

V = Cubic yards of aggregate, dry, loose.
W = Total weight of surfacing mixture in pounds
A = Weight of Asphalt in pounds
K = Unit weight of Aggregate in pounds per cubic foot.

The value "K" was determined by Test Method Tex-404-A "Determination for Unit Weight of Aggregate." Material for this test was sampled from the hot bin and tested at the moisture content found in the hot bin.

The value "K" was checked a minimum of one time for each 3,000 cubic yards of mineral aggregate. When in the opinion of the Engineer or the Contractor's representative, the value of "K" had changed, a check test was made. A new value for "K" was used if the checked value of "K" varied more than two percent (plus or minus) from the value being used.

5. PLANT OPERATION

A. Temperature:

Maintaining temperature of the mix within the acceptable range of 200° F $\pm$ 10° required constant attention and that the plant had to be started and operated each time for approximately a half hour by running aggregate thru the dryer until the temperature became constant prior to introducing asphalt into the mixer. The contractor later replaced the standard fuel valve with a variable valve in order to better control the temperature at the lower ranges.

B. Hot Bin Moisture:

It was also realized, from the experience gained from the experimental project, that the aggregates were going to retain some moisture in the hot bins. These moistures varied from 0.2 to 0.5% in the natural aggregates and 3.0 to 8% in the lightweight aggregates. It was surmised that this moisture wouldn't be detrimental to the mix as long as the temperature of the mix didn't substantially exceed the boiling point of water. Higher temperatures evaporated the moisture in the mix and produced excessive asphalt migration in the mix after it had been placed in the batch trucks.

(Figure 2)

Also experienced was a substantial mix temperature loss as moisture continued to be evaporated from the aggregate after it had left the dryer and even after it had been placed in the batch truck.

C. Material Degradation:

Another plant associated problem that arose was, continued manipulation of aggregates and feeding cold bins with a front end loader caused degradation of the aggregate gradation. One means by which this problem can be resolved is to require hot bin compartments and rescreening of the aggregate in the plant. Also aggregate gradation changes significantly affects the unit weight of the material and necessitates frequent "K" factor determination.

6. PHASE I CONSTRUCTION

A. Description and Purpose:

When the contractor had received a sufficient amount of material to begin construction, Phase I construction was initiated. Phase I construction consisted of paving 3.6 Miles of frontage road using each of the three approved aggregates. The purpose of Phase I construction was to develop satisfactory construction techniques in mixing and laying procedures for each material and to judge various mix designs under actual construction conditions.

B. Asphalt Content:

It was predetermined that the natural aggregate mixes would be applied with asphalt contents of 6.2, 6.7, 7.2, and 7.7 percent by weight (14.5, 15.5, 16.5 & 17.5% by volume). It was also predetermined that the lightweight mixes would be applied containing 10.0, 10.5 and 11.0 percent asphalt by weight (15.7, 16.4 & 17.1% by volume). It was hypothesized that the maximum asphalt content would be that content at which the asphalt began to migrate in the mix during transportation from the plant to the road.

C. Asphalt Source:

The asphalt used in all three mixes was produced by Kerr-McGee from Wynnwood, Oklahoma. This asphalt had a penetration of 71 and a ductility of 141. The asphalt was introduced into the mix at 275° F.

The asphalt used for Tack was RC-2 produced by Bell Oil and Gas from Ardmore, Oklahoma. This asphalt had a penetration of 135. The Tack was applied at approximately 150° F. with a standard asphalt distributor with the spray bar modified with the smallest available nozzles (3/32"). The rate of application was 0.04 to 0.05 gallons per square yard. The applied Tack was immediately rolled and spread with a light pneumatic roller. This rolling continued until the Tack broke. Tack Coat applied at these rates picked up on equipment tires in fine cobweb like masses much to the travelling public's distraction and irritation. The problem was somewhat alleviated by placing a plywood skirt around the tack roller. The batch trucks continued to be a problem.

D. Placement:

Placement of this material was performed with a standard track mounted Cedar Rapids asphalt spreading and finishing machine. This particular machine utilized a vibrating screed rather than a tamping bar. The screed was set with 1/8" lead on front. The laydown machine was normally operated at 66 feet per minute. The rate of travel wasn't critical as long as the ambient temperature was 85° F. and the temperature of the mix was approximately 200° F. When temperatures were low enough to cause stiffness of the mix reduction of the machine travel speed failed to alleviate tearing or pulling of the mat. The depth of mat placed was approximately 3/4".

This placement depth is possible when the underlying surface is smooth and uniform.

E. Rolling:

Compaction of the placed mat at the beginning of Phase I was performed with an unloaded 6 to 8 ton tandem steel wheel breakdown roller and a light (6 ton) pneumatic roller. Since the 6 to 8 ton tandem steel roller crushed or broke aggregate in the mat, it was replaced with a 1½ ton tandem steel wheel roller and the light pneumatic roller was retained even though it picked up some of the aggregate.

The pneumatic rolling was best performed where the mat temperature was 115° - 120° F. Rolling performed at these temperatures produced little or no aggregate pick up by the pneumatic roller. On clear warm days the mat temperature remained from 130° - 150° F. until evening presenting a problem in rolling. In an attempt to rectify this problem, soap in varying amounts was mixed with the roller's water. The soap helped to reduce the problem somewhat, but a small amount of aggregate pick up continued.

F. Hand Work:

Hand work of this type of mix with conventional hot mix tools and techniques is difficult at best and the resulting quality of material placed is uneven, rough, undesirable and normally unacceptable. No method of improving the quality of hand placed materials was developed during this project, other than avoiding hand placements and utilizing the laydown machine even on small irregular areas whenever possible. Where possible, irregular areas were overlaid full machine width and the excess width of material was removed and discarded.

Ramps, ramp gores, frontage road tapers, and auxiliary lane transitions are not areas conducive to the placement of materials meeting minimum acceptable standards for riding surfaces.

G. Temperature:

Ambient temperature and mix temperature are both important to workability, uniformity and quality of the mix and resulting mat surface. The minimum desirable ambient temperature is 80° with little or no wind. Ambient temperatures lower than 80° reduce the workability of the mix and cause pulling and tearing of the mat. Warm to extremely hot weather is very desirable concerning placement, but the mat will remain tender and susceptable to damage until the mat temperature is reduced. Therefore, the ideal ambient temperature range is 85° - 100° F.

The mix temperature also directly affects the workability and uniformity of the material and thereby the quality of the completed mat placement. Mix temperatures at the road below 180° F. produced a mix that was stiff and very difficult to work, especially as a beginning load. Interim loads of mix between 170° - 180° were successfully placed with a heated screed.

Higher mix temperatures greatly enhance the workability of the materials, but excessive temperatures will cause asphalt migration in the mix during transportation and even after the mix has been processed through the laydown machine. Maximum mix temperatures permissable are peculiar to the aggregate concerned, gradation of the aggregate, and the hot bin moisture content. Generally the maximum temperature limit during this phase of construction was 215° F. at the plant and a 10 to 15° loss during the 35 mile haul from the plant to the road.

H. Aggregate Displacement:

Shortly after the placement of the Stringtown material in the Phase I construction, traffic was placed on the newly laid mat at an exit ramp. The resulting aggregate pick up created a considerable amount of excitement among all parties concerned. Phase II construction on the thru lanes was scheduled to begin the next day, a Friday. The contractor agreed to apply a weak lime slurry on this Phase I area to mask the adhesiveness of the driving surface of the newly placed mat. This proved to be of little help other than cooling the mat to allow sufficient rolling prior to opening to traffic.

7. Phase II

A. Description and Purpose:

Phase II Construction was comprised of three separate test sections on the Thru Lanes of three different freeways, utilizing a different aggregate in each test section. Each test section was approximately one mile long, four lanes wide and usually included four ramps. The surface overlaid at each location was a fine graded asphalt pavement with very little remaining surface texture.

The letting of this contract was scheduled, such that, Phase II construction was performed during the summer months of 1973. Upon completion of Phase II construction, work on the project was suspended and the test sections were observed until the following spring. At the end of this observation period the Texas Highway Department, with FHWA concurrence, reserved the option of selecting the aggregate or aggregates to be incorporated in the Phase III construction on the remaining sixty-seven lane miles of freeway to be overlaid under this contract.

B. Tack:

The roadway was cleaned by sweeping with a self propelled rotary broom supplemented by hand brooming gutter lines when necessary. The Tack Coat was applied at 0.05 gallon per square yard and rolled with a light pneumatic roller until it broke. Application rates of this magnitude on fine textured surfaces caused significant traction problems for the laydown machine. The laydown machine was incapable of developing enough traction to push the batch trucks up grade. Rather than reduce the application rate of the tack, small amounts of grit and aggregate were lightly distributed in the track line of the laydown machine.

C. Asphalt Content:

Four approximately equal sections of mix containing asphalt contents of 6.2, 6.7, 7.2 and 7.7 percent by weight (14.5, 15.5, 16.5, & 17.5% by volume) for both natural aggregates were placed. Three approximately equal sections of mix containing asphalt contents of 10.0, 10.5 and 11.0 percent by weight (15.7, 16.4 & 17.1% by volume) for the Eastland Lightweight Aggregate were placed. The higher asphalt content for each aggregate exhibited slightly better workability. No other advantages associated with asphalt content were apparent during placement. Evaluation of the test sections after the observation period have shown no significant difference in any of the designs.

D. Temperature:

From the maintenance experimental project and Phase I of this project, minimum desirable mix temperatures were established. Also the maximum temperatures were assumed to be that temperature at which asphalt migration occurred in the hauling vehicle. Phase II of this contract presented the opportunity to verify these maximum temperature limits. The temperature range of 180° to 215° F was rigidly adhered to during Phase II construction on I 30 and I 35W, but mix temperatures of 235° F were required by the Resident Engineer for a portion of the Phase II construction of IH 20 where Rhyolite was being placed. Migration of the asphalt in some of the hauling vehicles was experienced at this temperature, and the maximum permissible temperature was lowered to 225° F. With mix temperatures of 225° F only isolated cases of asphalt migration during transportation occurred, and the amount of migration was greatly reduced; but this temperature still produced spotted flushing in the surface of the mat after two or three days under traffic. The maximum temperature was reduced to 215° F. At this mix temperature no asphalt migration during transportation was evident, but occassional spot flushing still occurred in the surface of the mat. Since the other natural aggregate produced little to no spot flushing when placed within the 180 to 215° F temperature range, we surmised that different aggregate-asphalt mix temperature ranges may vary slightly.

E. Moisture and Stability:

Moisture presents less of a problem when natural aggregates are being used since the moisture is more readily removed from natural aggregates during the drying process than from lightweight aggregates. Therefore, moisture has less effect on the stability of natural aggregate mixes.

When utilizing lightweight aggregates the stockpile and hot bin moisture contents should be given particular consideration. First, stockpile moistures commonly approach and exceed 20%. Removing all of this moisture during normal drying processes is impractical if not impossible due to the cellular structure of lightweight aggregates. It is not uncommon to have hot bin moistures between 5 and 8 percent.

Hot bin moistures above 5% tend to cause the mix to lose temperature rapidly, and to be tender for a longer period of time. When traffic is placed on a lightweight mat with high moisture content, the asphalt isn't progressively worn from the aggregate surface, but rather pulled from the top of the aggregate by individual wheel contact. This characteristic of high moisture content mixes contributes to substantial aggregate pick up when the mat is opened to traffic. While the mat is stabilized by low ambient temperatures, a mix with high moisture content will remain tender even when the ambient temperature is 80° F. Therefore, when mixes containing excessive moisture are placed, some means of minimizing aggregate pick up should be employed.

F. Rolling:

During Phase II of this contract initial rolling was performed with a 1½ ton tandem steel wheel roller. Interim rolling was performed with a light pneumatic roller. Finish rolling was performed with a 10 ton tandem steel wheel roller. The above rolling procedure was followed during construction on I 35W. The advantages versus the disadvantages of pneumatic rolling in this project were very controversial and indeterminate. The pneumatic roller caused aggregate pick up during high ambient temperatures or when rolling a lightweight aggregate mat with a high moisture content. Water-soap solutions of various strengths were tried in the water tank of the pneumatic roller. The soap solutions were ineffective in preventing aggregate pick up. Pneumatic rolling in this project was discontinued after completion of Phase II construction.

G. Limewater versus Aggregate Pick Up:

The amount of aggregate pick up experienced when traffic is placed on a tender mat, in many cases, is not sufficient to constitute damage in the surface quality of the mat. The amount of aggregate pick up may present a hazard to the travelling public as flying rock. This condition is most apt to occur with fast traffic when ambient temperatures are above 90° F. This problem may be helped by not opening the new surface course to traffic until it has been adequately cured and the surface temperature is below 115° F. Prolonged rolling at high surface temperatures has little effect in decreasing aggregate pick up by traffic.

The most effective means found to prevent aggregate loss was masking of the adhesive traffic surface. This was accomplished by applying a 2½% lime-water solution after rolling was completed. The lime water permitted traffic to wear away the asphalt from the surface without causing significant aggregate pick up. This method of stabilizing the mat was used when restricting traffic usage for prolonged periods was impractical.

H. Ramps:

The sequence of material placement was performed in the usual accepted manner. The thru lanes were overlaid first with the ramps and acceleration lanes postponed until the last. The ramps were overlaid with considerable hand work adjacent to the thru lanes and placed machine width on the frontage road end with the additional width removed. The placement of machine width and removal of the extra width did not negate hand work in that area, but it did minimize it. Had ramps been overlaid at the beginning, machine width could have been placed adjacent to the thru lanes also, thereby further reducing hand work. Prior to rolling, the extra material was easily removed with a small "Bob Cat" size front end loader. Materials that had to be removed after compaction were more difficult to remove and a neat line had to be cut with a cutter wheel mounted on the moldboard of a maintainer.

I. Joints:

Attaining acceptable transverse or longitudinal joints presented some peculiar problems. Transverse joints at the beginning of the day were attempted with a machine that was completely cold except for the screed. This tended to cool the mix and cause it to be stiff and unworkable and the material was prone to tearing and pulling. These difficulties were reduced by coating the screed with silicone. Interim transverse joints constructed during the day were accomplished with greater ease because of the heated finishing machine.

Longitudinal joints are best constructed by utilizing automatic screed controls and exactly matching the existing mat with abutting material. When over-riding of the existing mat occurs, as with more common mix designs, the over-riding aggregate is pulverized producing a ridgelike deformity at the joint. This pulverized material can not be removed by a raker as is done in more conventional mixes.

J. Aggregates:

Each aggregate used in Phase II construction possessed some minor peculiar characteristics, but none of the aggregates used offered any substantial advantage during the placement operations.

K. Evaluation & Conclusions:

The District Laboratory Engineer used five different tests to help evaluate the merits of each aggregate used. These tests were:

1. A modified silicone putty texture test
2. A modified outflow meter test
3. A modified sand texture test
4. Skid trailer tests
5. Stereoscopic pictures for evaluation of skid factor

The silicone putty test initially used the standard 4" plate, which was inadequate due to the deep texture of the Plant Mix Seal Coat. The silicone putty test was modified by enlarging the plate to 7" and tripling the volume of putty. (Figure 3). This modified test was successfully used in evaluating the texture only. (Figure 4).

FIGURE 3

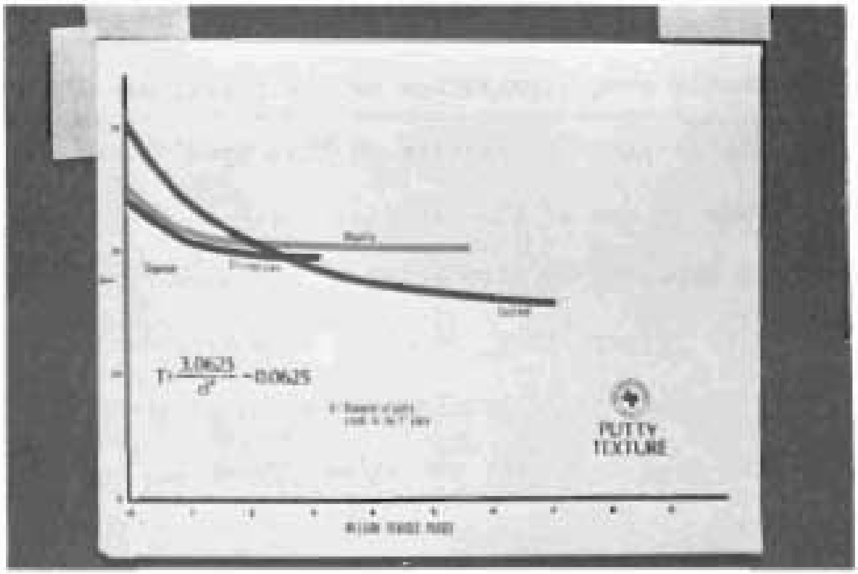

FIGURE 4

The water outflow test (Figure 5) also required modification due to the magnitude of the voids in the completed material. The high percent of voids caused the water cylinder to empty abruptly. Times were running from 0.2 to 0.4 seconds. The equipment was modified to add a ½" foam rubber gasket 12" in diameter next to the pavement with a ½" steel plate placed over the gasket. Both the gasket and the plate had a 4" hole to allow water to flow from the cylinder. The gasket was to form a better seal between the surface and the cylinder and thus provide a measure of the internal voids. These tests indicated little difference in the three different materials. (Figure 6).

The sand patch test (Figure 7) is a variation of the THD test method Tex-436-A "Measurement of Texture Depths by the Sand Patch Method." This test was modified by using three times the standard amount of sand. This test was a combination of the first two tests in that it not only measured the surface texture but also the internal voids to some extent. This test showed no significant difference between the aggregates (Figure 8).

The fourth, and probably most significant of the tests, was the use of the THD Skid Trailer (Figure 9). The results of this test showed there to be a significant difference in one of the materials used in Phase I and II. The Stringtown Limestone appeared to drop below a skid number of 35 at about 4 million vehicle passes (Figure 10). Based on this information it was decided to enter Phase III without Stringtown Limestone. A synthetic lightweight produced by Superock, Inc. from near Streetman, Texas was substituted for this limestone.

Stereoscopic pictures were taken of the pavement surface. The Research Section of Division 10, THD, is conducting a study to determine if skid

FIGURE 5

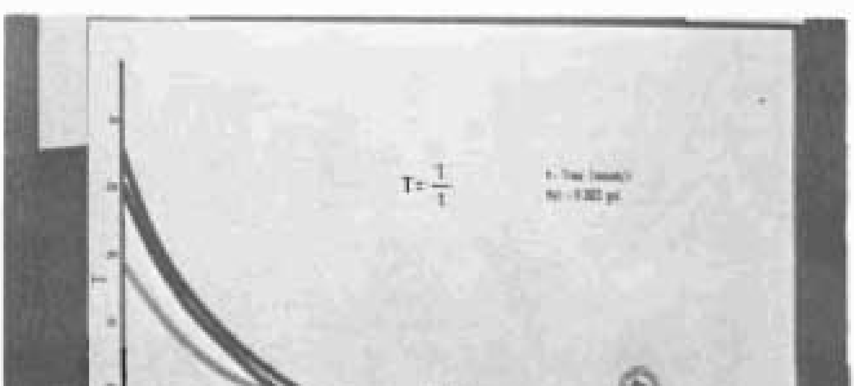

FIGURE 6

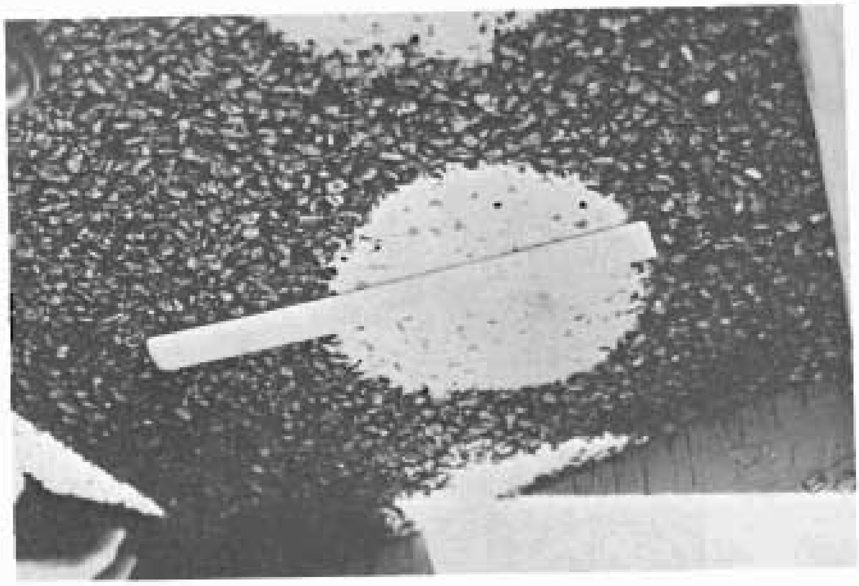

FIGURE 7

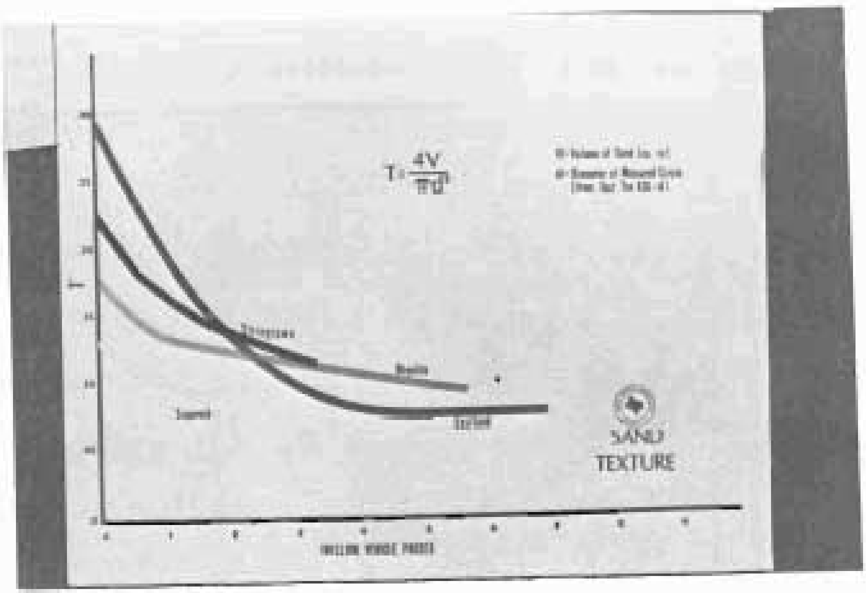

FIGURE 8

FIGURE 9

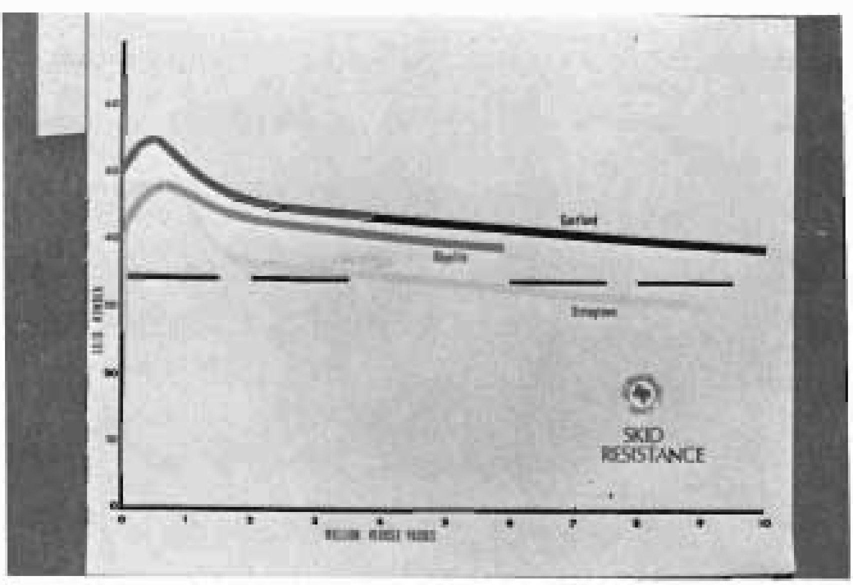

FIGURE 10

resistance can be measured from pictures. (Figures 11-12).

8. PHASE III CONSTRUCTION

A. Description:

Phase III construction on this contract was comprised of 67 lane miles of overlay on IH 30, IH 20, and IH 35W Freeways in Fort Worth. Based on the aggregate performances, the Texas Highway Department, with Federal Highway Administration concurrence, decided to use Rhyolite, Eastland Lightweight and to substitute Superock lightweight for the Stringtown limestone.

Prior to beginning of Phase III construction the contractor relocated his asphalt plant closer to the project. The maximum haul after relocation was approximately eighteen miles.

B. Placement:

Phase III construction by special provision was required to begin no later than May 1, 1973. The Texas Highway Department and the contractor agreed to begin construction April 15, 1973. The early morning ambient temperatures of 60° F + caused chilling and stiffness of the mix. The contractor tried to correct this situation by later morning starts, throwing out the lumps of cold mix, continuous heating of the screed, and silicone. None of these significantly alleviated the problem. Work had to be suspended on the project until the contractor insulated his batch trucks.

The insulating of the trucks was accomplished by using 6" rock wool sheeting compressed between the stiffeners of the truck bed and covered with 3/4" plywood. The plywood was well secured in place by bolting thru the bed walls. This was done on the two sides, the bottom, and across the tail gate.

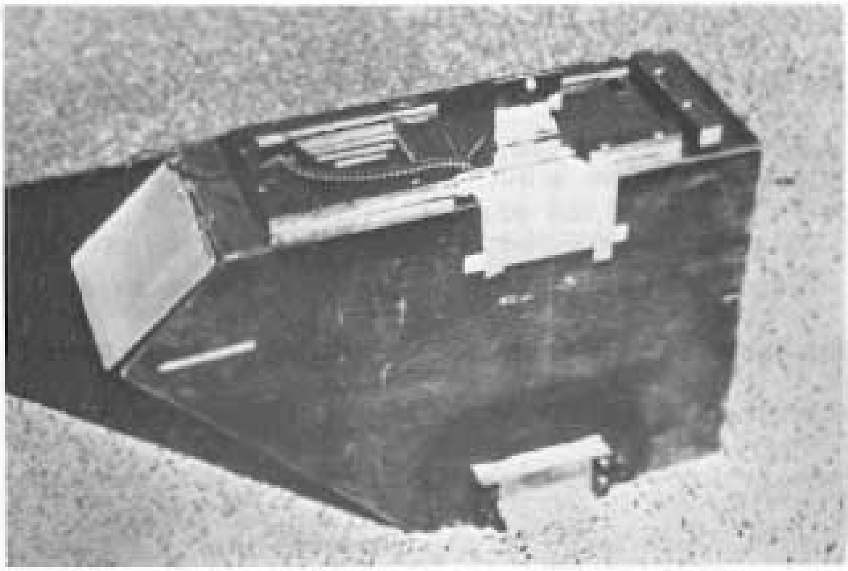

FIGURE 11

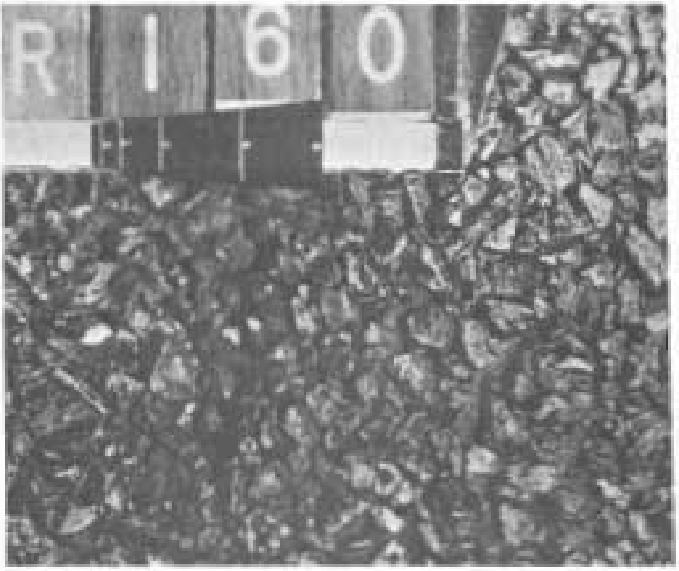

FIGURE 12

Work resumed with insulated, tarped batch trucks and satisfactory results were attained. When the ambient temperature reached 90° F, two trucks were left untarped and chilling of the mix occurred. Thereafter the trucks were tarped for the remainder of the project.

Also during the initial construction of Phase III, a short section was overlaid with a mat depth in excess of two inches. The Texas Highway Department considered requiring the contractor to remove and replace this material, but decided to leave it for observation. This mat has not corrugated, raveled, or otherwise moved. Therefore, further overlaying of the Plant Mix Seal Coat with another course now appears feasible.

The lower ambient temperature also contributed to higher yield requirements due to the decreased workability and increased tendency to tear in thin mat placements. As Phase III progressed into the summer, the much higher ambient temperatures enhanced the thin mat placement and yields generally improved. But, the higher ambient temperatures resulted in prolonged higher mat temperatures, thereby requiring masking of the surface when immediate traffic utilization was considered necessary.

C. <u>Rolling</u>:

Rolling during Phase III was performed with a 1½ ton tandem steel wheel as a break down roller, and with a 6-8 ton tandem steel wheel as a finish roller.

Each of the tandem steel wheel rollers made only one pass. Rolling from the low side to the high side served no useful purpose since no mat movement occurred nor did any significant break down occur. Rolling, while mandatory, is performed to key the aggregate together and not for densification as such.

During Phase III construction five loads of mix with approximately 50% plus 3/8" material were used in an emergency situation. This material performed comparably to materials conforming to the gradation requirements.

9. RESULTS

A. Improved Skid Resistance:

Tests indicate that the skid value for the freeways overlaid was improved by the Plant Mix Seal Coat. It also is believed that hydroplaning has been reduced if not eliminated in these sections. In one test section, accidents have been reduced by 18%.

B. Placement on Ramps:

Shortly after the Plant Mix Seal Coat mat was placed on some circular ramps with short radii of less than 150', the mat began to corrugate and ravel under traffic. This is not an unusual problem with asphaltic overlays; however, where this happened with Plant Mix Seal Coat, it happened almost immediately. It is felt that Plant Mix Seal Coat requires more curing time to reach an acceptable road stability than conventional mixes. Therefore, on short radii ramps or stop and start conditions, more curing time must be allowed or a mix containing more fines must be used.

When removal of Plant Mix Seal Coat was found to be necessary it was best accomplished with a maintainer with an ice blade attached to the center part of the moldboard with the cutting edges removed from the remainder of the moldboard. With this arrangement, care is necessary to prevent damage to the unprotected portions of the moldboard.

C. Spalling:

Spalling of the mat does occur at many of the underlying pavement joints, bridge armor joints, and other types of expansion joints. The Plant Mix Seal Coat mat spalls back, exaggerating the joint and causing a poor riding surface. These have been successfully repaired by maintenance using a low penetration asphalt and a clean aggregate to rebuild these small areas.

D. Water Retention:

The high percentage of voids in the mat are directly responsible for prolonged retention of moisture after a rain. This water retention may contribute to roadway deterioration when the facility is structurally unsound and is in need of waterproofing. The identification terminology of "Plant Mix Seal Coat" is a misnomer in that it does not seal the surface and should not be used over an open surface. After a normal rain, water can be found in the pavement for as long as five days.

This project contained one small area where the presence of water is prevalent due to slope seepage. The prevalence of water during rainy seasons has caused some stripping of aggregates in this small area.

E. Flushing and Corrective Measures:

Spot flushing of asphalt occurred in the surface of the mat in the Rhyolite mix and in the Eastland lightweight mix. This flushing was minimized by controlling the mix temperature. Even with rigid control of mix temperatures some spot flushing occurred. A plausible explanation for this flushing could be a change in the gradation of the aggregates.

10. CONCLUSIONS AND RECOMMENDATIONS

A. Restricted Uses:

This type of open friction course should not be used as a seal or waterproofing course, or directly on flexible base roadways. Also due to its water retention properties, it should not be used on structurally unsound pavements. This type of mix design should be utilized as a surface course where improved skid value and lessening of hydroplaning is desirable.

Since Plant Mix Seal Coat mixes are not easily hand worked and variable width areas are not conducive to high quality construction, these mixes are easier used where laying operations can be performed with a laydown machine.

B. Warm Weather Placement:

Minimum ambient temperatures of 60-70^{o} are mandatory for placement of a Plant Mix Seal Coat and warmer ambient temperatures are desirable for satisfactory results. Therefore, using this type of mix should be restricted to a five month period from approximately May 1 until October 1. When the mix is placed during these higher ambient temperatures the mat does not attain acceptable stabilities after a short curing period, and artificial masking of the driving surface may be necessary if the mat cannot be cured until evening hours when temperatures are lower. This artificial masking may be accomplished with 2-3% lime water solution applied with a water truck.

C. Instability:

The initial instability of this mix does not present any problems that cannot be overcome when placed on tangential sections or relatively flat curves, but in areas subjected to repeated lateral stress, instability is directly responsible for corrugating and raveling.

D. Tack:

There are proponents advocating or recommending that tack be omitted when placing Plant Mix Seal Coat type mixes. Strictly based on experience during this project, tack appeared to be desirable. The tack used in this project was RC-2 applied at 0.04 to 0.05 gallons per square yard. With this surface preparation, the Plant Mix Seal Coat was well anchored as determined during material removal from circular ramps.

E. Gradation:

During this project it was concluded that aggregate tolerances greater than those specified in this project will produce satisfactory results, but gradation control should be performed at a point other than the stockpile due to degradation of materials during the processing operation. A suggested gradation is:

Retained on 5/8" sieve	0
Retained on 1/2" sieve	0-5
Retained on 3/8" sieve	20-50
Retained on No. 4 sieve	92-100
Retained on No. 10 sieve	96-100

F. Placement Depth:

This type of mix is receptive to thin lift placements and may be placed in 3/4" lifts when the ambient temperature is 90° + and the surface to be overlaid is uniform. Also, as previously noted, this mix design may be placed in lift depths encompassing two or more aggregate layers without experiencing any movement due to traffic.

G. Durability and Maintenance:

Plant Mix Seal Coat mats are susceptible to damage during automobile accidents from sharp cutting edges and from petroleum distillate spills. Also, the spalling at joints and wide cracks requires maintenance. These are easily corrected with hot patches utilizing low penetration asphalt patches. The mat is otherwise durable and not subject to hot weather bleeding as is common with penetration courses.

Striping of this type mat should be performed after it has been under traffic for approximately two days. If the stripe is applied shortly after mat placement, it will disappear almost immediately as the traffic wears the asphalt from the aggregate surface.

The polish value test should be performed as a job control test on all natural aggregates rather than for source approval.

11. SUMMARY

Open graded friction courses appear to be a feasible and practicable solution in rectifying the hazardous condition of polished aggregates in existing pavement surfaces. This solution is applicable, during warm weather, to thru traffic facilities that are waterproof and structurally sound.