EVALUATION OF COLD-MIX EMULSION BLACK BASE
(M 150 and Auburn Road, Oakland County)

MICHIGAN DEPARTMENT OF STATE HIGHWAYS AND TRANSPORTATION

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

EVALUATION OF COLD-MIX EMULSION BLACK BASE
(M 150 and Auburn Road, Oakland County)

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A Category 2 project conducted in cooperation
with the U. S. Department of Transportation,
Federal Highway Administration

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Conventional 'black base' as used in Michigan, consists of hot plant-mixed bituminous-aggregate mixtures made with penetration grade asphalts. In December 1972 the Department's Pavement Selection Committee (now called the Engineering Operations Committee) decided to assess the feasibility of using cold-mix black base materials prepared with emulsified asphalts. This decision resulted in the initiation of a Category 2 experimental construction project performed in cooperation with the Federal Highway Administration. Experimental Work Plan 20 was prepared by the Research Laboratory for the project selected, located at M 150 at Auburn Rd in Oakland County (Control Section 63525, Job No. 05505A) and shown in Figure 1.

The purpose of this study was to determine handling, construction, and performance characteristics of a cold-mixed black base as compared with conventional black base construction. Availability of an additional construction method would, it was felt, permit consideration of a wider range of materials for different job conditions.

Construction

A plan view and typical sections of the experimental construction are shown in Figure 2. Construction operations involved mixture preparation and stockpiling, placement, compaction, and surfacing. The experimental emulsion cold-mix material consisted of specification 20A aggregate, blended with 6 percent (4 percent residue) MS-2s emulsified asphalt. Mixing was done in the pug-mill of a conventional batch plant with the aggregate containing about 4 percent moisture.

Some problem with balling was experienced during mixing. Change in asphalt formulation and reduced mixing time seemed to minimize this problem. Aggregate coating and asphalt distribution were not as complete and uniform as would be expected using hot plant mixes. The mixture was stockpiled about 10 days prior to placement as recommended by the asphalt supplier for the purpose of allowing for some drying of the material prior to placement and compaction. General appearance of the stockpiled mixture is shown in Figure 3.

Placement of Mixture

The experimental base material was placed in three layers directly on the subgrade in a trench adjacent to an existing concrete pavement. Although no density requirements were specified, tests by the Research Laboratory indicate that the material was compacted to nearly 97 percent of Marshall density:

In-Place Density[1], P.C.F.	126.8
Marshall Density[1], P.C.F.	131.0

[1] Dry unit weight of aggregate only.

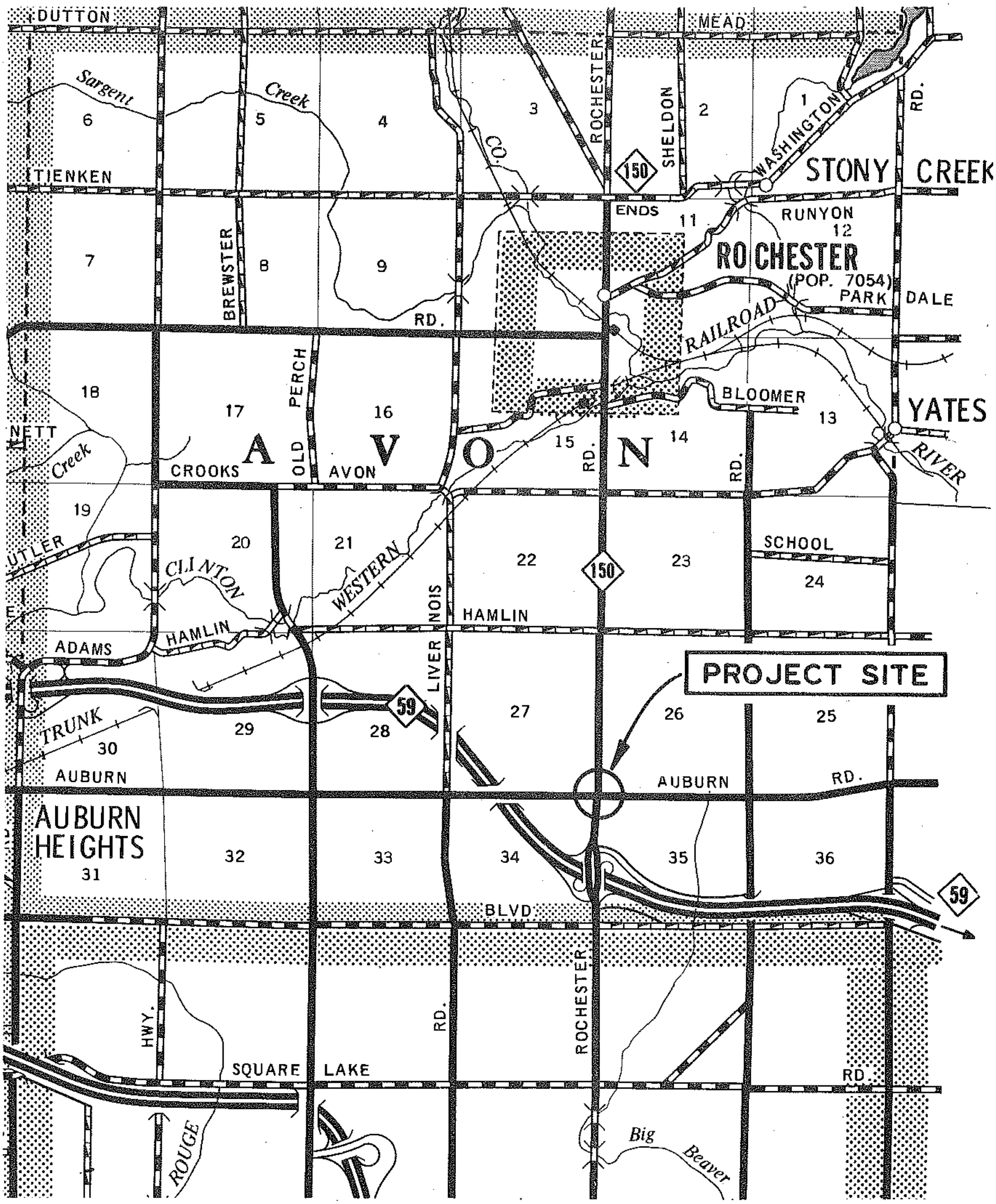


Figure 1. Experimental emulsion cold-mix black base construction site.

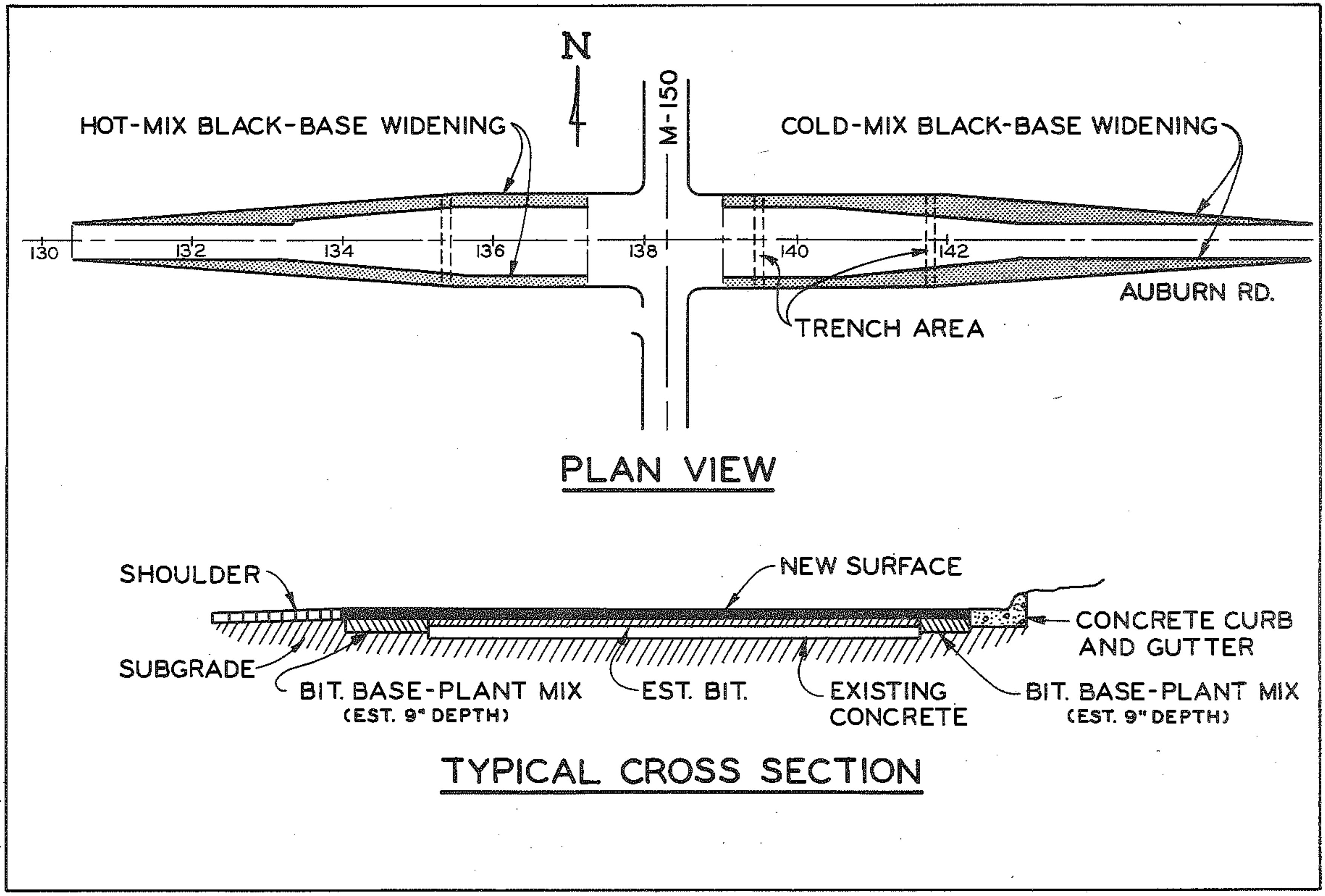
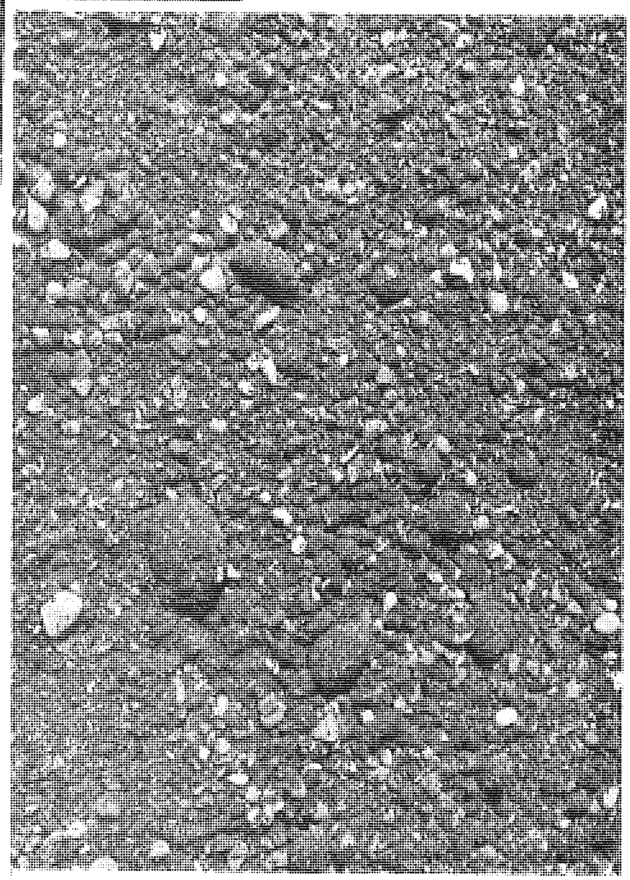


Figure 2. Plan and cross-section of experimental black base test sections.

Stockpiled cold-mixed emulsion black base material.



Texture and appearance of emulsion black base material.

Balling of asphalt and fines in emulsion black base mixture.

Figure 3. Stockpiled emulsion cold-mix black base material.

In-Place Moisture [2], percent	10.4
Asphalt Residue [2], percent	4.0
Compaction, percent	96.8

High moisture content, about 10 percent, caused some compaction difficulty but drying weather conditions permitted the attaining of adequate stability after one or two days. The moist, but drying, appearance of the material one day after compaction is shown in Figure 4. Although roller marks are visible, the material seemed stable under traffic at this time.

After the experimental base material was placed and compacted the test area was opened to traffic without surfacing until July 1974. This afforded an opportunity for observing the performance of the experimental area throughout the winter and spring. At two locations, trenches were cut across the old pavement for installation of sewer pipe. Nine inches of cold-mix base was placed over the backfill material (Fig. 5). Because the road would be open to traffic the trench areas were temporarily surfaced with a cold-patching mixture. As shown in Figure 6, no signs of failure attributable to the cold-mix base material developed over the winter and spring of 1974.

In July 1974 the test area was paved with 250 lb/sq yd of bituminous concrete surfacing. During the paving operation the leveling course shoved and pulled away from the base in about 15 percent of the experimental base area (Fig. 7). Tests showed moisture contents ranging from 5 to 7 percent in the base mixture. Construction notes indicate that the existing clay subgrade had been primed in these areas for some reason; this may have trapped water in the base mixture to cause the problem. The unstable base in these areas was removed and replaced with a hot plant-mix black base to expedite completion and no further problems have been observed.

Performance

Inspection of the project shows the entire experimental base area to be in good condition (after correction of the unstable portion) with no rutting, shoving, cracking or other signs of distress (Fig. 8). A good indication of the performance of the cold-mix base is the condition of the road surface at the location of trenches cut through the old concrete pavement for drainage construction. There are no cracks or other surface irregularities to indicate lesser support capability than that provided by the old pavement. Experimental black base material, placed over the trenched backfill during construction in 1973, has been carrying traffic without distress since that

[2] Based on dry unit weight of aggregate.

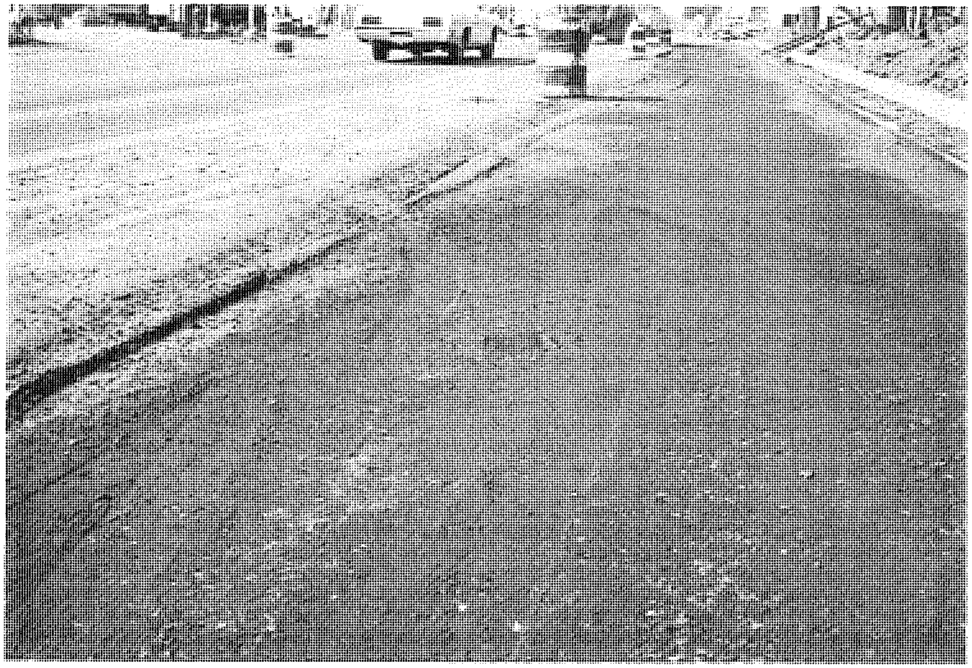


Figure 4. Moist appearance of the compacted cold-mix base material. Drying, generally progressing inward from the edges is accompanied by increased stability.

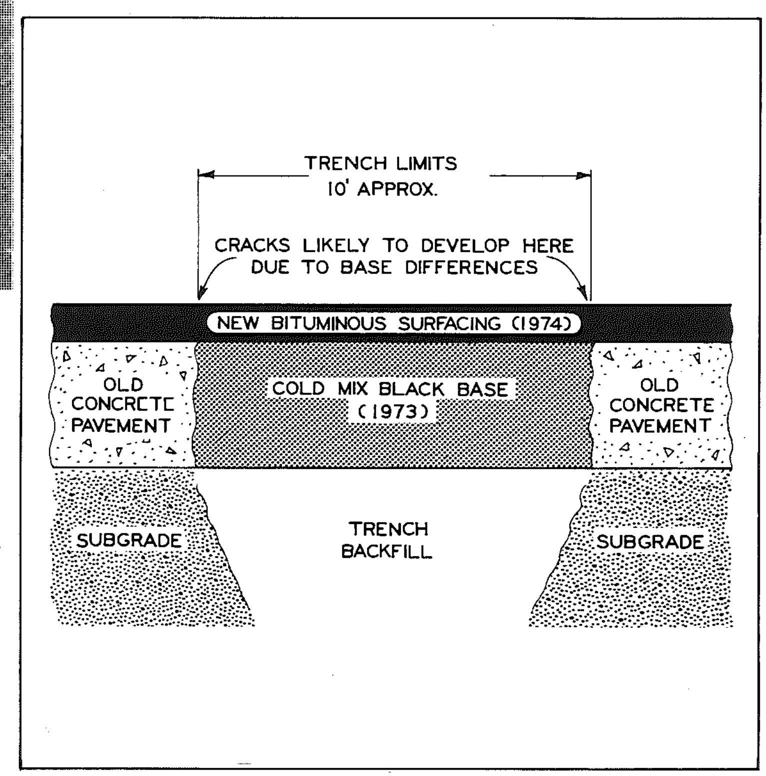
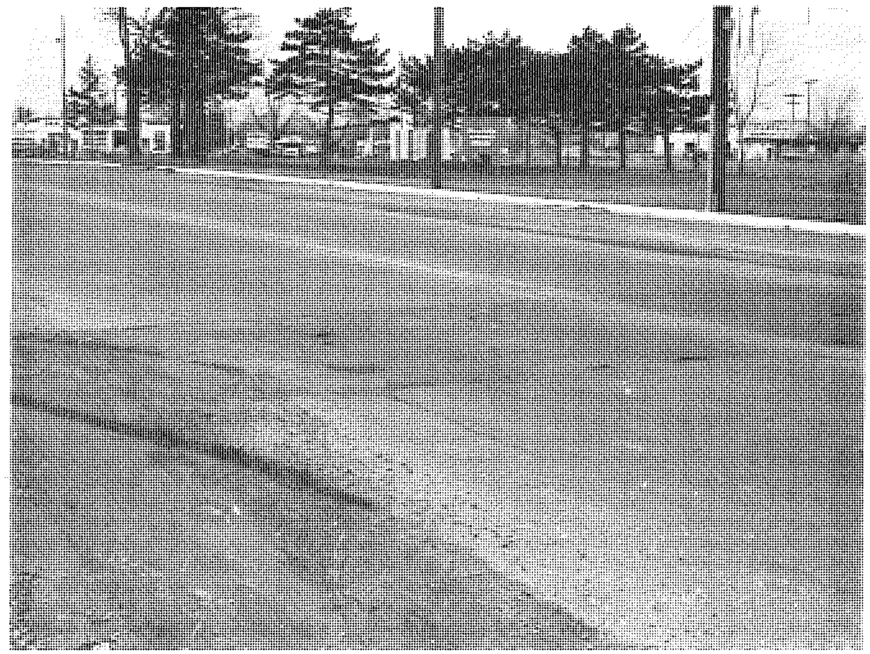


Figure 5. Longitudinal section through trench areas showing changes in base materials.

Surface condition of the cold-mix material is exposed along the lower left edge of the photograph.

Sewer trench cut with 1-1/2 in. of cold patch over cold-mix black base.

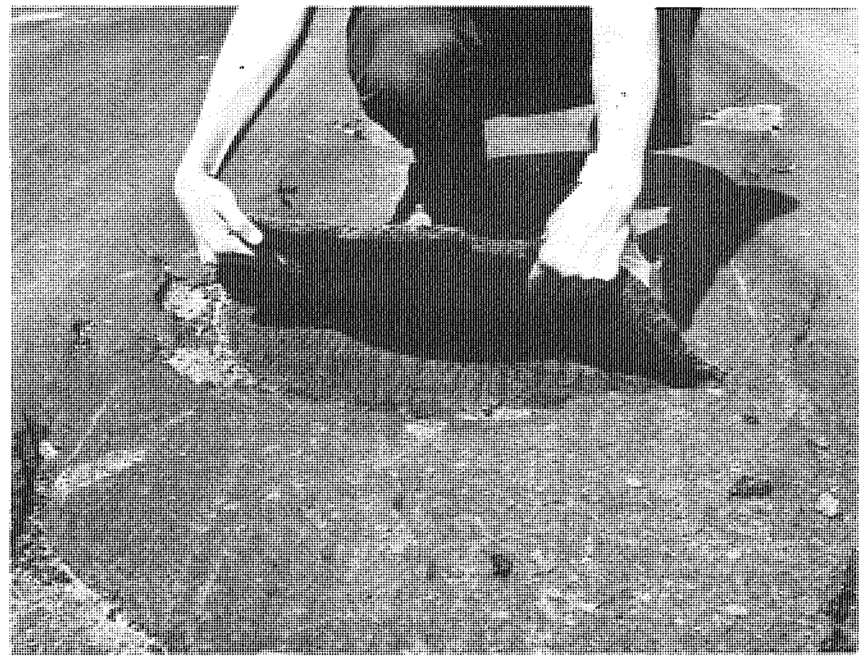


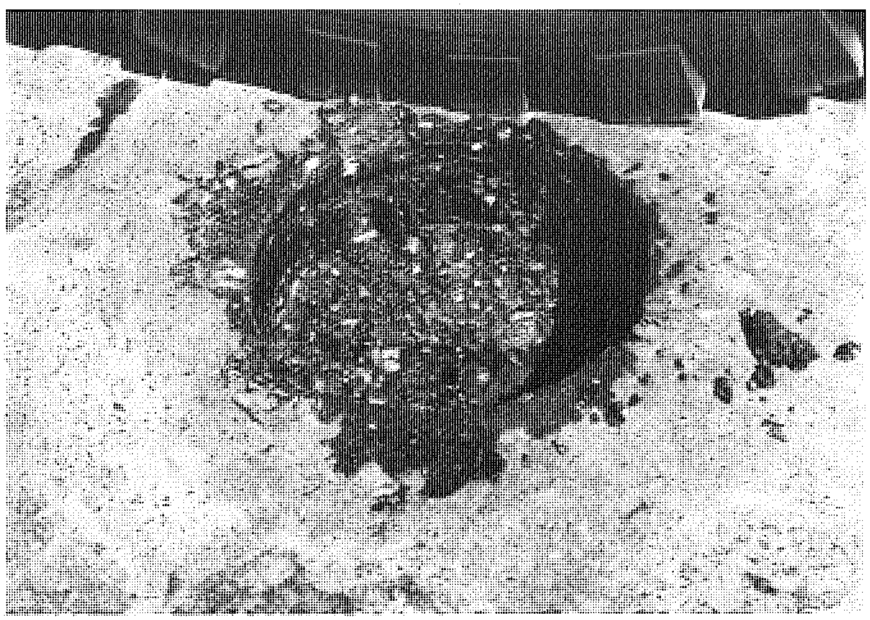
Surface condition of widening strip in area exposed to traffic during the 1973-74 winter (same exposed area as above).

Figure 6. Condition of cold-mix black base widening and trench cut after exposure to traffic and weather over the winter.

Distressed surfacing placed on wet, unstable emulsion black base.

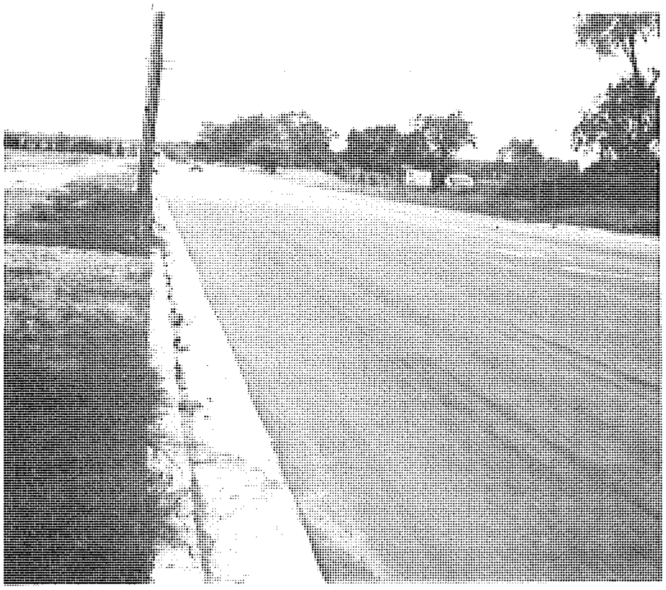
Leveling course separating from emulsion black base.



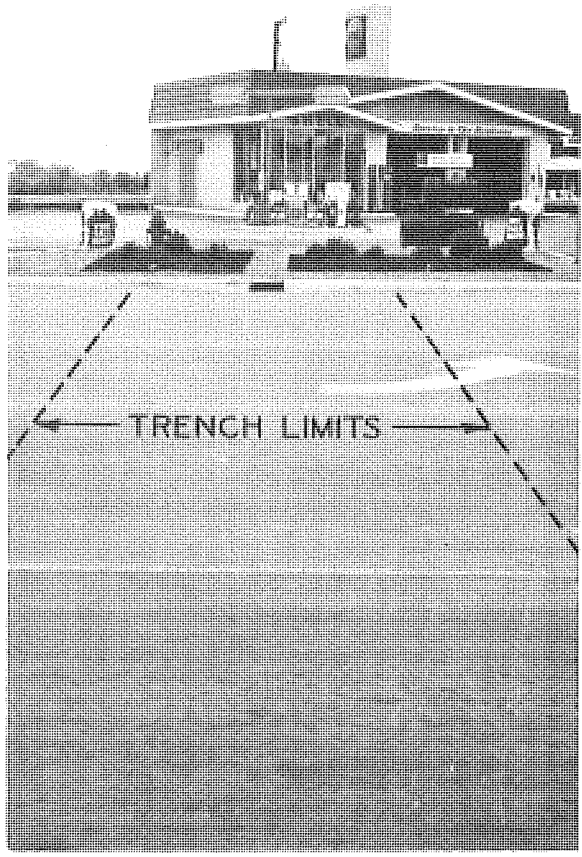


Saturated condition of emulsion black base in area of distressed surfacing.

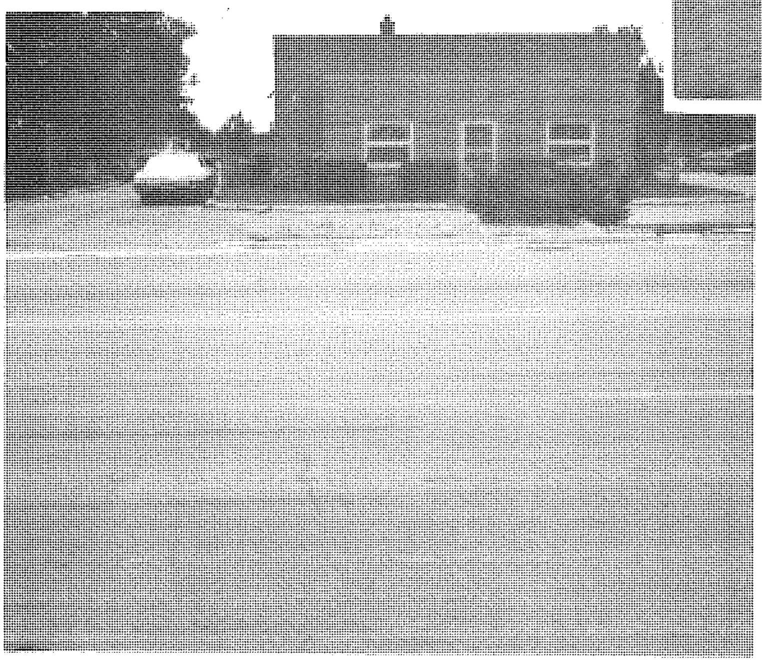
Figure 7. Surfacing problems originating from wet unstable cold-mix black base.



Cold-mix black base is under the lane adjacent to the curb.



A trench, extending across both existing concrete pavement and cold-mix base to opposite catch basins also has the cold-mix as a base. Note there are no cracks or other signs of surface irregularities at the trench limits. Cold-mix base is under the lane in the foreground and under the lane adjacent to the far curb.



Cold-mix black base widening under the lane at the bottom of the photo and under the lane adjacent to the far curb. Note reflective cracks in surfacing over old concrete pavement.

Figure 8. Condition of cold-mix black based test section in 1975, one year after surfacing.

time. This same level of performance is also apparent for the hot-mix black base section as shown by comparative photographs (Fig. 9). A section through the trench, Figure 5, indicates locations where distress due to the different bases might be expected.

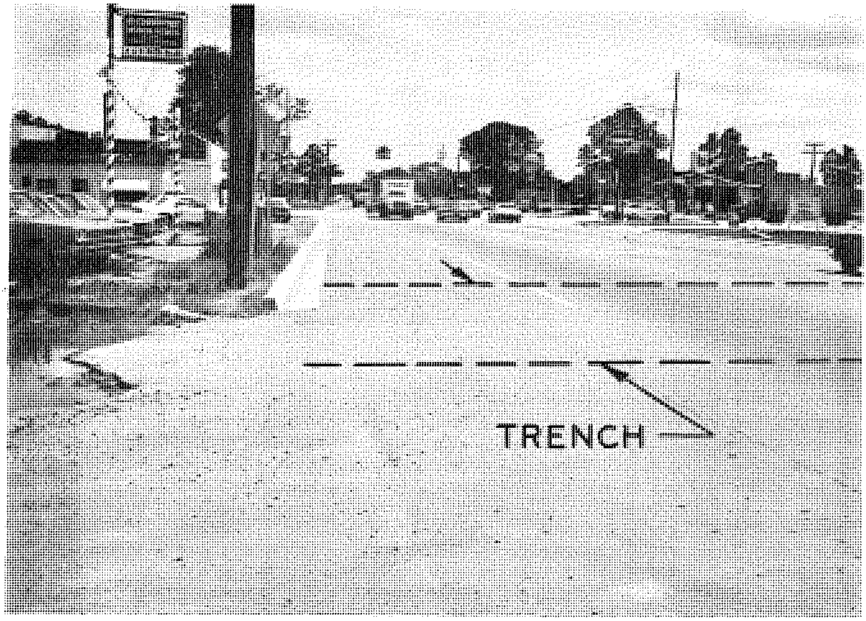
Strength and stability characteristics of the experimental cold-mix material were measured in the Research Laboratory using material sampled from the base at the time of placement and compaction. Tests were performed to measure shear strength, Marshall stability and flow, and elastic modulus under repeated loading. Results of these tests, given in Table 1, show the cold-mix black base to be as strong and stable, when properly cured, as conventional hot-mix black bases.

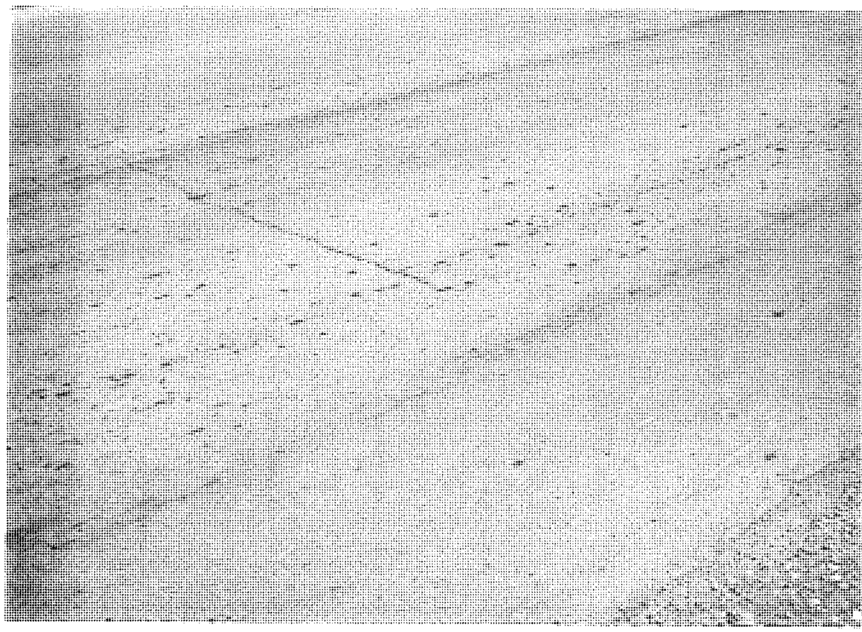
TABLE 1
STRENGTH AND STABILITY CHARACTERISTICS OF
COLD-MIX EMULSION BLACK BASE MATERIAL AS
COMPARED WITH CONVENTIONAL BLACK BASE MATERIALS

Characteristic	Emulsion Cold-Mix	Conventional Hot-Mix
Shear Strength		
Cohesion, C, psi	31	21.5 to 23 [1]
Friction Angle, $\phi°$	24	34.0 to 42 [1]
Quasi Elastic Modulus, E*, psi		
Cured one week	15,320	
Cured six months	41,230	
(curing not applicable)		30,000 to 40,000 [2]
Marshall Stability, S, lb		
Cured one week	835	
Cured six months	3,323	
(curing not applicable)		668 to 1,102 [2]

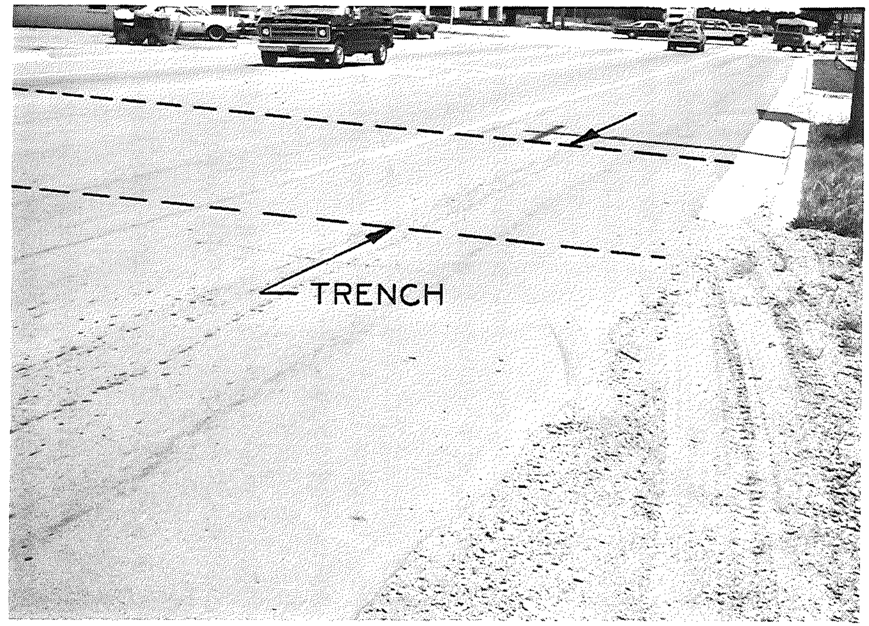
[1] AlNouri, Ilham, "The Effect of Fines (P-200) on Bituminous Base Mixtures," MDSHT Research Report R-753, 1970.

[2] AlNouri, Ilham, "Effect of Temperature on the Elastic Response of Asphalt Treated Base Material," MDSHT Research Report R-816, 1972.





Hot-mix black base widening is under a five foot wide strip paralleling the curbs. Note that there are no signs of distress at the trench limits.



Note the reflective crack over the old concrete pavement.

Figure 9. Condition of conventional hot-mix black base test section in 1975, one year after surfacing.

Conclusions

This experimental construction project provided initial experience for Department engineers in the use of cold-mixed emulsion black base materials. The most significant problem in using this emulsion cold-mix is its inconsistent stability due to moisture in the mixture, both at the time of compaction and at the time of surfacing. Observations and tests performed in connection with this project have resulted in the following additional conclusions.

1) The emulsion mixture is not as uniform and the aggregate not as well coated as is expected when using hot-mix materials.

2) Curing is required prior to surfacing, under conditions conducive to drying, in order to develop adequate strength in the compacted mixture to support the paving equipment.

3) When properly conditioned, compacted, and cured, emulsion cold-mix materials can result in stable highway bases.

4) Failures due to wet unstable cold-mix base material become apparent during or immediately after the surface paving operations. Areas which were successfully paved have remained in good condition throughout the three-year project evaluation period.

Recommendations

For highway base courses, where construction schedules and prompt completion are vital, the following recommendations are made:

1) Materials other than emulsion cold-mixes which are less dependent on ideal drying conditions should be used.

2) If emulsion cold-mix base materials are to be used they should be relatively dry when placed and compacted, 3 percent moisture or less, and should be placed only over well drained subbase or subgrade materials. Reduction of water content by drainage as well as surface evaporation is necessary to achieve initial stability adequate for surface paving.

3) The stable cold-mix base should be surfaced as soon as possible to prevent further moisture accumulation. Long term curing, to provide additional stability, can then proceed without the presence of excessive environmental moisture.

4) Further research should be conducted to establish moisture and stability criteria along with appropriate tests in order to provide effective controls for future jobs.

5) A dependable method of inspecting for adequate initial stability prior to paving should be developed. At the present time, test rolling over the entire area is recommended with an inspector walking beside the roller to watch for excessive deflections, cracking, and the soft rubbery appearance associated with moist unstable base conditions.