STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS
DIVISION OF HIGHWAYS

AN INVESTIGATION OF THE CAUSES OF DISTRESS APPEARING IN A BITUMINOUS SURFACED ROAD IN YOLO COUNTY

III-Yol-90-B
Between 2.7 Miles to 6.7 Miles
North of Madison

57-09

MATERIALS & RESEARCH DEPARTMENT

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State of California
Department of Public Works
Division of Highways
Materials and Research Department

April 24, 1957

III-Yol-90-B
Contract 55-3TC12
Lab. W.O. 35-S-3062

Mr. J. W. Trask
Assistant State Highway Engineer
Division of Highways
Sacramento, California

Dear Sir:

Submitted for your consideration is:

REPORT

of

AN INVESTIGATION OF

THE CAUSES OF DISTRESS APPEARING IN

THE BITUMINOUS SURFACING OF ROAD

III-YOL-90-B

BETWEEN 2.7 MILES TO 6.7 MILES

NORTH OF MADISON

Study made by. . . . . .Pavement Section
Under general direction of . . . . . Ernest Zube
Work supervised by . . . . . .Earle Dewing
Report prepared by . . . . . E. Zube and E. Dewing

Very truly yours,

F. N. Hveem
Materials & Research Engineer

Attach.
cc. J.A. Legarra
M. Harris
F.E. Baxter
A.S. Hart
C. Hamma
R.I. Nicholson

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An Investigation of The Causes of Distress Appearing in The Bituminous Surfacing of Road III-Yol-90-B

In a letter dated January 25, 1957, Mr. J. C. Young, Design Engineer, requested this department to determine if possible the cause of the cracking of the plant mix surfacing on Road III-Yol-90-B from 2.7 miles to 6.7 miles north of Madison. This road was constructed in 1955 under Contract 55-3TC12 and now shows considerable cracking throughout its length. The structural section consists of 1/2" open graded and 2-1/2" dense graded plant mixed surface over 8" Class A cement treated base over 5" of imported subbase material. This 16" of cover was placed over a basement soil of 4 R-value minimum.

Field investigations of this project were carried out in February and consisted of mapping the cracks, sampling the plant mixed surfacing, the Class A cement treated base, the subbase and basement soil. In addition, Benkelman beam deflection measurements were taken and a profilogram of the pavement was made.

Laboratory tests included R-value, plasticity index, sand equivalent and resilience of the soils, determination of the cement content of the treated base and extractions and penetrations of the recovered asphalt from the surfacing.

As shown in the attached maps cracking was prevalent throughout the project and the pattern developed showed that although the longitudinal cracks are more noticeable, transverse cracking occurs with regularity and is the dominant type. Longitudinal cracking seldom occurs in cuts or in fills of less than 1½' of height.

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Many of the longitudinal cracks follow the path of a construction joint of the underlying CTB but there are numerous instances where there is no apparent relation between the position of the crack and construction joints or panels. The cement treated base was mixed in 9' - 8' - 8' widths and many of the cracks occur parallel to and 8' or 9' from the outside edge of the pavement. There were no circular or curved cracks typical of major fill settlement.

Transverse cracks varied in length from 6' to the full roadway width of 24'. The worst cracked sections had 5 to 7 cracks per 100' and 70% of the cracks were full roadway width. The average transverse cracking occurs at approximately 20' intervals.

All cracks are wider at the surface than at depth. This is due to the tendency of the 1/2" open graded mix to spall or chip away at the crack. The crack trace through the underlying dense graded PMS and the cement treated base become finer and are sometimes difficult to see.

The R-values of four basement soils ranged from 8 to 25 and the actual provided cover is in excess of that required by our present design standards. Two compaction tests of the basement soil showed relative compactions of 92% and 99%.

The ISM consisted of a clean free draining gravel and sand. Samples were taken but no tests made as visual inspection indicated this material would easily meet the specified R-value of 50 minimum.

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The samples of the treated base were typical of cement treated base with a moderate cement content. The cylinders break during the coring and were recovered as partial cores rather than a coherent unit.

Construction records show the entire project was mixed between the 9th and 15th of July 1955. A P&H mixer was used and the full 8" depth was mixed in one operation. According to the records the cement added varied from 3.7% to 4.3% by weight.

There was little or no difference in the amount of cracking in the low and high cement content areas.

The cement content of five cores as determined by chemical analysis ranged between 2.7% and 4.2%.

In all cases the lower portion of the cement treated base sample was softer, less dense and contained less cement.

The results of all these tests indicate that the distress evidenced is not due to the quality or thickness of the base and subbase, nor due to the basement soil. In all sample locations sufficient cover was present to satisfy design requirements.

Benkelman beam deflections averaged .009" in good areas and approximately .013" in cracked locations indicating a low or nonresilient structure.

The results of penetration tests on the recovered asphalt show penetrations ranging from 8 to 15 for the dense graded plant mixed surfacing and 11 for the open graded plant mixed surfacing.

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This "nonflexible" surfacing is unable to bridge across the normal contraction or shrinkage cracks that develop in all cement treated bases. The tendency of the 1/2" open graded surfacing to spall along the cracks has accentuated the appearance of distress. Therefore, we believe that the extreme brittleness of the PMS is one of the major contributing causes of distress on this road.

Construction records for the project indicate a constant 4% bitumen used on the dense graded plant mixed surfacing placed on the traveled way. The 4% figure applied to the total tonnage of mix is in close agreement with the total quantities of asphalt shown in the final report.

The bitumen content recommended by the laboratory for 120-150 penetration asphalt was 5.3% to 5.6%. For the 85-100 penetration asphalt that was used on this project this would normally increase to around 6.0%. The asphalt content actually used, therefore, was nearly 2% under the required amount. This low asphalt content resulted in thin films that alone produce a brittle mix and also greatly accelerate further oxidation and hardening.

Structurally the section still appears sound. There is no differential displacement as yet at the cracks and the project has a low roughness indicated by a profilogram index of 10.

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It is believed that the life of the road can be greatly extended by comparatively minor surface repairs. It is the recommendation of this department that any badly spalled areas be filled in with plant mixed surfacing and that a double seal coat be placed or preferably a rich open graded plant mix blanket of say, 3/4" thickness. This would help fill up existing cracks, serve as a barrier to further oxidation and prevent the entrance of water through the existing dry open graded mixture. It is our opinion that any slight movement in the cement treated base will result in reflection cracking of any relatively thin dense graded blanket. The seal coat or open graded mix should provide somewhat more flexibility and retard the further appearance of reflection cracks.

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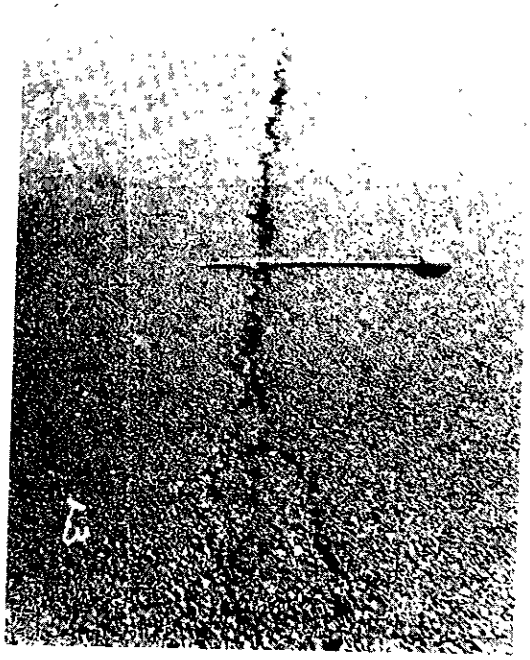

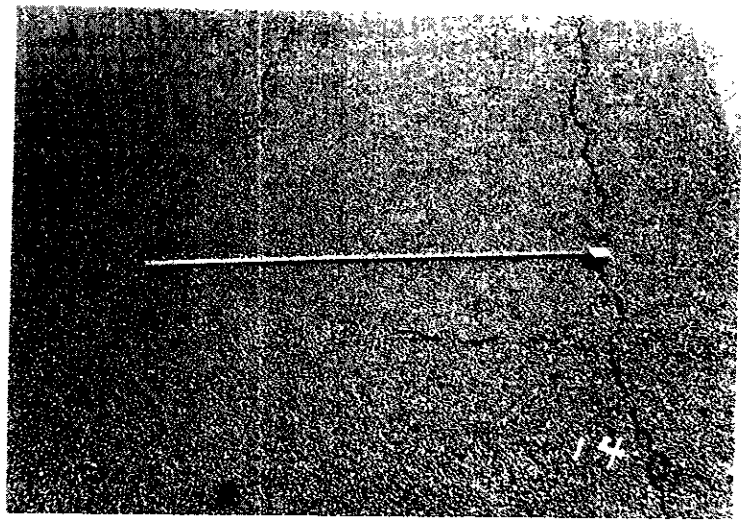

Typical Cracks Showing Spalling in Open Graded Mix

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Core as Recovered

Core Hole - Note Crack in C.T.B.

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