Evaluation of Pavement Bleeding on I-55 in Illinois

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Shortly after construction fat spots began to appear throughout the project on a 3-in. hot-mix asphalt (HMA) overlay of an existing portland cement concrete pavement. The fat spots appeared to occur at the end of truck loads. After time the fat spots developed into potholes and the asphalt appeared to be stripped from the aggregate at the bottom of the potholes. Some rutting and shoving also developed at the fat spots. The objective of this study was to evaluate the HMA and to determine potential causes of the fat spots. The test plan included inspecting the pavement visually and obtaining core samples from fat spots, adjacent to fat spots, and from random locations throughout the project. Rut-depth measurements were also obtained. The cores were tested for asphalt content, gradation, void content, and slag content. Several of the asphalt mix layers were split into top and bottom halves, and the asphalt content and gradation of each half were compared. The asphalt cement from several cores was recovered, and the viscosity and penetration were determined. The results of this study indicated that the most likely cause of the fat spots was contamination of the HMA with some solvent (probably diesel fuel) during the placement operation.

The existing pavement surface on I-55 near Collinsville, Illinois, was overlaid from 1985 to 1987 with 3 in. of asphalt mix. This work, finished in 1987, was performed under two contracts. The asphalt mix that experienced problems was placed in 1987.

Shortly after construction, personnel of the Illinois Department of Transportation (DOT) noticed fat spots throughout the project. Most of the spots appeared to occur at the end of truck loads. Over time these spots developed into potholes, and the asphalt appeared to be stripped from the aggregates at the bottom of the potholes. Some rutting and shoving also developed at the fat spots.

The objective of this study was to evaluate the asphalt mix placed on I-55 and to determine potential causes of the fat spots. The study included an inspection of the roadway to develop a detailed test plan. A test plan was developed that included cutting a trench through one of the fat spots, drilling cores in and adjacent to these spots as well as randomly throughout the project. The asphalt samples were evaluated to determine aggregate gradation, asphalt content and properties, and mix properties. The test data were analyzed to identify possible causes of the localized bleeding problems.

FIELD INSPECTION

The inspection of the pavement on I-55 in May 1989 verified that a number of fat spots existed throughout the project. The distance between the fat spots varied, but it appeared that the problem was generally associated with some segregation that typically occurs at the end of truck loads. In some places it appeared that the asphalt in these fat spots had migrated to the pavement surface. In these places it appeared that the asphalt had been stripped from the underlying aggregates. The test plan was set up to determine whether stripping had occurred or if some other problem had caused the fat spots. The area of pavement adjacent to these fat spots had become rough in some cases, and it appeared that the roughness would increase with time.

TEST PLAN

A test plan was developed for I-55 to determine the cause of localized bleeding. Samples of the asphalt mix were taken in the fat spots, adjacent to the fat spots, and at random locations from station 916+25 to station 937+50 (Figure 1). A total of thirty 4-in. cores was taken for testing. A trench approximately 2 ft wide and approximately full width was excavated at station 934+70, at a location that had bleeding spots, to determine if the problem could be identified by viewing the side of the trench.

Typical cores were taken at 300-ft. intervals to evaluate the average asphalt mix properties. Additional cores were taken in bleeding areas at stations 923+47, 936+10, and 936+93. One core was taken inside the bleeding area and one core was taken immediately adjacent to the bleeding area. The asphalt content and aggregate gradation of the samples in the bleeding areas were compared with that from adjacent areas and with that from the typical cores.

The cores in the bleeding areas and adjacent to the bleeding areas were sawed into a top half and a bottom half. The asphalt content and aggregate gradation were determined for each half in order to determine whether the asphalt cement and perhaps some fines had migrated from the bottom of the top layer to the surface.

Rut measurements were taken at the trench; the results are plotted in Figure 2. The rut depth at this location was approximately 0.6 in. A typical localized bleeding area is shown in Figure 3.

There was some concern about the amount of slag that was used in the asphalt mixture. Because slag has a high absorption, a high variability in slag content would adversely affect the optimum asphalt content. The amount of slag was measured by visually separating the slag particles from the limestone particles on individual sieve sizes during the aggregate gradation tests. The slag particles were weighed for each sieve

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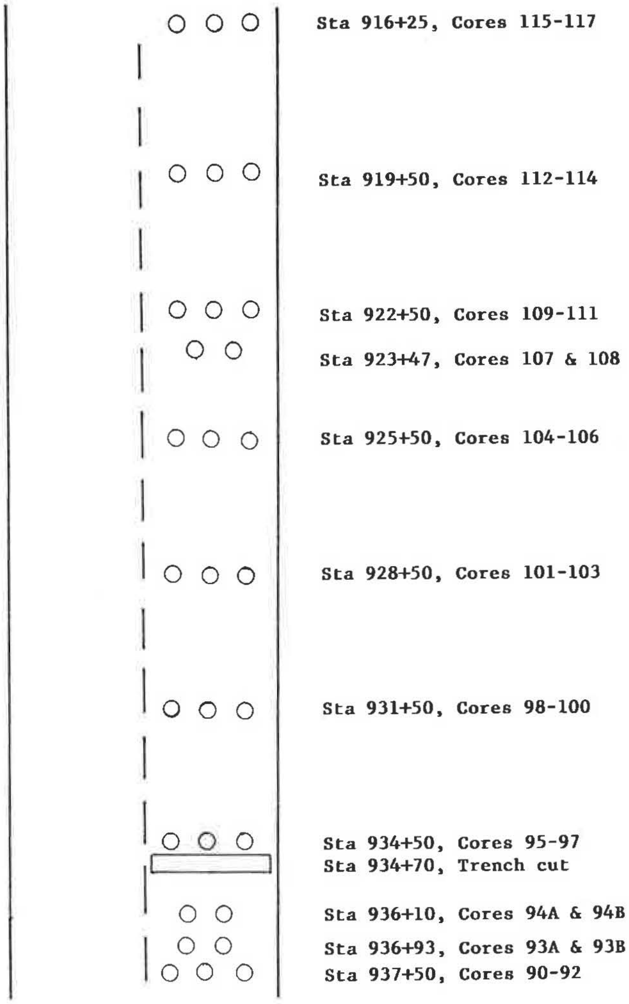

FIGURE 1 Layout of test section—northbound lanes of I-55 near Collinsville, Ill.

size and compared to the weight of the nonslag particles. The percentage of slag larger than the No. 16 sieve was determined in this way. Because this is not a standard test, the accuracy is questionable, but it was one method of estimating the slag content. The material smaller than a No. 16 sieve could not be separated visually, and hence it was not considered in the slag content.

TEST RESULTS AND DISCUSSION

The pavement section (Figure 2) shows that two layers of asphalt mixture were placed over an existing layer of concrete. The total thickness of asphalt mixture was approximately 3 in. Figure 2 shows that rutting had occurred in the surface and binder course. The rutting was more severe at the locations that had localized bleeding than in the other areas. The major concerns at the time of inspection were the rutting problem in general and the ravelling and potholes that were developing at the localized fat spots.

An inspection of the pavement adjacent to the trench cut through a bleeding spot did not indicate the causes of the problem. This inspection did show that the problem was confined to the top layer of asphalt mixture and that the lower half of the layer had less asphalt cement than the top half.

The results of slag content tests are presented in Table 1. The measured slag content ranged from a low of 28.4 to a high of 31.6. The job mix formula required 39.3 percent slag between the No. 4 and No. 16 sieves. The test used to measure slag is not a standard test; therefore the accuracy of the test is unknown. Because the measured amount of slag is consistent at each of the stations it is doubtful that variation in slag content caused the bleeding problem.

The aggregate gradation of the surface course is reasonably consistent at the various sampling locations. The average gradation of the surface course does deviate from the JMF on the No. 4 and No. 8 sieves (Table 1). After evaluation of the individual gradation it is believed that the gradation has had no effect on rutting or the localized bleeding problems. It is possible that segregation of the mix at particular points could be a problem. That is discussed later.

The measured in-place asphalt content is approximately 1 percent lower than the designed asphalt content (Table 1). This lower asphalt content could be the result of testing error, mix modifications made during construction, or failure of the contractor to meet the job mix formula. The relatively low in-place voids (4.6 percent average) show that the asphalt content actually used is not too low. Regardless of the reasons for an asphalt content lower than design, the asphalt content

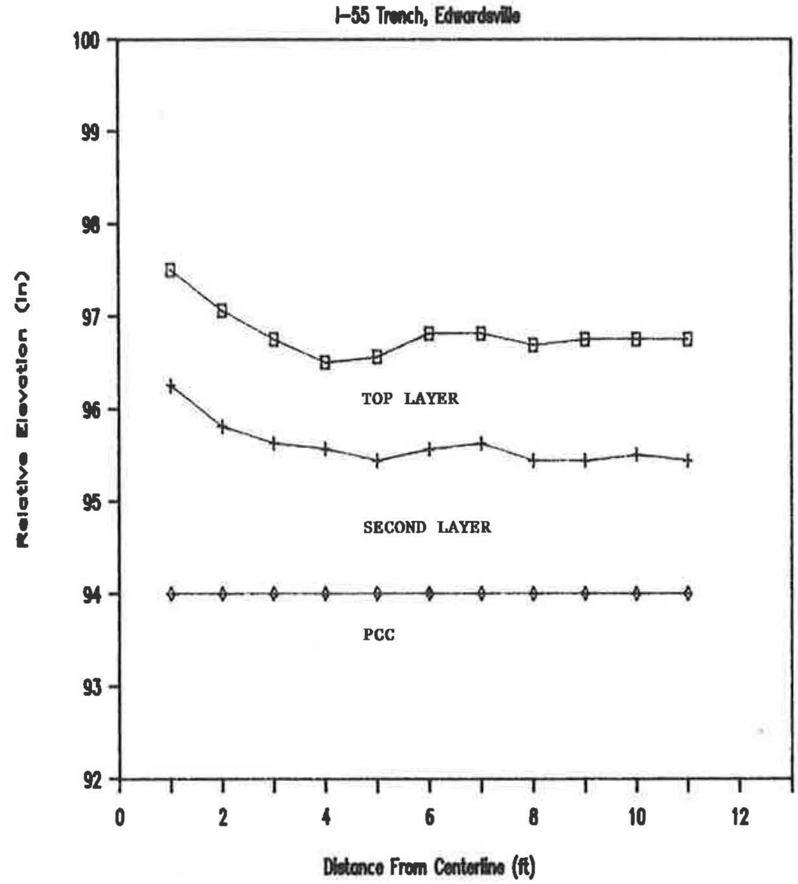

FIGURE 2 Trench cut at Station 934 + 70, northbound lane of I-55 near Collinsville, Ill.

FIGURE 3 Typical localized bleeding area, northbound lanes of I-55 near Collinsville, Ill.

actually measured on the final product appears to be acceptable on the basis of the in-place voids.

Samples of the asphalt mix in Layers 1 and 2 were recompacted with a Marshall hammer and with a Gyratory Testing Machine. The compaction results (Table 2) show that the voids were low in Layer 1 and satisfactory in Layer 2. The low voids in Layer 1 are likely one cause for rutting (*1–3*). The Gyratory Shear Index (GSI) values in layers 1 and 2 are 1.2 and 1.3, respectively. A mix with a GSI greater than 1.1 may have a tendency to rut; a mix with a GSI greater than 1.3 is almost certainly going to rut (*1*). The low voids and high GSI help explain the rutting problem but do not explain the bleeding problem at localized areas.

Test results from the mix obtained from localized bleeding areas are presented in Table 3. The average asphalt content is 5.4 percent higher in the top half of the asphalt cores than in the bottom half (8.8 percent in top half and 3.4 percent in bottom half). The average aggregate gradation is approximately 3 percent finer in the top of the cores than that in the bottom. This indicates that the asphalt and fines likely migrated from the bottom of the top layer to the surface.

Test results on material taken adjacent to the bleeding areas are presented in Table 4. These results show that the average gradations for the top half and bottom half are essentially the same. The average asphalt content is actually slightly higher in the bottom half of the cores, which is opposite of that shown in the bleeding area. A slightly higher asphalt content in the bottom half of the core could be the result of normal variability in test results, or there could be some scientific reason for it being lower. For example, the bottom half of the layer could include some tack coat material, which would increase

TABLE 1 PROPERTIES OF RANDOM SAMPLES OF ASPHALT MIX (TOP LAYER)

Property	JMF	916+25	919+50	922+50	925+50	928+50	931+50	934+50	937+50	Average
Rice Gravity	---	2.376	2.376	2.380	2.406	2.442	2.397	2.413	2.402	2.399
Bulk Gravity	---	2.271	2.304	2.292	2.279	2.298	2.298	2.257	2.305	2.288
Voids in Total Mix	---	4.4	3.0	3.7	5.3	5.9	4.1	6.5	4.0	4.6
Slag Content	39.3	29.3	29.8	28.4	31.2	30.5	30.8	30.7	31.6	30.3
Asphalt Content	7.3	6.7	6.5	6.2	6.3	5.6	6.5	6.1	6.4	6.3
Aggregate Gradation Sieve Size										
1/2 inch	100	100	100	100	100	100	100	100	100	100
3/8 inch	98	98	98	97	97	96	97	94	98	97
No. 4	52	60	64	59	63	50	56	54	54	58
No. 8	30	37	41	38	40	30	36	34	33	36
No. 16	20	25	28	26	27	22	25	24	24	25
No. 30	13	17	18	18	18	15	18	17	16	17
No. 50	9	11	12	11	11	11	12	11	11	11
No. 100	7	7	8	8	8	7	9	8	8	8
No. 200	5.3	4.8	6.4	5.8	5.8	5.4	6.3	5.8	5.5	5.7

TABLE 2 PROPERTIES OF RECOMPACTED MIX

Compactive Effort	Layer No.	Voids in Total Mix	Marshall Stability	Marshall Flow	Gyratory Shear Index
Marshall 75 Blows	1	2.2	3888	12	---
GTM (120 psi, 1 degree angle, 300 revolutions)	1	2.1	3165	14	1.2
Marshall 75 Blows	2	3.6	3194	12	---
GTM (120 psi, 1 degree angle, 300 revolutions)	2	3.1	3033	13	1.3

TABLE 3 PROPERTIES OF TOP HALF AND BOTTOM HALF OF SAMPLES TAKEN FROM BLEEDING AREAS (TOP LAYER)

Property	Top Half				Bottom Half			
	936+93	936+10	923+47	Average	936+93	936+10	923+47	Average
Asphalt Content	8.8	9.4	8.3	8.8	3.0	2.3	4.9	3.4
Aggregate Gradation Sieve Size								
1/2 inch	100	100	100	100	100	100	99	100
3/8 inch	96	97	100	98	98	99	97	98
No. 4	52	62	70	61	46	58	71	58
No. 8	31	39	44	38	26	33	45	35
No. 16	23	28	30	27	19	22	31	24
No. 30	17	22	20	20	14	15	21	17
No. 50	12	17	13	14	9	10	14	11
No. 100	9	14	10	11	6	6	10	7
No. 200	6.8	11.6	7.3	8.6	4.2	4.6	7.3	5.4

TABLE 4 PROPERTIES OF TOP HALF AND BOTTOM HALF OF SAMPLES TAKEN ADJACENT TO BLEEDING AREAS (TOP LAYER)

Property	Top Half				Bottom Half			
	936+93	936+10	923+47	Average	936+93	936+10	923+47	Average
Asphalt Content	5.6	6.2	6.1	6.0	6.1	6.7	6.5	6.4
Aggregate Gradation Sieve Size								
1/2 inch	100	100	100	100	100	100	100	100
3/8 inch	96	98	100	98	98	100	98	99
No. 4	51	59	64	58	53	56	64	58
No. 8	30	35	39	35	32	34	39	35
No. 16	21	24	26	24	23	24	27	25
No. 30	15	16	17	16	16	16	18	17
No. 50	11	12	11	11	11	11	12	11
No. 100	8	8	8	8	8	8	8	8
No. 200	5.8	6.4	5.8	6.0	6.0	5.9	5.9	5.9

the asphalt content. It is obvious that little or no migration has occurred outside the bleeding areas, but significant migration has occurred inside these areas.

A summary of the test results obtained from samples taken at random, inside bleeding areas, and adjacent to bleeding areas is presented in Table 5. These data show that the overall gradation and asphalt content on random samples, samples from bleeding areas, and samples adjacent to bleeding area are approximately the same. The major difference is the higher amount of material passing the No. 200 sieve in the bleeding areas. This indicates that the mixture initially placed contained the correct gradation and asphalt content but after compaction or traffic or both the asphalt cement and fines migrated from the bottom of the top layer to the surface.

The asphalt was recovered from the bleeding area and adjacent to the bleeding area to determine if there were differences in asphalt properties between the two areas. It is obvious from Table 6 that there are significant differences. The properties of the asphalt from the bleeding areas are considerably softer than the properties of asphalt adjacent to bleeding areas. In fact the asphalt binder from bleeding areas was softer than the original asphalt would have been. For instance, the viscosity of 958 is close to that for an AC-10, 460 is close to that for AC-5, and 322 is close to that required for an AC-2.5. The original asphalt cement on this project was an AC-20. Hence the viscosity of the asphalt recovered from the in-place mix should be significantly higher than the results indicated.

The low viscosity of the recovered asphalt cement indicates some type of contamination. Because the viscosity of the asphalt cement recovered from samples taken adjacent to bleeding areas is reasonable, the contamination must have occurred after mixing. It is suspected that the contamination either came from the use of diesel or some other unacceptable release agent to coat truck beds or from some spillage of one of these materials on the binder course before overlaying. Diesel fuel is the most likely contaminant because it evaporates slowly, and thus would keep the viscosity of the asphalt low for a long period of time. The specific cause of the contamination problem was not identified.

TABLE 5 SUMMARY OF ASPHALT CONTENTS AND GRADATION AT VARIOUS LOCATIONS IN TOP LAYER

Property	JMF	Average of Random Samples	Bleeding Areas			Adjacent to Bleeding Areas		
			Top Half	Bottom Half	Combined	Top Half	Bottom Half	Combined
Asphalt Content	7.3	6.3	8.8	3.4	6.1	6.0	6.4	6.2
Aggregate Gradation Sieve Size								
1/2 inch	100	100	100	100	100	100	100	100
3/8 inch	98	97	98	98	98	98	99	98
No. 4	52	58	61	58	60	58	58	58
No. 8	30	36	38	35	36	35	35	35
No. 16	20	25	27	24	26	24	25	24
No. 30	13	17	20	17	18	16	17	16
No. 50	9	11	14	11	12	11	11	11
No. 100	7	8	11	7	9	8	8	8
No. 200	5.3	5.7	8.6	5.4	7.0	6.0	5.9	6.0

TABLE 6 SUMMARY OF ASPHALT PROPERTIES IN BLEEDING AREAS AND ADJACENT TO BLEEDING AREAS

Property	Bleeding Areas			Adjacent to Bleeding Areas		
	936+93	936+10	923+47	936+93	936+10	923+47
Viscosity (140°F, Poises)	958	460	322	10003	5430	2575
Penetration (0.1 mm)	290+	169+	350+	30	36	151

SUMMARY

Small localized bleeding areas were identified on I-55 a short time after placement. The bleeding areas developed into potholes in some cases and increased rutting. A test pattern was developed to determine causes of the bleeding problem. After completion of tests it was obvious that the bleeding was a result of migration of the asphalt cement and filler from the bottom of the surface course to the top of the course. Tests also showed that the asphalt cement recovered from the bleeding areas had much lower viscosities than expected, even lower than the original viscosity. It was concluded from this that the bleeding was caused by contamination with some solvent, probably diesel fuel. Further investigation, which included conversations with the contractor and state DOT personnel and a review of the construction records, did not identify the exact cause(s) of contamination.

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