RESEARCH RESULTS FROM REHABILITATED AASHO ROAD TEST BASE STUDY

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A special study of stabilized and unstabilized granular material as base for flexible and rigid pavements was included in the rehabilitation of AASHO Road Test pavement sections located near Ottawa, Illinois. The rehabilitation was completed and the pavement opened to regular traffic as part of Interstate Route 80 in 1962. The design and construction of the special base test sections and their behavior after 12 years of service under regular highway traffic loadings are discussed. The base materials included a bituminous-aggregate mixture (BAM), a cement-aggregate mixture (CAM), crushed stone and gravel.

In the flexible pavement base study, the BAM base has performed best, with the loss in serviceability being the least. Rutting was the greatest in the crushed stone base section and least in the CAM. Transverse cracking was greatest in the CAM and least in the crushed stone base. Structural distress was greatest in the crushed stone and least in the BAM.

In the rigid pavement base study, the stabilized bases were effective in reducing transverse cracking of the PCC pavement in 100-ft long panels and in reducing spalling and faulting at contraction joints. Panel cracking was least for BAM and greatest for the gravel base. Joint opening in the winter was wider but much more uniform for the sections containing stabilized base.

BACKGROUND

Part of the original plan of the AASHO Road Test located along the alignment of Interstate Route 80 at Ottawa, Illinois was that, following completion of the controlled load testing, the test tangents would be rehabilitated as part of I-80 so that the behavior of remaining test sections would be studied under regular mixed traffic.

Figure 1 depicts the general location of the project. The dotted lines are the turnarounds of the four major test loops which were removed during rehabilitation. The westbound pavement is the flexible pavement tangent, and the eastbound is rigid. The loop to the far west, which was designed around 12-kip single- and 24-kip tandem-axle loads, was inadequate for regular traffic, and was removed during the rehabilitation and replaced with a 10-inch-thick portland cement concrete pavement. The test tangents of the three remaining loops were rehabilitated, and new pavement was built to connect the tangents and form an 8-mile segment of Interstate 80.

Included in the rehabilitation was a special base study consisting of stabilized and unstabilized granular material as base for flexible pavement, and as base (or subbase as it is referred to in Illinois) under rigid pavement.

BASE STUDY - FLEXIBLE PAVEMENT

Base types in the flexible pavement study included a bituminous aggregate mixture (BAM), a cement-aggregate mixture (CAM), and crushed stone. The surfacing was a dense-graded bituminous concrete corresponding to the Illinois Class I binder and surface course mixtures. The subbase was a dense-graded gravel corresponding to that normally specified by Illinois for gravel base and subbase construction.

Base thickness were 8 in. (20.3 cm.), and 12 in. (30.5 cm.) for the BAM, and 10 in. (25.4 cm.), 12 in. (30.5 cm.), and 14 in. (35.6 cm.) for the CAM. The surfacing was 4 1/2 in. (11.4 cm.) and the subbase was 4 in. (10.2 cm.) thick for the BAM and CAM sections. The crushed stone base section included a 4 1/2-in. (11.4 cm.) thick surfacing, an 8 1/2-in. (21.6 cm.) thick base, and 23 in. (58.4 cm.) of gravel subbase.

The BAM base was the same as that used in the original Road Test base study except that the sand-gravel material was salvaged from the original test sections during rehabilitation. The asphalt was 85-100 penetration grade paving asphalt.

The results of extraction tests and Marshall stability tests on samples of the mixture are given in Table 1. The aggregate was a 1-in. (2.54 cm.) maximum size, with 69.6 percent passing the No. 4 sieve and 5.3 percent minus 200 sieve size. The asphalt content was 5.2 percent, and stability and flow values were 1370 and 11.0, respectively. The mixture was placed and compacted in 2-in. (5.1 cm.) thick lifts to a mean density of 94.8 percent of theoretical.

The CAM base, likewise, was the same as that used in the original test, except that the aggregate was salvaged. The sand-gravel material was mixed with 4 percent cement at 8 percent moisture, and placed and compacted in 4- to 5-in. (10.2 - 12.7 cm.) thick lifts with a vibratory compactor and small tamping roller. Final finish was obtained with a small tandem roller. The completed surface was then treated with rapid-curing liquid asphalt applied at a rate of 0.2 gallons per square yard to serve as the curing coat.

The laboratory wet density of the CAM base was 148.0 pcf and the mean field wet density was 150.1 pcf. The mean compressive strength was 746 psi at 7 days and 926 psi at 14 days.

The crushed limestone base corresponded to that normally specified by Illinois for Type A granular base construction. The material was adjusted to optimum moisture content in a central mix plant, placed over the subbase with a spreader box, and compacted to not less than 100 percent of standard AASHO density with a vibratory compactor in lifts approximately 4 in. (10.2 cm.) thick when compacted.

The material was 1-in. maximum size with 53 percent passing the No. 4 sieve and 11 percent passing the 200 mesh sieve. The maximum dry density was 138.5 pcf at an optimum moisture content of 7.1 percent. The mean percent compaction obtained in the field was 101.3 at a moisture content of 6.3 percent.

Construction was completed and the rehabilitated test pavements were opened to traffic in November 1962.

Figure 2 depicts the traffic that has been served by the test pavements. As shown, the traffic was relatively light in the beginning, but has rapidly and steadily increased, going from 4200 vehicles per day in 1963 to 15,700 in 1973. The ADT has dropped during the past year to 14,700, which undoubtedly is a reflection of the energy crisis. The distribution of vehicle types in the traffic stream has remained fairly constant, averaging 67 percent passenger cars, 25 percent multiple-unit vehicles (truck-tractor semitrailers and combinations), and 8 percent single-unit 2-axle and 3-axle trucks. The equivalent 18-kip single-axle load applications generated by this traffic on the flexible pavements over the 12-year period amount to somewhat over 6.7 million.

Performance data collected during the 12-year test period have included condition surveys, rut-depth measurements, Roughness Index measurements, and Present Serviceability Index computations.

Performance relative to cracking and patching is given in Table 2. Transverse and longitudinal cracking are expressed in lineal feet per 1000 square feet of pavement surface. Area (or alligator-type) cracking and patching are in square feet per 1000 square feet of pavement. The patching was all confined to skin patching with cold-mix. As shown, transverse cracking was most pronounced in the CAM base sections and least in the crushed stone. This is as one would expect, as CAM is rigid in nature and susceptible to shrinkage during curing. Transverse cracking decreased as base thickness increased in the CAM. This relationship does not show up in the BAM. Transverse cracking in the CAM base sections was even more serious in that "tenting" (surface heaving at cracks) developed at all transverse cracks, which adversely affected pavement riding quality. Longitudinal cracking was very light in CAM and practically nonexistent in the BAM and crushed stone. Alligator cracking which is indicative of distress in the base was far more pronounced in crushed stone base section, being ten times greater than in the 10-in. (25.4 cm.) CAM, and many more times greater than any other section. Likewise, patching was the greatest in the crushed stone section. Area cracking and patching both were almost completely absent in the BAM sections. Overall structural distress, as indicated by cracking and patching, was greatest in the crushed stone base and least in the BAM.

The average depth of rutting in the wheel paths of the special base test sections is given in Table 3. The values were obtained by averaging a series of measurements in both wheel paths throughout the length of each section. Rutting was greatest in the crushed stone base section and least in the CAM sections. Depth of rutting is not related to base thickness in either the BAM or CAM base sections.

The development of rutting with time is depicted in Figure 3 for each of the three base types. As would be expected, rutting developed slowest in the CAM base sections. It is interesting to note that rutting was greatest in the BAM base sections during the first five years, after which rutting continued to develop at a faster rate

Figure 1. Location of rehabilitated AASHO Road Test pavement section.

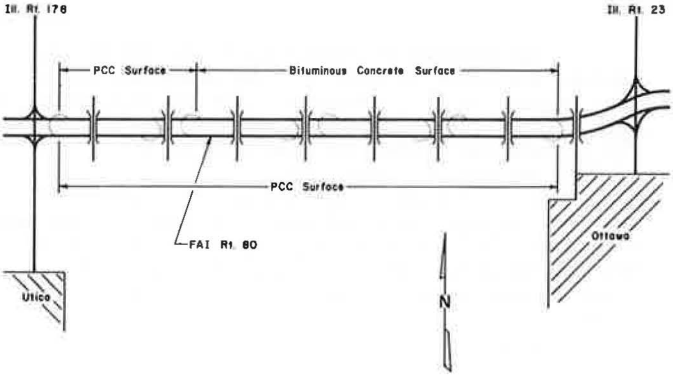


Table 1. Results of extraction and Marshall stability tests on BAM base.

Sieve Size	Percent Passing		
1 in.	100	Asphalt Content (%)	5.2
3/4 in.	96.5	Marshall Stability	1370
No. 4	69.6	Flow	11.0
No. 10	51.2	Air Voids (%)	1.71
No. 200	5.3		

Figure 2. Average daily traffic for calendar year 1963 through 1974.

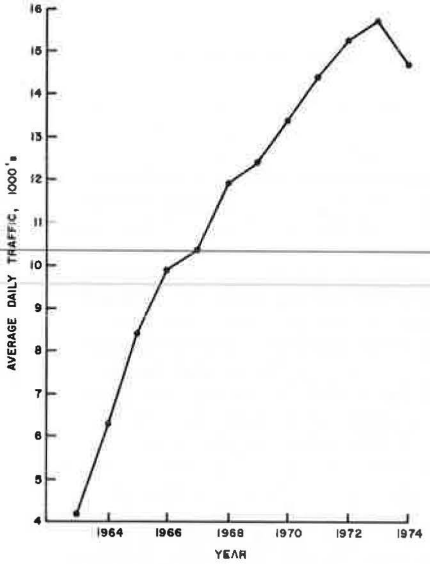


Table 2. Cracking and patching quantities.

	Transverse (lin. ft/ 1000 sq. ft)	Longitudinal (lin. ft/ 1000 sq. ft)	Area Cracking (sq. ft/ 1000 sq. ft)	Patching (sq. ft/ 1000 sq. ft)
8" BAM	23	0	1.5	0
10" BAM	10	1	1.6	1.6
12" BAM	26	0	0	0
10" CAM	52	10	24	4.5
12" CAM	40	13	11	27
14" CAM	33	0	2.8	0
8.5" Cr. Stone	13	0	246	42

Table 3. Depth of rutting in wheelpaths.

Test Section	Rut Depth, in.
8" BAM	0.51
10" BAM	0.48
12" BAM	0.50
10" CAM	0.35
12" CAM	0.37
14" CAM	0.36
8.5" Cr. Stone	0.66

Table 4. Final roughness index (RI) and present serviceability index (PSI) values of special base flexible sections.

Test Section	RI	PSI
8" BAM	63	3.6
10" BAM	40	4.3
12" BAM	33	4.7
10" CAM	153	2.2
12" CAM	127	2.5
14" CAM	127	2.5
8.5" Cr. Stone	74	2.9

Figure 3. Development of wheelpath rutting in special base test sections.

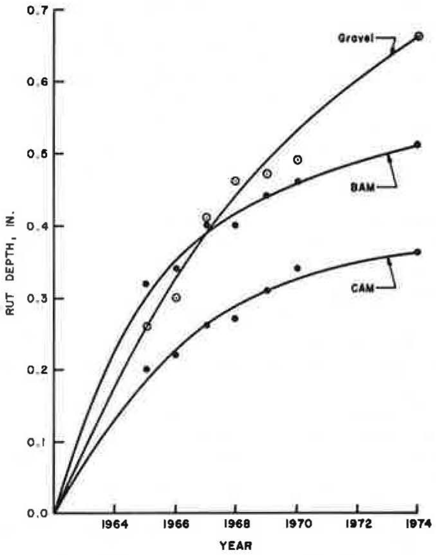
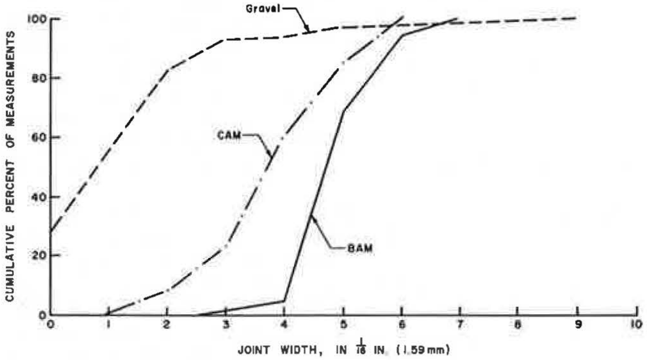


Table 5. Summary of condition survey data and final roughness index values for rigid pavement base study sections.

Test Sections	No. of Transverse Cracks/100' Panel	Mean Spalled Area/Joint, sq. ft	Faulting, in.		1974 RI
			Mean	Max.	
4" BAM	1.7	1.1	1/8	1/4	58
4" CAM	4.2	1.1	1/8	1/4	63
6" Gravel	7.5	1.7	3/16	1/2	75

Figure 4. Cumulative frequency distribution of contraction joint openings measured in February 1973.



in the crushed stone base section, and exceeded that in the BAM.

The final Roughness Index and Present Serviceability Index values for the various test sections as determined in 1974 are shown in Table 4. As can be seen, the BAM base sections were still in excellent condition. The riding quality of the pavements would be rated as "very smooth" and present level of service was very good to excellent. The CAM base sections, on the other hand, have provided the poorest ride, and the PSI's have reduced to a level indicating a need for rehabilitation. The crushed stone base section had maintained a reasonably good level of ride -- an RI value of 74 is in the "smooth" rating. This section, however, as previously mentioned, had developed excessive rutting in the wheel paths and considerable structural distress, which resulted in lowering its level of service to a value approaching that considered indicative of need of rehabilitation.

In summarizing the performance of the flexible pavement special base sections, the BAM base has performed the best. The pavements are still very smooth, and the serviceability levels were good to excellent. The pavements were free of any structural distress. The major defect was the excessive rutting, 0.5 inch, that had developed in the wheel paths.

The CAM base sections have developed the least amount of rutting. Structural distress in the base, as indicated by area cracking, was minimal. Transverse cracking and the subsequent "tenting" at these cracks, however, have greatly increased the Roughness Index of the pavement and reduced the PSI values to a level indicating the need for resurfacing.

The crushed stone base section has retained a reasonably good quality ride -- RI-74. As previously mentioned, however, this section had developed much more structural distress than the other special base test sections. Area cracking and patching combined totaled 288 square feet per 1000 square feet of pavement, or 28.8 percent of the surface area. This distress, combined with the excessive rutting, had reduced the PSI to 2.9.

BASE STUDY - RIGID PAVEMENT

The special base study on the rigid tangent included BAM, CAM and gravel. The BAM and CAM were the same mixture used in the flexible base study. Likewise, the gravel was the same material used as the subbase in the flexible base study. The BAM and CAM bases were 4 in. (10.2 cm.) thick and gravel was 6 in. (15.2 cm.) thick. The pavement in all test sections was 10 in. (25.4 cm.) thick, reinforced with welded wire pavement fabric, and contained sawed contraction joints with load transfer devices spaced at 100-ft (30.5 cm.) intervals.

The study has shown some distinct advantages of stabilized over granular base for use under portland cement concrete pavement, with the BAM being somewhat better than the CAM.

As shown in Table 5, the stabilized bases were effective in reducing transverse cracking in the pavement, and in reducing spalling and faulting at joints. Transverse cracking averaged 1.7 cracks per 100-ft pavement panel for the BAM section, as compared to 4.2 for the CAM and 7.5 for the gravel base sections. The average amount of spalling at a joint was 1.1 sq. ft for the BAM and CAM as compared to 1.7 for the gravel. Faulting was not excessive, but the average for the BAM and CAM was only 2/3 of that for gravel. The maximum fault measured in the gravel base sections was twice that measured in the BAM and CAM. The measured Roughness Index after 12 years of service indicates that all special base pavement sections are "very smooth." The stabilized base sections, however, are somewhat smoother than the gravel base sections.

A set of measurements of openings at contraction joints was made in February 1973, and the results are shown in Fig. 4 where cumulative percent of measurements are plotted against joint width for each of the three types of base. As can be seen, joint openings were wider but considerably more uniform for the stabilized base, being widest and most uniform for the BAM. Average joint openings were 5/16 in. (7.94 mm.) for BAM, 1/4 in. (6.35 mm.) for CAM, and 1/8 in. (3.18 mm.) for the gravel base. Approximately 90 percent of the joints in the BAM base section were opened from 1/4 in. (6.35 mm.) to 3/8 in. (9.53 mm.), and all openings were confined between 3/16 in. (1.59 mm.) and 9/16 in. (14.29 mm.). It is interesting to note that the gravel base sections had the greatest number of transverse panel cracks in the PCC pavement. While the individual joint opening measurements were not compared with the number of cracks in adjacent panels, pavement contraction undoubtedly was taking place at the cracks rather than at joints in the 28 percent of joints on gravel base that did not open. The reduced panel cracking and increased openings at contraction joints in the stabilized base sections suggest that stabilizing the base reduces the friction, or subgrade drag, between the PCC slab and the base.