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FINAL REPORT

DURABILITY OF CLASSED LIMESTONE COARSE AGGREGATE STUDY, US 169, JOHNSON COUNTY, KANSAS

Rodney A. Montney, P.E.
Robert F. Heinen
John Wojakowski, P.E.
Kansas Department of Transportation
Topeka, Kansas

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16 Abstract

The Kansas Department of Transportation began evaluating individual beds in limestone quarries for suitability for use in concrete pavement in 1980. Aggregates that were suitable for use in Portland Cement Concrete Pavement (PCCP) were designated as Durability Class I Aggregate. By 1986 several quarries had been evaluated and it was decided to construct a project with various Durability Classed Aggregates to prove the system that was used to classify the limestones. Class I Limestone has a 95% probability of providing 20 years of service life before the pavement is rehabilitated due to D-cracking. Although the aggregates that were requested for this project were not provided, this project does demonstrate the effectiveness of KDOT's specification and the rapid deterioration of pavement once D-cracking becomes evident.

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Prepared by

Rodney A. Montney, P.E.
Robert F. Heinen
John Wojakowski, P.E., Retired
Kansas Department of Transportation
Topeka, Kansas

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EXECUTIVE SUMMARY

The Kansas Department of Transportation began evaluating individual beds in limestone quarries for suitability for use in concrete pavement in 1980. Aggregates that were suitable for use in Portland Cement Concrete Pavement (PCCP) were designated as Durability Class I Aggregate. By 1986 several quarries had been evaluated and it was decided to construct a project with various Durability Classed Aggregates to prove the system that was used to classify the limestones. Class I Limestone has a 95% probability of providing 20 years of service life before the pavement is rehabilitated due to D-cracking. Although the aggregates that were requested for this project were not provided, this project does demonstrate the effectiveness of KDOT's specification and the rapid deterioration of pavement once D-cracking becomes evident.

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INTRODUCTION

Aggregates used in Portland Cement Concrete Pavement (PCCP) must possess a reasonably high degree of quality. The combination of coarse and fine aggregate generally occupies 60 to 70 percent of the concrete volume and strongly influences its properties and performance. The Kansas Department of Transportation (KDOT) uses AASHTO T-161 (ASTM C-666) to evaluate limestones for use in concrete placed on grade such as PCCP. Evaluation of individual beds in each quarry began in 1980. To be acceptable for use in PCCP in Kansas the limestone must have a Durability Factor of 95 or greater, and an expansion of 0.025 or less. KDOT refers to these acceptable aggregates as Class I. This 1986 project attempted to use four different sources (Cases) of limestone in PCCP mixtures containing 50 percent coarse aggregate. This is a field test of the Kansas Department of Transportation specification for durability classed aggregate.

PROJECT DETAILS

This pavement, constructed on US-169 in Johnson County, was 9” plain PCCP with 15’ skewed joints. No dowel bars were used for load transfer. These sections are located about 5 miles south of I-35 in Olathe, north and south of Reference Post 143. Their stationing is shown below:

Section 1	SB 289 + 78 to 307 + 25
Section 2	SB 242 + 53 to 257 + 53
Section 3	NB 271 + 00 to 253 + 85
Section 4	NB 311 + 10 to 296 + 60

The special provision for this project specified the following requirements for the limestone that was to be used in each test section.

Section	Durability Factor	Expansion (Percent)	Modified Freeze Thaw
1	95 min.	0.025 max.	0.90 min
2	95 min.	0.025 max.	0.85 to 0.89
3	70 to 79	0.026 to 0.099	0.90 min.
4	70 max. or T	0.100 min.	0.90 min.

T = Testing Terminated

Testing on aggregate delivered to the project indicated that the quality of the aggregates for use in test sections 3 and 4 was better than specified. However, due to the 90 day cure time prior to testing and the 4 to 5 weeks of testing time, the final results were not known in time to reject the questionable materials and obtain additional materials of the specified quality. The aggregate that was delivered was already incorporated into the pavement.

The results of the testing that was conducted on the limestones that were delivered to the project are listed below:

Section	Sample Date	Sample Type	Durability Factor	Expansion (percent)	Modified Freeze & Thaw
1	8/26/86	Production	97	0.011	0.98
2	6/03/86	Production	98	0.011	0.96
3	6/03/86	Production	93	0.040	0.96
4	8/26/86	Production	91	0.013	0.95

These results indicate that there were 2 test sections (1 and 2) constructed with Class I Aggregate and 2 sections that were not (3 and 4). Aggregates with the durability factors specified for sections 3 and 4 would be expected to show severe D-cracking within the first 10 years of pavement life. Aggregates that were supplied for sections 3 and 4 should last considerably longer that the anticipated 10 year life. However, the durability factors were still lower than the other two test sections, so the decision was

made to continue monitoring the project. Sections 3 and 4 were still expected to show signs of D-cracking before sections 1 and 2.

PAVEMENT EVALUATION

Cores were taken at the joints of sections 3 and 4 in 1992. None of the cores showed evidence of D-cracking at 6 years of pavement life. D-cracking appeared on the surface of 56% of the joints in Section 4 in 1995. In 1996 67% of the joints in Section 4 displayed D-cracking and minor D-cracking appeared in Section 3. Sections 3 and 4 had averages of 13” and 9” of spalling per joint respectively. Sections 1 and 2 each averaged less than 6” of spalling per joint. In 1997 the D-cracking in section 4 became more pronounced and 93% of the joints in section 3 displayed significant spalling and typical D-cracking that is associated with it.

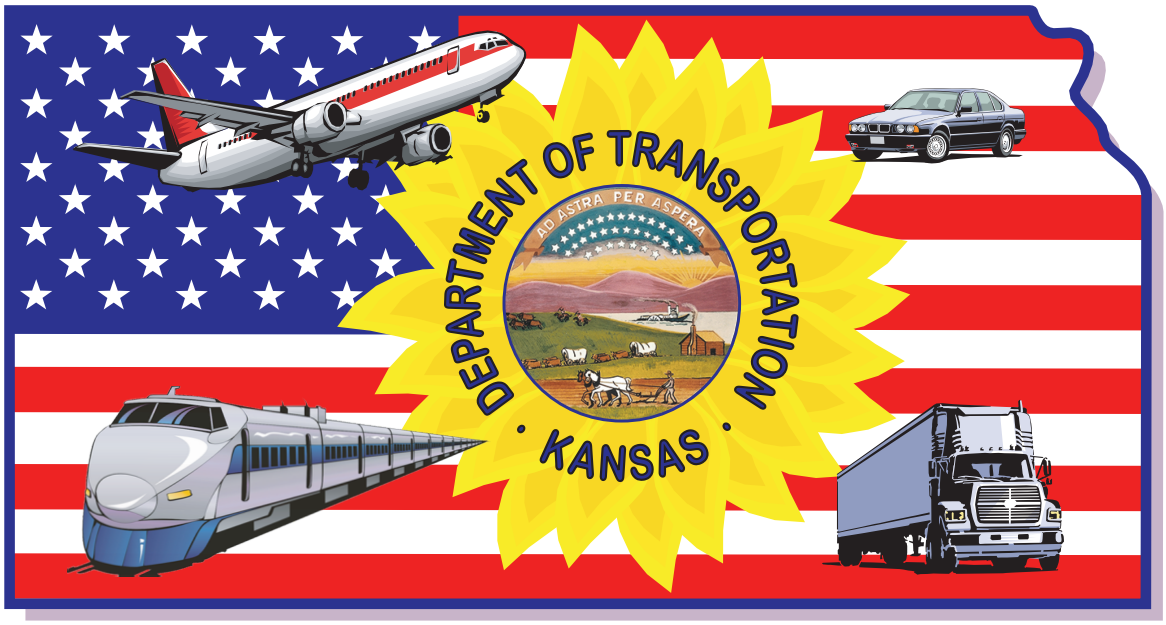
Faulting in all 4 test sections of this non-dowel jointed pavement was still less than 1/8” in 1997. However, in the summer of 1999, a major rehabilitation was done on this project including sections 1, 2, and 3. The pavement in section 4 was too badly deteriorated from D-Cracking distress to rehabilitate so it was deferred and was completely reconstructed with new full depth concrete pavement in the 2000 construction season. The joints in the rehabilitated sections were retrofitted with dowel bars and then the pavement surface was milled to smooth any irregularities. Some areas on this project received partial depth and full depth concrete patches. Some minor patching was done using asphaltic concrete. The patching eliminated the D-cracked areas in section 3. After this, all the transverse and longitudinal joints were widened, cleaned and resealed using a hot asphalt fiber joint sealant that fills the joints and is allowed to flow approximately 76 mm to either side of the joint. In 2005 no mid-panel cracks or

other distresses were noted in any of the repaired sections except for section 3 which displayed a few joint spalls.

CONCLUSIONS

The pavement in section 4 was deteriorated and replaced within 14 years of construction. The limestone in section 4 had a durability factor of 91 which was the lowest of the 4 sections. The D-cracked joints in section 3 were replaced within 13 years of construction. The pavement patching was also due to excessive spalling of the joints. Six years after the rehabilitation, the joints in section 3 again began to show signs of distress. Sections 1 and 2 showed no signs of distress 6 years after the dowel bar retrofit.

Although this project did not demonstrate the rapid deterioration that can happen when extremely low durability factor aggregates are used in concrete pavement, it did demonstrate how quickly a pavement can deteriorate once D-cracking becomes evident. Cores from this pavement showed no sign of D-cracking in 1992. D-cracking appeared on the surface of section 4 in 1995. The pavement in section 4 was deteriorated beyond repair by 1999 and replaced in the year 2000. Had the durability factor of the limestone used in section 4 been below 70 as requested, this deterioration would have occurred at an even more accelerated rate.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