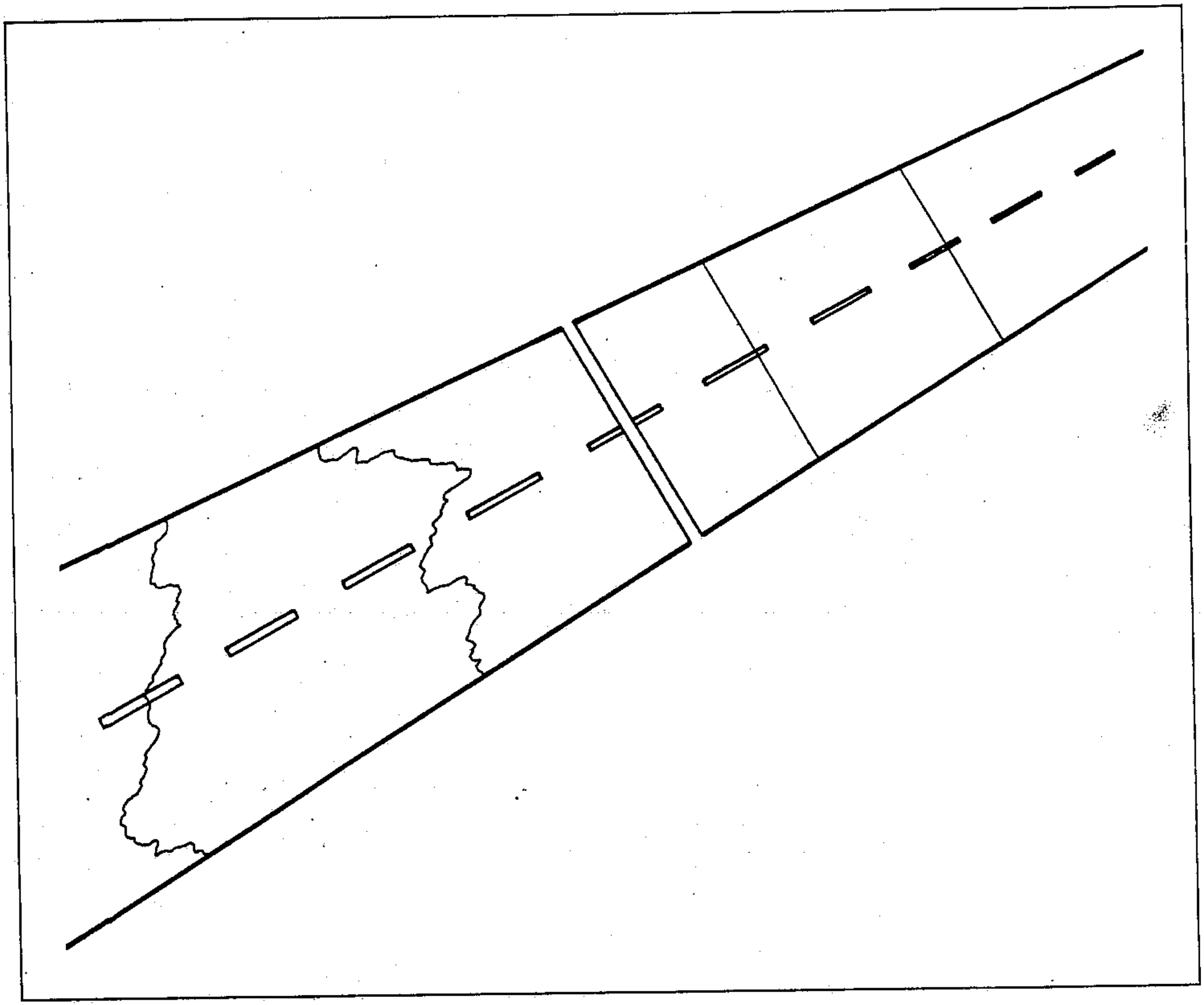

Crack Control of Pozzolanic Bases

Physical Research Report No. 98 / December 1984

Illinois Department of Transportation
Division of Highways

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16. Abstract

Illinois Department of Transportation policies permit three types of stabilized base courses for flexible pavements. In Chicago, pozzolanic aggregate mixtures (PAM) are cheaper than bituminous- and cement-stabilized mixes. As a result, many of the reconstruction projects in that area are being built with PAM as the base course material.

The PAM base course gains its strength through chemical reactions very similar to those characterizing Portland cement concrete. During this process, moisture is depleted, the mixture shrinks, and shrinkage cracks occur. These shrinkage cracks inevitably reflect through the bituminous surface.

To combat this problem, Illinois borrowed a technique used by Portland cement concrete pavers. Joints were cut in the newly placed PAM base course to control the location of the shrinkage cracks and, hence, the reflective cracks. Several joint designs and joint spacings were evaluated. This paper describes the project, summarizes its cost, and evaluates its effectiveness.

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IHR-513
CRACK CONTROL OF POZZOLONIC BASES
Research Summary

In the fall of 1982, the Department constructed an experimental crack control section on Ogden Aveune (US Rt. 54) in Lilse, Illinois. This is a 5-lane facility with an ADT over 20,000, with less than 1 percent truck traffic.

The pavement consisted of 4 inches of granular subbase, 10 inches of PAM, 4-1/2 inches of binder and surface. Three joint spacings were incorporated at 15- 25- and 40-feet and three joint designs as follows:

Design A: PAM was saw cut to 3-1/2 inch depth and binder and surface placed

Design B: PAM was saw cut to 3-1/2 inch depth. Binder and surface were placed. Saw cuts were then placed to a depth of 3 inches in the AC directly over the PAM saw cuts. These surface joints were then sealed with a rubberized asphalt.

Design C: PAM was saw cut to 3-1/2 inch depth. A geofextile "band-aid" 24 inches wide placed. The binder and surface were then placed.

Performance:

The saw cut in Design A has reflected through the surface and looks very much like a crack, except that it is straight. On the 15-foot joint spacings, the cracks are not as wide on the 25' or 40' joints.

Design A, with the 40' spacing, cost an additional $.21/sq. yd. and increased the pavement cost 1.6%.

Design B, with the sawed and sealed surface, seems to be performing the best. All joint spacings appear to have controlled cracking as there are no mid-panel cracks on any of the joints.

Design B, with the 40-foot spacings, cost an additional $1.40/sq. yd. and increased the pavement cost 10.5%.

Design C, which used the geotextile "band-aid", looks like Design A. The geotextile did not prevent crack reflection. The extra cost of the geotextile cannot be justified since it had little or no effect on crack reflection.

With a 40' joint spacing, Design C, cost an additional $.58/sq. yd. and increased the pavement cost 4.3%.

New Research:

In the fall of 1985, Vollmer Road in Chicago Heights was constructed using crack control. Joint spacings of 40 feet were used with a few at 60 and 80 feet. New joint designs were also used; namely, Design B from Ogden Avenue and saw-cutting through AC surface into PAM thereby eliminating matching saw cuts.

It is the intent of the Bureau to follow these projects until 7/87 and evaluate their performance.

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CRACK CONTROL OF POZZOLANIC BASES

by

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INTRODUCTION

Illinois Department of Transportation policies permit three types of stabilized base courses for flexible pavements. In Chicago, pozzolanic aggregate mixtures (PAM) are cheaper than bituminous- and cement-stabilized mixes. As a result, many of the reconstruction projects in that area are being built with PAM as the base course material.

The PAM base course gains its strength through chemical reactions very similar to those characterizing Portland cement concrete. During this process, moisture is depleted, the mixture shrinks, and shrinkage cracks occur. These shrinkage cracks inevitably reflect through the bituminous surface.

The appearance of wandering reflection cracks in the surface detracts from the appearance of the new roadway and disturbs the traveling public. Although the cracking initially is a cosmetic problem, the chances of long-term durability problems also are increased. The cracks allow water, often containing deicing salts, to enter the base. The salt water, combined with freeze-thaw cycles, may lead to localized deterioration and a decrease in rideability.

Shrinkage cracks cannot be avoided. However, the concrete industry controls the location and shape of the cracks by sawing joints at periodic intervals in the freshly placed mix. If the same approach would work for PAM base courses, saw cuts in freshly placed PAM would induce straight shrinkage cracks, leading to straight reflective cracks in the asphalt surface. These regularly occurring "joints" in the surface course would be more acceptable to the public and could be waterproofed by any of several techniques.

The spacing of saw cuts in the PAM base course was thought to be critical. If the cuts were too far apart, shrinkage cracks might occur between the "joints." If the spacing were closer than necessary, the cost could become prohibitive. In 1982 the Department decided to construct an experimental section to determine the feasibility of crack control for PAM bases.

DESCRIPTION OF OGDEN AVENUE

To expedite matters, the Department decided to incorporate an experimental section within a project already under contract. After evaluating several candidates, the reconstruction of Ogden Avenue (Route US 34) was selected.

Ogden Avenue, located in Lisle, Illinois, just southwest of Chicago, is a two-directional, 5-lane facility. Because of the numerous businesses along the route, the center lane is dedicated to left-turn movements. Average daily traffic is 20,000, with less than one percent commercial truck traffic.

The typical cross section for the reconstruction called for 4 inches of granular subbase, 10 inches of PAM base, 3 inches of bituminous binder and 1 1/2 inches of bituminous surface. Curb and gutter was to be constructed along the entire project with numerous entrances provided for businesses.

EXPERIMENTAL DESIGN

Several miles of Ogden Avenue were being rebuilt. Only about 1000 feet of the project was affected by the crack control experiment.

The experimental feature consisted of three separate designs. In each case, construction of the subbase and base courses was governed by the existing contract specifications. Only after the PAM base course had been compacted and sealed for curing did the construction procedures vary. The three designs are listed below.

Design A: Joints were cut in the PAM base course to a depth of 3 1/2 inches. Binder and surface were placed directly over the PAM.

Design B: Joints were cut to a depth of 3 1/2 inches in the PAM base course. Binder and surface were placed. Joints were then cut 3 inches deep into the asphalt directly over the joints in the base course. These surface joints were then sealed with hot-poured rubberized asphalt.

Design C: Joints were cut to a depth of 3 1/2 inches in the PAM base course. A geotextile strip 24 inches wide was placed over the joint using an AC-10 to bond it in place. The binder and surface were then placed.

Each of the three designs incorporated joint spacing of 15, 25, and 40 feet as shown in Figure 1. Station 700+00 shown in the figure is located about one mile east of Route Ill. 53. The experimental feature extends to the west for a total of 1005 feet. A 1000-foot control

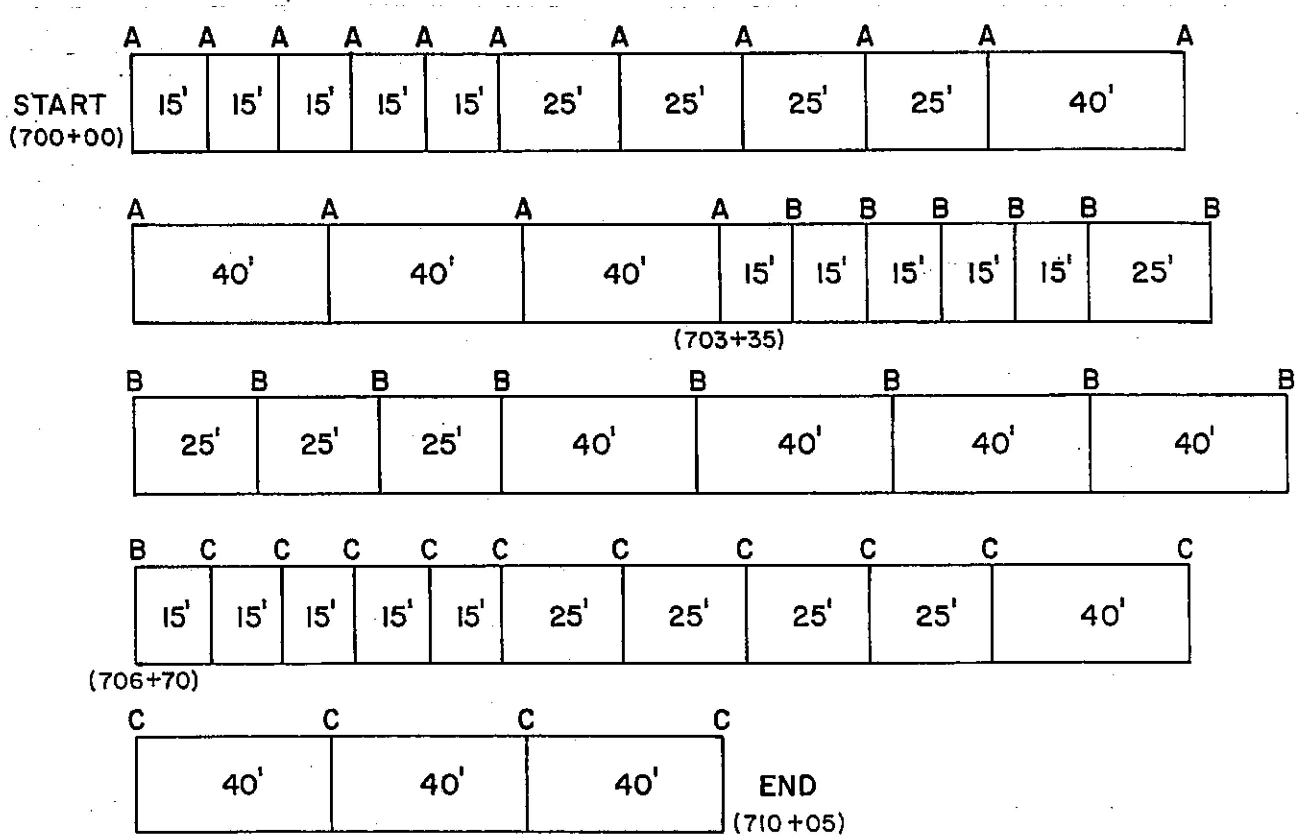

Figure 1. Experimental Design.

section (normal construction - no joints) was selected adjacent to the experimental section for comparison purposes.

COST OF DESIGN ALTERNATIVES

Since the project was already under contract, the costs for incorporating the experimental section reflect negotiated rates. These costs are believed to be higher than if a competitive bidding situation had existed.

- Sawing joints in the PAM base - $0.91 per lineal foot.
- Geotextile application - $1.65 per lineal foot.
- Sawing and sealing surface joints - $5.31 per lineal foot.

These prices can be converted into cost per square yard by dividing the cost of each joint treatment by the number of square yards between the joints. For Design A, each joint cost $50.05. For 15-foot spacing, the area between joints was 91.67 square yards. Thus, the cost per square yard of pavement could be expressed as $\frac{\$50.05}{91.67\ yd^2} = \$0.55/yd^2$

Table 1 contains the costs on a square yard basis for each joint design and joint spacing.

Table 1. Cost of Crack Control. ($\$/yd^2$)

DESIGN	JOINT SPACING		
	15 ft	25 ft	40 ft
A	0.55	0.33	0.21
B	3.73	2.24	1.40
C	1.54	0.92	0.58

Based upon actual bid prices of 4-inch granular subbase, 10-inch PAM base, the prime coat used for curing, 3-inch binder and 1 1/2-inch surface, the total cost of the pavement section was $\$13.06/yd^2$. Dividing the costs of crack control (shown in Table 1) by the total cost of the pavement produces a "percent increase of cost" for crack control. Table 2 contains these values.

Table 2. Increased Cost. (% of Pavement Costs)

DESIGN	JOINT SPACING		
	15 ft	25 ft	40 ft
A	4.1	2.5	1.6
B	27.9	16.8	10.5
C	11.5	6.9	4.3

The cost of the new pavement section for the Ogden Avenue reconstruction project was only about 1/3 of the total project cost. Old pavement removal, drainage correction, and traffic control consumed 2/3 of the project dollars.

Table 3 presents the percentage increase in terms of total contract price for the various joint designs and spacings.

Table 3. Increased Cost. (% of Total Project Costs)

DESIGN	JOINT SPACING		
	15 ft	25 ft	40 ft
A	1.4	0.9	0.6
B	9.7	5.8	3.6
C	4.0	2.4	1.5

PAVEMENT CONDITION SURVEYS

The experimental and control sections have been surveyed periodically since their construction in the Fall of 1982. A summary of the observations is given below.

EXPERIMENTAL SECTIONS

Two years after construction, every joint has reflected through the surface, but there are no cracks anywhere else within the experimental section. Other than delaying the appearance of the reflective cracks by a few months, the shorter joint spacings have offered no visible benefit over the longer spacings.

The appearance of Design B (where the surface was cut and sealed) is far superior to Designs A and C. Design A controlled the location of the cracks, but the cracks appear rather ragged and would be difficult to seal. The surface joints provided in Design B remain well sealed and look very much like Portland cement concrete joints. Design C appears to be the worst of the three designs. The reflected surface cracks are ragged like those in Design A but seem to wander to a greater degree.

CONTROL SECTION

The reflective cracks in the control section (no joints) have occurred at random intervals. While most of the cracks are perpendicular to the curb line, they rarely extend across the 55-foot pavement at one location. Instead, a series of shorter cracks often offset by several feet span the pavement. The cracks are ragged in appearance, very similar to those of Designs A and C. Figure 2 contains a plan view of the crack locations in the control section.

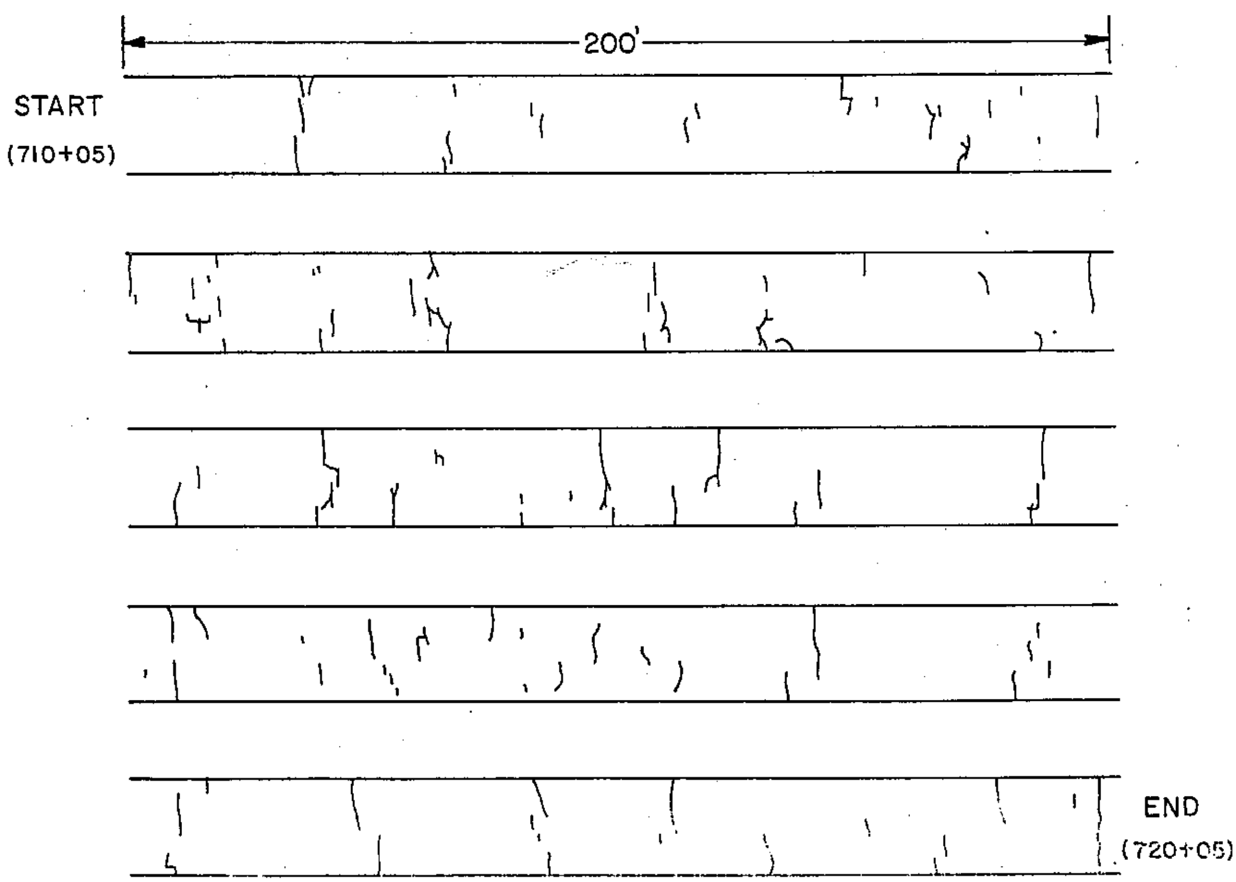

Figure 2. Crack Pattern in Control Section.

DEFLECTION TESTING

In an attempt to determine whether the different designs have affected durability, the Illinois DOT's Road Rater was used to take deflection measurements at each joint. An 8,000-pound peak-to-peak load was applied at 15 Hz. The average deflection values for each design and the control section are shown in Table 4.

Table 4. Dynamic Deflection (Mils).

DESIGN	JOINT SPACING		
	15 ft	25 ft	40 ft
A	4.6	6.1	5.6
B	5.0	7.0	7.6
C	4.0	4.0	4.9
CONTROL	← 5.8 →		

Surprisingly, Design B (the jointed and sealed surface) had the highest deflection. However, all of the deflections are considered to be quite low, indicating excellent base support at all locations. The fact that Design B has the highest deflection may be attributed to the total absence of slab action since its surface was severed.

CONCLUSIONS

To date all three joint spacings in all three designs have successfully controlled the location of the surface cracks. However, the project has only been in place two years, and the Department believes it too early to conclude that a 40-foot joint spacing is as effective as the shorter spacings.

From a purely aesthetic viewpoint, Design B was by far the most successful. The sealed surface joints do not detract from the pavement's appearance. The reflective cracks appearing above the base joints in Designs A and C are just that - cracks. The location has been controlled but the ragged appearance of the reflective cracks is not pleasing.

Deflection measurements taken on both the experimental and control section indicate there has been no loss of base strength anywhere along the project. It is too early to determine whether the sealed joints of Design B will result in increased base durability.