OFFICE MEMORANDUM

DATE: April 27, 1976

TO: L. T. Oehler
Engineer of Research

FROM: F. Copple

SUBJECT: Comparative Performance of Contraction Joints on I 75, Saginaw and Genesee Counties.
Research Project 75 TI-303. Research Report No. R-996.

At the Engineering Operations Committee meeting on October 1, 1975, the Research Laboratory was requested to investigate the reason for the dramatic difference in the performance of contraction joints on two different lengths of I 75.

Figure 1 shows locations of the areas of highway under investigation. The northern length of pavement, Construction Projects 73171, C4, C6, and C8 had joints which appeared to be virtually perfect while the southern length, Construction Projects 25131, C3 and C5, showed serious deterioration at almost every joint.

L. D. Abbey, Assistant District Maintenance Engineer at Saginaw, reported the northern length of pavement, which was constructed in 1961, had no blowups and only about one percent of the joints showed serious deterioration. He estimated an annual joint maintenance cost of about $500 per mile. In contrast, Mr. Abbey reported the southern length of pavement, constructed in 1962, had 185 joint (single lane) blowups, about 85 percent of the joints showed serious deterioration, and estimated annual joint maintenance costs of $5,000 to $8,000 per mile. Figures 2 and 3 show photographs of a few joints on each project.

An investigation of factors involved showed that the coarse aggregate was the only major difference between the two lengths of pavement. The projects with poor joints used coarse aggregate from American Aggregates Corporation at its pit near Oxford (25131, C3) and from the Groveland Pit (25131, C5). The projects with good joints used coarse aggregate from the Inland Lime and Stone Pit (limestone).

The effect of coarse aggregate on joint blowups was shown more than 30 years ago by Woods, Sweet, and Shelburne (1). In 1965, the Research Laboratory investigated two adjacent pavement projects, one with joints that appeared perfect and the other with almost every joint distressed.

Research Report No. R-555, which describes the pavements, located on US 127 in Hillsdale County, is attached. It was concluded in the Report, that the key variable was coarse aggregate. The portion of US 127 with poor joints consisted of coarse aggregate from the Oxford, Green Oak, and Vernier Pits; while the pavement with good joints was made of coarse aggregate from the Silica Pit, a limestone.

In 1970, Oehler and Holbrook (2) also reported that concrete pavements using limestone aggregates demonstrated superior structural performance. They further reported structural performance to be adversely affected by cherts, non-durable, and hard absorbent particles.

Why have limestone concrete pavements in Michigan performed so well structurally? Perhaps because limestone has a low coefficient of thermal expansion as compared to many other types of aggregates found in Michigan. Limestone has a coefficient of thermal expansion averaging about $2.5 \times 10^{-6}/F$ whereas an average value of 5 to $5\text{-}1/2 \times 10^{-6}/F$ is common for concrete. Woods, Sweet, and Shelburne (1) reported that limestone projects in Indiana performed poorly, possibly because of impurities.

In conclusion, it is certain that coarse aggregates are a major influence in the performance of concrete pavement joints. Although, limestone, at least in lower Michigan, is associated with good joint performance, we don't really know all the reasons why. A thorough research study would be required to determine the mechanism of coarse aggregate influence on joint performance.

TESTING AND RESEARCH DIVISION

Supervisor
Pavement Performance Group

FC:bf

REFERENCES

1. Woods, K. B., Sweet, H. S., and Shelburne, T. E., "Pavement Blowups Correlated with Source of Coarse Aggregate," HRB Proceedings, 1945.

2. Oehler, L. T., and Holbrook, L. F., "Performance of Michigan's Postwar Concrete Pavement," MDSHT Research Report No. R-711, June 1970.

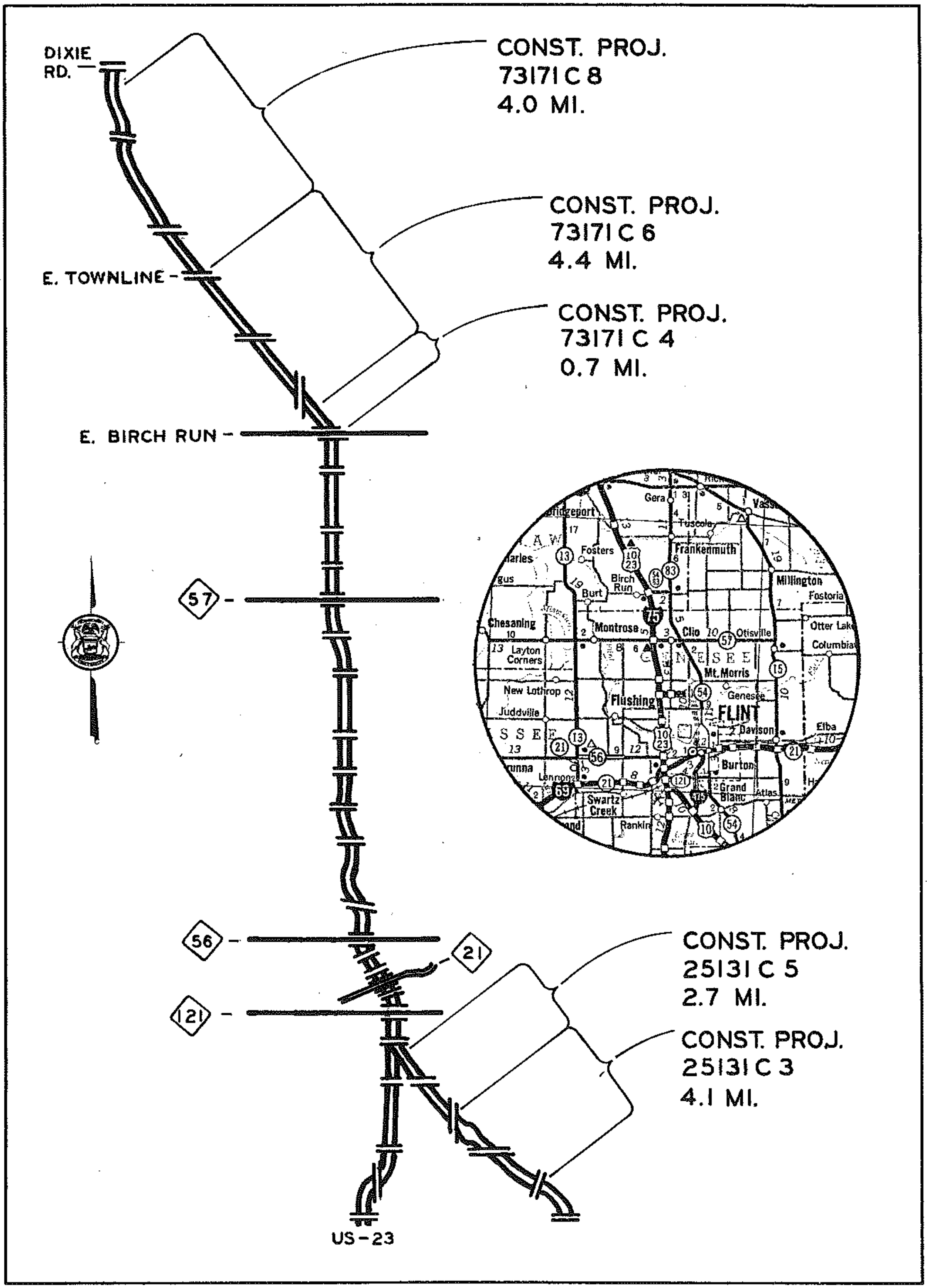

Figure 1. Projects used in comparison study of contraction joint performance.

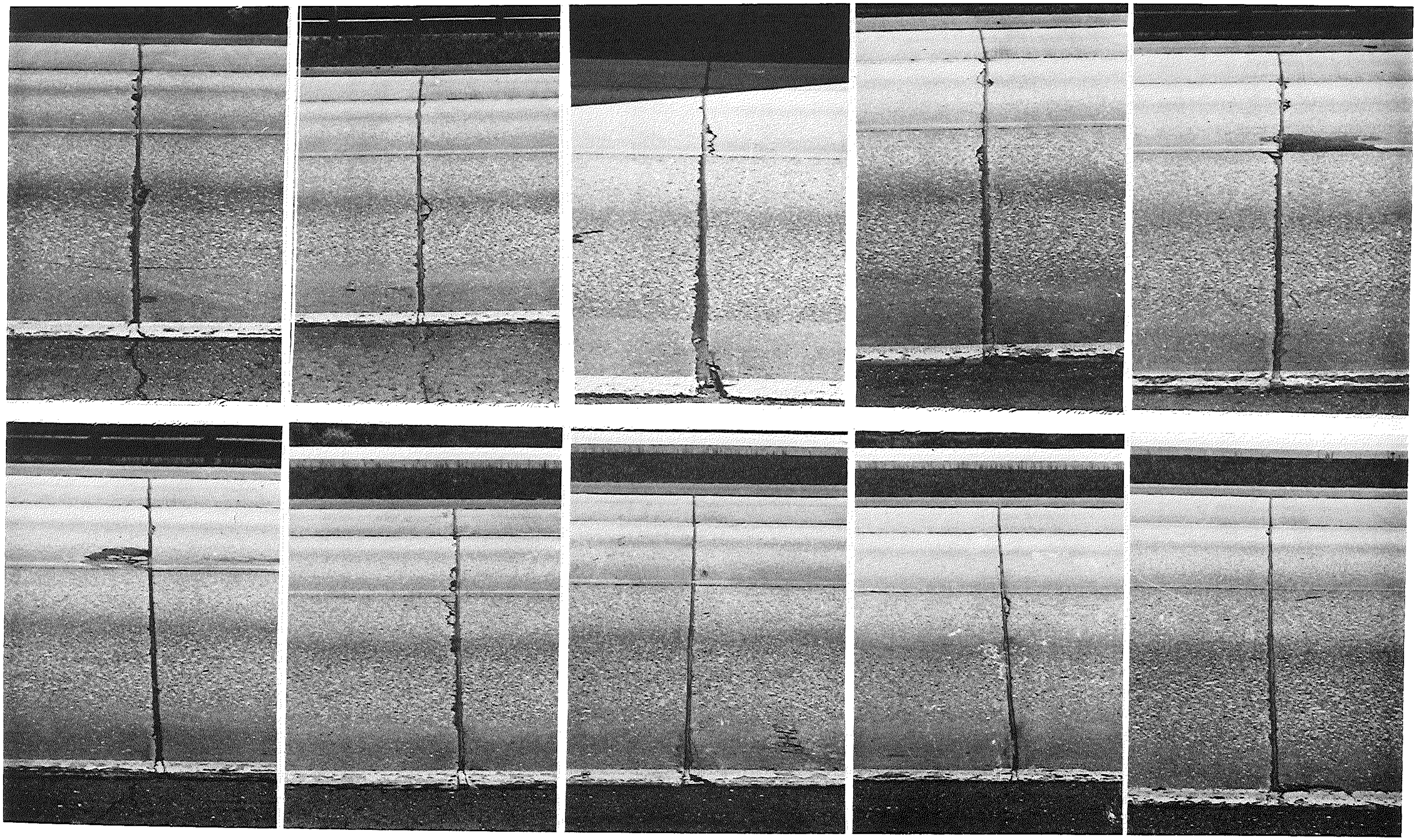

Figure 2. I 75 Saginaw County (between Birch Run and Bridgeport). First 10 joints starting 300 ft north of South County Line.

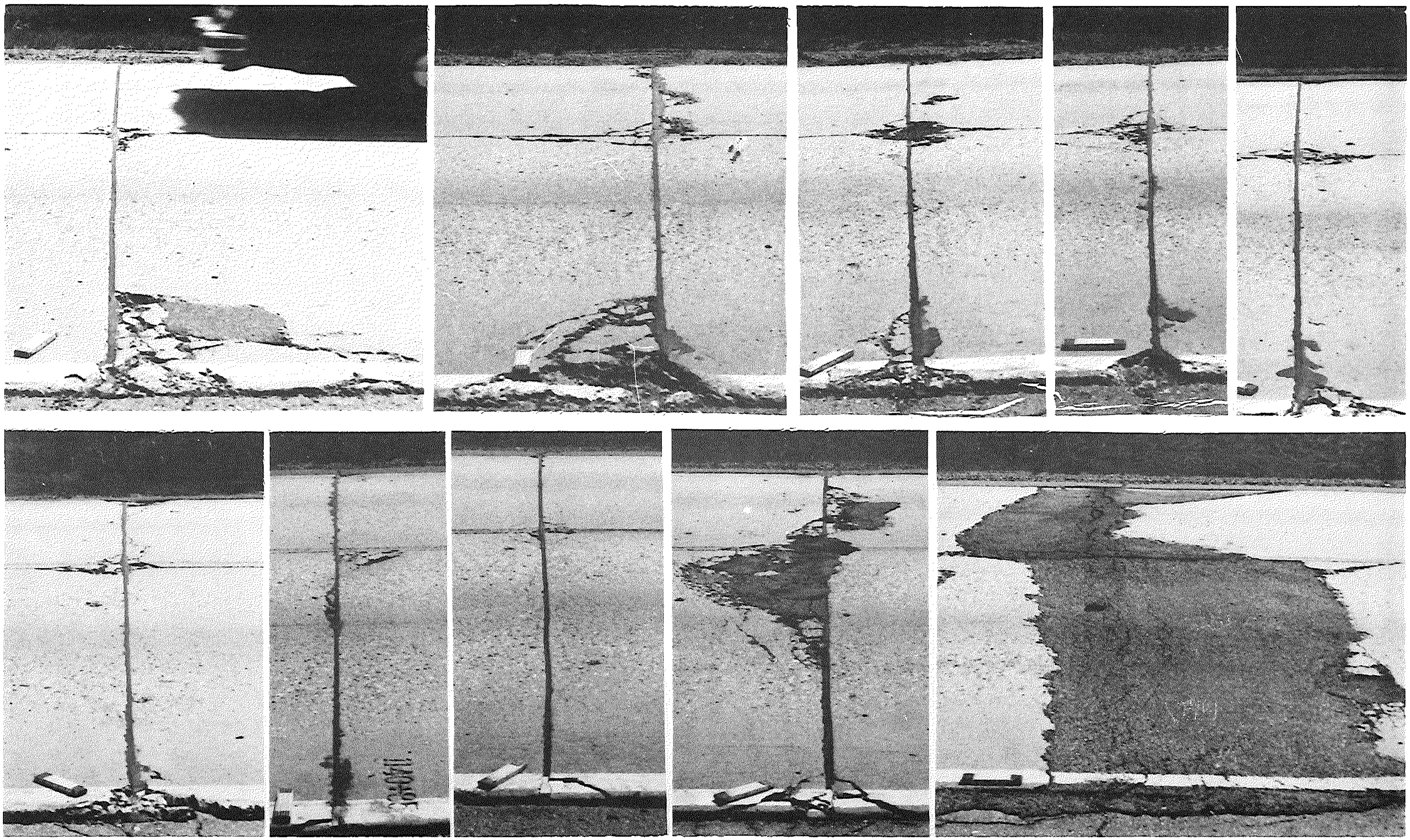

Figure 3. I 75 Genesee County (between South County Line and US 23). First 10 joints starting 300 ft north of Oakland County Line.

OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

March 1, 1966

To: E. A. Finney, Director
Research Laboratory Division

From: F. Copple

Subject: Inspection of Pavement Joints on US 127: Hudson to Ohio State Line. Project 39 F-7(14). Research Report No. R-555R.

On September 22, 1965, Construction Projects 30-04, C3 and 30-04, C5 located on US 127 from Hudson south to the Ohio border, were inspected by G. R. Cudney, J. E. Simonsen, and F. Copple.

(1) Construction Project 30-04, C3

Almost every joint in this project, which extends about 5 miles south from Hudson, was distressed to some degree, with about 50 percent of the joints in very bad condition. Figure 1 shows a badly distressed joint typical of this project with its profile revealed through a hole dug in the shoulder.

The concrete at the joint had disintegrated in a wedge shape, tapering up to the dowel bars from the plastic base plate. The concrete above the dowels was fractured into small pieces, as though subjected to severe compression. The surface of this project had numerous popouts (Figs. 1 and 2).

Characteristics of this construction project are as follows:

Date of concrete pour -- September-October 1947
Project length -- 5 mi.
Pavement width -- 22 ft
Slab depth -- 8 in.
Reinforcement -- standard wire mesh
Slab length -- 100 ft
Load transfer -- 1 by 15 in. dowel bars at 12-in. centers
Curing -- clear membrane
Cement -- Huron Vinsol Resin
Fine aggregate -- Elliot Pit, Hudson (Harry Pickett)
Coarse aggregate -- Oxford Pit (American Aggregate)
Green Oak Pit (American Aggregate)

Construction Project 30-04, C5

Joints in the northern portion (Sta. 105+27 to 266+00) of this project were in excellent condition with almost no distress evident. Figure 3 shows a typical joint in this area. However, from Sta. 105+27 south to the Ohio border, numerous joints had serious spalls where maintenance was required.

By digging through the shoulder, the profile of an apparently sound joint in the northern portion was revealed as shown in Figure 4. In this area, the concrete had disintegrated in a typical wedge, with its wider end across the plastic base plate, tapering to an apex near the dowel bars. This suggests that a series of joint failures may be imminent in the currently satisfactory northern portion of this project.

Pavement characteristics of this project are as follows:

Date of concrete pour -- September-October 1949
Project length -- 4.8 mi.
Pavement width -- 22 ft
Slab depth -- 8 in.
Reinforcement -- standard wire mesh
Slab length -- 99 ft
Load transfer -- 1 by 15 in. dowel bars at 12-in. centers
Curing -- clear membrane
Cement -- Huron Vinsol Resin
Fine aggregate -- Vernier Pit, Ransome Twp. (Harry Pickett)
Coarse aggregate -- Sta. 22+11.5 to 105+27: from Vernier Pit, Ransome Twp. (Harry Pickett)
Sta. 105+27 to 136+39: from Silica Pit (Sylvania, Ohio)
Sta. 136+39 to 266+00: 4A from the Silica Pit and 10A from the Vernier Pit.

Subbase Testing

At the request of W. W. McLaughlin, samples from the subbase of both projects were obtained and tested in the Research Laboratory's soils laboratory. Eleven areas, selected at random throughout the lengths of the projects were sampled on November 4, 1965 at the general locations shown in Figure 5.

These subbases were placed before the introduction of current specifications which require gradation control for this type of material. Granular materials selected by the Soils Engineer for these jobs were probably of the Coloma or Bellefontaine series, with which possibly were mixer other granular materials salvaged from older roadways in the area.

Average results obtained from testing the eleven subbase samples were as follows:

	Percent Passing	
Sieve Size	30-04, C3	30-04, C5
3/4-inch	98.7	99.7
3/8-inch	95.2	99.3
No. 4	90.7	98.1
No. 8	85.8	96.7
No. 30	67.3	92.3
No. 200	12.4	15.6
Average Field Moisture Content, percent	8.0	9.1

Both materials can be grouped under AASHO classifications as A-2-4 soils, a designation indicating a good subgrade rating. These tests show no indication that subgrade composition has contributed to the condition of the concrete surfaces. In fact, due to the lower fines content, the subgrade beneath Project 30-04, C3, with the poorer joints, should be somewhat more satisfactory than that under Project 30-04, C5.

Discussion

The 1964 ADT for the length of US 127 under study varied from about 3500 just south of Hudson to 2600 just north of the Ohio border. About 12 percent of the vehicles were commercial.

Performance of the two projects may be summarized as follows:

Construction Project	Joint Performance	Popouts	Transverse Cracks
30-04, C3	Very Poor	Numerous	Numerous
30-04, C5			
Sta. 22+11.5 to 105+27	Poor	Numerous	Numerous
Sta. 105+27 to 136+39	Excellent	Almost None	Numerous
Sta. 136+39 to 266+00	Excellent	Almost None	Numerous

Comparison of these three data tabulations shows that the only apparent difference in the construction factors of pavements with excellent and poor joints is the coarse aggregate used in the concrete. The pavement constructed using coarse aggregate from the Silica Pit (limestone) had joints that performed excellently. Figure 5 shows the distribution of the various sources of concrete coarse aggregate used in the projects.

Samples of the crumbly concrete material were taken from the rotted wedges of joints in both construction projects. Analysis of this material indicated 0.34 lb of free sodium chloride per ton of concrete in Project C3 and 0.62 lb per ton in Project C5. These results support the theory that concrete deterioration in the lower section of joints is aggravated by the penetration of salt solutions (from ice control chemicals) into the pavement joints, and their subsequent impoundment by joint base plates.

It is proposed to make an annual condition survey of sample lengths of Project 30-04, C5 to determine if and when the joints begin to fail.

OFFICE OF TESTING AND RESEARCH

F. Copple

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Soils Unit
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FC:jcb

cc: G. R. Cudney
L. T. Oehler
R. C. Mainfort

Figure 1. Distressed joint with end exposed: Construction Project 30-04, C3.

Figure 2. Numerous popouts in pavement surface: Construction Project 30-04, C3.

Figure 3. Typical joint in Construction Project 30-04, C5, between Stations 102+57 and 266+00.

Figure 4. End view of sound joint in Construction Project 30-04, C5, before removal of end plate (top), and after removal of end plate (bottom). Note disintegration of concrete above base plate.

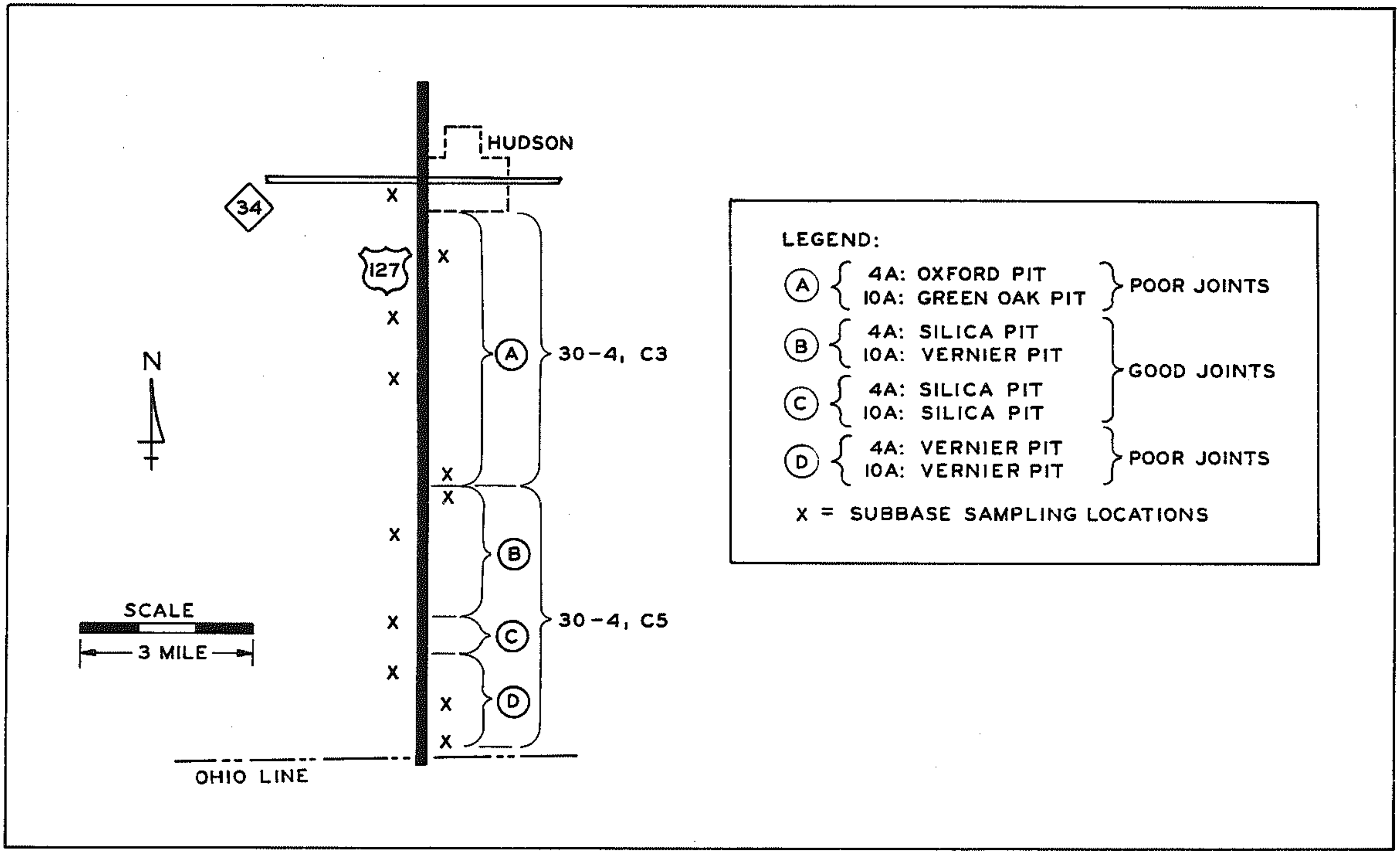

Figure 5. Distribution of coarse aggregates used in concrete on US 127 projects from Hudson to Ohio State Line.