BULKHEAD JOINTS FOR CONCRETE BASE SHOULDERS

Final Report

MICHIGAN DEPARTMENT OF
STATE HIGHWAYS AND TRANSPORTATION

BULKHEAD JOINTS FOR CONCRETE BASE SHOULDERS

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Final Report on "Category 2" Experimental Construction Project

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Introduction

This is the final report covering the performance of lane ties used in bulkhead joints for concrete base shoulders. The project was initiated as a result of the Pavement Selection Committee meeting of April 1970. The work was done by the Michigan Department of State Highways and Transportation as a "Category 2" experiment, in cooperation with the Federal Highway Administration.

The Department's Construction Division selected the location for the experiment, prepared the authorizations, and supervised the construction of the project. The Research Laboratory established reference points for measurements, and is responsible for evaluating and reporting results.

Thermal expansion and frost action have, on occasion, resulted in horizontal and vertical displacement of concrete base shoulders. This displacement interferes with the lateral drainage of the roadway, allows increased amounts of water to penetrate into the base, and is troublesome with regard to snow removal operations (the raised shoulders interfere with scraper blades, and damage to both blades and shoulders can occur).

It was the objective of this study to determine if the addition of lane ties has a beneficial effect in deterring differential movements between the roadway and concrete base shoulders.

General Information

Hookbolt lane ties were installed in the concrete base course shoulder widening for ramps C and E of the La Porte Rd interchange and on the ramps of the nearby rest area on I 94 near the Indiana State Line (State Project BI 11014-010). The lane ties were placed by authorization on the original contract. Ramps A, B, and F of the same interchange have no lane ties and were used as control ramps. Ramps A, B, and F were constructed under State Project BI 11014-012. Figure 1 shows the location and layout of the experimental and control ramps.

Instrumentation

All the ramps were instrumented with flat-head stainless steel rivets which have a conical recess machined in the top to accept mating cones on the ends of the reading devices. The rivets were set 4 in. each side of the bulkhead joint and at 50-ft intervals along the length of the ramps. Only the 7-ft wide shoulders were instrumented. The 7-ft wide shoulders are located on the right side of the ramps with respect to the direction of traffic.

In order to obtain stable reference points, the rivets were recessed approximately 1 to 1-1/2 in. into the bituminous wearing course and grouted

in the concrete base course with non-shrinking mortar. Recessing the rivets eliminated their loss due to scraper blade damage during snow removal operations. Rivets in the roadway were similarly recessed. The ramps were instrumented shortly after construction. Ramp B was completed in the fall of 1970, the remaining ramps were finished in the fall of 1971.

Measurements

Measurements for joint opening and faulting are made across the longitudinal bulkhead joint. Joint opening measurements are made with a vernier caliper, and fault measurements with the special fixture shown in Figure 2. The two forward legs of the instrument are set in the rivets, the rear leg is adjustable and is used to level the device. A reading is then taken from the scale on the right side of the fixture. Changes in reading from one time to another indicate a relative vertical displacement of the roadway and shoulder. Readings have been taken in the spring and fall of each year since the ramps were instrumented.

Observations

Table 1 shows the average joint opening for each ramp, along with related information. The amount of joint opening shown is the average of the total number of readings taken on each ramp in March 1976.

TABLE 1
SUMMARY OF RAMP DATA

Ramp Designation	Project Number	Hook Bolts	Instrumented Section	Length, ft	Number of Readings	Average Joint Openings as of March 1976, in.
A	BI 11014-012	No	Sta. 31+50 to Sta. 19+84	1166	24	0.10
B	BI 11014-012	No	Sta. 33+95 to Sta. 21+50	1245	26	0.13
C	BI 11014-010	Yes	Sta. 12+56 to Sta. 22+50	994	21	0.04*
E	BI 11014-010	Yes	Sta. 10+81 to Sta. 19+74	893	20	0.02
F	BI 11014-012	No	Sta. 28+96 to Sta. 16+02	1294	27	0.07
Rest Area "On" Ramp	BI 11014-010	Yes	Sta. 7+00 to Sta. 16+48	948	20	0.07*
Rest Area "Off" Ramp	BI 11014-010	Yes	Sta. 30+69 to Sta. 40+95	1026	22	0.03

* By deleting the initial three reference points, averages drop to 0.02 and 0.03 in. for ramp C and rest area "on" ramp, respectively.

The average joint openings of ramp C and the rest area "on" ramp are somewhat misleading due to the fact that the first three reference points contribute greatly to the averages shown (0.04 and 0.07 in.). By deleting these initial three readings, the averages drop to 0.02 and 0.03 for ramp C and the rest area "on" ramp, respectively. These averages are close to the average movements shown by the other tied ramps. The possibility exists that the large joint openings at the beginning of the ramps are caused by omission of the lane ties. Also, the only location exhibiting any sizeable vertical displacement is at the beginning of the rest area "on" ramp. At this location, the shoulder has raised approximately 5/16 in.

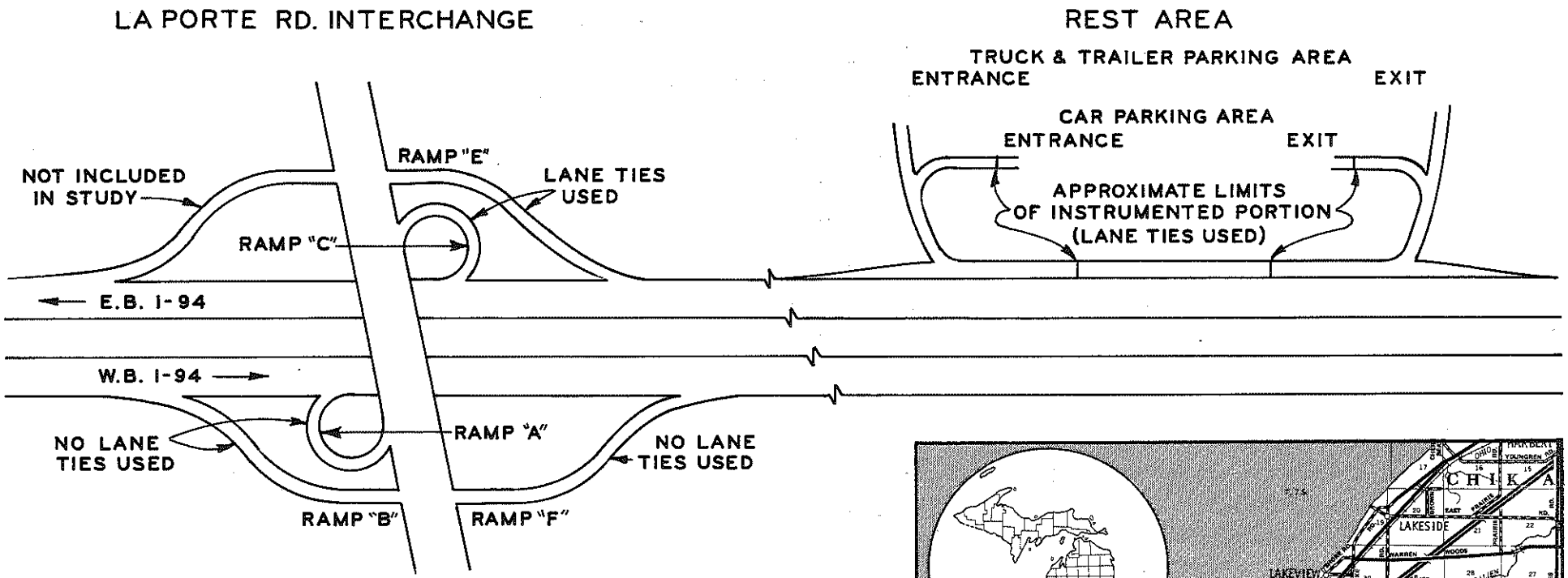
Readings taken since instrumentation of the ramps have shown a continuing increase in average joint opening on ramps without lane ties. The average openings on ramps with lane ties increased slightly from 1971 to 1975 and remained constant from 1975 to 1976. The average increase in joint opening, with respect to time, for ramps with and without lane ties is shown in Figure 3.

As was stated in the report issued two years after construction of the ramps, "It appears that once an opening is established, penetration of water into the base along with freeze-thaw cycles contribute to further opening of the joint." This assumption has been verified by measurements obtained since that report was issued. It appears that the openings established in untied ramps will continue to increase. Joint openings in ramps with lane ties seem to stop at an average opening of 0.020 and 0.030 in.

Observations on concrete base course with and without lane ties in the I 94 - I 69 interchange, show similar results, with the bulkhead joints spreading open where lane ties were omitted. Although little vertical movement of the shoulders has been recorded on these experimental sections; it is quite likely that vertical displacement will take place at locations where soil conditions are susceptible to frost heave action.

Conclusion and Recommendation

Based on the performance of instrumented concrete base shoulders, the use of lane ties is beneficial in maintaining tight bulkhead joints. Therefore, since the cost of lane ties is minimal, we recommend lane ties be used on all future concrete base course shoulders or widenings.



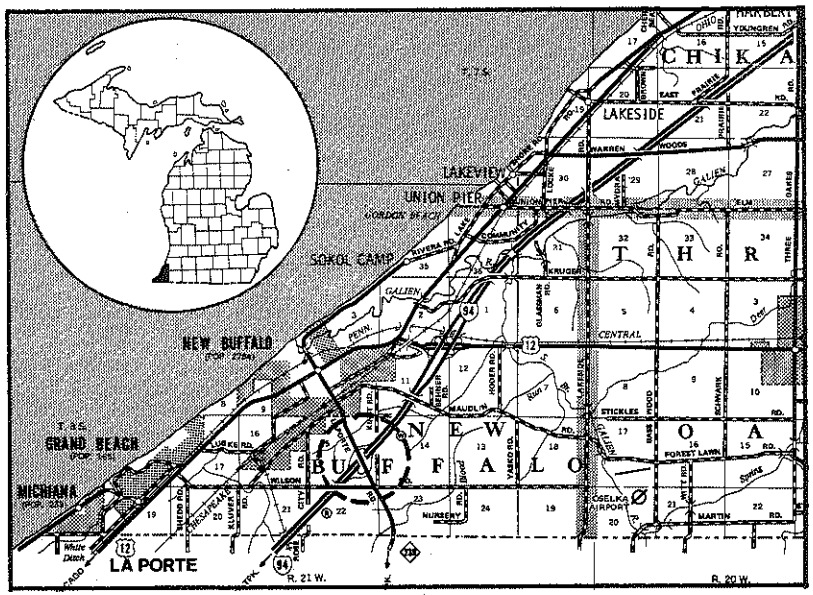


Figure 1. Location and layout of instrumented ramps.

Figure 2. Special fixture for measuring faulting of joint.

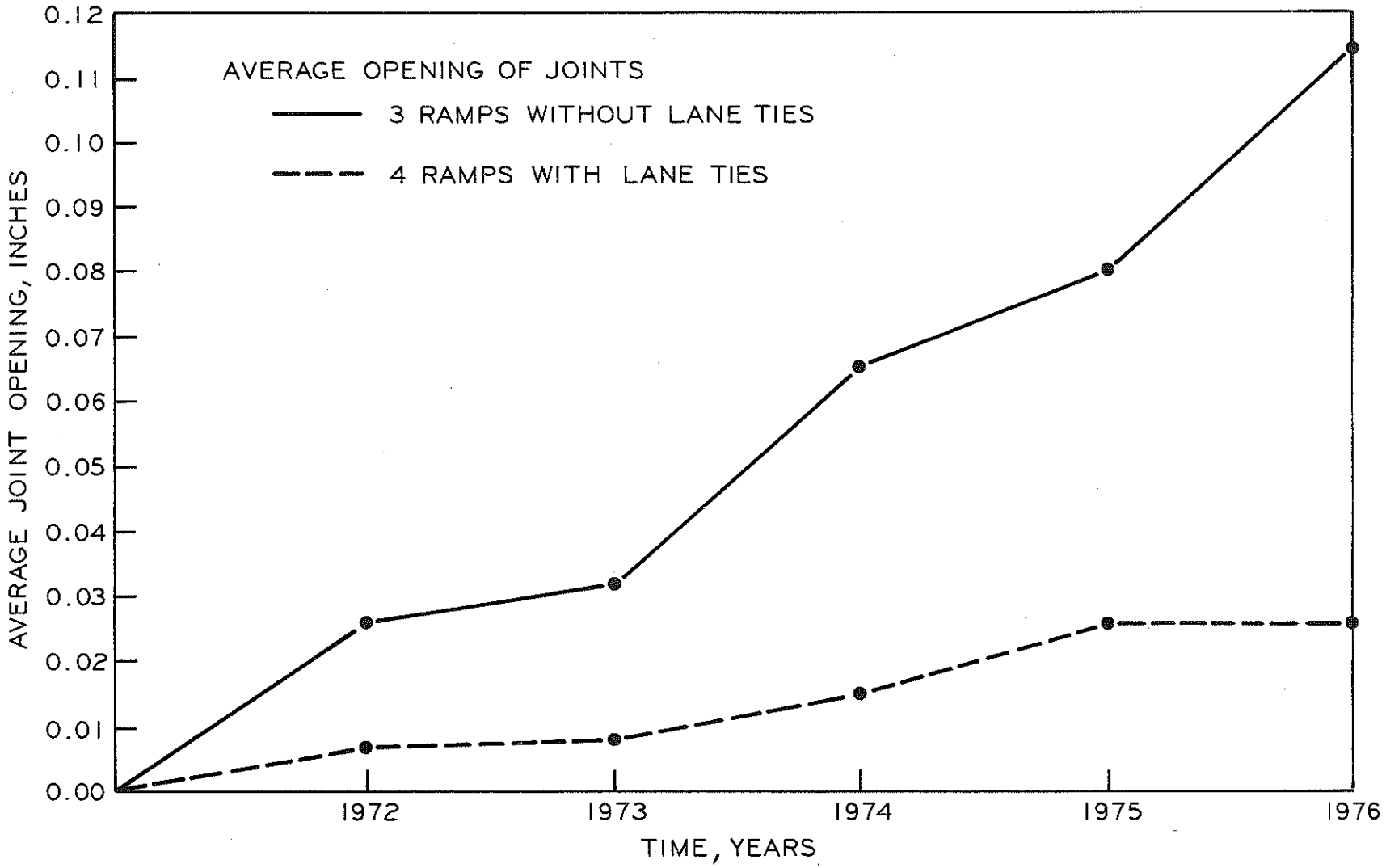


Figure 3. Average increase of joint opening for ramps with and without lane ties.