EXPERIMENTAL CONCRETE AND BITUMINOUS SHOULDERS
(Progress Report)

MICHIGAN
HIGHWAY RESEARCH LABORATORY SECTION

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EXPERIMENTAL CONCRETE AND BITUMINOUS SHOULDERS
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Introduction

This progress report covers the findings to date of the evaluation of experimental concrete and bituminous shoulders. The work is being done by the Michigan Department of State Highways and Transportation as a "Category 2" experiment, in cooperation with the Federal Highway Administration.

The purpose of this study is to evaluate the cost and performance of experimental concrete and bituminous shoulders in comparison with the standard shoulder used for Michigan Interstate freeway construction.

General Information

Construction procedures, details, initial costs, instrumentation, and methods of measurement have been previously reported in MDSHT Research Report R-844 (January 1973). Briefly, an experimental portland cement concrete shoulder, two experimental bituminous shoulders, and the standard shoulder for Interstate construction, were installed in a test area on I 69 between Charlotte and Olivet. Three test sections of each type were constructed. Details of the installation are shown in Figures 1, 2 and 3.

Each section is approximately one-half mile long; only the outside shoulders are included in the experiment. The concrete shoulders were built in the fall of 1971. Most of the remaining shoulder construction was done, and the roadway opened to traffic in late 1972.

Performance of the bituminous shoulders is checked by condition surveys, noting the amount of cracking and other observable deterioration. The concrete shoulders contain instrumented sections from which longitudinal and transverse joint movements and elevation changes are obtained. In addition to the readings taken, the concrete shoulders are also checked for any observable deterioration.

Since only the initial construction costs are available at this time, analysis of initial expenditure as compared to long term performance of the shoulders will not be discussed in this report. This information will be reported as it becomes available.

Observations

The onset of bad weather prevented the placement of the seal coat on "Type A" bituminous shoulders. These sections remained through the first winter with the asphalt stabilized soil aggregate exposed. Application of the seal coat was performed in the spring of 1973.

The initial condition survey performed shortly after construction (fall, 1972) revealed no obvious flaws in any of the sections.

Results of the condition survey performed one year later (fall, 1973) are given in the following paragraphs.

"Type A" bituminous shoulders - After approximately one year of service, there is no visible deterioration of any portion of this type shoulder. Figure 4 shows the typical condition of "Type A" shoulders in the fall of 1973.

"Type B" bituminous shoulders - Figure 5 shows a typical portion of the "Type B" shoulder. This type shoulder does not show any visible deterioration after approximately one year of service.

Standard bituminous shoulders - After one winter, the standard shoulders used for Michigan Interstate freeway construction have developed longitudinal cracking throughout the entire sections under observation. Cracking has occurred longitudinally along both edges of the shoulder. Near the pavement, a single longitudinal crack is present approximately six inches from the edge. On the outside edge, "alligator cracking" of the shoulder has occurred in an area approximately two feet wide. The center portion of the shoulder shows no evidence of deterioration. A typical portion of the standard shoulders is shown in Figure 6.

Concrete shoulders - Figure 7 shows the typical condition of concrete shoulders in the fall of 1973. After approximately one year of service, the concrete shoulders show no visible deterioration except at four isolated locations. Three of these locations are at expansion joints, near the pavement edge, and one is at a contraction joint on the outside edge.

Further investigation of the failures at expansion joints has revealed the cause. Figure 8 shows one of the expansion joint failures. As can be seen, the expansion joint filler is offset from the sawed joint groove. At this location, the offset is approximately two inches; the other expansion joint failures are similar.

Previous laboratory investigations involving this type of joint distress have verified the detrimental factors. As the pavement expands, the induced horizontal compression of the filler causes it to extrude vertically. Since in this case the filler is now restrained on all sides, where ordinarily it would be free to move upward in the joint groove, the extrusion exerts an upward force on the concrete above it, and initiates the failure.

Figure 9 shows the failure at a shoulder contraction joint which appears to have been caused by grade settlement.

Since the culpable factors were present at the time of construction, none of the mentioned distressed areas can be classified as performance related failures.

There is no evidence of commutative cracking of the pavement adjacent to shoulder joints, or cornerbreaks of shoulder slabs in any of the sections.

Measurements of shoulder movements indicate that at this time there is no significant displacement taking place, either laterally or vertically, along the shoulder-pavement joint. Therefore, only longitudinal movements will be discussed.

For ease of comparison, longitudinal movements at contraction joints have been separated into three categories. These are, mainline pavement contraction joints, shoulder joints coinciding with those on the mainline, and interior shoulder joints, that is, those joints on the shoulder between the mainline pavement joints (Fig. 10).

At the time of the last measurements (August 1973), the average seasonal movement of the mainline pavement contraction joints was 0.123 in. The maximum movement exhibited was 0.184 in. and the minimum 0.007 in. The small value comprising the lower end of the range is caused by a joint which is resisting movement. There is one such joint evident in the instrumented portions of the concrete shoulder sections, which include 15 joints in total.

Shoulder joints which coincide with contraction joints on the mainline show average seasonal movements of 0.102 in., with a range from 0.034 to 0.185 in. The movement of coinciding shoulder joints is approximately 80 percent of the movements exhibited by mainline pavement joints.

Interior shoulder joints have average movements of 0.015 in. from summer to winter. The range of movements is from zero to 0.063 in. Independent slabs of the size involved in the concrete shoulders would be expected to exhibit more uniform movement. However, it appears that there are considerable differences in the amount of bond between the pavement slabs and the short shoulder slabs that are attached by lane ties. In some cases, the shorter slabs are being "dragged" by the longer pavement sections.

The average temperature differential at which the readings were obtained was 56 F.

Summary

The condition survey of the experimental shoulder sections performed after approximately one year of service has revealed the following:

1. Standard shoulders have developed cracks near both edges.
2. There is no visible deterioration of "Types A" and "B" bituminous shoulders.
3. There are no performance related failures of the concrete shoulder sections.

Measurements of concrete shoulder movements show that at this time there is no significant lateral or vertical movement taking place along the shoulder-pavement joint, so the lane ties are effective.

The average seasonal movement of shoulder joints coinciding with pavement joints is approximately 80 percent of the movement exhibited by the pavement joints.

Conclusions

It is obvious from the early results that all three types of experimental shoulders are performing better than the standard section.

Measurements of joint movement show that special criteria should be used for the design of seals for shoulder joints that coincide with pavement joints. (Obviously conditions will be considerably different for concrete shoulders adjacent to continuously reinforced pavements, than for those evaluated here.)

Performance data will continue to be collected and maintained by the Research Laboratory. Additional information obtained will be presented in subsequent reports.

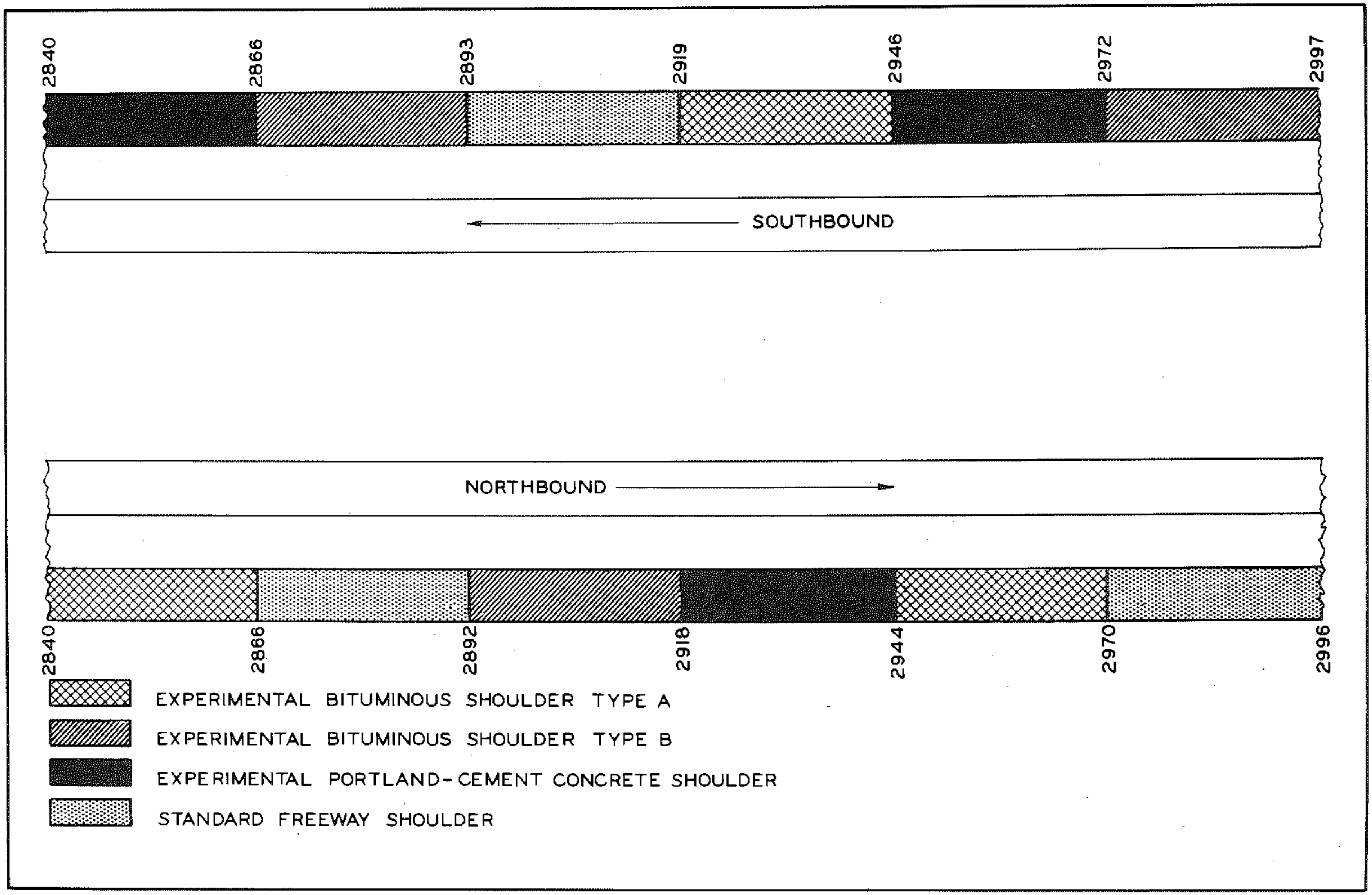

Figure 1. Test section locations for experimental shoulders.

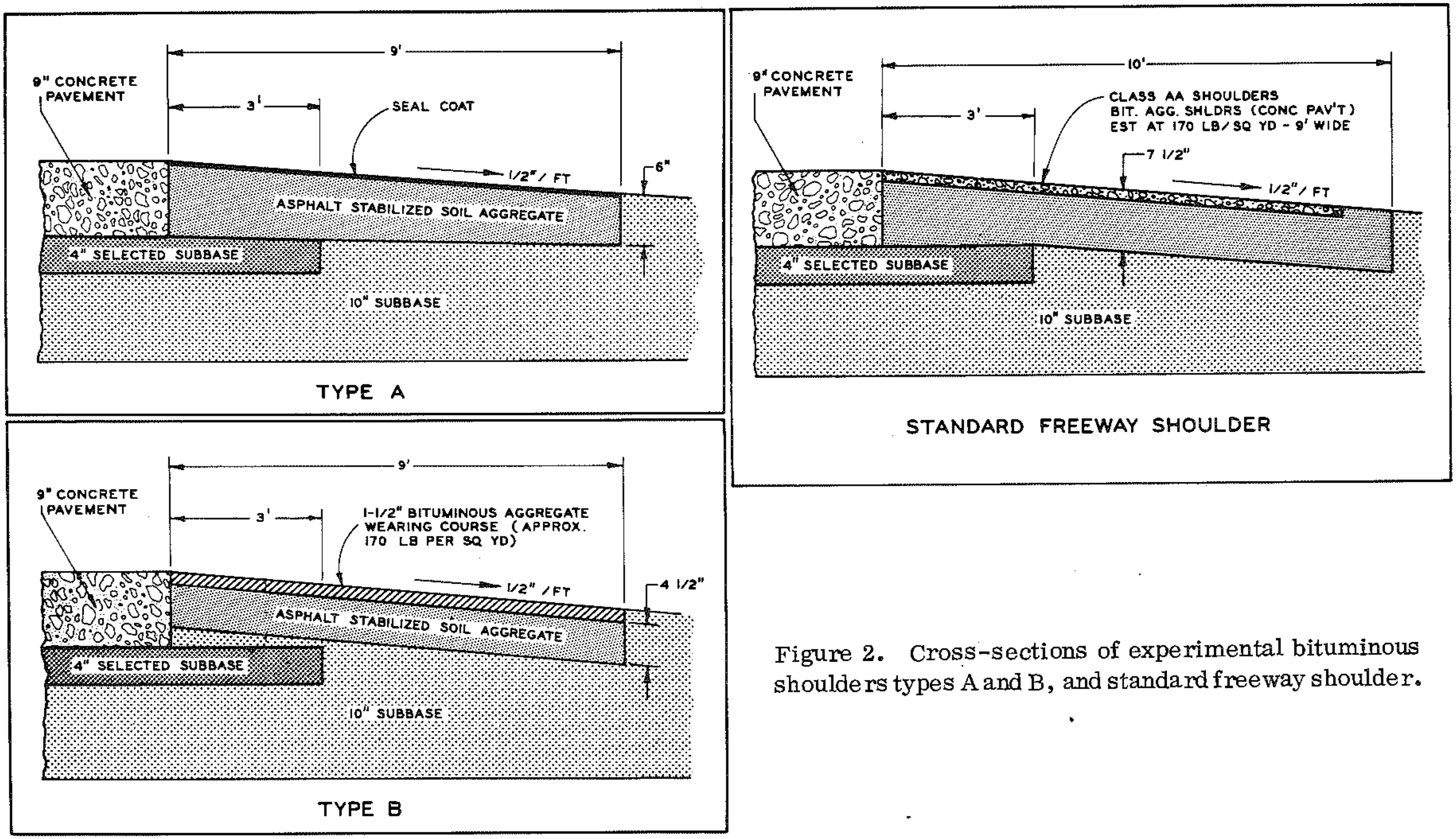

Figure 2. Cross-sections of experimental bituminous shoulders types A and B, and standard freeway shoulder.

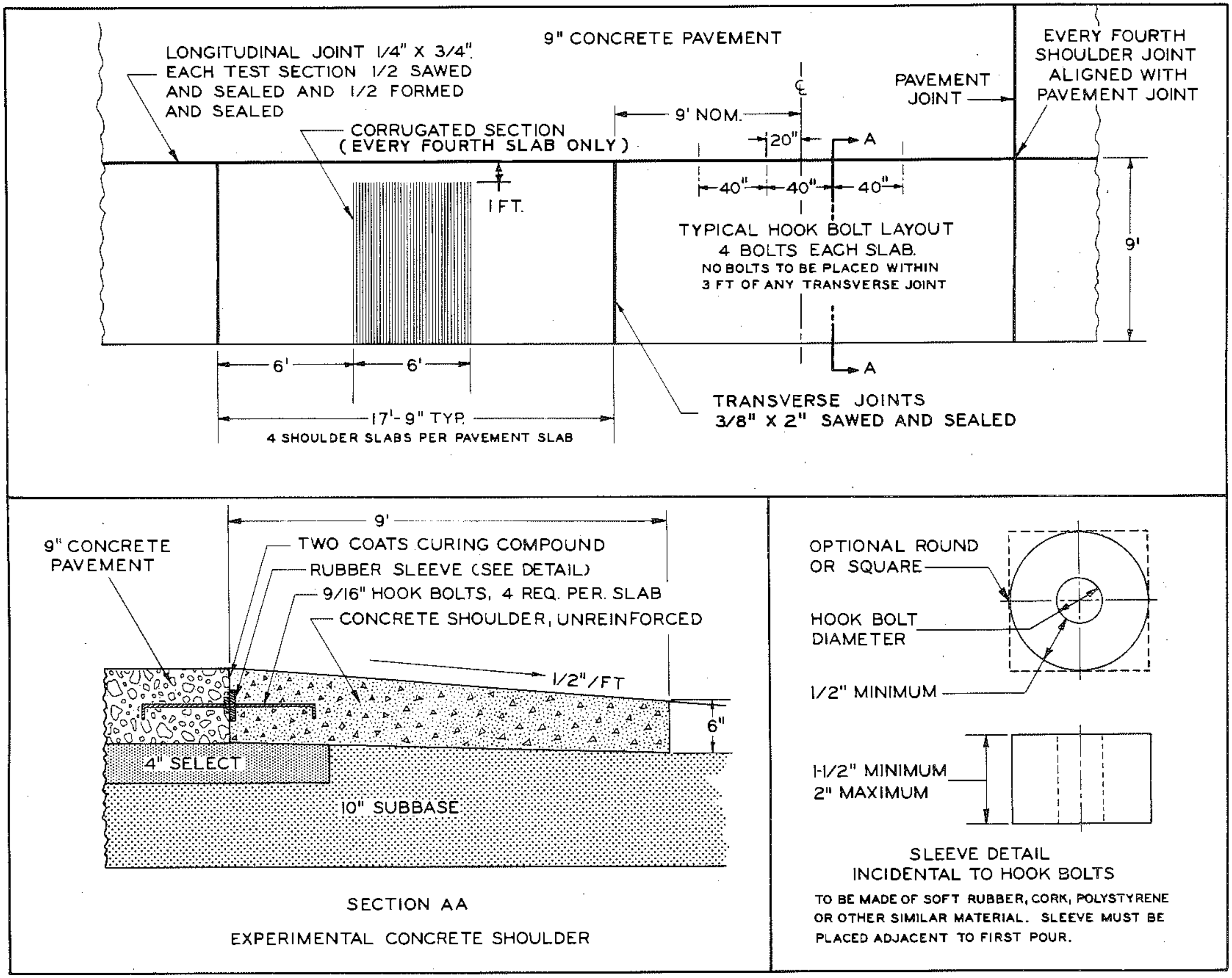

Figure 3. Construction details of experimental portland cement concrete shoulder.

Figure 4. Typical condition of "Type A" shoulder after approximately one year of service.

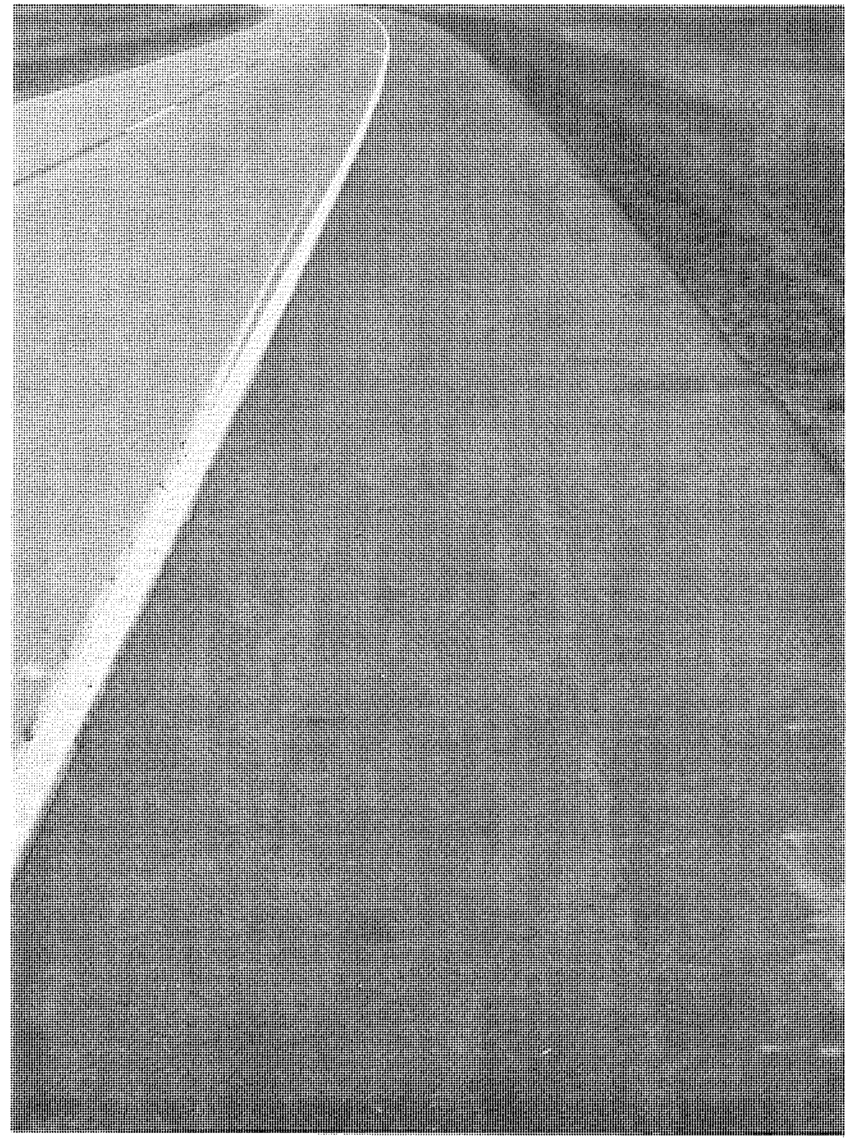

Figure 5. Typical condition of "Type B" shoulder after approximately one year of service.

Figure 6. Typical condition of standard shoulder after approximately one year of service.

Figure 7. Typical condition of concrete shoulder after approximately one year of service.

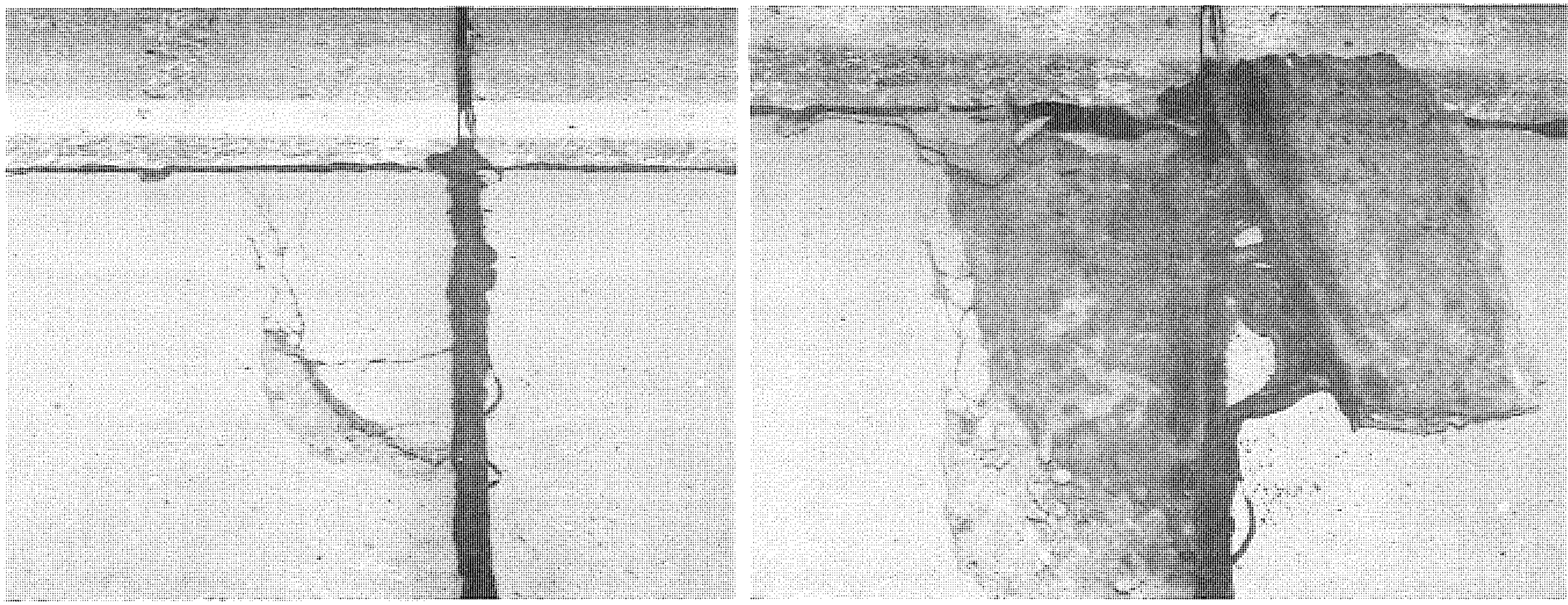

Figure 8. Failure at shoulder expansion joint. Extent of failure (left) and removed portion of concrete (right). Note filler offset, both in the pavement and on the removed portion of concrete.

Figure 9. Grade settlement at concrete shoulder joint.

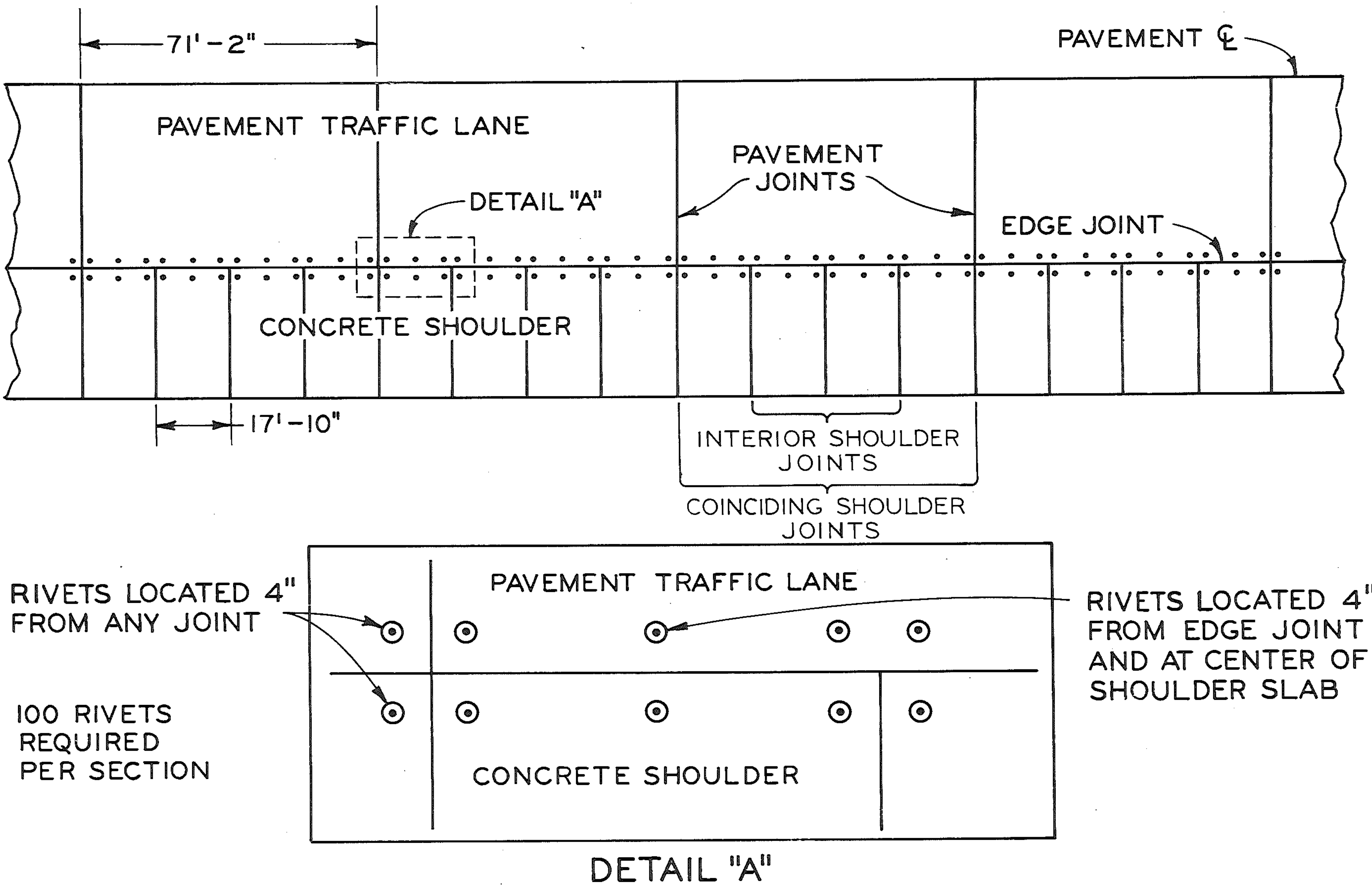

Figure 10. Rivet locations for instrumented sections of concrete shoulder project. One section of 16 shoulder slabs was instrumented as shown in each of 3 half mile test sections.