FINAL REPORT

EVALUATION OF A BRIDGE DECK EXPANSION JOINT

by

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(The opinions, findings, and conclusions expressed in this report are those of the author and not necessarily those of the sponsoring agencies.)

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ABSTRACT

Two Royston Unidam LK-120 bridge deck expansion joints were installed as experimental features on the Rte. 50 EBL bridge over the Shenandoah River in Clark County, Virginia. The joints were evaluated with respect to their ease of installation and performance after five years of service. It was found that the joint is difficult to install to the prescribed opening distance between the hold-down angles. The performance of the elastomeric material has not been totally satisfactory. On one of the two joints the elastomer has failed over a 3-ft length in the right-hand lane, and considerable sagging of this material in both joints suggests that the failure may become more widespread with time. As a result, the riding quality over the joints has been impaired and traffic impact noise has increased. In general, the performance of the joint has been unimpressive and its use on other bridges is not recommended.

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INTRODUCTION

During the past twenty years many different types of bridge deck expansion joints have been developed by private industry and installed on many of the nation's bridges. Some were installed in a time when there was no formal process in place which the various departments of highways could use for evaluating their performance. In more recent years, however, many have been installed as experimental features during the construction of some bridges. (1,2,3) As an experimental feature, these joints are evaluated with respect to their ease of installation during construction and their performance during one or more years of service under vehicular traffic.

A particular type of proprietary joint, the Royston Unidam Type LK-120, was installed in 1980 as an experimental feature on the eastbound lane (EBL) of the Rte. 50 bridge over the Shenandoah River in Clarke County, Virginia. This report includes a review of the installation of that expansion joint and an evaluation of its performance after five years in service.

GENERAL DESCRIPTION OF THE EXPANSION JOINT

The Royston Unidam Type LK-120 bridge deck expansion joint is an elastomeric material reinforced by regularly spaced, circular steel bars which run parallel to the traffic flow to supply support and stiffness over the joint opening. The joint material is placed in a blocked-out trench and bolted to steel hold-down angles which, in turn, are anchored to the concrete bridge deck. After the elastomeric material is installed, the remaining blocked-out area is filled with an asphaltic material that covers and conceals the anchorage system.

A plan view of the Royston joint is shown in Figure 1. A transverse section taken through the joint is shown in Figure 2. A unique feature of the joint is the mounting of the elastomer to the deck. Bolts are enclosed in the elastomer on each side and are used to attach it to the vertical legs of the steel angles. After the elastomer is installed and the bolts tightened, the nuts are welded to the angles so that no slippage can occur.

The installed cost of the joint was $415 per linear ft.

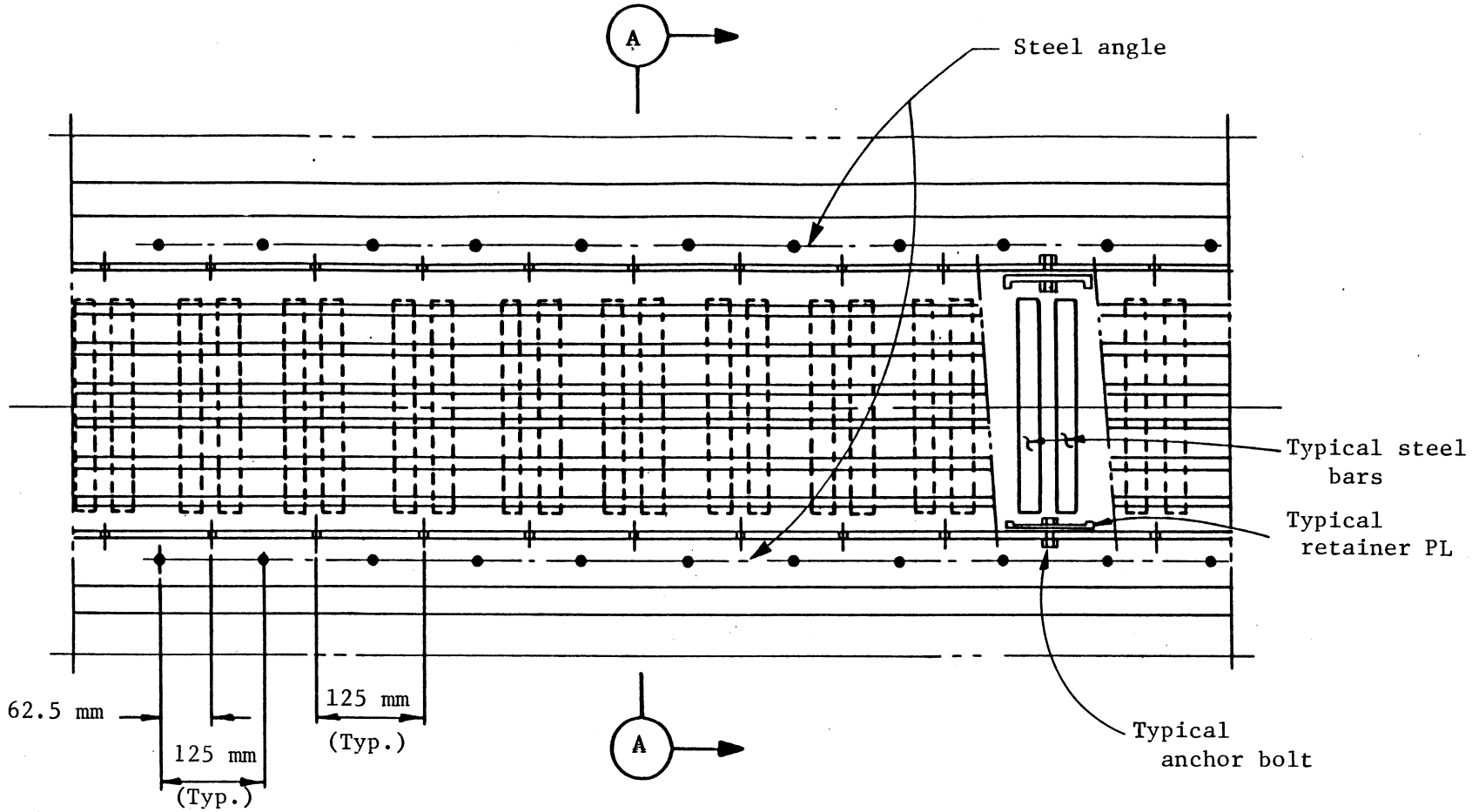
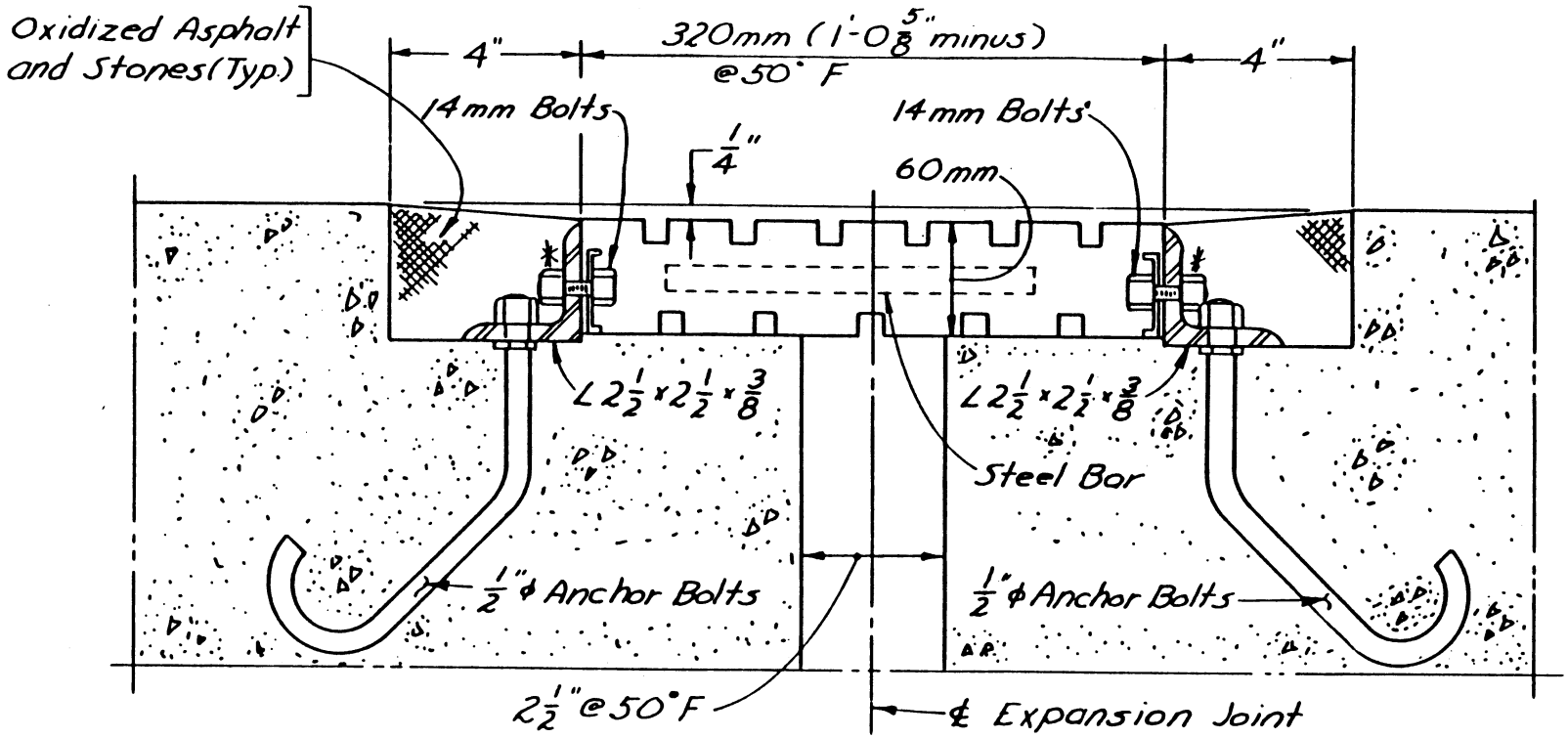


Figure 1. Plan view of the Royston Unidam Type LK-120 bridge deck expansion joint.



SECTION A-A

Figure 2. A typical transverse section of the Royston joint.

OBJECTIVE

The ultimate objective of bridge engineers is to find, or develop, a bridge deck expansion joint system that will accomplish all of the following:

1. Provide for longitudinal and rotational movements in the structure that must be accommodated at the bridge joints

2. Prevent the leakage of water and contaminants to the supporting bearings, girders, and substructure

3. Prevent debris and deleterious solid materials from entering the joint opening or obstructing the joint's ability to function properly

4. Be inexpensive and reasonably easy to install

5. Provide a long service life with minimum maintenance requirements

Accordingly, the objective of this evaluation was to determine how well the Royston Unidam Type LK-120 joint meets these requirements.

BRIDGE DESCRIPTION

The EBL of the Rte. 50 bridge over the Shenandoah River is approximately 1,095 ft long and is composed of thirteen spans. Nine of the spans are approximately 52 ft 6 in long and lie on either side of a four-span continuous unit crossing the river. This unit is composed of two 172-ft spans and two 138-ft spans. The center of the continuous unit is fixed, and expansion is allowed to take place in both directions. A Royston Unidam expansion joint is located at each end of the continuous span unit.

The bridge has a two-lane, 36 ft 8 in roadway width. All structural steel used on the bridge was of the A588 weathering type. The 1984 traffic count on the EBL was 3,740 vehicles per day. Of this total, 415 were tractor trailers and approximately 800 were small trucks and buses.

INSTALLATION OF THE JOINT

Procedure

The anchor bolts and the slotted steel angles were positioned at the joint prior to placement of the concrete deck. Figure 3 is a view of the joint area where the concrete for one span has been placed but that for the

adjacent span has not. It can be noted that the steel angles used for mounting the elastomer are in place. In placing the Unidam joint it is important that these angles be set the required distance apart, since the vertical faces of the preformed elastomer must abut those of the angles as nearly as possible. If the distance between the vertical faces of the angles is too great, for example, there will be a gap between the elastomer and the angles. On both joints the distance between the steel angles, as installed, was too great. Consequently, installation of the elastomer was delayed until several thin steel shims were fabricated to fill the gaps. Two 1/4 in thick steel shims were used on the joint at the east end and one at the joint on the west end of the continuous spans. The installation of the elastomer thus had to be delayed until the shims were fabricated and delivered to the bridge site.

The elastomers for the joints were installed on August 4, 1980. Two tears were found in the elastomer for the west joint and the material was at first rejected, but because of the time that would be required to obtain new material, and in the interest of placing the bridge in service, it was installed and then replaced with new material in October 1981.

Once the concrete deck has been placed, the slotted steel angles are permanently set and the elastomer can be installed. On this particular bridge a 2 in wide, 1/4 in thick sealing material was placed between the shim and the vertical leg of the angle to seal the interface (Figure 4). Next, the steel rods were inserted into the openings in the neoprene and the openings plugged (The openings and plugs for the rods alternate from side to side of the elastomer.) The elastomer was then placed in the trough between the two slotted steel angles such that the horizontal anchor bolts dropped into the slots (Figure 5). When the nuts were tightened, the horizontal anchor bolts tended to slip inside of the elastomer. In many cases it was necessary for the workmen to wedge a screwdriver against the anchor bolt so that the nut could be tightened. To prevent the nuts from working loose during service under traffic, they were spot welded to the steel angles (Figure 6). It should be noted that no mastic or sealing material was placed on the horizontal surface of the trough. The seal between the vertical legs of the steel angles and the elastomer was depended upon to prevent leakage through the joint.

The remaining 4-in trough on each side of the elastomer was cleaned, a primer adhesive applied, and the trough finally filled with an asphaltic material (Figure 7). The asphaltic material was compacted to complete the installation.

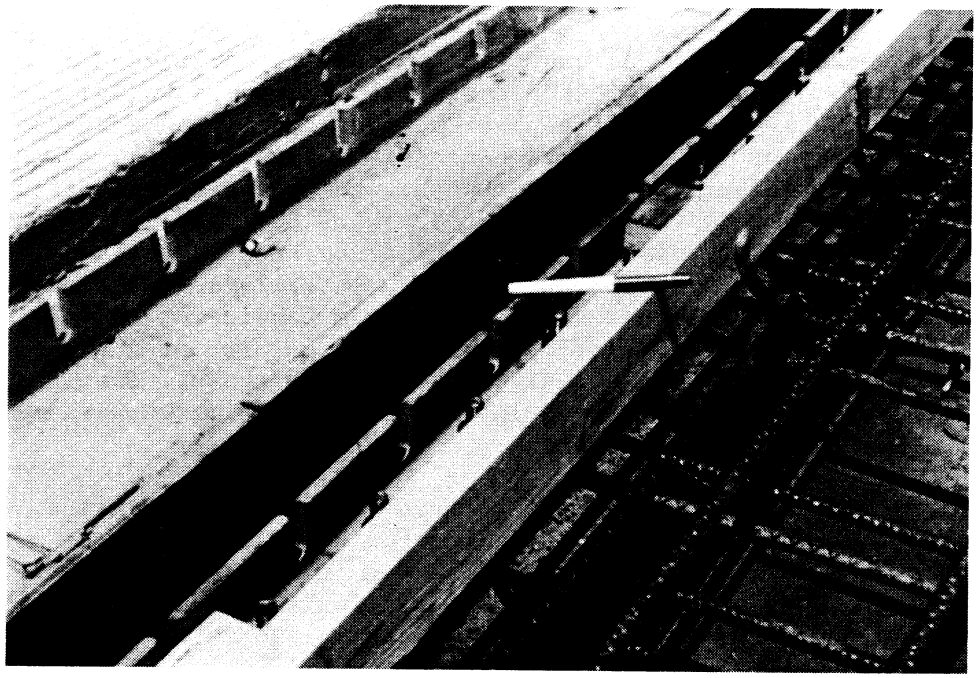


Figure 3. View of the joint area during bridge deck construction. Note that the angles used for mounting the elastomer are positioned prior to placement of the concrete deck.

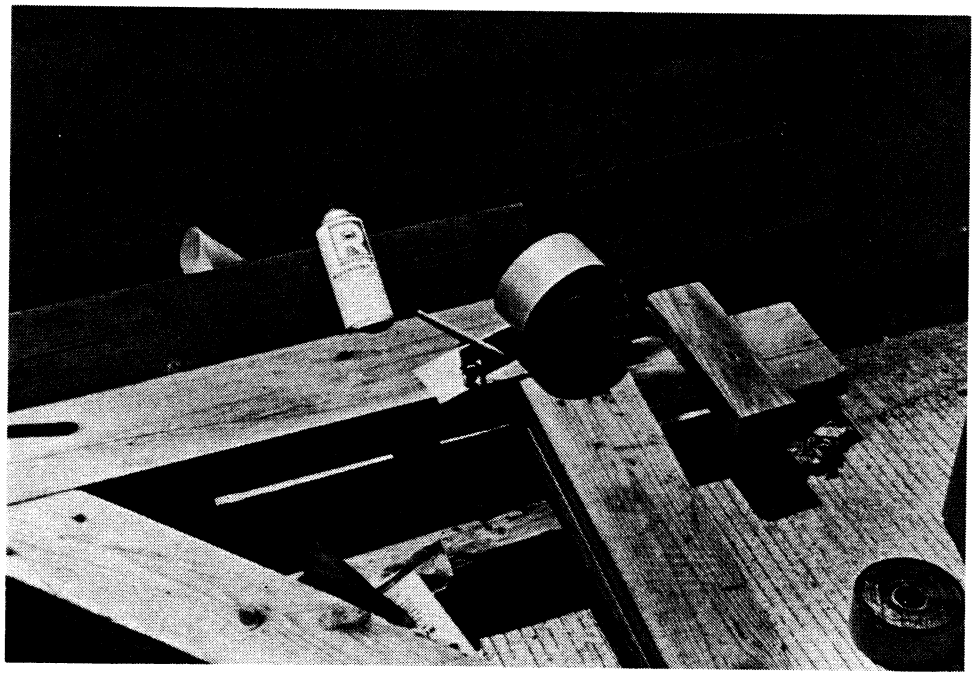


Figure 4. Sealing material used between the shim and vertical leg of the angles.

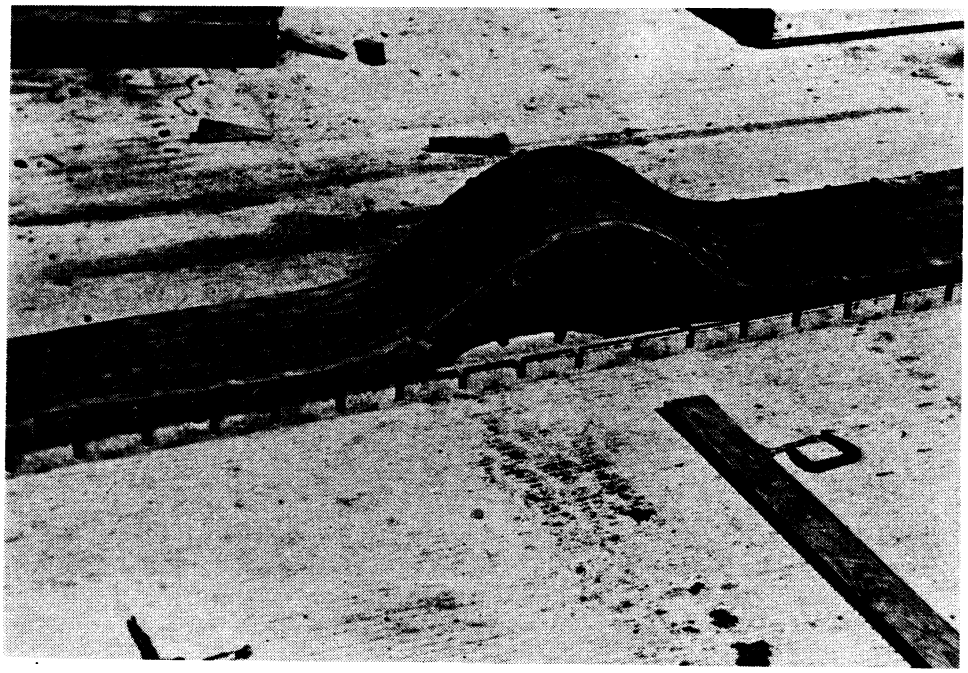


Figure 5. Elastomer being placed in joint area.

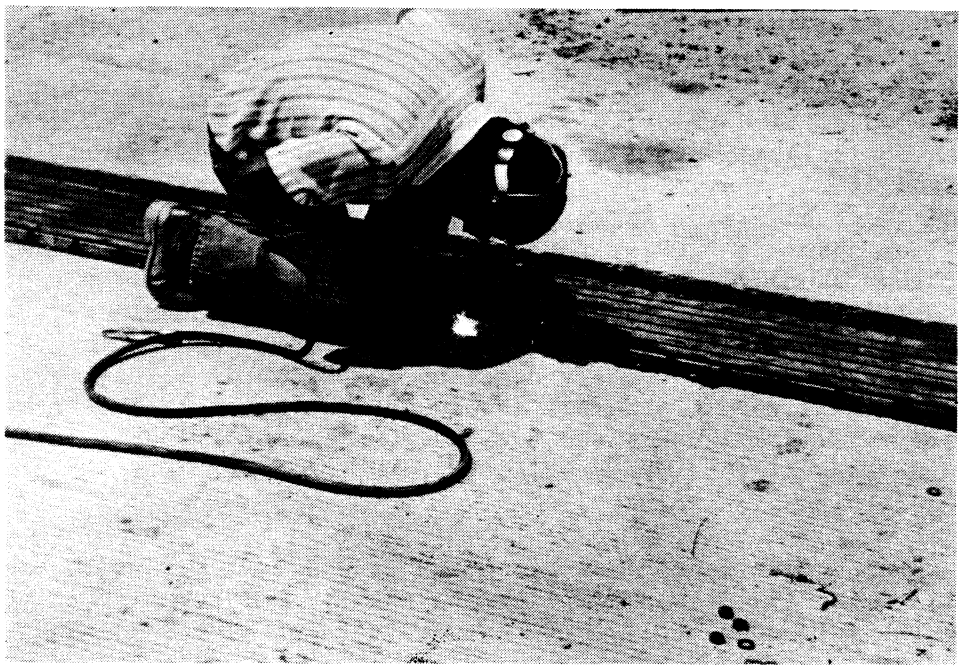


Figure 6. Anchor bolt nuts being welded to vertical leg of anchorage angle.

Figure 7. Placing asphaltic material in small troughs on each side of the elastomer.

Observations

The requirement that the horizontal clearance between the two hold-down angles be 320 mm at 50°F (Figure 2) is, from a practical viewpoint, difficult to meet. Because of the time required to install the supporting form work and the anchorage and hold-down angle assembly it is virtually impossible to position it precisely. Even if it were possible to install the second angle in such a manner that it could be adjusted in a short period of time prior to placement of the deck concrete, the final position would likely still not be correct. The reasons for this are simply that time, thermal changes, rotations due to deflections, and changing inertial properties all simultaneously vary during the placement of the deck concrete. These factors, added to the pressures, impact, and jolting that usually occur during concrete placement, produce a highly complex situation. On each of the joints placed on the bridge, the final distance between the two vertical legs of the hold-down angle was in error; one on the order of 1/4 in, the other on the order of 1/2 in. Viewed in retrospect, this result probably should have been expected. It is, therefore, very likely that the extra cost of providing shims or making other width adjustments would often be associated with the use of this bridge deck expansion joint.

Because the horizontal anchor bolts tended to twist within the elastomer material, it was difficult to tighten the anchor bolt nuts against the hold-down angles. To ensure that the anchor bolts would not loosen after the bridge was placed in service, the nuts were welded to the vertical leg of the hold-down angles. While this appears to be a necessary procedure, the field welding adds to the time and cost of installing the joint material.

PERFORMANCE

The east joint was inspected after one year of service and again after five years of service. Since the elastomer of the west joint was replaced after approximately one year's service, it was inspected again after approximately four years of service.

After one year of service the west joint elastomer was removed. A view of the bottom side of this elastomer is shown in Figure 8. The rust stains evident suggest that water may have gotten through the joint, thus allowing rust stains from the steel angles, anchor bolts, or the inserted steel rods to be deposited on the bottom of the elastomer and in the trough area. Other than these stains, no other deterioration of the west joint was apparent after one year of service. No deterioration of the east joint was evident after the first year of service.

After five years of service the east joint had either collapsed or compressed considerably beyond the 1/4-in depression with respect to the adjacent concrete deck as originally installed (see Figure 2). The collapse of the neoprene is clearly indicated in Figure 9 by the ruler lying across the joint near the right wheel path of the right-hand lane. At the center of the joint the elastomer had sagged by approximately 1 in, suggesting at least a partial failure of the material to maintain its initial structural shape. Some degree of sag in the elastomer beyond that of its original position was noted. However, the right-hand lane, in general, exhibited more sag than the left-hand lane.

The elastomer in the west joint, which had been in service for only four years at the time of the evaluation, exhibited more severe sagging in the right-hand lane than did the east joint. In the area of the right-hand wheel path of the right-hand lane the elastomer had failed. As shown in Figure 10, the elastomer could be deflected several inches under only modest pressure. This failure extended over approximately 3 ft of the joint at the time of the inspection. Without removing the elastomer, it was not possible to identify the exact cause of the failure. However, the failure appeared to be in the structural integrity of the elastomeric material itself. As a result of the failure in the right-hand wheel path of the west joint and the excessive sag in other areas of both joints, the riding quality over the joints had been impaired and the noise resulting from traffic impact had increased.

Inspection on the underside of the bridge revealed considerable streak staining on the pier caps, which suggested that leakage of water through the joints had occurred. The greatest amount of pier staining was below the right wheel path of the right-hand lane of the west joint (Figure 11). A lesser amount of staining was evident below the area of the left wheel path. The evidence of the heaviest leakage through the joint, therefore, appeared to coincide with the severity of the failure of the elastomer. Some streak staining of the pier cap below the east joint suggested that some leakage was occurring there as well.

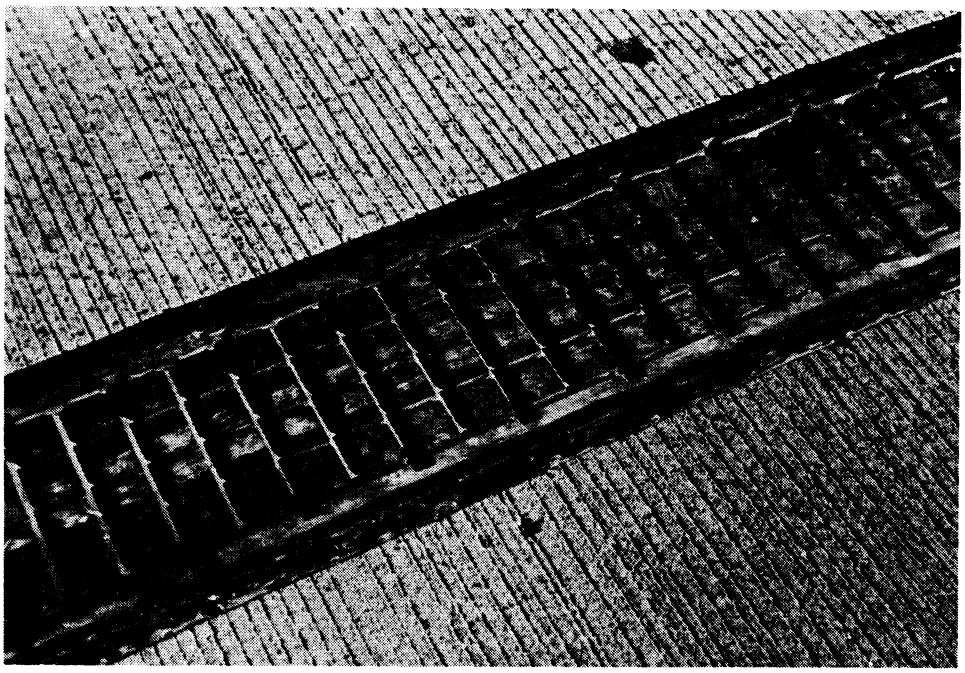


Figure 8. Underside of elastomer removed from west joint after approximately one year of service. Rust stains on the elastomer were evident.

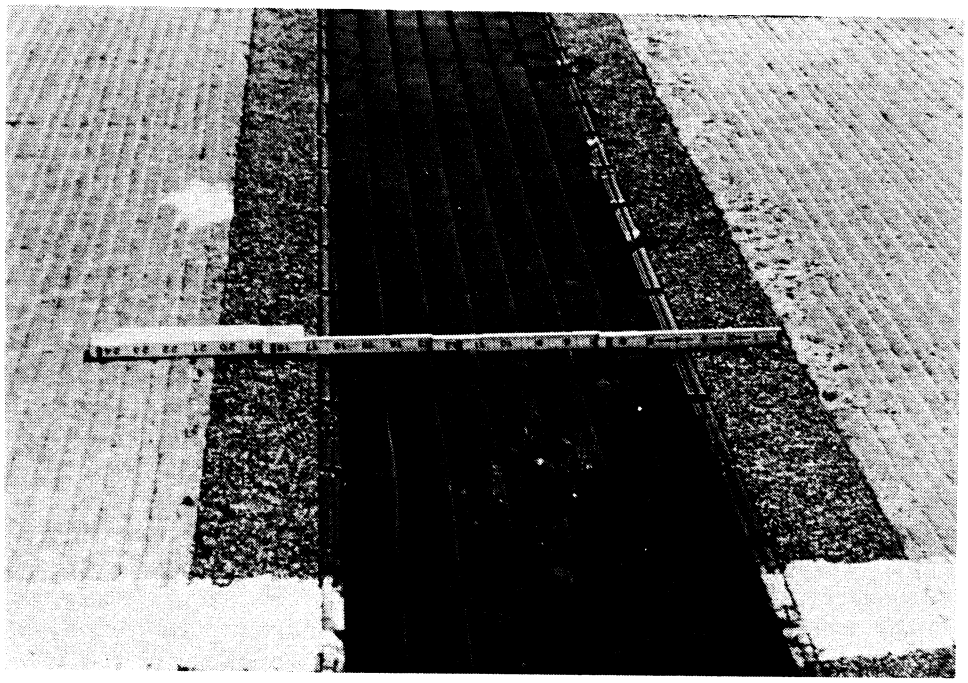


Figure 9. Excessive sagging of the elastomer of the east joint suggests partial failure of the material.

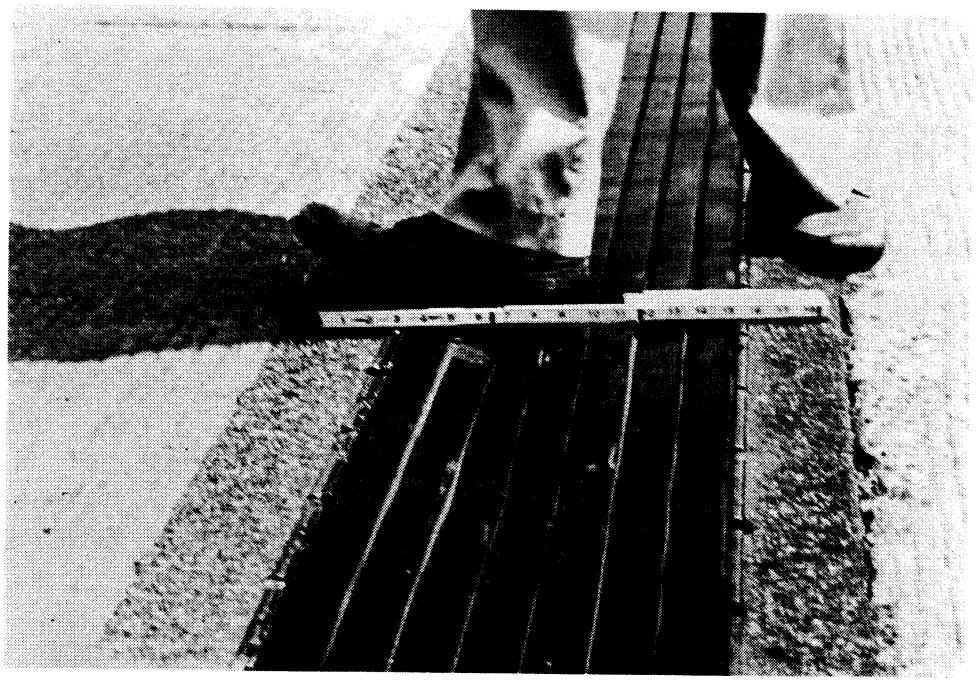


Figure 10. Apparent failure of elastomer in the right-hand wheel path of the right-hand lane (west joint).

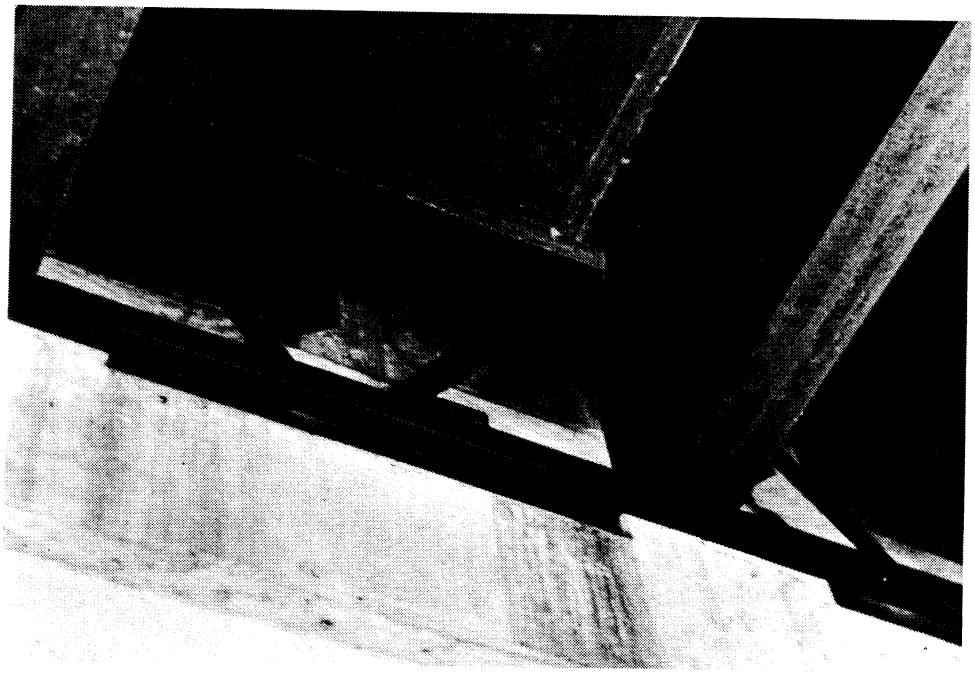


Figure 11. Streak staining on the pier cap below the west joint.

Some very minor snowplow damage was noted at two spots on the west and one on the east joint. None of these scrapes appeared to have been severe enough to be of concern. The asphaltic material on both sides of the joint was in generally good condition after five years of service. Some shrinkage and irregularity in the surface of the material was evident, however. At several spots some minor breaking of the asphaltic material had developed. This could worsen with time under traffic and environmental conditions.

Debris accumulation in the joint was not a problem.

CONCLUSIONS

The following conclusions are based on observations during the installation of two Royston Unidam LK-120 bridge deck expansion joints and on their performance after five years of service.

1. The joint is difficult to install to the prescribed opening distance between the hold-down angles. On the two installations evaluated, additional steel shims had to be fabricated and inserted in the opening so that the elastomer material would fit. The horizontal anchor bolts used to attach the elastomer to the hold-down angles are difficult to tighten and require welding to ensure that they remain tight. This welding is required and probably increases the installation costs compared to those for joints not required to be welded. At a cost of $415 per linear foot in 1980, the joint is not inexpensive.

2. The evidence of streak staining on the pier caps indicated that the joints were not completely waterproof. This was particularly true under a section of one of the joints where the elastomer had undergone some degree of failure.

3. The design of the joint material prevents debris and other solids from entering the joint opening.

4. The elastomer of one of the two joints had failed over an approximately 3-ft length in the right wheel path of the right-hand lane. Considerble sagging in the elastomer of both joints suggests that failure of the material may become more widespread with time. Due to this problem, the riding quality over the joints has been impaired and the noise resulting from traffic impact has increased.

5. No significant snowplow damage of the joints was observed after five years of service.

6. The performance of the joint under an average daily traffic volume of 3,740 and five years of service is unimpressive. Many bridges

similar to the one involved in this study have traffic counts in the 20,000 vehicles per day range or greater, and have less expensive joints that have performed as well or better.

7. The joint appears to be providing for all structural movements that have been experienced to date on the bridge.

RECOMMENDATION

Based on the observations discussed in this report and the performance of the joint material over a five-year period, and considering its high initial cost, use of this bridge deck expansion joint is not recommended.

ACKNOWLEDGEMENT

The author expresses his appreciation to L. L. Misenheimer, district bridge engineer in the Staunton District, for his assistance and cooperation in scheduling and conducting this evaluation.

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