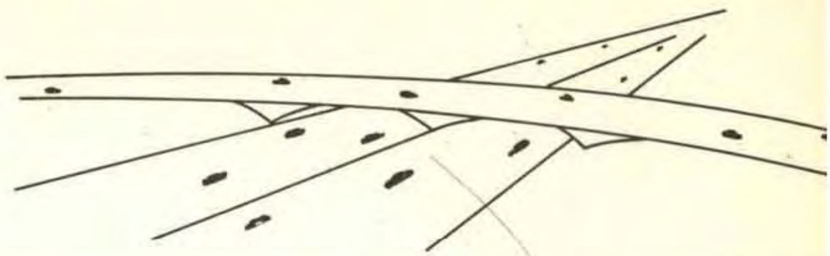

DEPARTMENTAL RESEARCH

Report Number : 39 – 3

A REPORT ON CONTINUITY BETWEEN REINFORCED CONCRETE PAVEMENT AND A CONTINUOUS SLAB BRIDGE

TEXAS HIGHWAY DEPARTMENT

A REPORT

ON

CONTINUITY BETWEEN A

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

AND A

CONTINUOUS SLAB BRIDGE

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Evaluation of Terminal Anchorage Installations
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ABSTRACT

The transition between the highway pavement and bridge deck has long been one of the major sources of problems concerning the performance and maintenance of the highway system as a whole. In 1963, construction was begun on a project where a continuously reinforced concrete pavement, bridge abutment, and continuous slab bridge were all tied together in an attempt to maintain roadway continuity. This report covers observations made in the two year period following completion of this system. The success of this system gives promise that improvements can be made in this area of highway construction.

I. INTRODUCTION

The transition between the highway pavement and bridge deck has long been one of the major sources of problems concerning the performance and maintenance of the highway system as a whole. Three major problems commonly found at this point deal with sealing the joint between the pavement and bridge deck slabs, road roughness caused by the joint and seal, and a necessity for anchoring the pavement slab from contractive and expansive movement. The accepted methods have tended to become unsightly as the joint aged and are expensive, both in initial cost and subsequent maintenance costs. A more ideal condition would exist if the pavement slab continued across the structure without interruption, thus eliminating the need for terminal anchorage and joint seals. Furthermore, the riding qualities would exhibit a marked improvement.

An attempt was made to maintain roadway continuity in the construction of the Irving Lee Street Overpass located in the northbound lane of Interstate Highway 35 at the southern outskirts of Waco, Texas. Design details of the structure and highway were handled by the Bridge Division of the Texas Highway Department and the District 9 design staff with construction supervision falling under the auspices of District 9.

The Research Section of the Highway Design Division was asked by the Bureau of Public Roads to follow the performance of this roadway system and report its findings as a part of this research project. The following report covers observations made during the two years since completion of construction.

II. DETAILS OF THE EXPERIMENT

The Irving Lee Street Overpass consists of two separate structures spanning Irving Lee Street as it passes under the main lanes of Interstate Highway 35. Both structures are identical 125 foot continuous slab units with spans of 35, 55, and 35 feet. Both units are crown width structures 40 feet wide. The overall layout of this area is shown in Figure 1.

Control Unit

The southbound structure was constructed in the usual manner with a five lug terminal anchorage system to anchor the pavement slab and a crown width structure approach slab at each end of the structure (Figure 2). The approach slabs were separated from the structure by one inch expansion joints and from the pavement slabs by 1-1/2 inch expansion joints. Every feature of the southbound unit followed typical design and construction procedures, thus it serves as the control unit in evaluating the performance of the experimental aspects of the northbound unit.

Experimental Unit

The northbound unit differs from the southbound unit in that in the attempt to maintain roadway continuity, the terminal anchorage system was eliminated and the pavement, approach slabs and structure were all tied together (Figure 3). Transverse construction joints were used in lieu of the expansion joints employed in the control unit. The regular longitudinal pavement steel extended into the approach slab so that one-half of this steel was terminated three feet and the other half four feet past the construction joint. The longitudinal paving steel consisted of thirty-nine number five bars with a center to center spacing of 7-1/2 inches. This arrangement gives a longitudinal steel percentage of 0.52 percent for the pavement.

The approach slab steel parallel to the highway centerline consisted of eighty-one number five bars with a center to center spacing of six inches giving a steel percentage in this direction of 0.654 percent. The increased number of bars is due to both a smaller spacing and a greater width. The approach slab tapered from a thickness of eight inches at the pavement joint to nine inches at the bridge connection. The approach slab was tied to the abutment bent by twenty-eight number four ties. Each tie was embedded and hooked into the approach slab twice, thus the equivalent area of fifty-six number four bars was furnished to tie the approach slab to the bent. Forty number five tie bars spaced twelve inches on center extended two feet into the approach slab from the bridge to tie these slabs together. The complete steel layout is shown in Figure 5. Other than the aforementioned treatment at the joints, the pavement, approach slab, and structure were of typical design.

III. FIELD OBSERVATIONS

Two detailed inspections and several periodic inspections have been made of the Irving Lee Street Overpass by members of the Research Section. The initial inspection was made early in February, 1965. A strong norther was blowing at the time of the inspection and the air temperature was in the low forties. The morning low temperature had been 34 degrees. The second major inspection was made late in March, 1966. The air temperature was much warmer, ranging between 70 and 74 degrees, but once again, a strong wind was blowing and the sky was overcast. On both inspection trips, a record was made of the location of cracks in the approach slabs and in the pavement for several hundred feet in each direction from both structures. Photographs and crack width measurements were also taken and the following observations were recorded.

Control Unit, Southbound Lane

The pavement at each end had very tight cracks which started about 20 feet from the approach slabs, placing the first crack between the first and second anchor lugs. The pavement south of the structure had an average crack spacing of 13.63 feet, while that to the north had an average crack spacing of 8.57 feet. On the initial run, cracks near the structure measured 0.004 - 0.010 inch in width while those located about 100 feet from the structure measured 0.012 - 0.014 inch.* Cracks measured during the second major inspection revealed cracks near the south end of the structure averaged about 0.006 inch in width while those north of the structure were somewhat wider, averaging about 0.016 inch.

The initial inspection revealed that both 40 foot (crown width) approach slabs had cracked longitudinally near their centers and no other cracks were visible in either slab. No changes in these slabs were noted throughout the inspection period.

Little change was noted in the width of the expansion joints throughout the period of inspection. The joints between the approach slabs and the structure varied in the neighborhood of a quarter of an inch while those between the approach slabs and the pavement ends varied less than two tenths of an inch.

All four seals had water and sand encapsulated in bubbles throughout their lengths and some spalling was occurring along the faces of the joints.

The visual appearance of the control unit was typical of many similar units throughout the State. The wide expansion joints were rather prominent, but the riding qualities were good.

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* Surface crack widths obtained through the use of a microscope with a graduated eyepiece.

Experimental Unit, Northbound Lane

The crack pattern of the pavement started within 12 feet of the approach slab at both ends of the structure. The average crack spacing was 11.11 feet for the pavement south of the structure and 12.0 feet for pavement north of the structure. A typical crack pattern for CRCP extended all the way to the approach slabs at both ends. The cracks near the pavement ends, unlike those in the Control Unit, were similar in width to those elsewhere in the pavement slabs. Measured crack widths ranged from 0.008 to 0.024 inch in early morning to 0.006 to 0.018 inch at noon. The pavement crack pattern appeared to follow normal CRCP crack patterns throughout its length.

The joints between the pavement slab and approach slab appeared tight at each end. Both such joints appeared to be typical transverse construction joints.

At the time of the initial inspection, the joints between the structure and the approach slabs were both rather wide. At the north end, a quarter could just be inserted in the joint (approximately 1/16 inch); at the south end, the joint was about the width of a half dollar (3/32 inch). These wider joints were probably caused more by movement of the bridge than by the pavement pulling the approach slabs back.

The approach slabs of the experimental unit showed signs of distress that were not present in the Control Unit. Each slab contained a transverse crack near the structure and a transverse crack running somewhat parabolically from the point where the pavement joined the approach slab to a maximum distance of about five feet from the joint separating the pavement from the approach slab. Each approach slab also contained three minor cracks running in a direction approximately parallel to the longitudinal direction of the pavement. All of the cracks located are shown on the crack layout, Figure 4. The parabolic cracks were rather wide; crack widths in excess of 0.100 inch were measured.

The latest inspection revealed only one additional crack. This crack was located in the approach slab at the north end of the structure. This was a very minor crack running in the direction of the pavement which was actually a short extension of an earlier crack. All of the cracks running longitudinally in the direction of the pavement were barely visible. This was true at both ends of the structure. The average crack width for the parabolic crack in the north approach slab was 0.057 inch and in the south approach slab was 0.041 inch. The average crack width for the transverse cracks near the structure was 0.026 inch and 0.014 inch respectively in the north and south approach slabs. These widths were about the same as the year before.

Unfortunately the construction joints between the approach slabs and the structure had been routed to a depth of about one-half inch and a width of 0.3 - 0.4 inch. A seal had been placed in this groove. This seal is a tough, plyable, rubber-like material, grey in color, closely matching the concrete. The seal was loose for four or five inches near the middle of the slab at the south end of the structure. By lifting the seal, it was possible to expose the construction joint crack as well as note the extent of routing done to place the seal. The construction joint measured slightly wider than the thickness of a dime. This was somewhat tighter than it was the year before.

In summary, the general appearance of the entire area was very good. The pavement at both ends of both structures appeared excellent. Cracks in the control section were somewhat tighter as they approached the structure but both roadways appeared normal. The approach slab cracks were a little wide but within reason, and no detrimental effects were apparent from these cracks.

IV. DIAGNOSTIC ANALYSIS

Examination of the steel placement pattern reveals that the regular longitudinal reinforcement of the CRCP did not continue through the approach slab, but was cut off within the approach slab. To obtain adequate load transfer, the additional steel required at all normal transverse construction joints (twenty-four #5 bars, three feet long) were also used across the pavement-approach slab joint. One-half of the longitudinal steel was extended three feet and the other half was extended four feet into the approach slab. The major portion of the parabolic crack occurred at the point of termination of the longitudinal steel (see Figure 4).

The approach slab was tied to the abutment bent with fifty-six #4 bars, embedded in the bent and hooked into the slab. The bridge and approach slab were tied together by forty #5 bars, four feet long. The transverse crack near the structure occurred at the point of termination of this steel.

Examination of the concrete placement dates reveals what is probably the predominate cause of the unusual crack pattern in the approach slabs. The structure was placed on October 21 and 22, 1963; the pavement was placed on January 9, 1964; and the approach slabs were not placed until January 27, 1964, thus a situation similar to that found at other "leave outs" was created.[2] The pavement and structure slabs were well on their way toward achieving full strength when the approach slab was poured and the "green" approach slab was unable to absorb the tensile forces generated by the contraction of the adjoining slabs.

Even though the aforementioned approach slab cracks were somewhat wide, the system as a whole was performing well. No detrimental effects were visible anywhere and the general appearance was greatly superior to that of the Control Unit and to other units nearby.

The approximate equality in crack widths at all points in the pavement slab for the experimental unit indicates that partial or full continuity was achieved. The tighter crack widths near the end of the Control Unit indicates terminal movement is being experienced. Since the pavement for the experimental unit was restrained even though movement was experienced at the bridge expansion joint, it may be concluded that the pavement was anchored by the mechanical ties to the abutment bent. Periodic observations have not revealed any detrimental effects in the abutment, therefore, this simple connection may provide a feasible economical method of preventing terminal movement on continuous pavements.

V. CONCLUSIONS

To achieve total continuity between the highway pavement and bridge deck is probably not feasible at this time. The Irving Lee Street Overpass demonstrates that a marked improvement can be made over current design techniques which would eliminate much of the maintenance now required. Certain modifications, however, should be made in the Irving Lee Street design before attempting duplication of this system. Recommended changes are as follows:

1. The approach slab should be eliminated. The approach slab proved to be the weak link in the Irving Lee design due to its late construction. The pavement slab should be continued all the way to the bridge and anchored into the abutment bent. If crown width is desired, the pavement could be extended to crown width by means of normal longitudinal construction joints.

2. The dowels tieing the bridge to the pavement should be eliminated. Due to several factors, the bridge should be left free to move.

By following the aforementioned recommendations, total continuity would not be achieved, but several improvements would be realized. First of all, the expensive terminal anchorage systems now in use could be eliminated. The special approach slabs, sleeper slabs and two expansion joints would also be unnecessary. The other expansion joints might be eliminated under some conditions. The elimination of expansion joints would greatly reduce maintenance and improve the riding qualities of the pavement, thus the Irving Lee Street Overpass appears to be an important step toward improving the transition between the pavement and structure.

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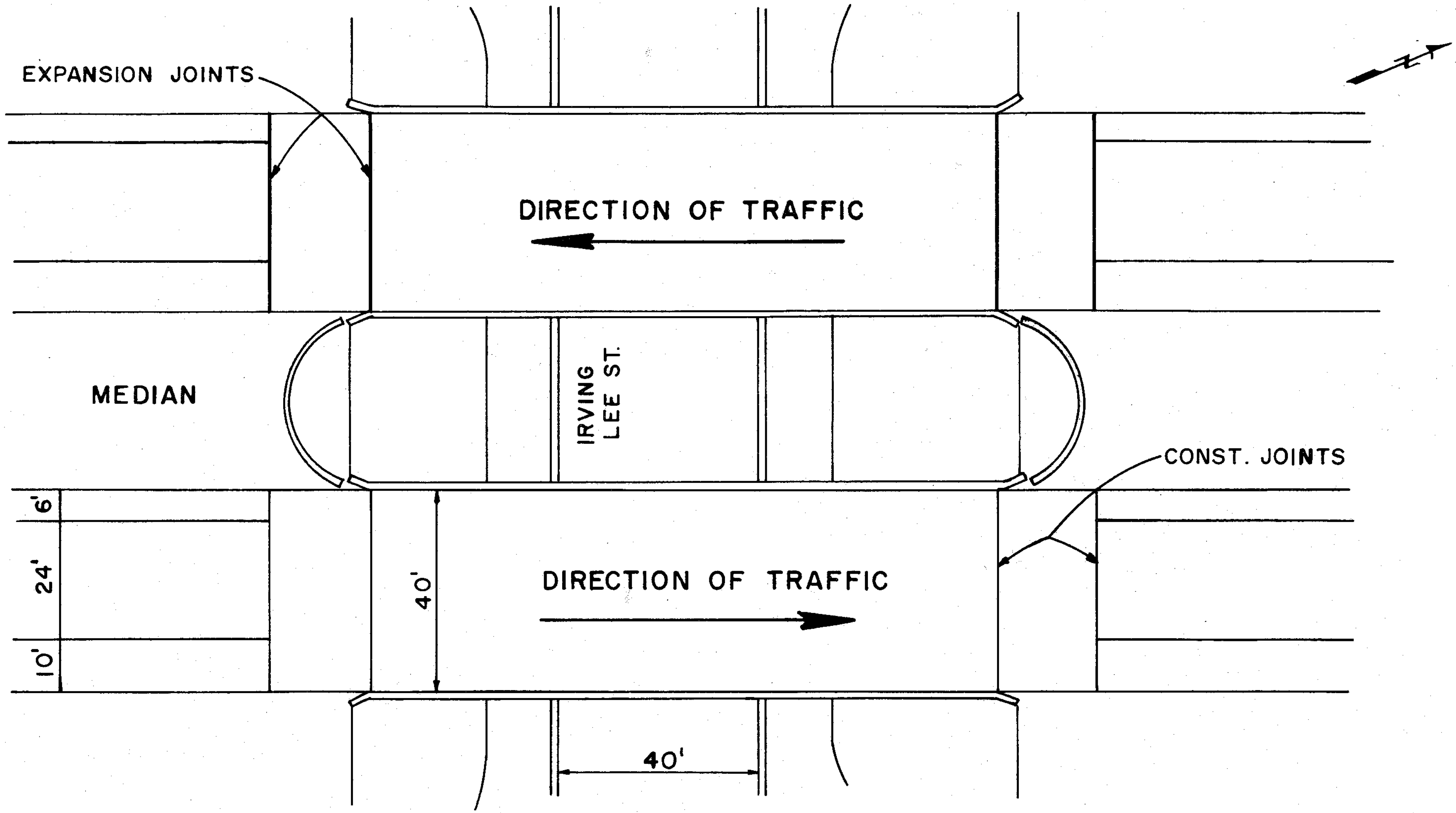
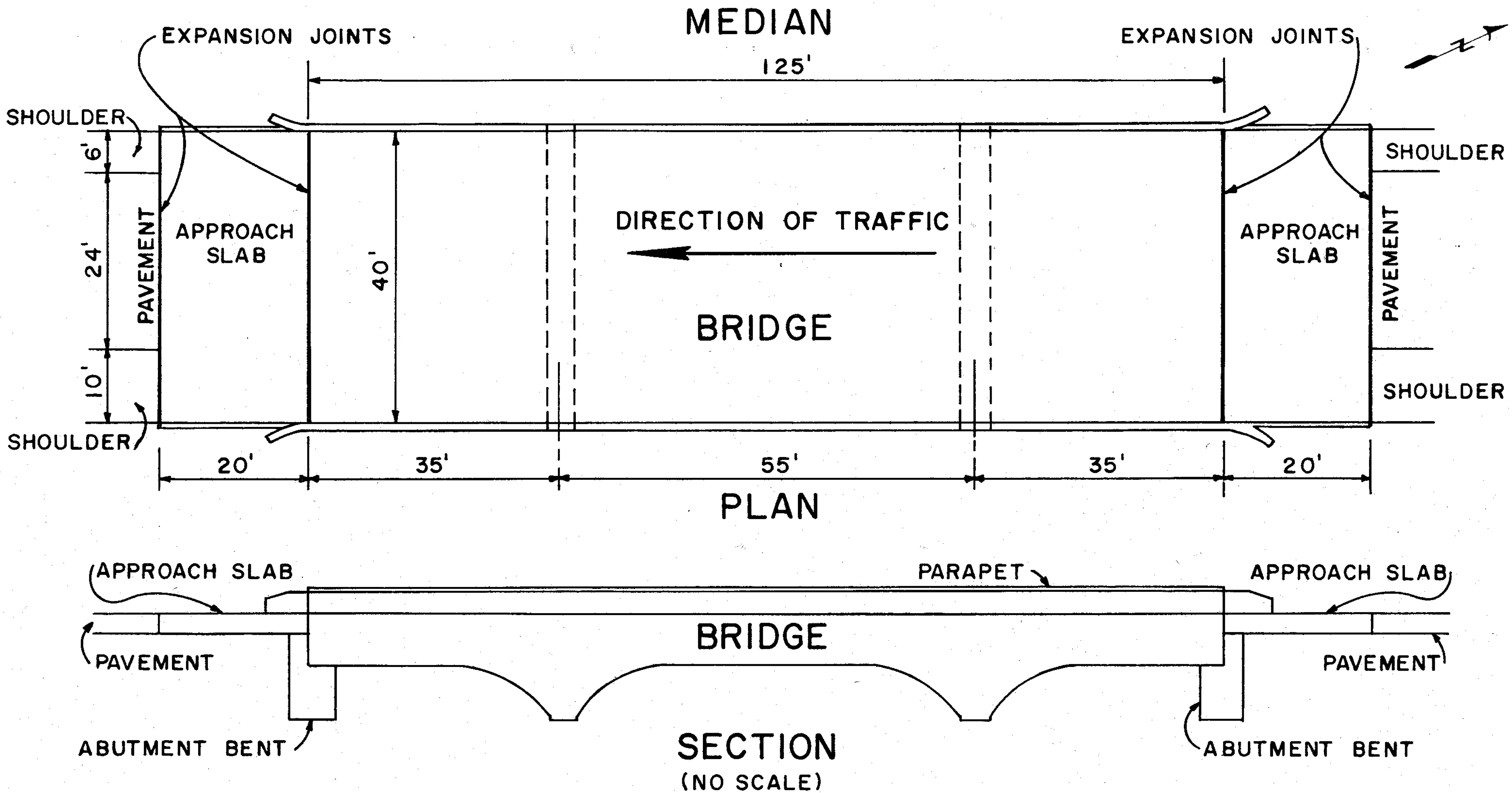
A P P E N D I X



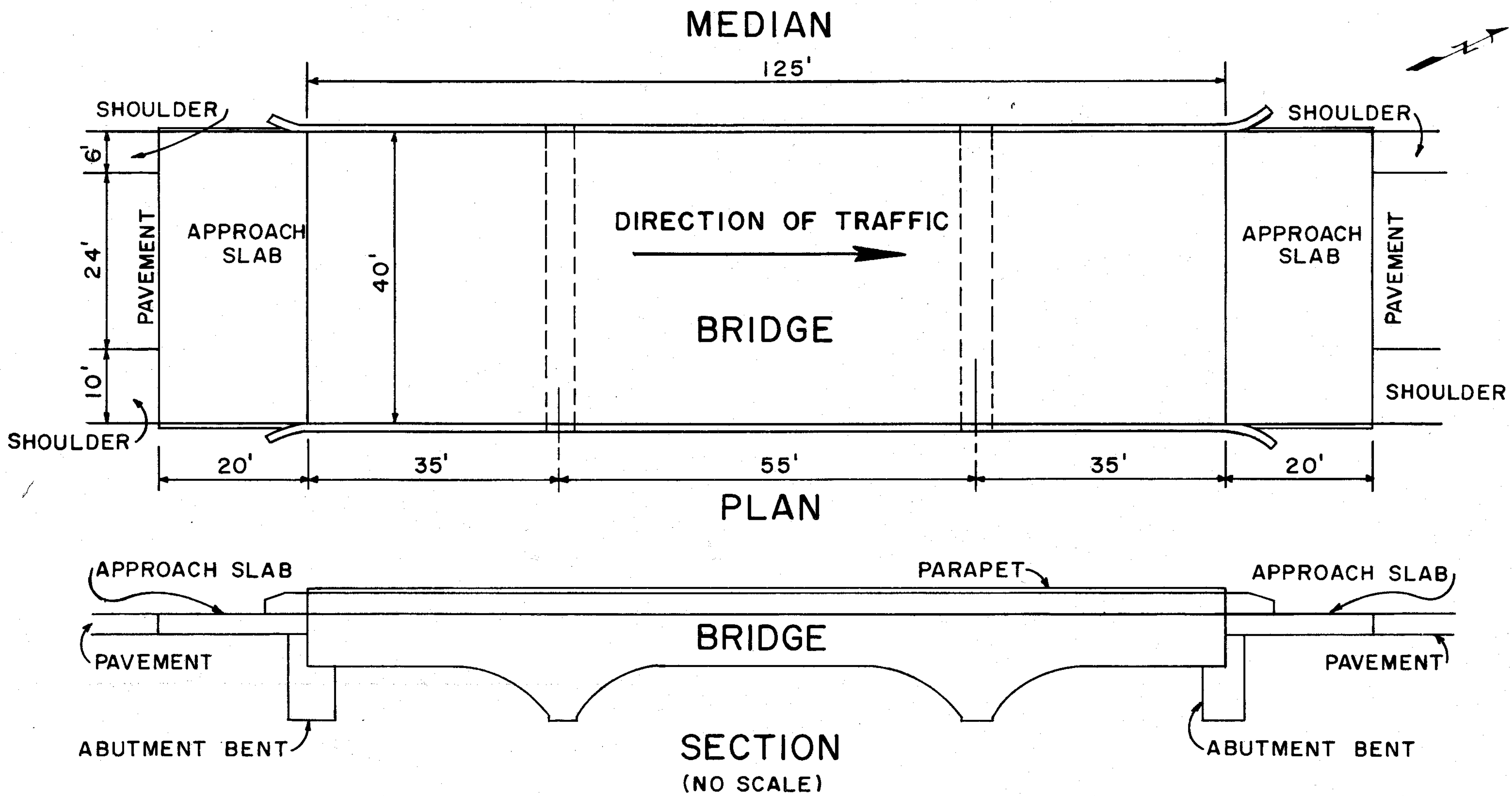
GENERAL SITE LAYOUT

FIGURE 1



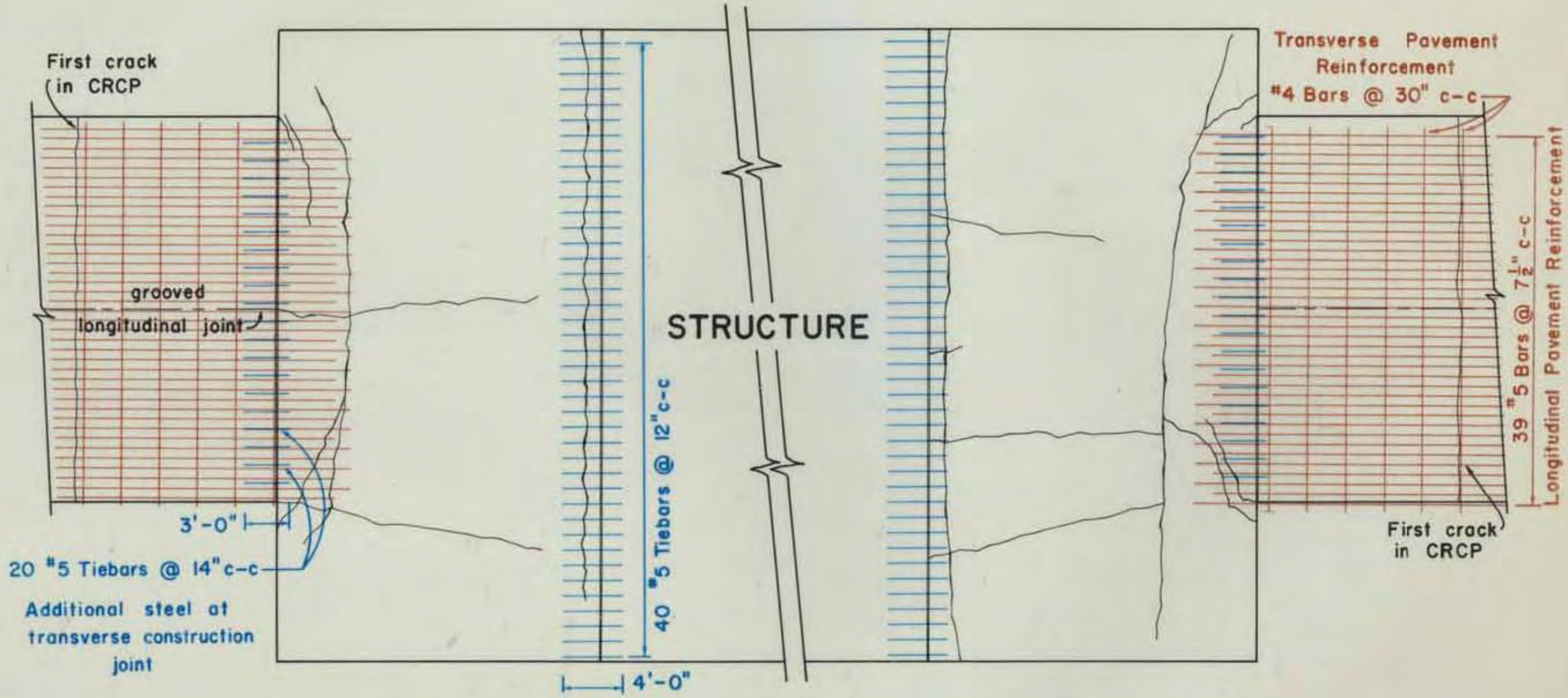
LAYOUT OF CONTROL UNIT

FIGURE 2



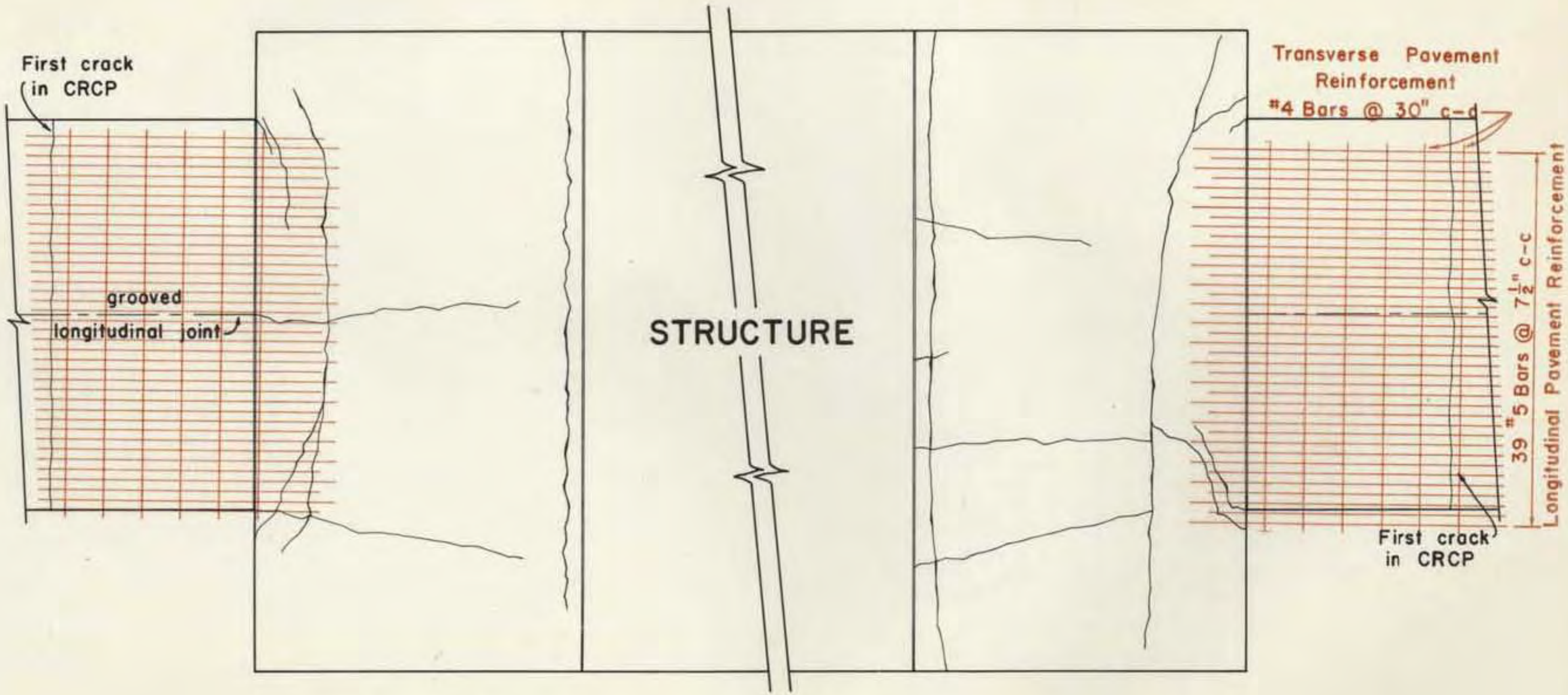
LAYOUT OF EXPERIMENTAL UNIT

FIGURE 3



CRACK PATTERN OF EXPERIMENTAL UNIT

FIGURE 4



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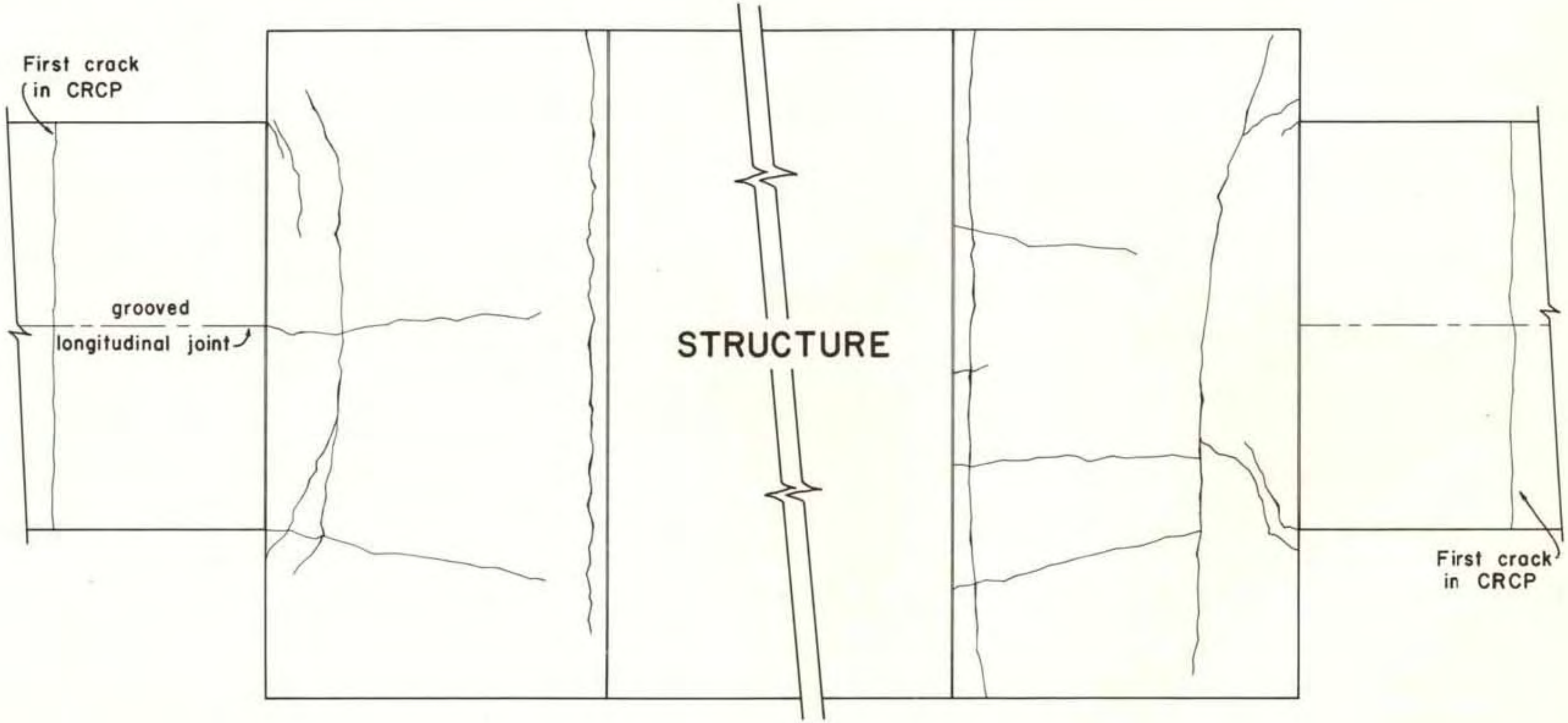

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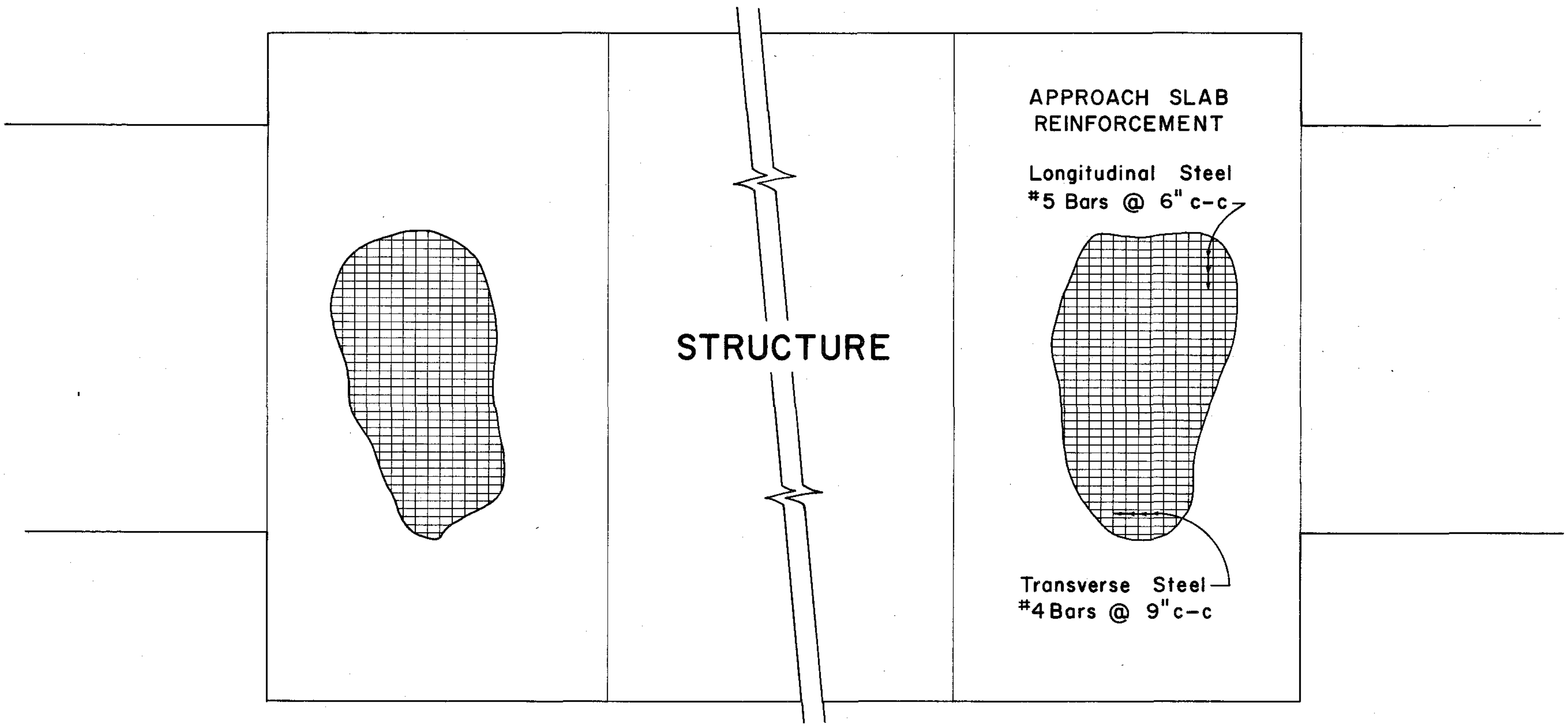
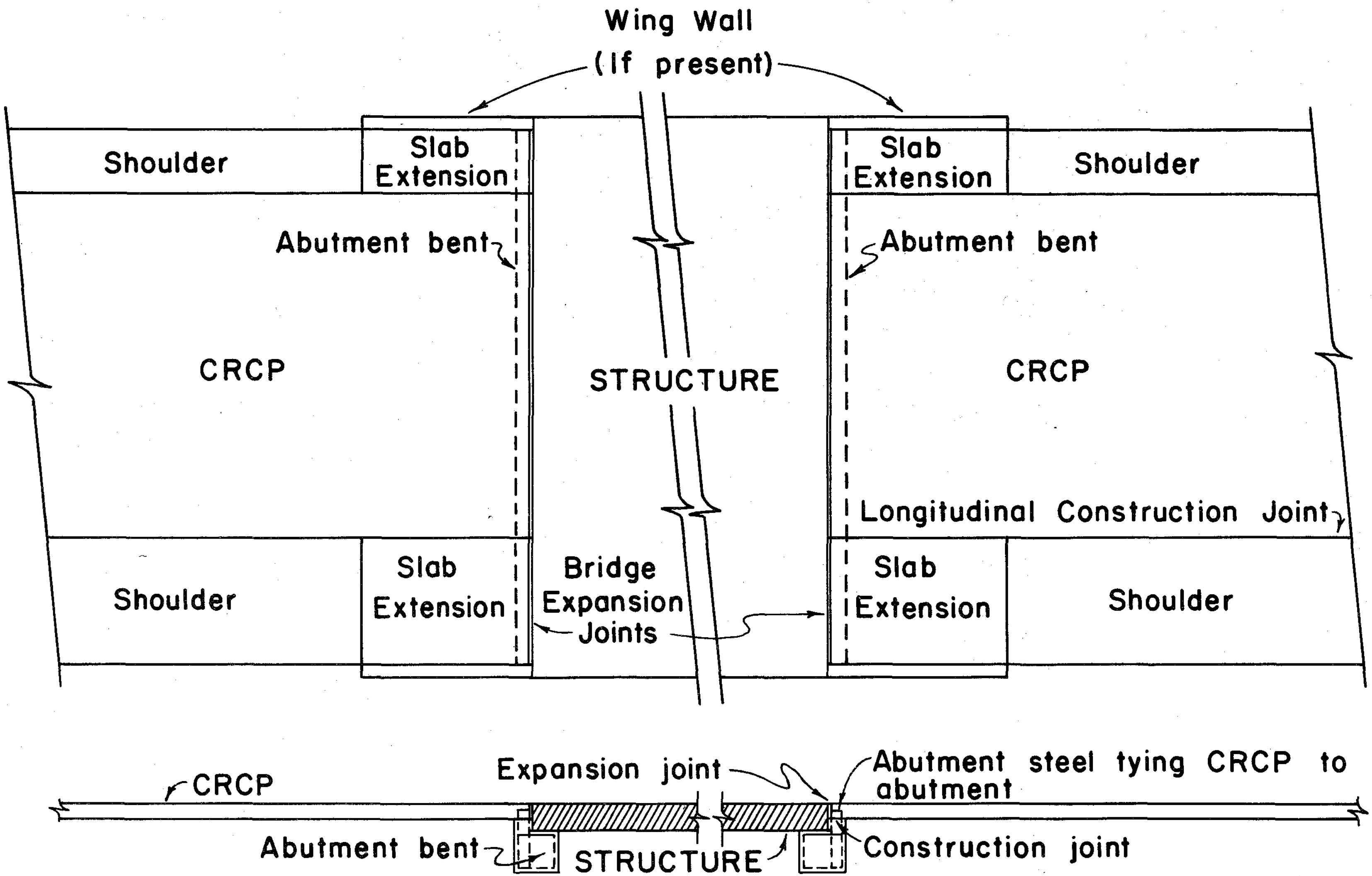


LAYOUT OF STEEL IN EXPERIMENTAL UNIT

FIGURE 5



PROPOSED DESIGN CHANGES TO ELIMINATE APPROACH SLAB

FIGURE 6