PRELIMINARY REPORT — RAMIFICATIONS OF WELDING A SOLEPLATE TO A PRECAST METAL INSERT OF A PRESTRESSED SINGLE-TEE BEAM

by

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SUMMARY

A model of the bearing assembly specified on the plans for the bridges being constructed in Norton, Virginia, was prepared in the laboratory at the Research Council. The shielded metal-arc welding process was used to weld the soleplate to the metal insert. The electric arc, varying from 175-225 amps, and several 5/32 inch E6010 electrodes were used in making the weld. Thermocouples and tempilstiks were used to monitor the temperature distribution throughout the bearing assembly during the welding.

Based on the laboratory investigation, it is believed that the bearing assembly requiring the 3/8 inch field groove weld specified for the Norton bridges will be satisfactory but may not necessarily be the most desirable. It is recommended that cement grout be used to fill any cracks which form between the insert plate and the concrete because of welding. Also, for aesthetic purposes, the concrete should be protected from the discoloration caused by welding. If the performance or appearance of the bearing assembly used in the Norton bridges turns out to be less than desirable or if welding appears to require unnecessary field labor and cost, it is recommended that the Department consider the use of an alternative bearing assembly in future prestressed bridge members.

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INTRODUCTION

As outlined in a working plan distributed in November 1975,[1] a laboratory investigation was conducted to determine how the temperature due to field welding a soleplate to the metal insert cast into a prestressed single-tee affects the elastomeric bearing pad, soleplate epoxy and grit coatings and the concrete in the prestressed single tee.

LABORATORY INVESTIGATION

A model of the bearing assembly was prepared in the laboratory at the Research Council in December 1975. A plywood form was constructed and thermocouple wires were secured at various locations throughout the form (see Figure 1 attached). Class A5 concrete (density = 146 pcf) made with Type III cement was mixed and placed in the form. A table vibrator provided consolidation. The model was steam cured for 21 hours at 150°F. Cylinder strengths of 4,100 psi were obtained after 14 1/2 hours of steaming. Following the completion of the steam curing, additional thermocouple wires were attached to the model.

Twenty-eight days after the concrete was cast, the bearing assembly was placed in a hydraulic press and loaded to 11,000 lbs. to simulate the dead load of a 42-ft. single-tee beam and to provide lateral support during the welding process (see Figure 2). Copper-constantan thermocouple wires were connected to a Honeywell thermocouple recorder to provide data on temperatures between 0° and 225° F. Iron-constantan thermocouple wires were connected to a Thermo Electric Multimite instrument to measure temperatures up to 600° F. Tempilstik marks were placed on the soleplate to determine areas where temperatures exceeded 600° and 800° F (Figure 3).

The shielded metal-arc welding process was used to weld the soleplate to the metal insert. The electric arc, varying from 175-225 amps at 23 to 24 volts, and several 5/32 inch E6010 electrodes were used in making the weld. The welding was begun by preheating the weld area to approximately 150° F with an oxyacetylene flame. Following the preheating, three passes of the electrode were required to provide the required 3/8 inch groove weld. To fill the groove completely, a total of five passes were made on one side of the model with an electric arc varing from 170 to 200 amps. Four passes were made on the other side with an electric arc of 200 to 225 amps. The approximate time required for each 6-inch pass was one minute and the average cooling interval between passes was two minutes. The first side was welded between 3:00 and 3:15 p.m. on January 7, 1976, and the second side between 10:10 and 10:23 a.m. the following morning. Following the completion of the welding, test cylinders were broken which indicated that the concrete compressive strength at the time of the welding was 6,000 psi.

RESULTS

The most significant and immediately apparent effects due to the welding were (1) the warping of the soleplate (see Figure 4), (2) the delamination between the concrete and the metal insert plate directly above the weld (see Figure 5), (3) the discoloration of the concrete in the area of the weld, and (4) the loss of bond between the epoxy and grit coatings on some areas of the soleplate (Figure 6).

An exaggerated version of the warpage is shown in Figure 7. The 1-inch thick soleplate currently specified for the single-tee bridges should warp about one-half as much as the 3/4-inch thick soleplate used in the laboratory model. A 1-inch soleplate should also reduce the amount of bond loss between the epoxy and grit coatings. However, delamination between the concrete and the insert plate above the weld may be somewhat greater when a 1-inch soleplate is used.

The distribution of the maximum temperatures in x, y, and x', y planes through the model caused by welding is shown in Figure 8. Maximum temperatures ranged from 95° F at the bottom of the bearing pad to 400° F at the top of the bearing pad. The maximum temperature reached by the epoxy and grit coatings on the bottom of the soleplate was 400° F. Temperatures in the area of fusion between the soleplate and metal insert probably reached $2,700^{\circ}$ F.[2] The concrete in the immediate vicinity of the weld reached a temperature in excess of 600° F, but concrete approximately 8 inches from the weld area remained at room temperature. Because steel transmits heat better than concrete does, the maximum temperature in the concrete in the vicinity of the studs (x', y plane, Figure 8) was somewhat higher than in the concrete between the studs (x, y plane, Figure 8).

Figure 9 shows the distribution of the maximum temperatures in the y', z' plane through the weld caused by preheat, one pass, three passes, and five passes. It is apparent that temperatures can be held to a minimum if the bearing assembly is allowed to cool to the preheat temperature before starting a pass.

Figure 10 shows an estimate of the time interval after welding for a point at a given distance from the weld to reach a maximum temperature. The curves are based on heat transmission solely through the specified material except for an initial 3/4-inch transmission through steel. Heat spreads through the steel much faster than through concrete or elastomer, For example, the temperature in the bottom of the bearing pad reached a maximum of 95° F approximately 18 minutes after the five welding passes had been completed. Approximately 18 minutes were required for concrete 7 inches from the weld area to reach a peak temperature. A point in the concrete or elastomer which is influenced by the rate of heat transmission in the steel can be expected to reach a maximum temperature at a time which falls within the areas bounded by the curves in Figure 10 for steel and for concrete or elastomer, respectively. For example, a point at the top of the bearing pad and 1 1/2 inches from the weld would reach a maximum temperature about 1 minute after welding was complete (see curve for steel) whereas, a point at the bottom of the bearing pad and 1 1/2 inches from the weld would reach a maximum temperature about 18 minutes after welding was complete (see curve for bearing pad).

DISCUSSION

The warped soleplate produced by this laboratory investigation will not comply with Section 411.08 of the Virginia Department of Highways & Transportation Road and Bridge Specifications, which requires "a uniform bearing over the whole area".[3] However, the warpage of a 1-inch thick soleplate as specified on the plans for the Norton bridges should be significantly less, and for all practical purposes should provide a satisfactory bearing. The warpage can be decreased by decreasing the number of passes or by increasing the interpass temperature.[2] However, the use of higher interpass temperatures is not recommended since higher temperatures may prove harmful to the bearing assembly and concrete. Warpage also may be decreased by adequately bracing the parts or by using other than continuous welding techniques, each of which may be economically impractical. Warpage may be best improved or corrected in this situation by reducing the weld size, or by using an alternative bearing assembly.

The delamination between the concrete and the top of the insert plate above the weld may increase when a 1-inch soleplate is used unless steps are taken to reduce warpage. The delamination provides a bad appearance and should favor corrosion of the metal insert plate. It would be advantageous to fill the crack with a cement grout. Where aesthetics is a matter of concern the discoloration of the concrete above the weld area can be eliminated by shielding the concrete from the welding. As can be seen from Figure 5, the application of duct tape to the concrete can prevent discoloration.

The loss of grit was confined to the area of the soleplate in contact with the bearing pad, but was not extensive enough to alter the behavior of the pad. With a 1-inch soleplate the loss of grit should be negligible. However, if temperatures on the bottom of soleplate were to exceed 400^{o} F, a significant breakdown in the bond between the epoxy and grit may occur.

All of the problems suggested by the laboratory investigation of the bearing assembly specified for the Norton bridges could be eliminated by removing the field weld, the soleplate, and the anchor bolts from the assembly. The metal insert could rest on the elastomeric pad and concrete steps could be cast into the tops of the abutments and pier cap beam to provide support in the transverse direction.[4]

CONCLUSIONS

The following conclusions are based on the assumption that the welding process, equipment, and procedures used in the field will be comparable to those used in the laboratory investigation.

1) The elastomeric bearing pad will not be damaged by field welding with the pad and beam in place.

2) The epoxy and grit coatings on the bottom of the soleplate will not be significantly damaged, although some loss in bond may occur.

3) Slight warpage of the soleplate can be anticipated, and therefore, strictly speaking, it will not comply with Section 411.08 of the Virginia Department of Highways & Transportation Road and Bridge Specifications. However, for all practical purposes the bearing should be satisfactory if a groove weld is applied to both sides of the soleplate at approximately the same time, the single-tee is braced to prevent asymmetrical warping, and the thickness of the soleplate is 1 inch or more.

4) Delamination between the concrete and the top of the insert plate can be expected.

5) Discoloration of the concrete can be expected in the vicinity of the welding.

RECOMMENDATIONS

1) Use the 3/8-inch field groove weld and the 1-inch thick soleplate as specified on the plans for the Norton bridges, but consider reducing the specified weld size and increasing the specified soleplate thickness on future prestressed bridge members.

2) Use cement grout to plug cracks which develop between the top of the insert plate and concrete.

3) Use a shielding material such as tape to protect the concrete from discoloration if aesthetics is a concern.

4) Consider the use of an alternative bearing assembly in future prestressed members, if the performance or appearance of the bearing assembly used in the Norton bridges turns out to be less than desirable or if welding appears to require unnecessary field labor and cost. A bearing assembly which eliminates the field weld and the soleplate should provide a practical alternative.

ACKNOWLEDGEMENTS

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2. Udin, Harry E., Edward Funk, and John Walff, Welding for Engineers, John Wiley and Sons, Inc., New York, N. Y., 1954.

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4. "Precast Prestressed Concrete Short Span Bridges", Prestressed Concrete Institute, Chicago, Illinois, 1975.

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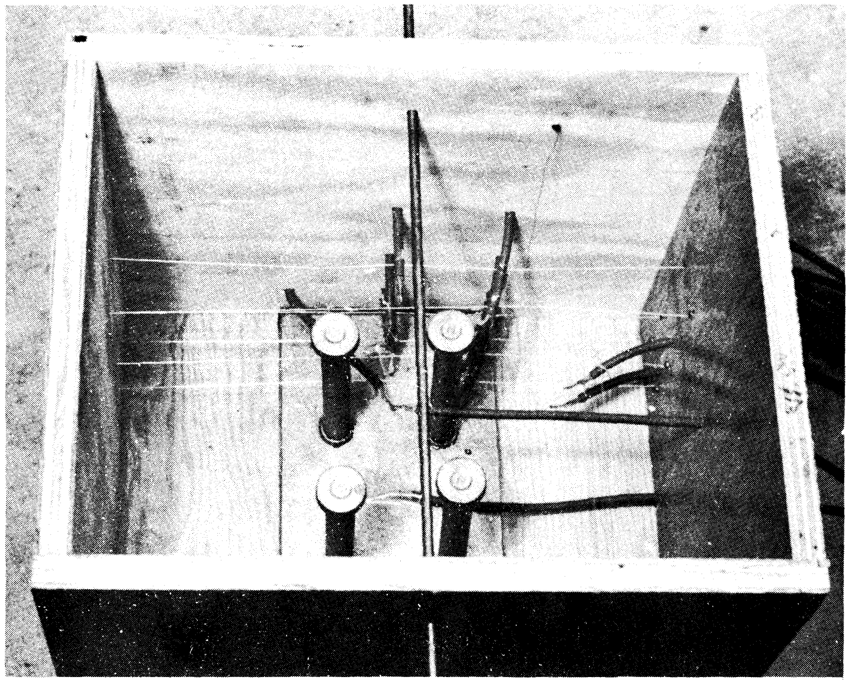

Figure 1. Form for casting model of bearing assembly.

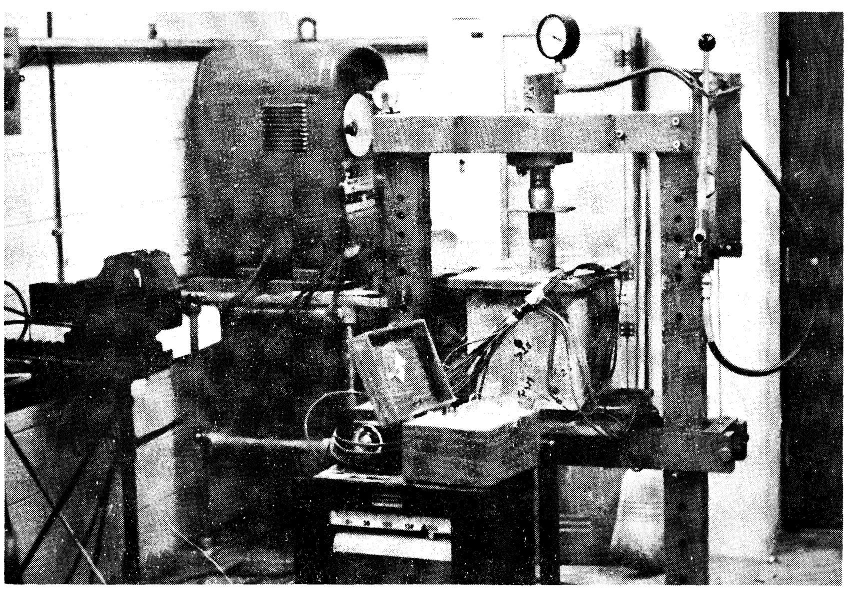

Figure 2. Model of bearing assembly as prepared for welding.

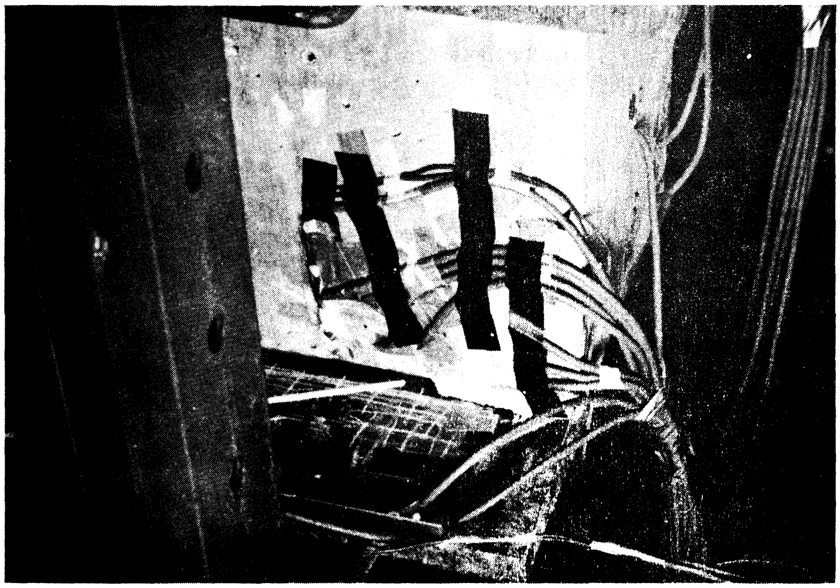

Figure 3. Tempilstik marks and thermocouple wires prior to welding.

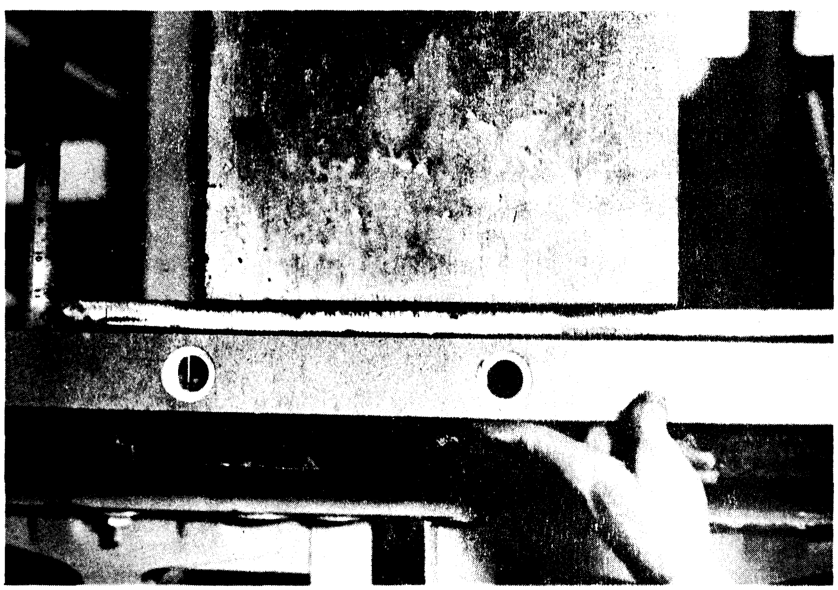

Figure 4. Warpage of soleplate caused by welding.

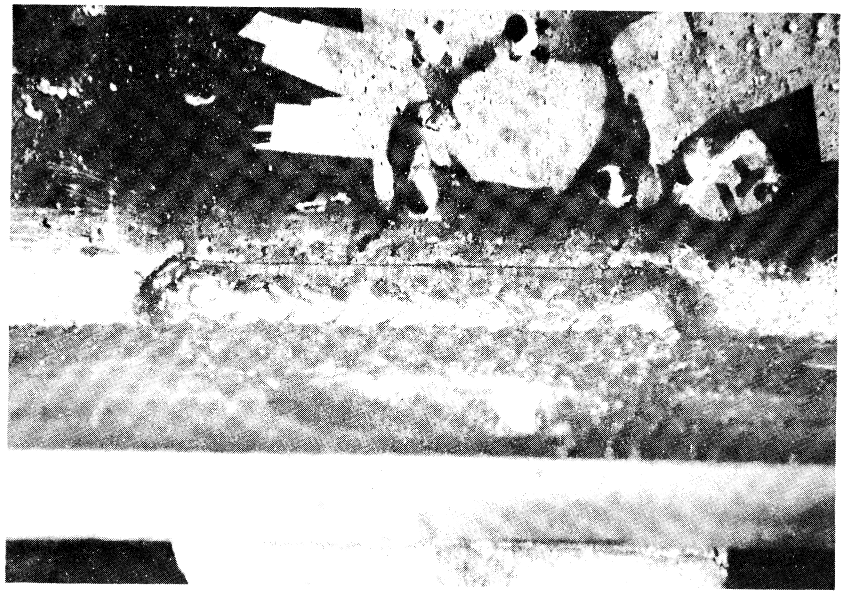

Figure 5. Delamination between the concrete and metal insert and discoloration of concrete caused by welding.

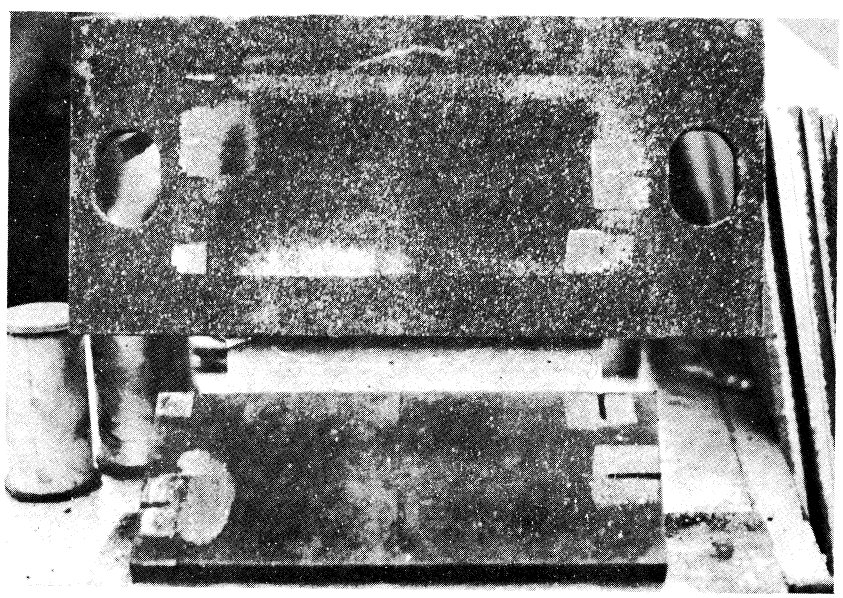

Figure 6. Loss of bond between the soleplate,epoxy and grit.

Soleplate thickness (inches)		3/4*	1**
Δ A	(inches)	0.025	0.01
Δ B		0.01	0.00
Δ C		0.10	0.04
Δ D		0.01	>0.01

* actual values
** estimated

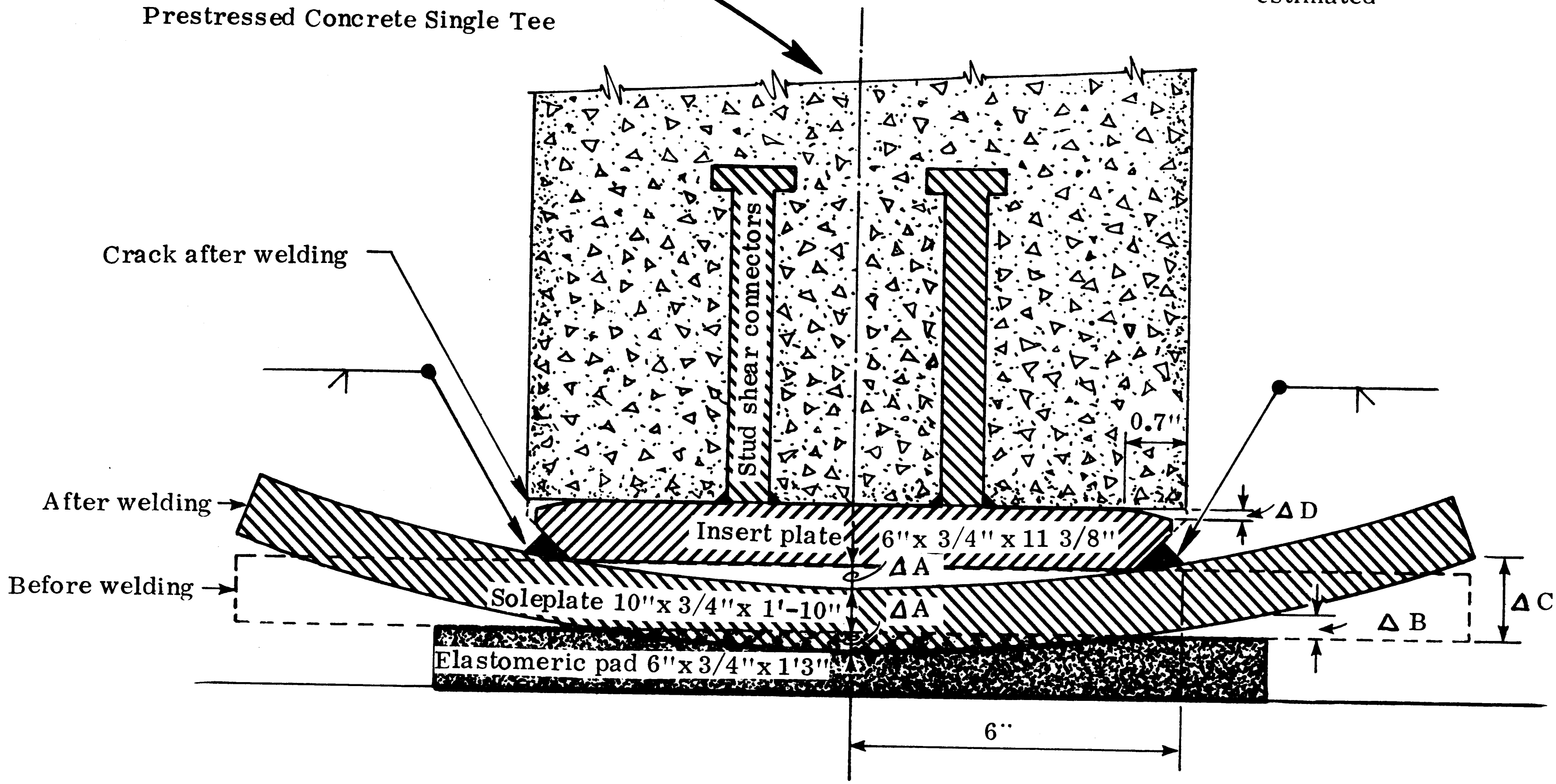

Figure 7. Distortion caused by welding (not to scale)

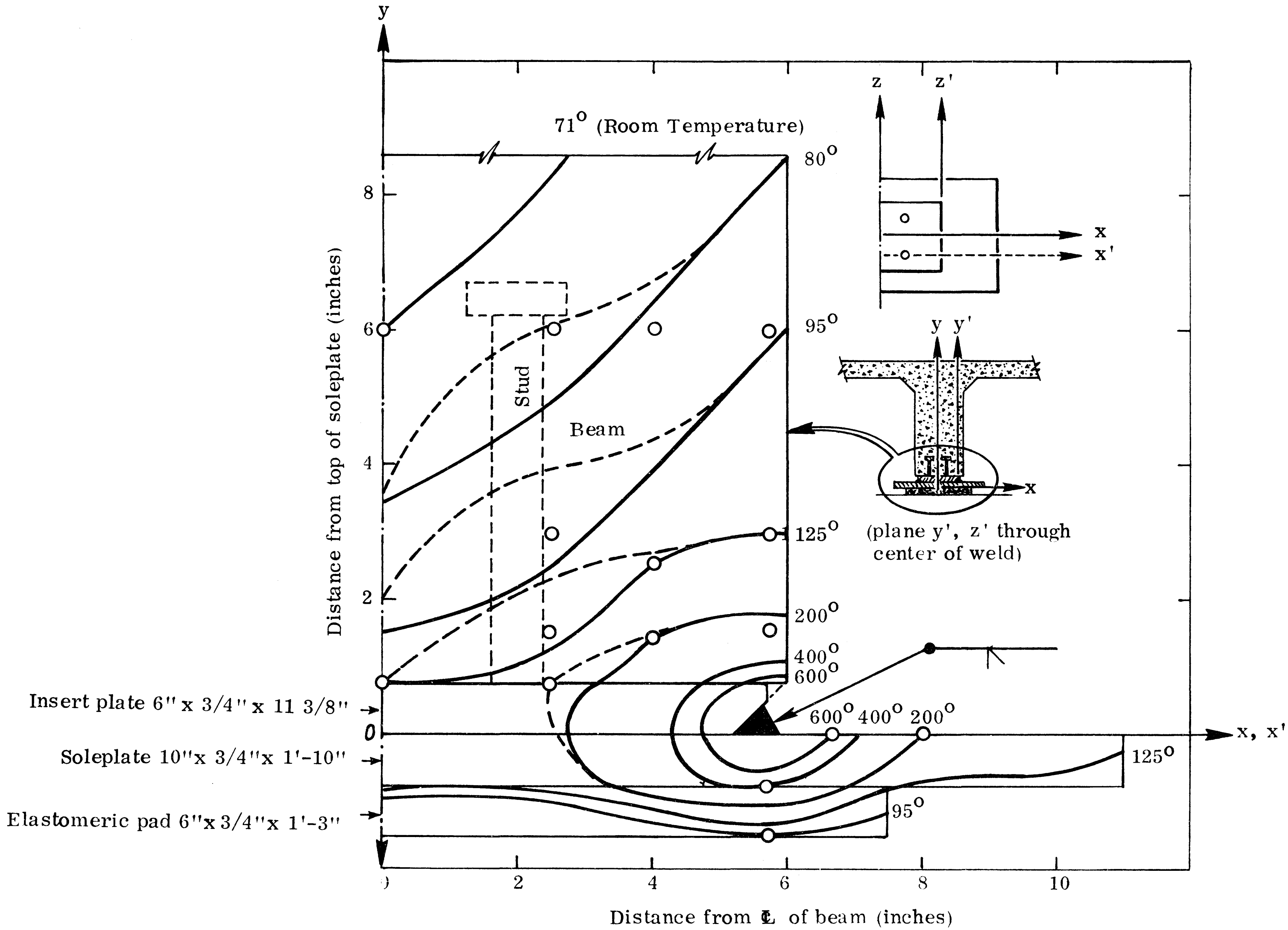

Figure 8. Distribution of maximum temperatures in x, y, and x', y planes through model due to welding.

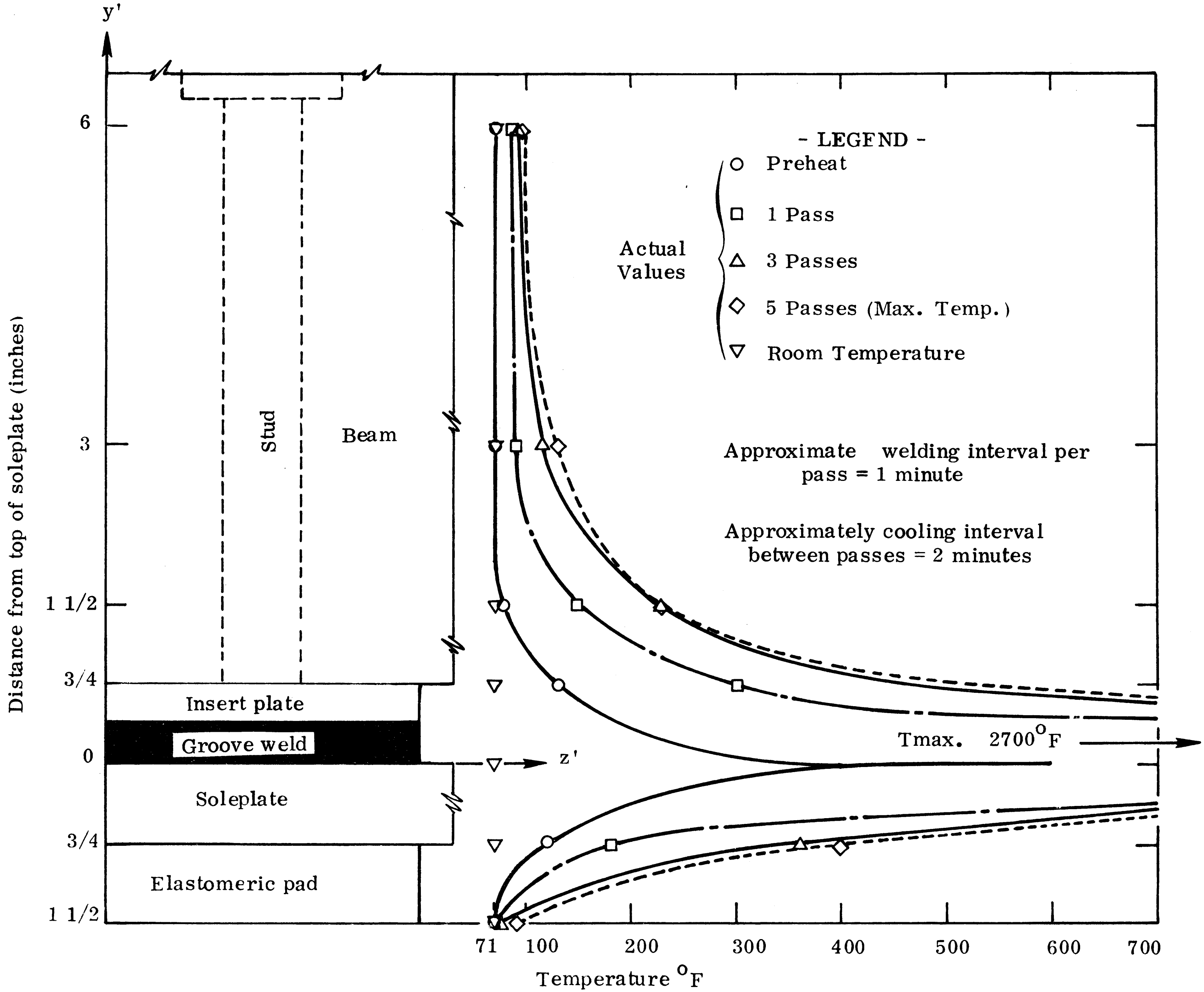

Figure 9. Maximum temperatures °F in y' z' plane (see Figure 7) through weld.

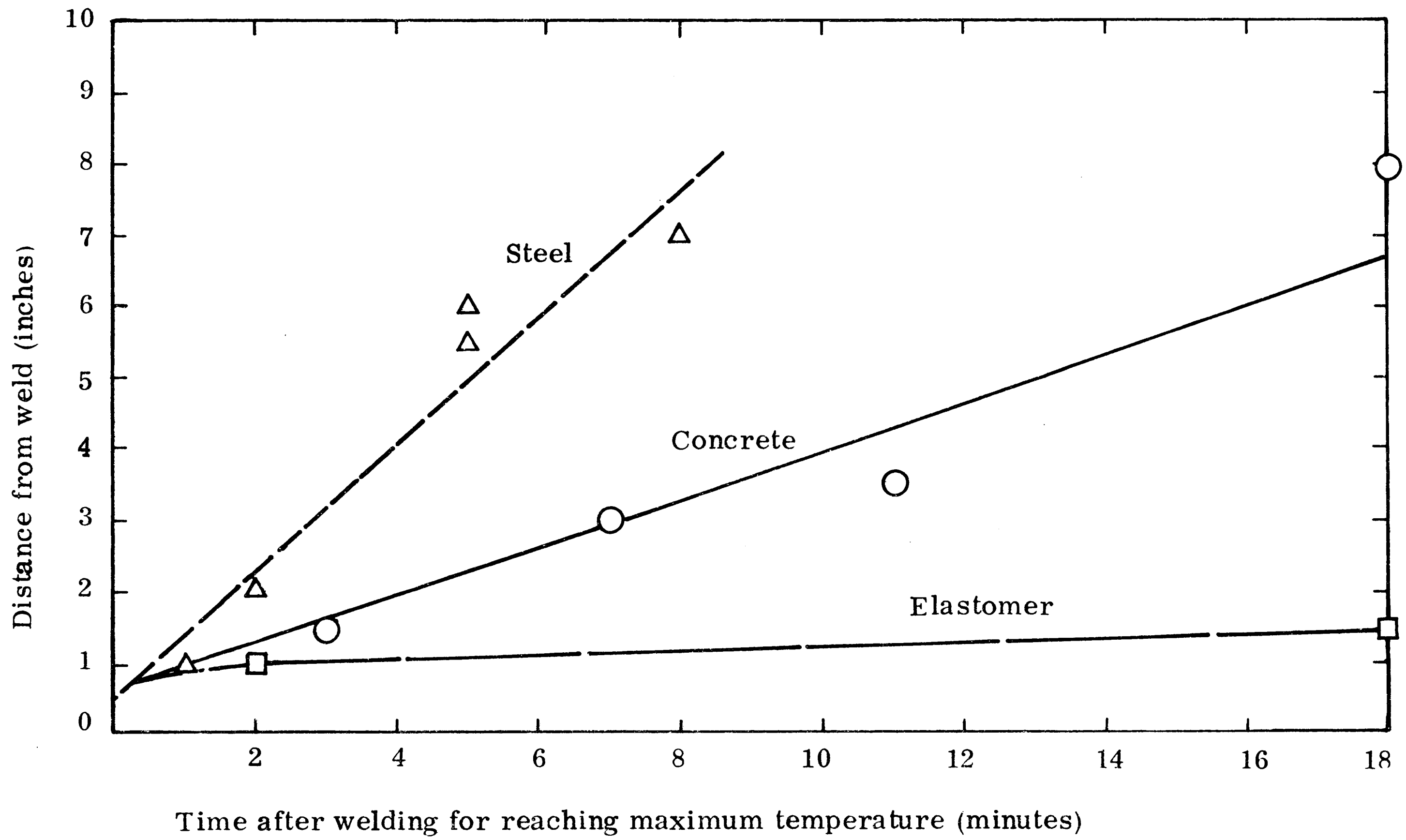

Figure 10. Time after welding vs. distance from weld for reaching maximum temperatures in specified material (heat conductivity through specified material with the exception of an initial 3/4" transmission through steel).