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MICHIGAN
STATE HIGHWAY DEPARTMENT
Charles M. Ziegler
State Highway Commissioner

STUDY OF THE EFFECTIVENESS OF HOOK BOLTS
FOR USE AS TIEBARS FOR LONGITUDINAL JOINTS

Gene Gudney

Highway Research Project ~~39-F-1~~

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Research Laboratory
Testing and Research Division
Report No. 198
November 3, 1953

MICHIGAN
STATE HIGHWAY DEPARTMENT
CHARLES M. ZIEGLER
State Highway Commissioner
TESTING AND RESEARCH DIVISION

Project No. F19-9-CRECU
F16-21-CRECTH
Pur. Order No. _____
Lab. No. _____ Date Rec'd. _____

SAMPLE IDENTIFICATION

Name of Material Right Angle Anchor Bolts
 Manufacturer or Producer Jones E. M. C. Knight, Inc.
 Address Chicago Ill
 Sampled from Stock on job
Give car number and initial, if rail shipment. If sampled at pit, give 1/4 section, section, town line and range.
 Quantity of Material Represented by Sample 12000 complete units
 Consigned to: Sargent Const. Co. Sargent Mich
If sampled at source, state to whom and where material is to be shipped.
 Sampled by H. A. Laake Name Title Proj. Eng. Date Sampled 6-22-54
 Submitted by H. A. Laake Name Title P.D. Roy Address Box 22 Bay City
 Intended Use tie bars in longitudinal bulk head Const. Joint.
 Specification _____ Sender's Identification _____
 Remarks Send Report To CR-101 County _____
 Maint. Sec. No. _____

Consign Samples to State Highway Laboratory, University of Michigan, Ann Arbor, Mich.
NOTE: PLEASE OBSERVE SAMPLING INSTRUCTIONS ON REVERSE SIDE

INSTRUCTIONS FOR SELECTING AND SHIPPING SAMPLES

The following instructions will apply unless otherwise specified:

1. Samples should be selected with care and should be representative of the material sampled.
2. Pack to withstand rough shipment. Mark pipe and tile conspicuously "Handle with care. Fragile."
3. Place this sheet in the accompanying tag envelope, which should be securely attached to the container in which the sample is shipped. Also, inclose duplicate identification sheet inside wrapping, or if shipped in cloth sack, inside the sack.
4. When immediate report is not required, ship samples by freight.
5. Cloth bags, screw top cans and friction top cans may be obtained from the Laboratory.

SIZE AND NUMBER OF SAMPLES REQUIRED AND TYPE OF CONTAINERS

PORTLAND CEMENT AND MINERAL FILLER—8 to 12 lb. A composite sample is obtained by taking a portion from one sack in every forty and should be representative of 500 bbl., or less. Ship in closely woven bag, can or tight box.

SAND—40 to 60 lb. A sample should represent not more than 100 cu. yd. Use a closely woven bag, or tight box. Do not use sacks which have contained sugar, grain, or other organic matter.

GRAVEL OR CRUSHED STONE—80 to 100 lb. A sample should represent not more than 100 cu. yd. Use a closely woven bag or tight box. For abrasion, sample must be all retained on a No. 4 sieve.

WATER—One quart. A sample should be sent in from each source to be used in concrete. Ship in screw top can.

REINFORCING STEEL—Two pieces 27 in. long of each size from each consignment of 10 tons or less. For mesh reinforcement, two samples 30" x 30", with each gauge wire represented, from each carload or its equivalent.

PIPE AND TILE—Reinforced Concrete Culvert and Sewer Pipe—one per cent of each size. Nonreinforced Concrete Culvert and Sewer Pipe—one per cent of each size but not less than 2 pieces. Vitrified Clay Culvert and Sewer Pipe—one per cent of each size, but not less than 2 pieces. Drain tile (Concrete and Vitrified Clay)—one per cent of each size, but not less than 5 pieces.

CORRUGATED METAL PIPE—Three pieces approximately 6 in. square from each 20 culverts of each heat and gauge number of each size. Ship in small cloth sack or box.

ASPHALT AND TAR—One quart. A sample should represent one carload, or in case of barrel shipment, the consignment. If material is a solid, clean surface thoroughly before selecting sample. Ship liquids in screw top cans and solids in friction top cans. Cans must be clean and dry.

ASPHALT EMULSION—One gallon for each carload and two quarts from each barrel shipment. Ship in glass container, properly packed.

BITUMINOUS PAVEMENT SAMPLES—If taken from the loose mixture, about 10 lb. Samples should represent the day's run. If taken from the rolled pavement, approximately 12 in. square. Ship in well wrapped package.

GUARD RAIL CABLE—One sample at least 4 ft. long from each 1000 ft. or less.

PREMOLDED JOINT FILLER—For pavements, one sample 2 ft. long and full depth of joint from each consignment. For Structures—One square foot of material, sample to be at least 5 inches wide.

PAVING BRICK—10 bricks from each 15,000 or less.

MASONRY BRICK—10 bricks from each 50,000 or less.

PAINT AND LACQUER—One pint sample from each consignment. Mix paint thoroughly before sampling.

CALCIUM CHLORIDE—One quart in air-tight Mason jar for each shipment.

STUDY OF THE EFFECTIVENESS OF HOOK BOLTS
FOR USE AS TIEBARS FOR LONGITUDINAL JOINTS

At the request of L. B. Laird, Assistant Construction Engineer, an investigation was made to determine the effectiveness of hooked bolts (J-bars) in holding together and transferring load across longitudinal pavement joints.

The hook bolts, or J-bars, consist of two 9/16" diameter plain steel bars hooked at one end with a 90 degree bend and joined together at the other end with a threaded sleeve. Regular 1/2" diameter deformed steel tie bars were subjected to the same tests for comparative purposes.

SCOPE:

The first part of this study was concerned with the determination of ultimate tensile strengths and failure characteristics of three different types of bars. Tension tests were performed on three structural grade steel J-bars, three hard grade deformed steel tie bars, and three structural grade deformed steel tie bars. These bars were all tested on a standard tensile testing machine.

The second phase of this study consisted of casting each of the three types of bars in concrete blocks, simulating a tie bar device in a longitudinal joint. Both unkeyed and keyed blocks were tested. The keyway for the keyed specimens appeared as a trapezoid in cross-section with the base dimensions, running vertically, of 1 1/2" and 2 1/2" and a height of the trapezoid (horizontal dimension) of 1". Each specimen consisted of two joined concrete blocks which were twelve inches wide, seven inches deep, and sixteen inches long. Each of the two types of tie bars were embedded a length of fifteen inches into each block. The J-bars were embedded six inches into one block, and eight inches into the other block, the sleeve being flush with the joint face. All bars were cast at mid-depth of the blocks. One keyed and one

unkeyed specimen of each of the three different types of bars were cast, and all specimens were cured in a moist room for approximately seven days. The unkeyed specimens were poured with each block being cast separately, the second block being poured the day following the pouring of the first block, effecting a butt joint. The keyed specimens were cast in a similar manner. Prior to testing of both the keyed and unkeyed specimens the bond was broken between the blocks so that the load transfer was effected completely by the tie device under test.

Each specimen was then placed in the MSHD load transfer testing machine. (See Figure 1). This machine provides a method of applying pure shear increments at the joint face, and obtaining relative deflections of the two blocks.

The loads were applied in 500 pound increments in the following manner:

1. No load to 3000 pounds
2. No load to 6000 pounds
3. No load to 9000 pounds
4. No load to 12000 pounds
5. No load to failure.

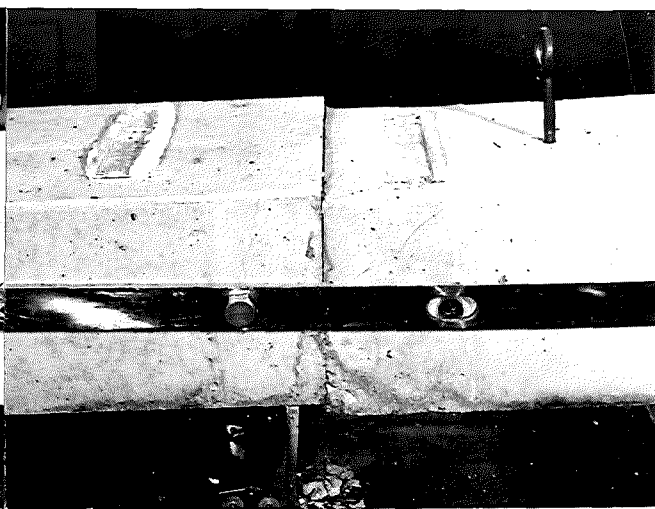
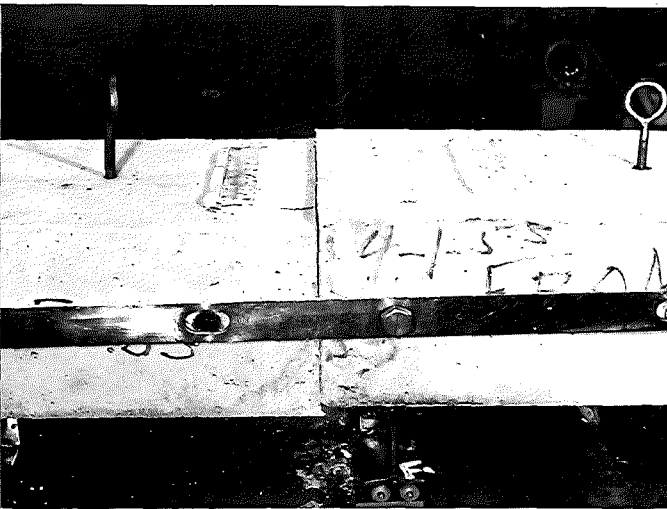
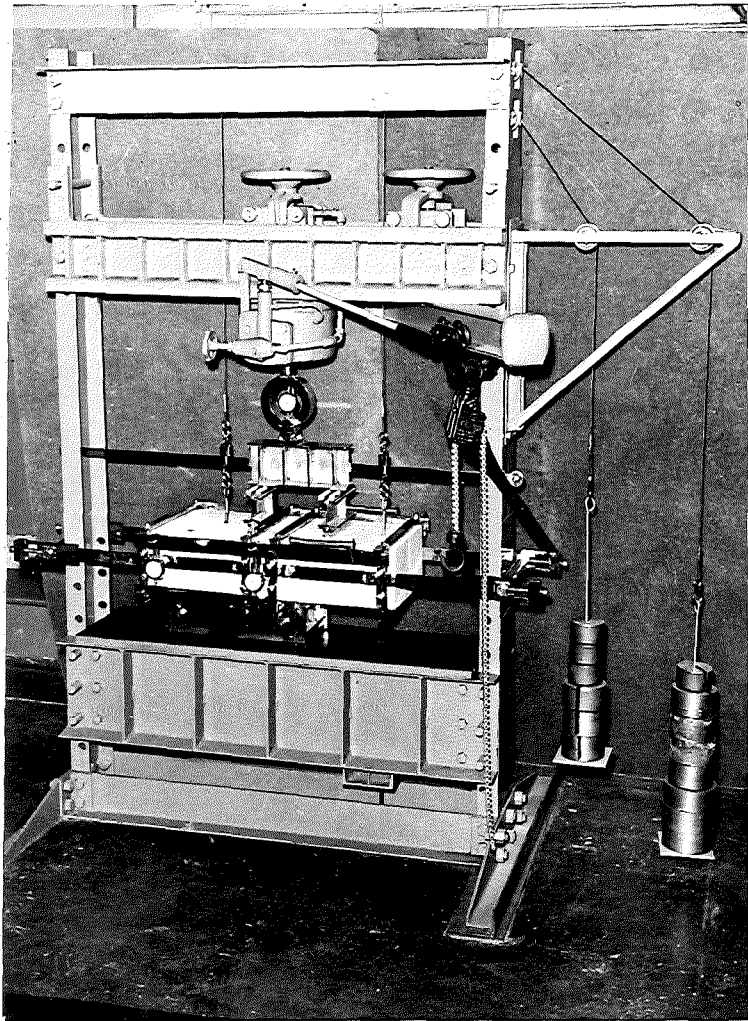
This method of loading provides a measure of relative residual deflections of the three types of bars. Figures 2 and 3 show a typical concrete specimen at failure.

Test cylinders were made from each batch of concrete used in pouring the blocks. These cylinders were allowed to cure for seven days in a moist room and tested to determine the ultimate concrete compressive stress.

RESULTS:

A. Tension Test

1. The average ultimate load and the average ultimate stress for three specimens of each type of bar tested in tension were as follows:



▲ FIGURE 2. TYPICAL CONCRETE FAILURE OF SPECIMEN IN LOAD TRNFER TEST MACHINE. FRONT FACE.

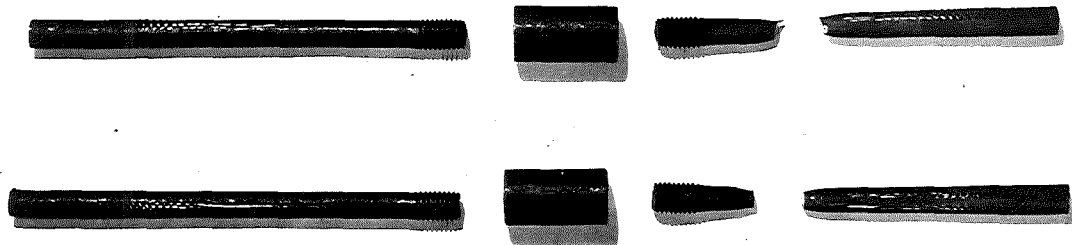
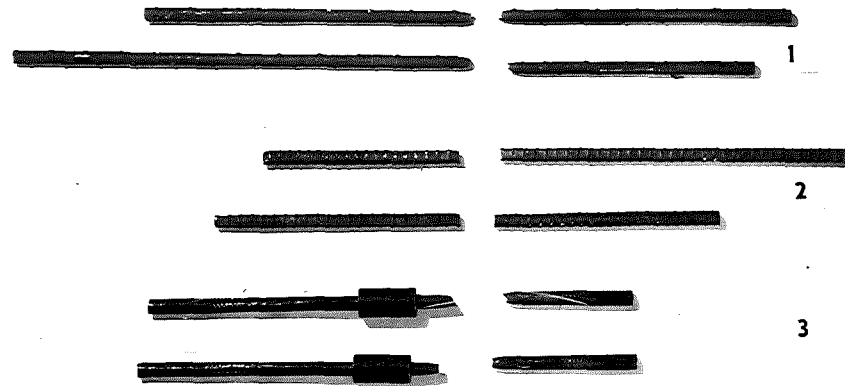
▲ FIGURE 3. BACK FACE OF SAME SPECIMEN AS IN FIGURE 2.

▲ FIGURE 1. MICHIGAN STATE HIGHWAY DEPARTMENT LOAD TRANSFER TESTING MACHINE.

FIGURE 4. TENSION TEST FAILURES

- 1 - STRUCTURAL GRADE STEEL TIE BAR
- 2 - HARD GRADE STEEL TIE BAR
- 3 - STRUCTURAL GRADE STEEL J-BAR

▲ FIGURE 5. J-BAR TENSION FAILURE WITH THREADED PORTION REMOVED.



3

1

2

3

	<u>Ultimate Load</u>	<u>Ultimate Stress</u>
(a) Structural grade steel J-bar	15,720#	63,000 psi
(b) Structural grade steel tie bar	9,760 14,640#	74,500 psi
(c) Hard grade steel tie bar	21,830#	106,000 psi

2. All three J-bars failed in tension through the bar on a section outside of the threaded sleeve. (See Figures 4 & 5).

B. Load Transfer Test

1. The J-bar specimens showed less recovery from load at the smaller increments than did either of the two tie bar specimens. However, at the larger increments, all three types showed about the same amount of recovery. (See Figure 6)

2. The J-bar type was less rigid than were either of the two tie bar types in transferring load across the joint in the range of loads above the yield stresses of the bars.

3. Below the yield stress and up to about 3000 pounds of joint face shear, the J-bar and the structural grade steel tie bar were about equally effective in transferring load. (See Figure 7)

4. With the keyed blocks, there was very little difference in the performance of the three types of bars, thus indicating that the concrete was effectively resisting the shearing forces. The keyed blocks were about 80% more rigid in this test than the blocks without the keyways. Figure 6 shows the effect of keying the blocks together.

The average compressive strength of the cylinders made from concretes used with the hard grade tie bar and the J-bar was 2600 psi, while that of the cylinders made from concrete used with the structural grade tie bar was 3000 psi.

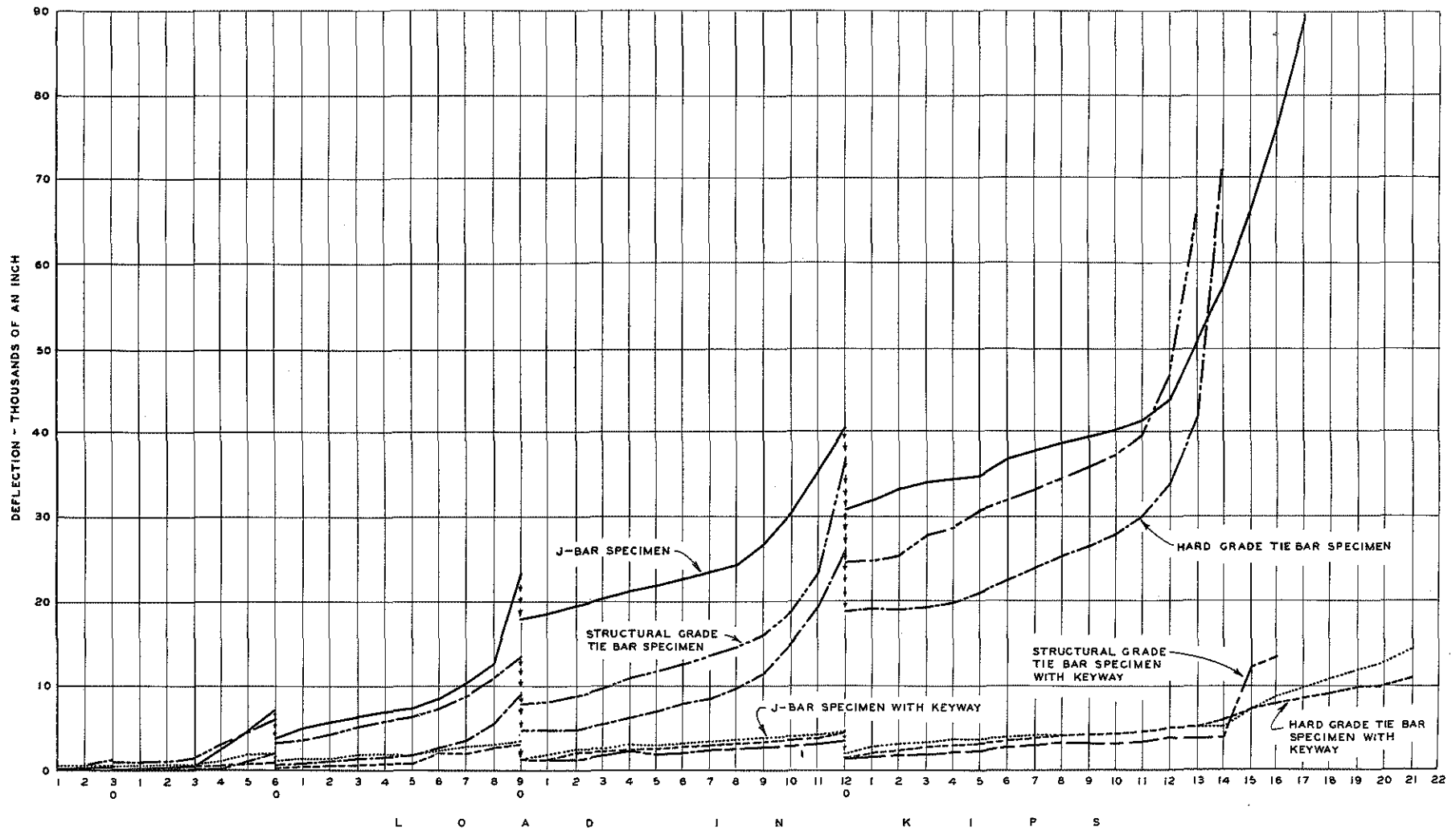


FIGURE 6

LOAD DEFLECTION GRAPH FOR VARIOUS SPECIMENS
SHOWING RESIDUAL DEFLECTIONS

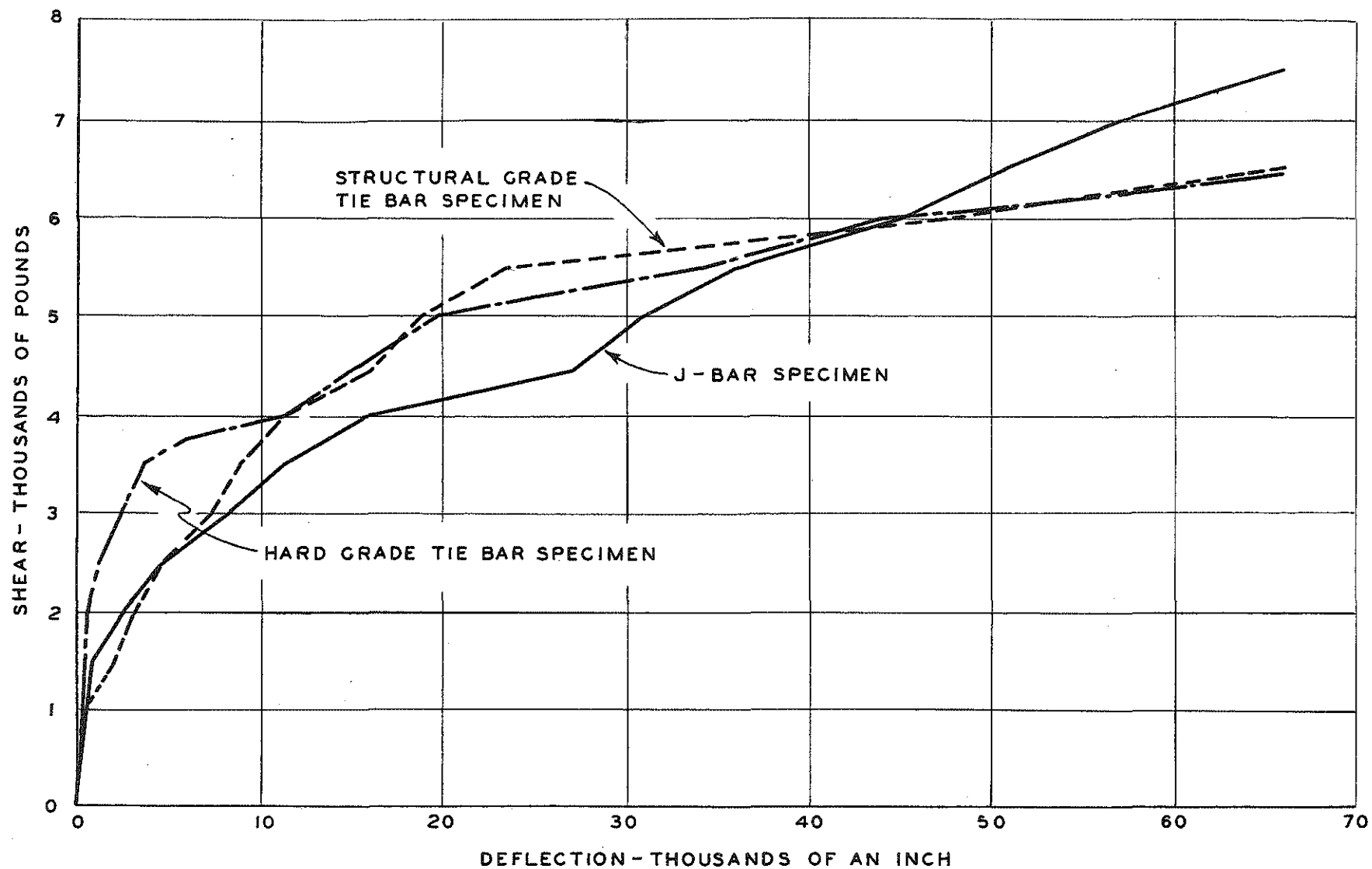


FIGURE 7

SHEAR DEFLECTION GRAPH FOR SPECIMENS WITHOUT KEYWAYS

DISCUSSION:

The primary purpose of any device used in longitudinal pavement joints is to hold the two adjacent slabs firmly together. Consequently, this device will be subjected to tensile stress in order to keep the slabs from pulling apart.

The critical section for tensile failure in the J-bars that were tested, was outside of the threaded sleeve connection. Thus, this device would be just as effective in tension as a straight continuous bar of the same strength and size.

In the load transfer phase of this test, the bond between the two blocks was broken before the actual test was run. In other words, the bar device was resisting all of the applied shear. In actual longitudinal joints, when the adjacent slabs are held together closely by the tie device, a large portion of the load will be transferred by aggregate interlock. From the results of the tension tests, it appears that the J-bars will fulfill their primary function of holding the adjacent pavement slabs together, and therefore should function satisfactorily as tie devices for longitudinal joints.