MACHINE FINISHING OF I 96 BRIDGES OVER THE GRAND RIVER
B01 and B02 of 23151A

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B01 and B02 of 23151A

In the letter of transmittal for Research Report No. R-373 ("Machine Finishing of Bridge B01 of 11016: I 94 over the St. Joseph River"), dated March 19, 1962, it was agreed that transverse machine finishing would be observed during deck operations for a long-span rolled beam or plate girder bridge. With longer spans, larger deflections of stringers under the dead load of the finishing machine might have greater adverse effect on riding quality.

The I 96 bridges over the Grand River near Lansing were subsequently selected for continuation of this study. This report consists of an evaluation of stringer deflections for Bridge B01 of 23151A (formerly B3 of 23-16-4) obtained during various stages of the finishing operations, and a roughness appraisal of completed deck surfaces of Bridges B01 and B02 of 23151A. Deflections of Bridge B02 of 23151A (formerly B4 of 23-16-4) were also measured, but will not be reported due to the erratic nature of the observed deflection data.

Bridges B01 and B02 of 23151A carry I 96 eastbound and westbound roadways, respectively, over the Grand River approximately 6.3 mi southwest of Lansing. The eastbound bridge (B01) is on a 60° skew and is 399 ft 6 in. long, while the westbound bridge (B02) is normal to the construction centerline and is 302 ft 6 in. long. Each bridge consists of two anchor spans and one suspended span, with each span consisting of four plate girder stringers and a composite deck with a clear roadway width of 30 ft. In addition to the typical cross-section for Bridge B01 shown in Fig. 1, longitudinal schematic diagrams and typical plate girder elevations for both bridges are shown in Figs. 2 and 3.

Construction Operations

The finishing machine used (Fig. 4) was manufactured by the Cleveland Formgrader Co. Weighing 8840 lb and of a truss-type construction, it was supported at each end by two 1-ft diam wheels on 6-ft centers. In addition, the machine had a single, 12-in. wide oscillating screed with a maximum lateral screed displacement of 8 in.

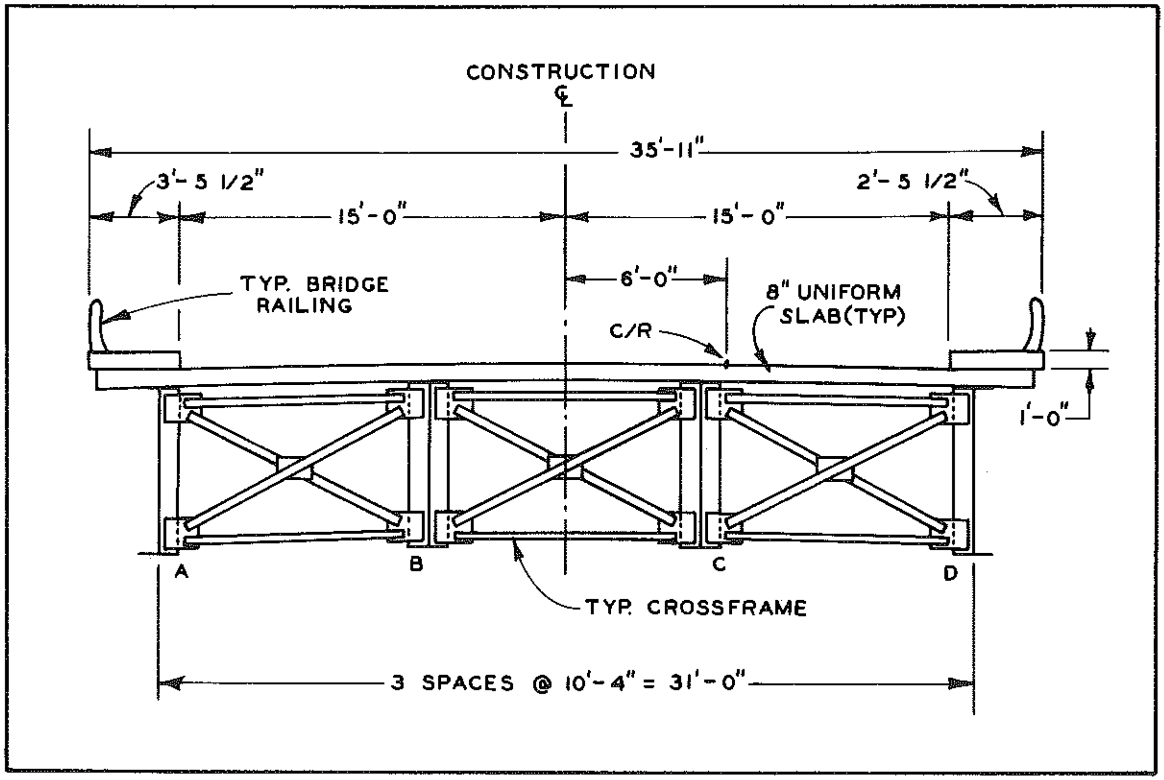

Figure 1. Typical cross-section of Bridge B01.

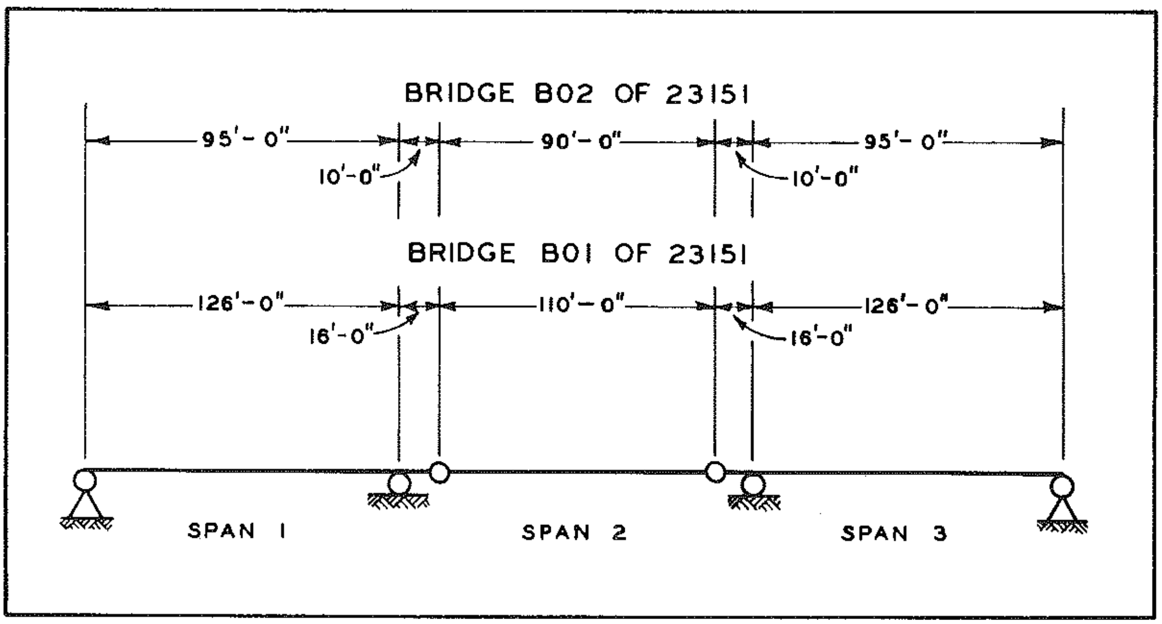

Figure 2. Schematic diagram for both bridges.

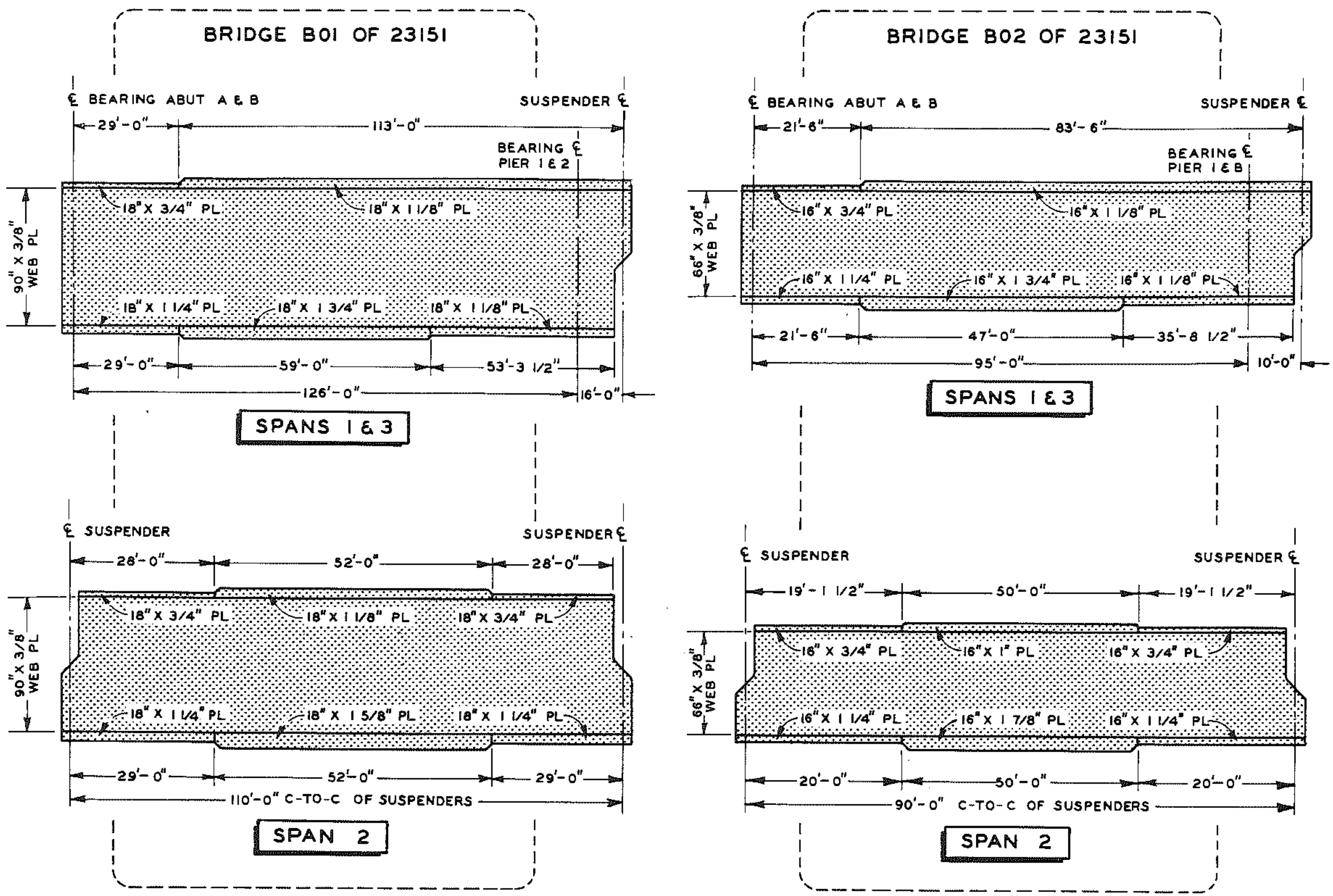

Figure 3. Typical plate girder elevations, showing change in flange plate thickness.

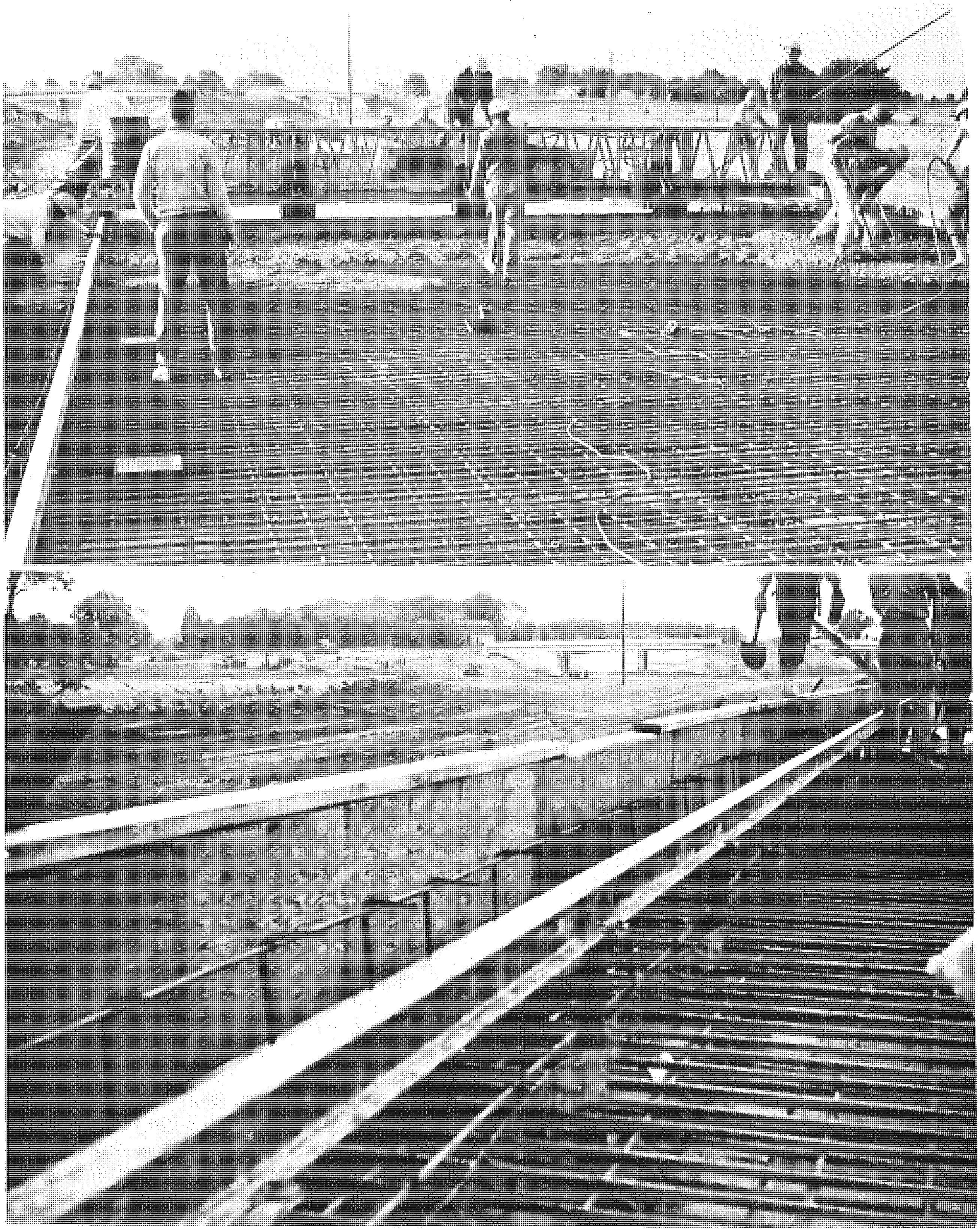

Figure 4. Finishing machine and support rail; bridge finishing machine (top) and threaded pipe and machine rail support (bottom).

The rails on which the machine rode were supported every 5 ft on pipes threaded into sleeves welded to the top flanges of the two fascia stringers. These pipe posts were covered with bituminous wrapping paper to facilitate their removal and re-use after a pouring sequence was finished. The completed rail support is shown in Fig. 4. Plywood forms were used in the construction of both structures.

Concrete was transported from the transit mix trucks to the finisher using a crane equipped with a 2-yd capacity bucket as shown in Fig. 5. Pouring of each bridge began with the suspended span (Span 2) first, followed by Span 1 next, and then Span 3.

Deflection Evaluation

Span 1 on both the eastbound (B01) and westbound (B02) bridges was selected for measurement of stringer deflections. All deflections were measured with 0.001-in. dial indicators. The basic deflection measuring set-up consisted of two lengths of steel conduit acting telescopically. One length was 3/4-in. diam and pinned to the stringer, while the other was 1/2-in. diam and firmly attached to a base, either set in the ground or fixed to the bridge slope wall. A dial indicator was clamped to the larger-diameter conduit and a bearing angle to the smaller, as indicated in the typical deflectometer set-up shown in Fig. 6.

On Bridge B01 of 23151A deflections were measured at the quarter and half points of the four stringers of Span 1 with reference to Abutment A. A simple schematic plan view is given in Fig. 7 showing load distribution and locations of Stringers A, B, C, and D (a similar schematic is given for B02 in Fig. 9). Span 1 transverse load distributions for the finishing machine only, and those showing the effects of the machine and concrete during placing and finishing operations, were obtained with reference to the quarter, half, and three-quarter points of Stringer A (Figs. 8 and 10). Additional distributions comparing measured and computed dead load deflections are shown in Figs. 11 and 12.

In analysing these distributions, deviations in computed and measured values may be attributed largely to the following two conditions:

1. Diaphragms located at approximately the one-fifth points of the span stiffened the section to the extent that any load applied was transferred to each stringer in a more uniform manner. Thus, theoretical stringer deflections, computed on the assumption of simple support and without diaphragm consideration, will vary from the measured values, as shown in Figs. 11 and 12.

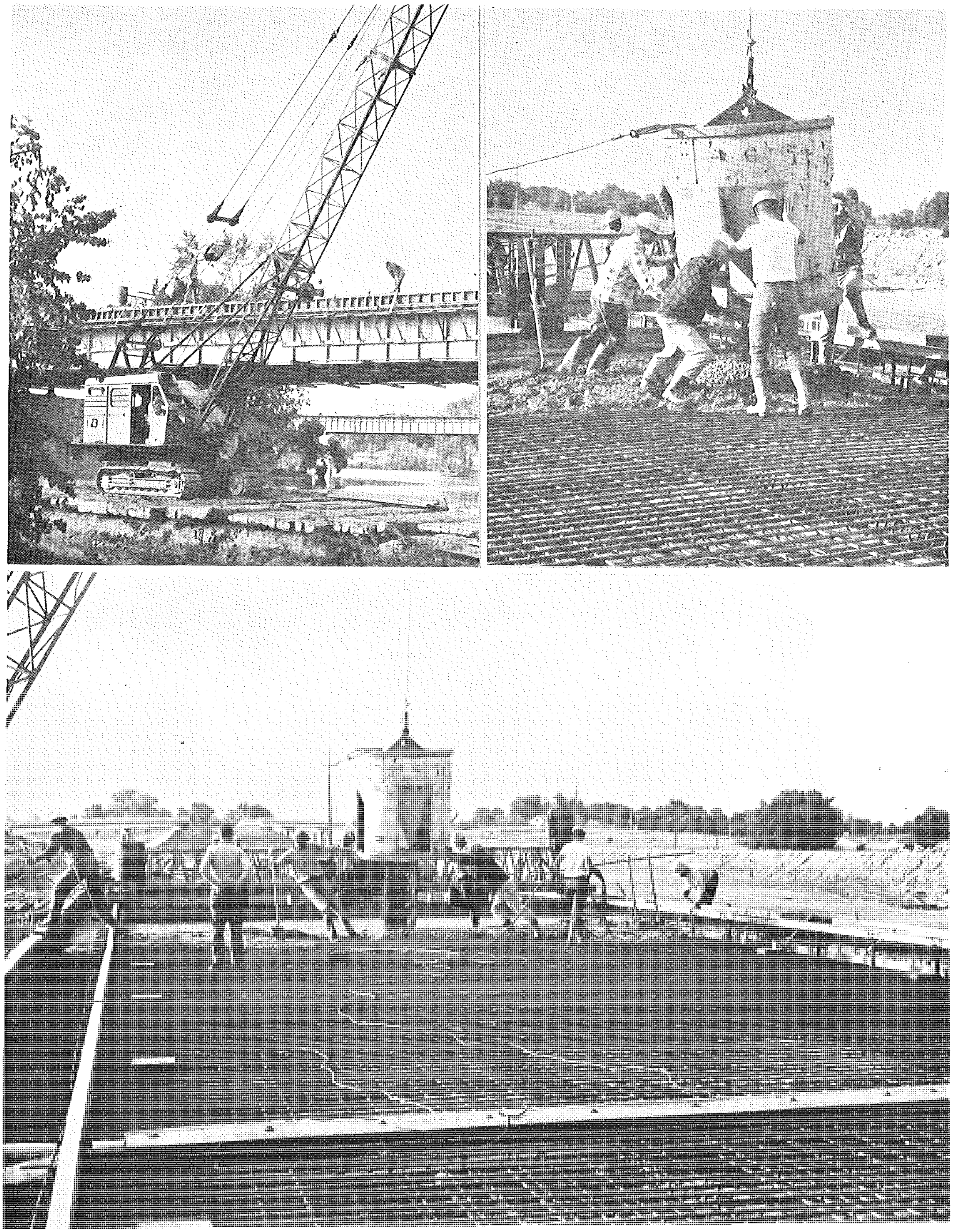

Figure 5. Placing of concrete.

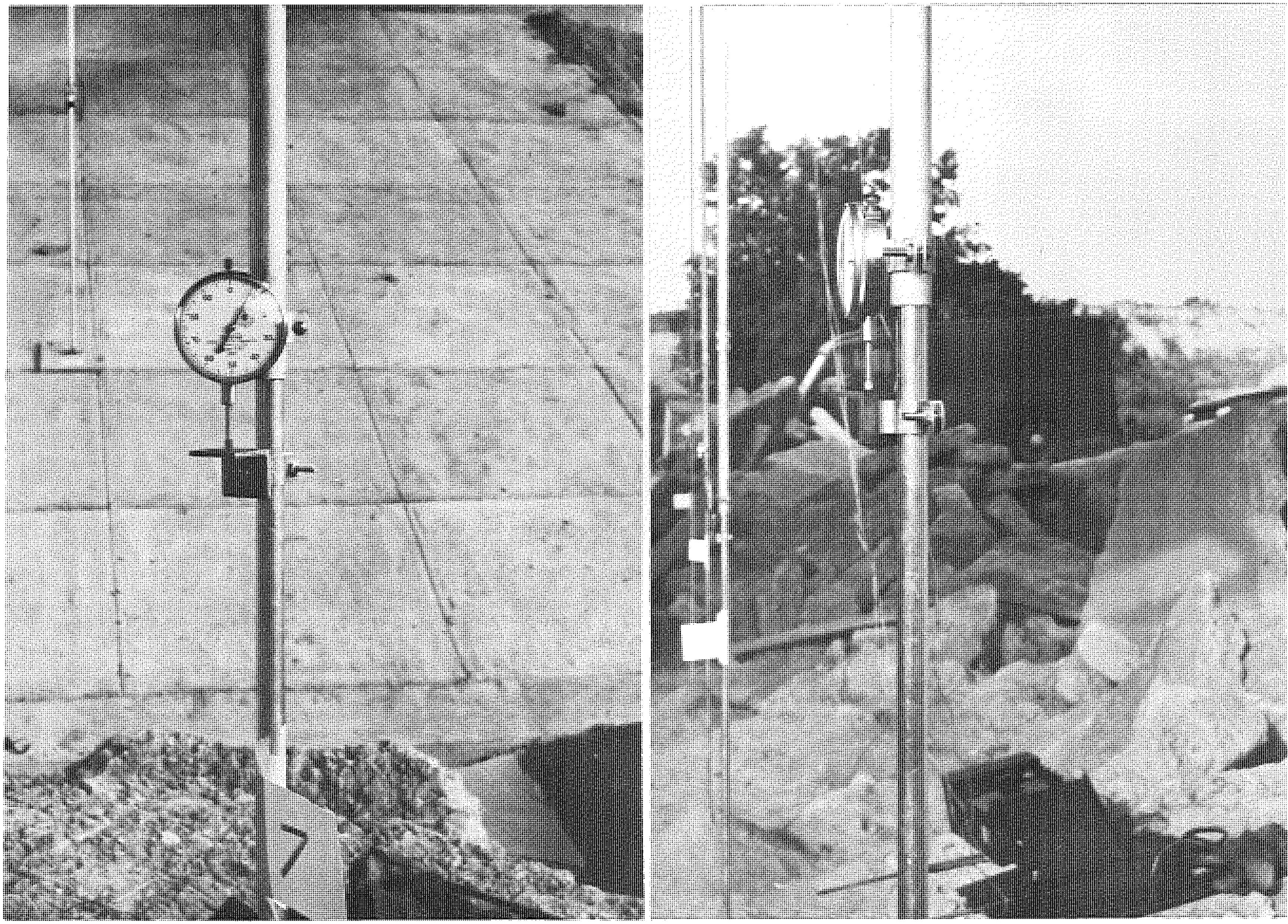

Figure 6. Typical set-up for measurement of stringer deflections.

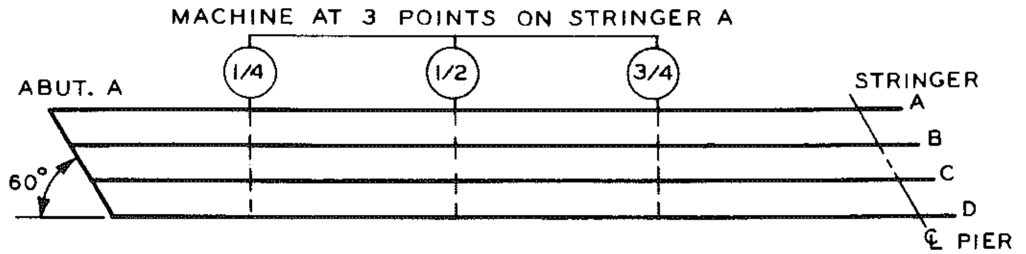

Figure 7. Plan view of Span 1 of B01 showing position of machine for distributions of Fig. 8.

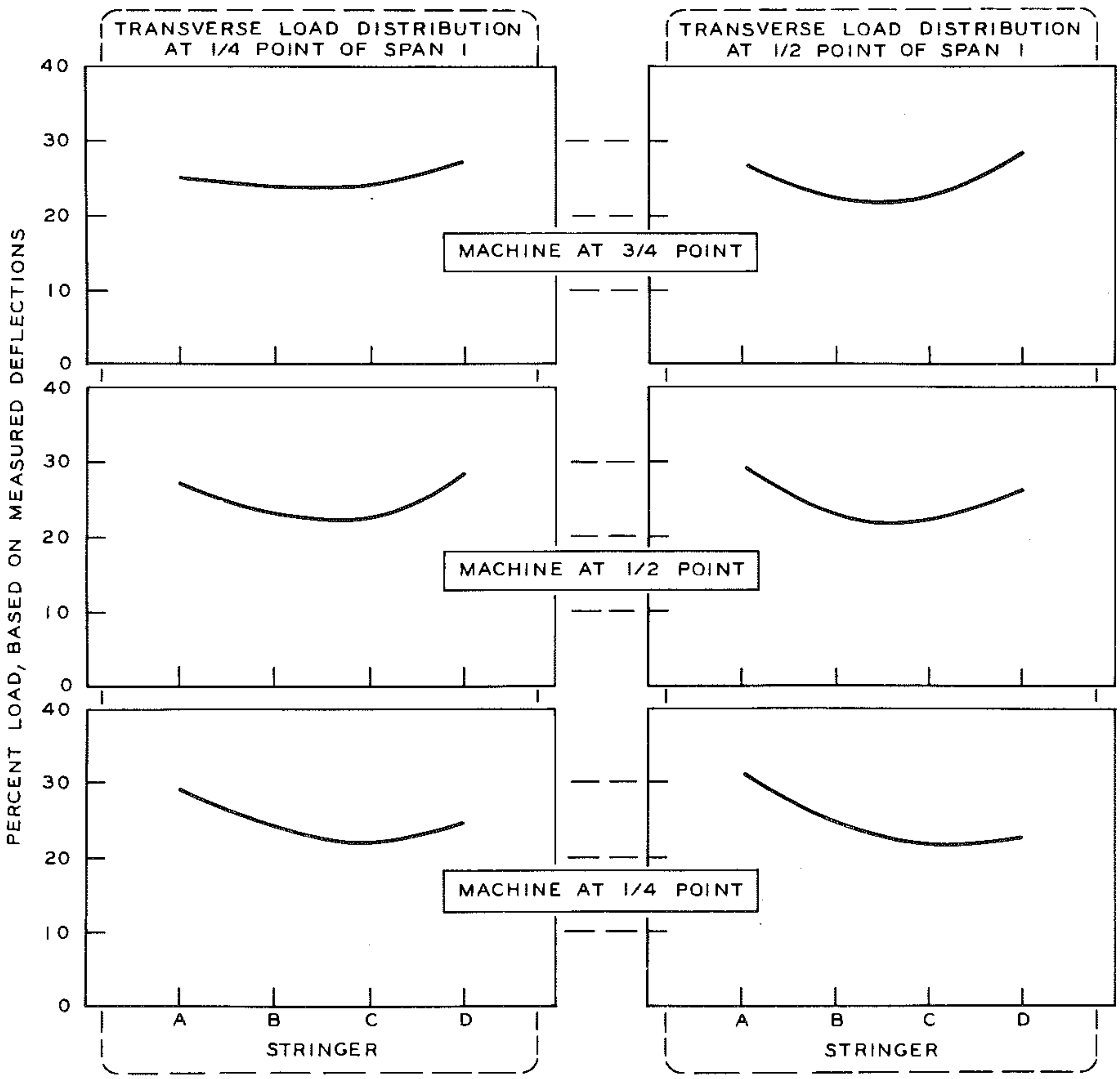

Figure 8. Measured transverse load distributions of Span 1 for finishing machine only at three points on Stringer A.

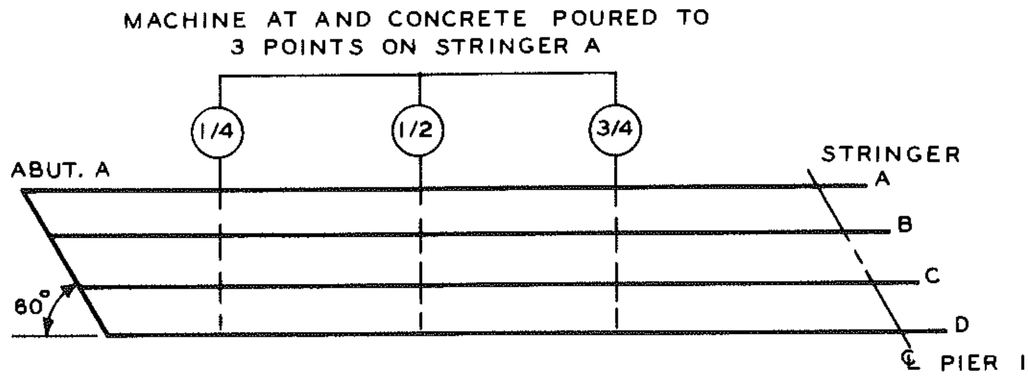

Figure 9. Plan view of Span 1 of B01 showing distribution of load for Fig. 10.

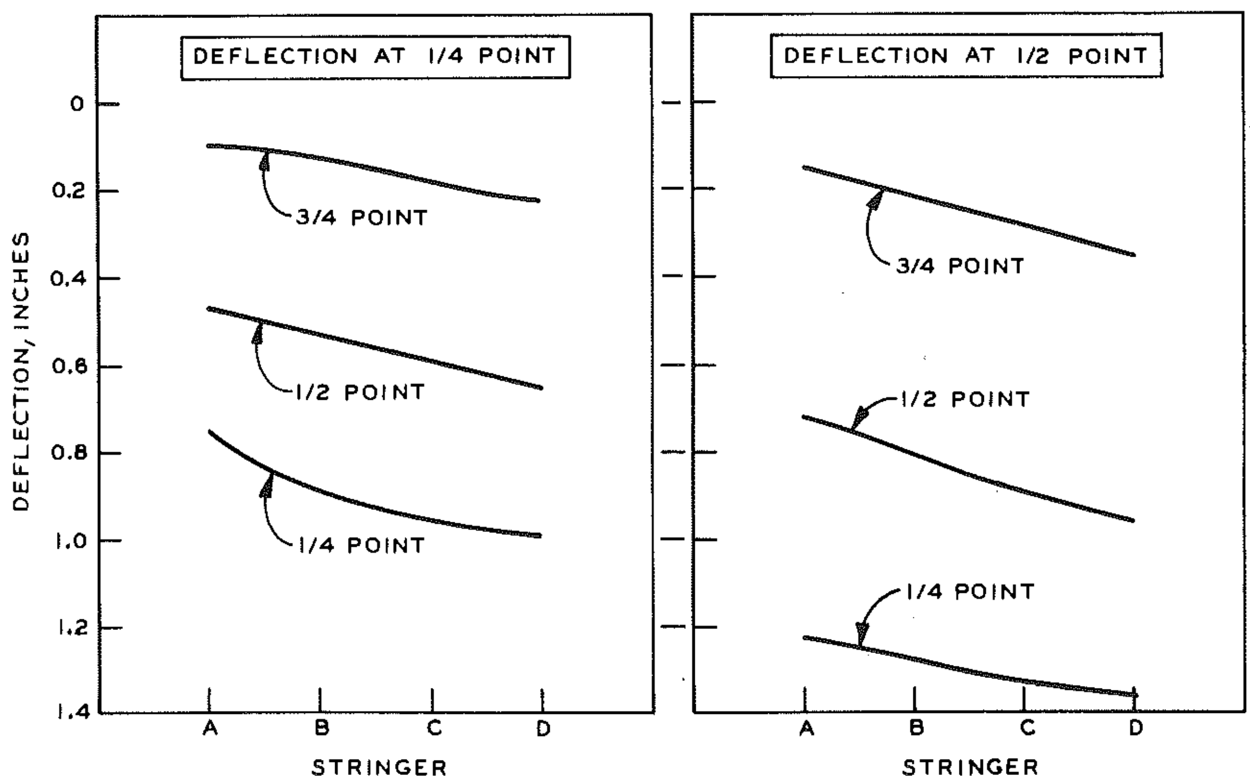

Figure 10. Transverse load distribution of Span 1 with machine at and concrete poured to three points on Stringer A.

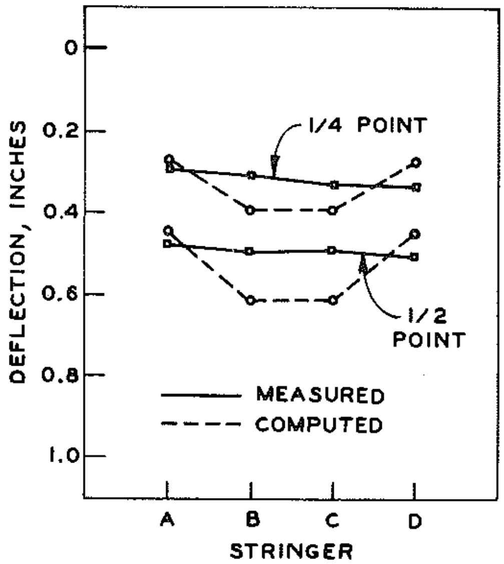

Figure 11. Computed and measured dead load deflections of Span 1, with Span 2 (suspended plus cantilever) deck completed.

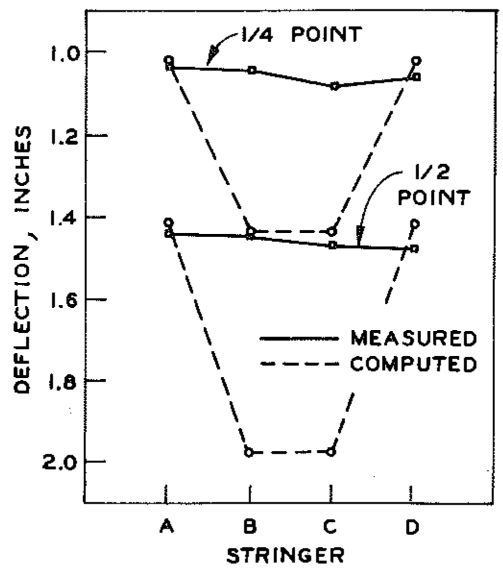

Figure 12. Computed and measured dead load deflections of Span 1.

2. Asymmetry of the distribution curves may be attributed to unsymmetrical loading because of the bridge skewness.

In Research Report No. R-373 (March 1962), G. R. Cudney noted in discussing deflection distribution, as imposed on stringers by finishing machine loads, that the final configuration of a deck may be affected by two situations:

> "First, since the screed elevation during finishing at any point of the span is governed by the deflection of the fascia stringers, there is a tendency for progressive flattening of the crown and reduction of slab thickness from the fascia stringers toward the center interior stringers. The magnitude of this deviation will be equal to the relative machine load and slab load deflection of the fascia stringer, and any interior stringer, and will be greatest at the point on the span where relative fascia and center stringer deflection is maximum.
>
> "In the second situation, the tendency is for the slab to become concave, or dish-shaped, between stringers at any point on the span as a result of the machine's moving away from that point and eventually off the span. The magnitude of this deviation will be equal to the relative machine load deflections of adjacent stringers."

The maximum observed relative fascia and interior stringer deflection occurred with the machine and concrete deck finished to the quarter point of Stringer A (Fig. 10). The magnitude of this difference was 0.15 in. The maximum deviation with the machine and concrete deck finished to the one-half point of Stringer A was 0.08-in. The maximum relative machine load deflection of adjacent stringers was 0.012 in., and was measured with the machine at the one-half point of Stringer A. None of these deflections were judged to have any significant influence on final elevation of a transverse cross-section of the deck surface.

Roughness Evaluation

The surface roughness of each bridge was measured with the profilometer, or 18-ft rolling straight edge, developed by the Research Laboratory Division. The profilometer, field test procedures, and data analysis are described in Research Report No. R-421 (May 1963). The following roughness classification, expressed in terms of accumulated inches per mile, has been applied to data obtained with the bridge profilometer:

Good = less than 100
Average = 100 to 160
Poor = above 160

Roughness values for Bridges B01 and B02, when measured with the profilometer, are given in Fig. 13.

Evaluation of data for both bridges on the basis of this roughness classification permits the following observations:

1. Average roughness values indicate that of the total of six span runs obtained for both bridges (three for each bridge), four would be classified as "average," while two would rate in the "good" category. However, it should be noted that three of the four span runs classified as "average" are within 4 in. per mi. of qualifying as "good" in riding quality.

2. Measured roughness values indicate that in addition to relatively good riding quality on individual spans, this quality was uniform over the whole surface.

3. In evaluating surface roughness as experienced by a motorist passing over the bridge, it seems reasonable to assume that in addition to comparison on a span-to-span basis, roughness of the entire bridge

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PROFILOMETER BRIDGE ROUGHNESS MEASUREMENTS
TEST RESULT TABULATION
Research Project 61 F-65

Form 1011

Bridge No. B01 of 23151 Location I 96 over the Grand River (both bridges)

Date Measured 12-13-62 Number of Spans 3 each Length (including approaches) 596.3

Dual Structures (separate for each roadway) Yes [ ] No [X]

Single Structure Yes [X] No [ ] Method of Finishing Transverse Mochine (both)

East Bound Roadway

Item	Length	Profilometer Roughness Value - R inches per mile				
		Traffic Lane		Passing Lane		Average
		O.W.P.	I.W.P.	O.W.P.	I.W.P.	
Span 1	126.1	120.6	119.2	85.4	125.2	112.6
2	142.5	116.0	105.8	78.6	102.4	100.7
3	127.7	118.8	101.1	78.0	97.3	98.8
4						
5						
6						
Weighted Average for Bridge		118.4	108.5	80.6	108:0	
West Approach	100.0	100.8	108.5	83.4	85.7	
East Approach	100.0	93.0	69.7	57.6	54.2	
Weighted Average for Bridge and Approaches		111.2	102.1	77.2	95.5	

Bridge No. B02 of 23151 Length (including approaches) 501.8

West Bound Roadway Date Measured 11-26-62

Item	Length	Profilometer Roughness Value - R inches per mile				
		Traffic Lane		Passing Lane		Average
		O.W.P.	I.W.P.	O.W.P.	I.W.P.	
Span 1	95.7	113.7	88.3	105.6	107.8	103.9
2	110.4	107.6	100.7	96.0	100.7	101.3
3	95.7	111.5	50.8	92.4	124.4	94.8
4						
5						
6						
Weighted Average for Bridge		110.9	80.9	97.9	110.4	
West Approach	100.0	88.3	65.6	65.6	67.4	
East Approach	100.0	60.7	56.7	69.3	70.0	
Weighted Average for Bridge and Approaches		96.4	72.5	85.8	94.1	

Remarks On both bridges all spans ond joints numbered from west to east.
In addition, P.O.B. and P.O.E. of spans are not over piers.

Figure 13. Deck roughness test results.

length and small sections of approach and leaving pavements should also be considered. On such a basis, average roughness values for Bridges B01 and B02 would equal 96.1 and 87.5 in. per mi., permitting classification of both bridges as "good."

Summary

The resulting section, composed of plate girder stringers and diaphragms included at approximately the one-fifth points, was so stiffened that relative stringer deflections during and after the finishing operation could be considered as having no significant influence on final surface configurations.

Surface roughness measured on both bridges was generally more uniform and above the average usually obtained by transverse machine finishing. A large amount of the measured roughness may be attributed to the "rippling effect" or "herringbone pattern" on the bridge surface, caused by lateral displacement of the screed inherent in machine finishing in the transverse direction. This surface roughness could be substantially reduced by using a longitudinal finishing machine, which operates parallel to the direction of traffic.

In final analysis, it would be concluded that machine finishing of both Bridges B01 and B02 produced a good riding surface.