STRENGTH COMPARISON OF STEEL SIGN POSTS

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In a memorandum dated January 16, 1961, the Research Laboratory Division informed the Traffic Division, in response to an inquiry concerning approval of a 6 lb per ft back-to-back post assembly fabricated by the Missouri Rolling Mill Corp. of St. Louis, that on the basis of cross-sectional properties and stiffness this assembly was not an acceptable alternate to either the 3-in. standard pipe or the 6 lb per ft "Piggybak" steel assembly manufactured by the Pollak Steel Co. of Cincinnati, the latter two being covered by the second paragraph under "Materials" in the MSHD Standard Specifications for Standard Steel Pipe.

It was further pointed out in this letter, in connection with this specification, that there was some question about the basis for determining acceptable alternates. This problem was subsequently discussed in a meeting held on February 23, 1961, and attended by representatives of the Office of Testing and Research, the Office of Maintenance, and the Traffic Division. It was mentioned that the Traffic Division used strength, not stiffness, as the basis for determining alternate post sections, and that on this basis the Pollak Piggybak assemblies were equivalent to respective pipe sections. In any structural design one member is not structurally equivalent to another unless it is equivalent with respect to both strength and stiffness. In discussing strength equivalence, it must be remembered that the theoretical yield strength of the steel used in the Piggybak and Missouri posts (50,000 psi) is 1.67 times that of the steel pipe (30,000 psi). In order to confirm the strength equivalence of the Piggybak and Missouri post sections with respect to pipe, it was decided to conduct a series of load-deflection tests. Since the two individual post sections were bolted together, the extent to which this assembly functioned as an integral unit could be evaluated.

The post types were compared in two groups. In the first were 3-in. diam steel pipe, the 6 lb per ft Piggybak assembly, and two 3 lb per ft Missouri posts bolted together. The post types compared in the second group were 4-in. diam steel pipe and the 8 lb per ft Piggybak assemblies. The Buffalo Steel Corp. of Tonawanda, New York, has informed the Laboratory that it is developing a new post which will soon be available for testing, in both 6 and 8 lb per ft back-to-back assemblies.

Average cross-sections of each of the five types of post tested are shown in Fig. 1 and their average physical properties presented in Table 1. The bolt spacings of the 6 and 8 lb per ft Piggybaks and the 6 lb per ft Missouri posts are given in Fig. 2.

TABLE 1
PHYSICAL PROPERTIES

Section Type	Area, sq in.	Weight, lb per ft	I_{x-x}, in.^{4}	S_{x-x}, in.^{3}
4-in. Steel Pipe	2.96	10.8	6.84	3.03
8 lb per ft Pollak	2.38	8.0	3.11	1.78
3-in. Steel Pipe	2.28	7.6	3.12	1.77
6 lb per ft Pollak	1.77	6.0	2.20	1.26
6 lb per ft Missouri	1.88	6.0	1.67	1.11

Post Tests

To compare the strength values of the various posts a test setup simulating actual field conditions was devised as shown in Fig. 3. Post specimens were supported at Points A and B, and calibrated circular weights equal to the load, P, were applied by a hanger assembly at Point C (Fig. 4).

Initial and residual deflections caused by increments of load were measured at Point C with a surface gage and a steel scale (Fig. 5). In addition, dial indicators were placed at both supports to measure any deflection. The deflection observed at the supports was negligible. The dial indicators are shown in Fig. 6 and are also visible in Fig. 4.

Initial and residual deflection versus load are plotted for each of the five sections in Figs. 7 and 8, with each solid-line curve representing the average of two tests. For comparison, the theoretical load-deflection curves of Point C were plotted and are denoted as dashed-line curves.

A criterion of 0.1-in. residual deflection was formulated for strength comparison on the basis of the test results. The loads at 0.1-in. residual deflection and the flexural stresses resulting from these loads are given in Table 2. In addition, the theoretical flexural stresses at the yield point and loads required to cause these stresses are included in Table 2.

TABLE 2
THEORETICAL AND TEST PERFORMANCE DATA

Post Type	Theoretical Performance at Yield		Test Performance	
	Load, lb	Stress, psi	Load, lb*	Stress, psi
4-in. Steel Pipe	630	30,000	545	23,305
8 lb per ft Pollak	630	50,000	255	22,200
3-in. Steel Pipe	360	30,000	335	28,070
6 lb per ft Pollak	445	50,000	295	34,445
6 lb per ft Missouri	390	50,000	60	11,010

* Load at 0.1-in. residual deflection

Test Results

Two conclusions could be drawn from the Piggybak and Missouri post test results. Either slippage occurred between the two surfaces, or the rail steel lacked the yield strength values assumed in the theoretical computations, or both factors could have affected performance.

To resolve the question of yield strength deficiency, simple beam tests were made to determine flexural stresses at yield for the Pollak Steel and Missouri Rolling Mill sections. Since individual sections were used, no slippage could occur. Loads were applied vertically to the sections with a hydraulic ram using a 6-ft simple span, and were measured with a proving ring. Deflections were measured at the center of the span with a dial indicator. The flexural stresses at yield as determined from the simple beam tests agreed with the values assumed in the theoretical computations.

Slippage between the two surfaces was then the only remaining consideration. The Piggybak posts arrived at the Laboratory preassembled. The bolt torque was then checked for agreement with the value recommended by Pollak Steel. The Missouri posts arrived with the holes drilled for the bolts, but as separate sections, which were then assembled according to the manufacturer's specifications, using 3/8-in. diam high-strength bolts threaded the entire length, and spaced as shown in Fig. 2. The same 50 in-lb bolt torque specified for the Piggybaks was used on the Missouri posts since no bolt torque was recommended by the Missouri Rolling Mill Corp.

After each test was completed, the bolts were removed and examined. Thread deformation was found on bolts both from the Piggybak and Missouri posts. This would indicate that the type of bolt used was not an adequate fastener to make the two individual sections act as an integral unit. In addition, the average hole size was found to be 25/64-in. diam for the Piggybaks and 7/16-in. diam for the Missouri posts. Oversized holes would also be a factor in slippage of the sections.

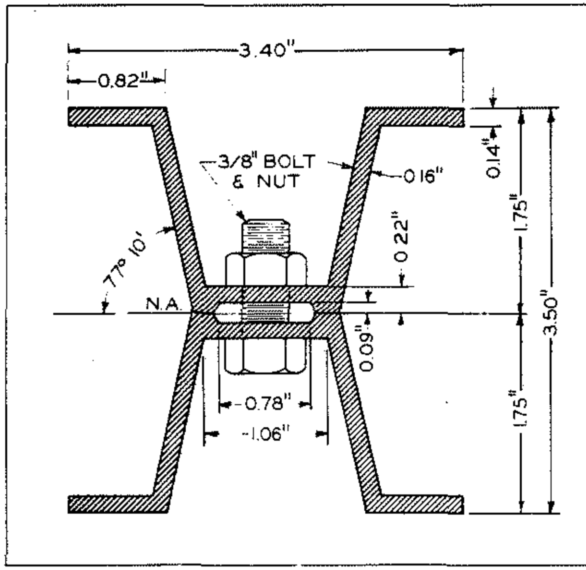
Using the load at 0.1-in. residual deflection, or the flexural stress resulting from this load, as a criterion for failure in these tests, the 6 and 8 lb per ft Piggybaks and the 6 lb per ft Missouri posts were not equal to the 3- and 4-in. steel pipes, respectively. Since a primary function of the fastener is to resist shear caused by bending, and since slippage definitely occurred in the post assemblies, the individual sections bolted together with the specified high-strength bolts clearly did not act as an integral unit.

This assembly could possibly be improved by replacing the recommended bolts with bolts having a shank. Diameters of this shank and the bolt hole should be approximately equal and the shank long enough to completely engage the two posts. This should reduce the likelihood of thread deformation such as occurred in the tests, and allow the two individual posts to act more as a unit.

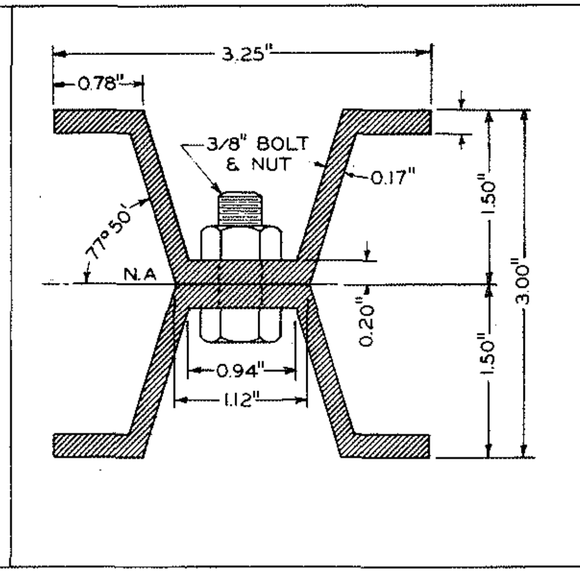
Conclusions

As Figs. 7 and 8 show, loads are practically equal where load-deflection curves deviate from a straight line and at 0.1-in. residual deflection. Since this deviation denotes non-elastic bending or slippage of the assembled sections, loads at 0.1-in. residual deflection were used as criteria for failure in these tests.

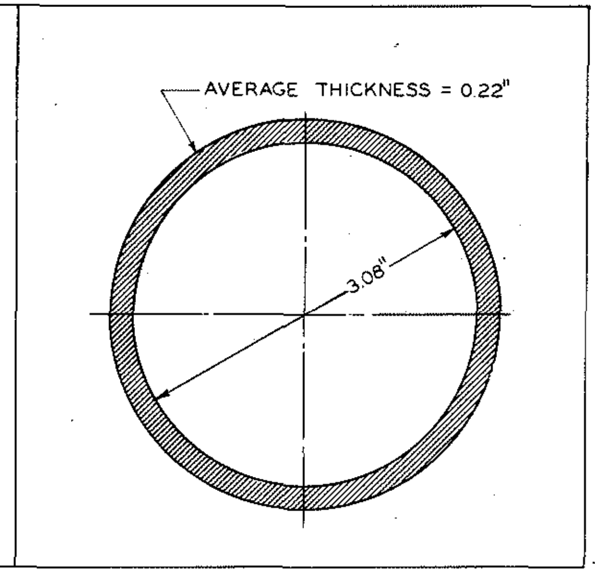
On the basis of these tests, the 6 lb per ft Missouri assembly is not equivalent in strength or stiffness to either the 6 lb per ft Pollak assembly or the 3-in. pipe. In addition, the 6 and 8 lb per ft Pollak posts are not equivalent in strength or stiffness to the 3- and 4-in. pipes, respectively.



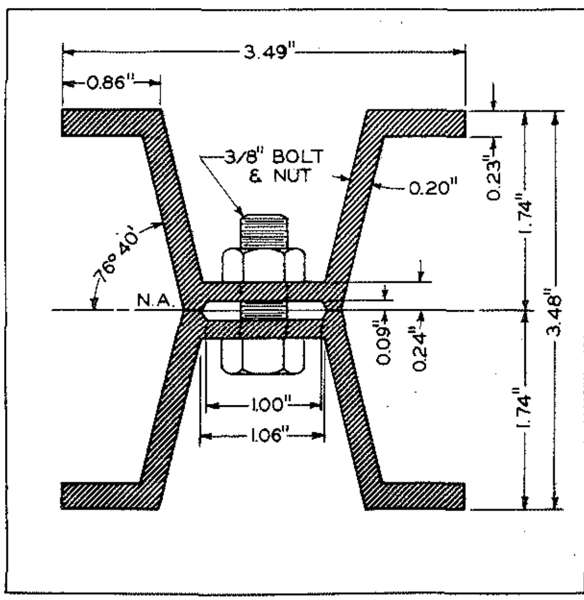
6 lb per ft Pollak post



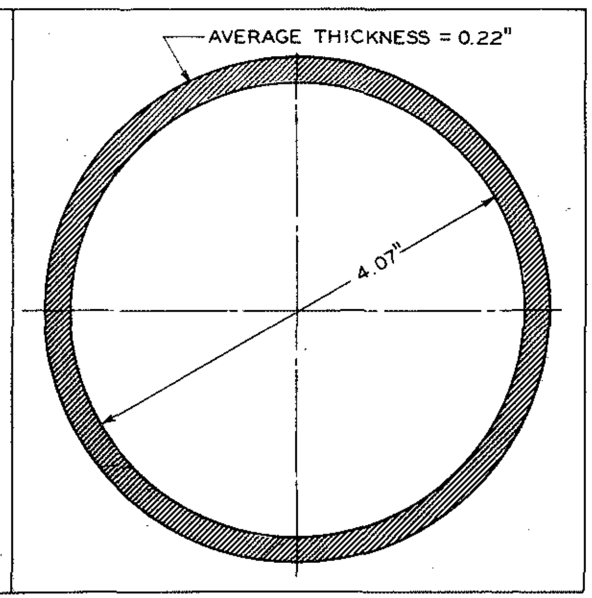
Two 3 lb per ft Missouri posts back-to-back



3-in. pipe



8 lb per ft Pollak post



4-in. pipe

Figure 1. Average cross-sections of post specimens.

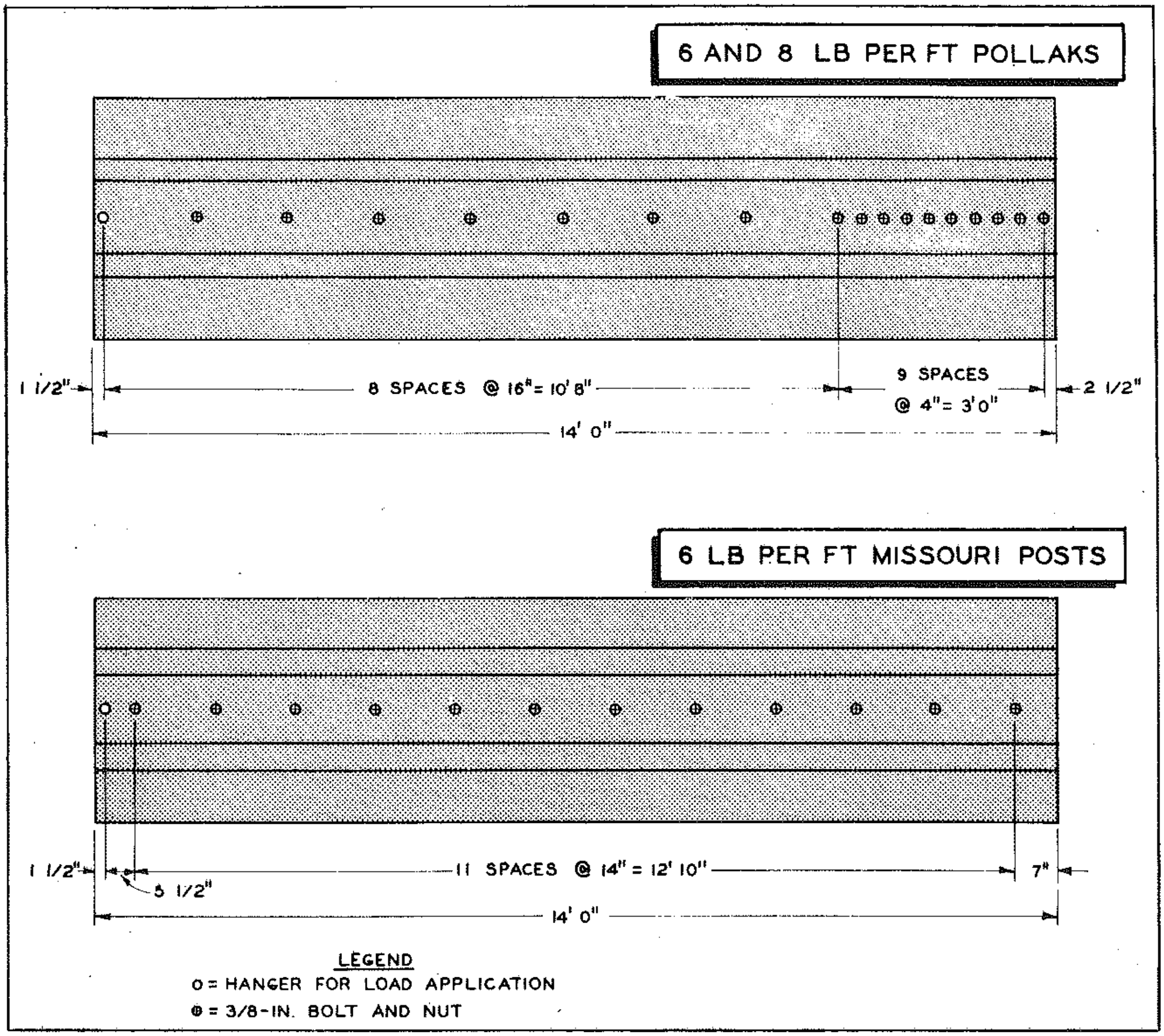


Figure 2. Plan view showing bolt spacings.

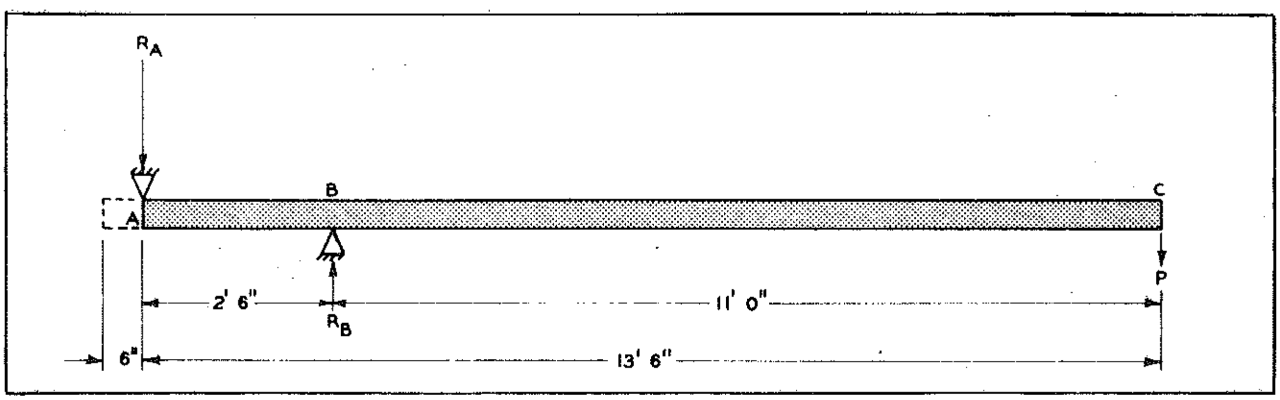
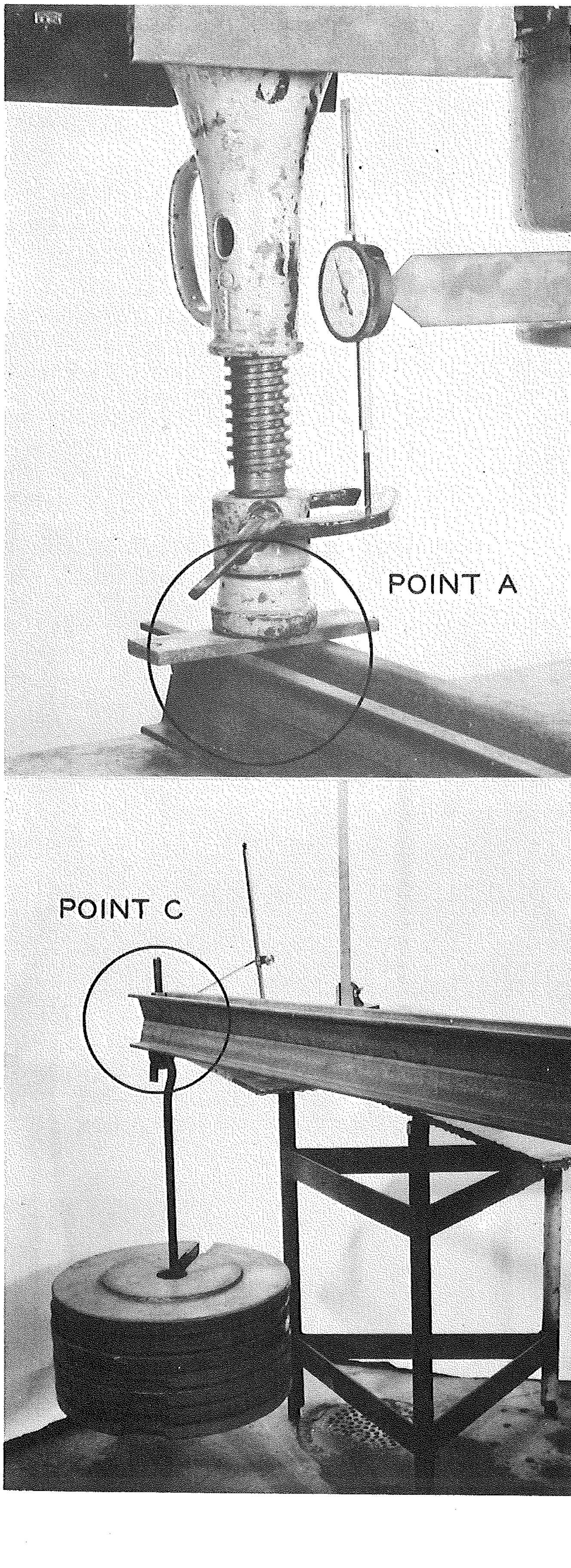


Figure 3. Typical test setup.



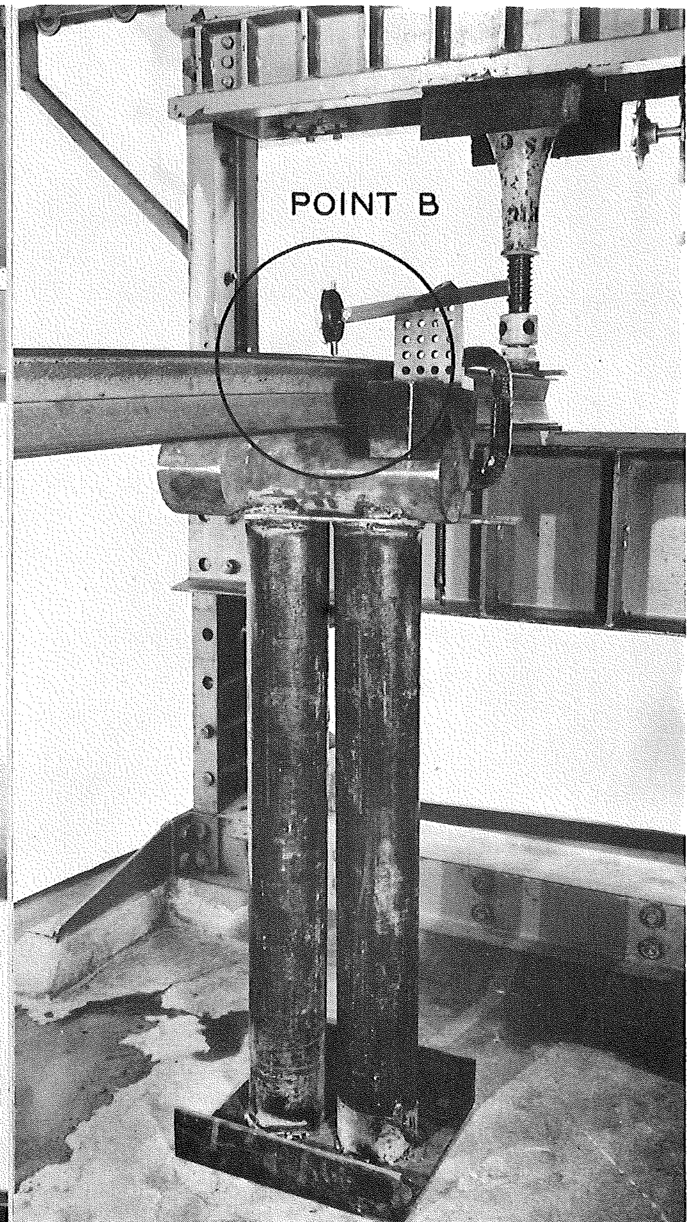


Figure 4. Typical test setup, with Pollak post in place, showing points of support and loading point.

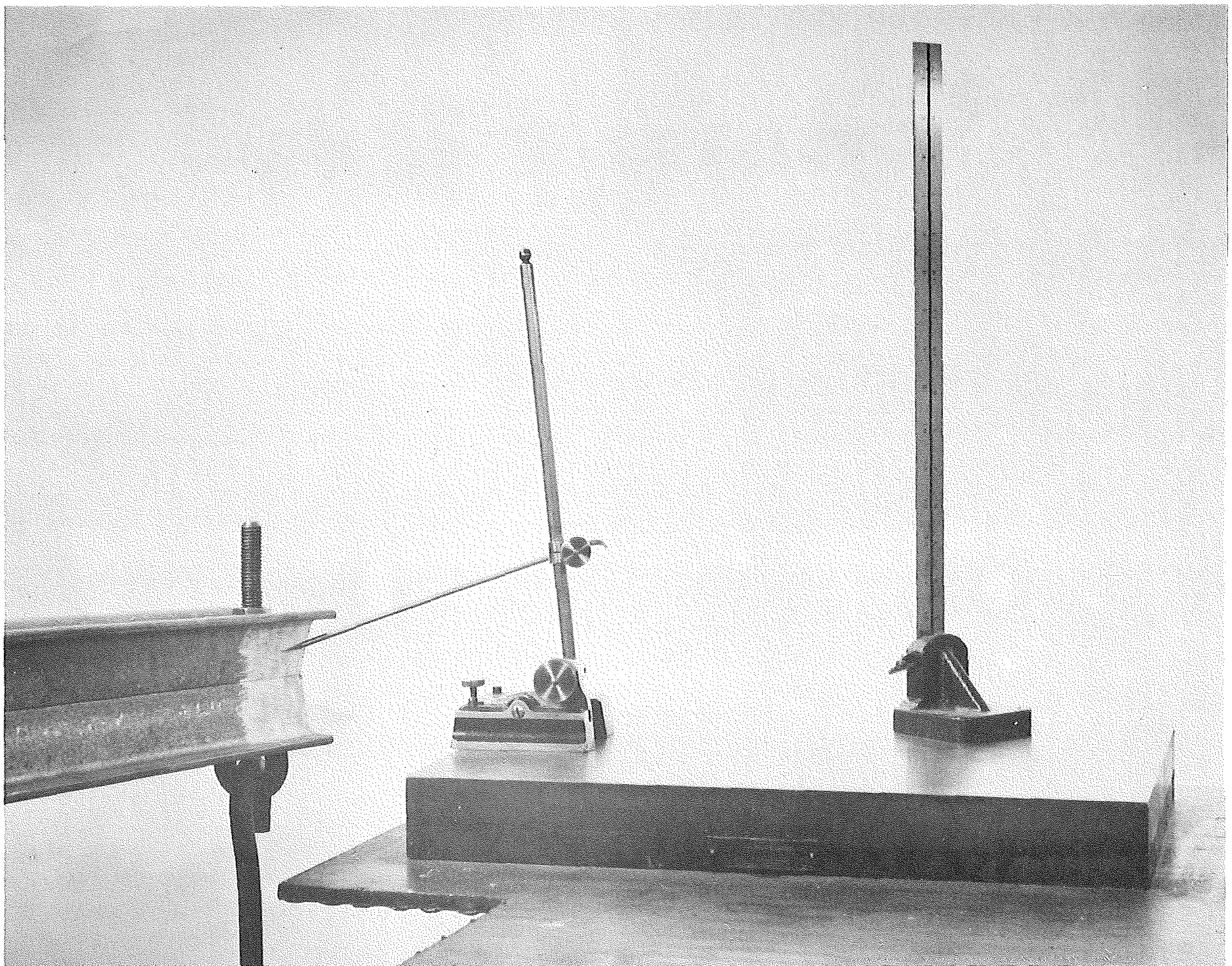


Figure 5. Measurement of vertical deflection, at the loading point.

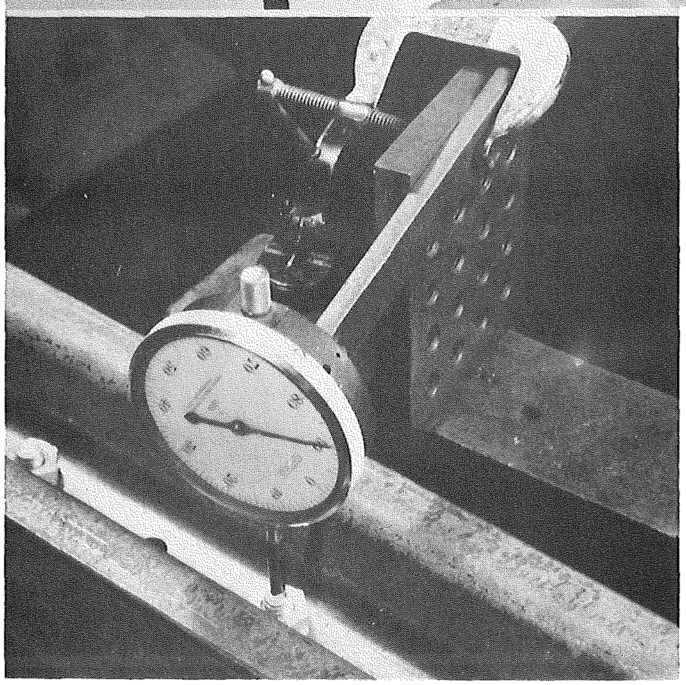


Figure 6. Dial indicator for vertical deflection measurement at point of support.

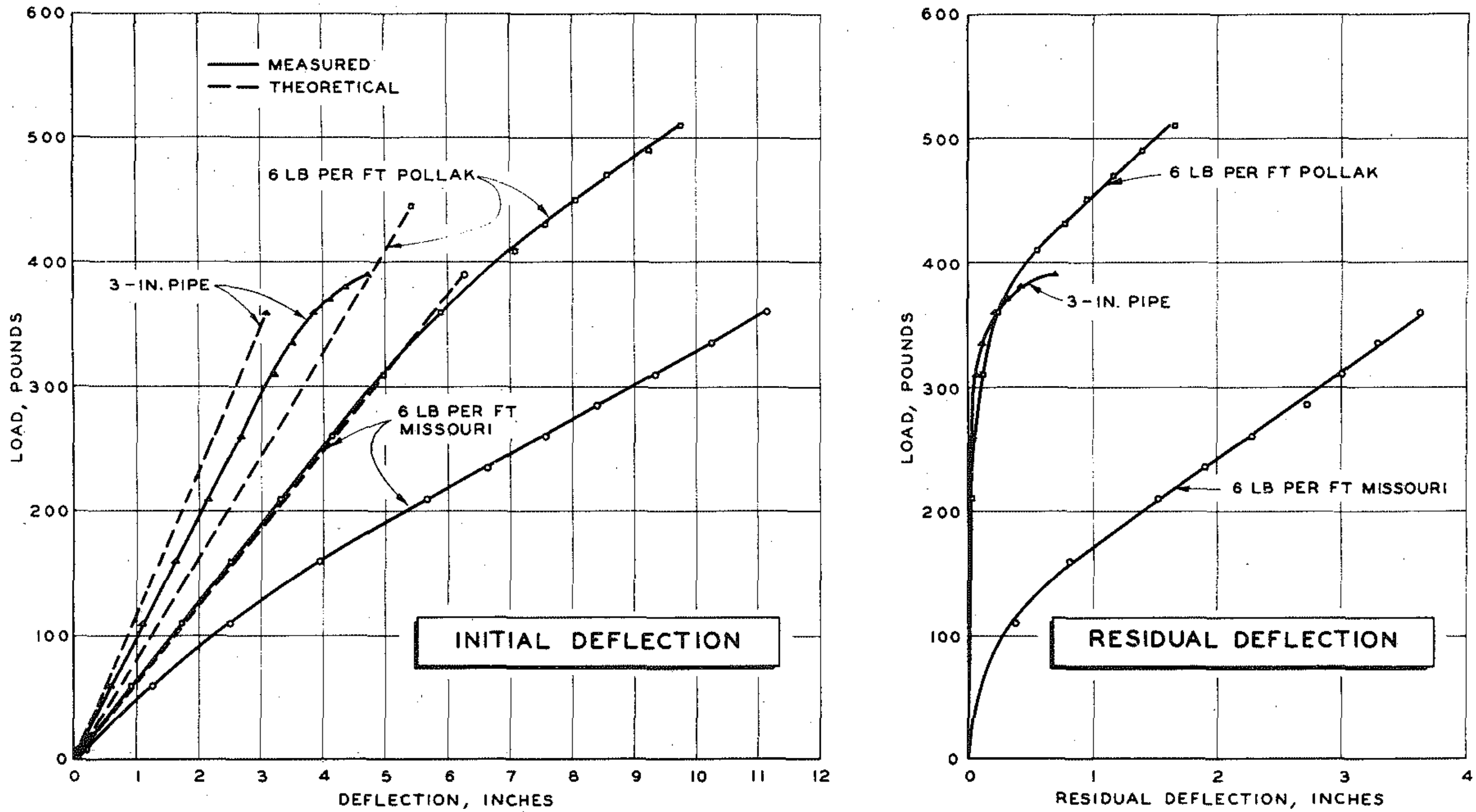


Figure 7. Load-deflection curves (first group).

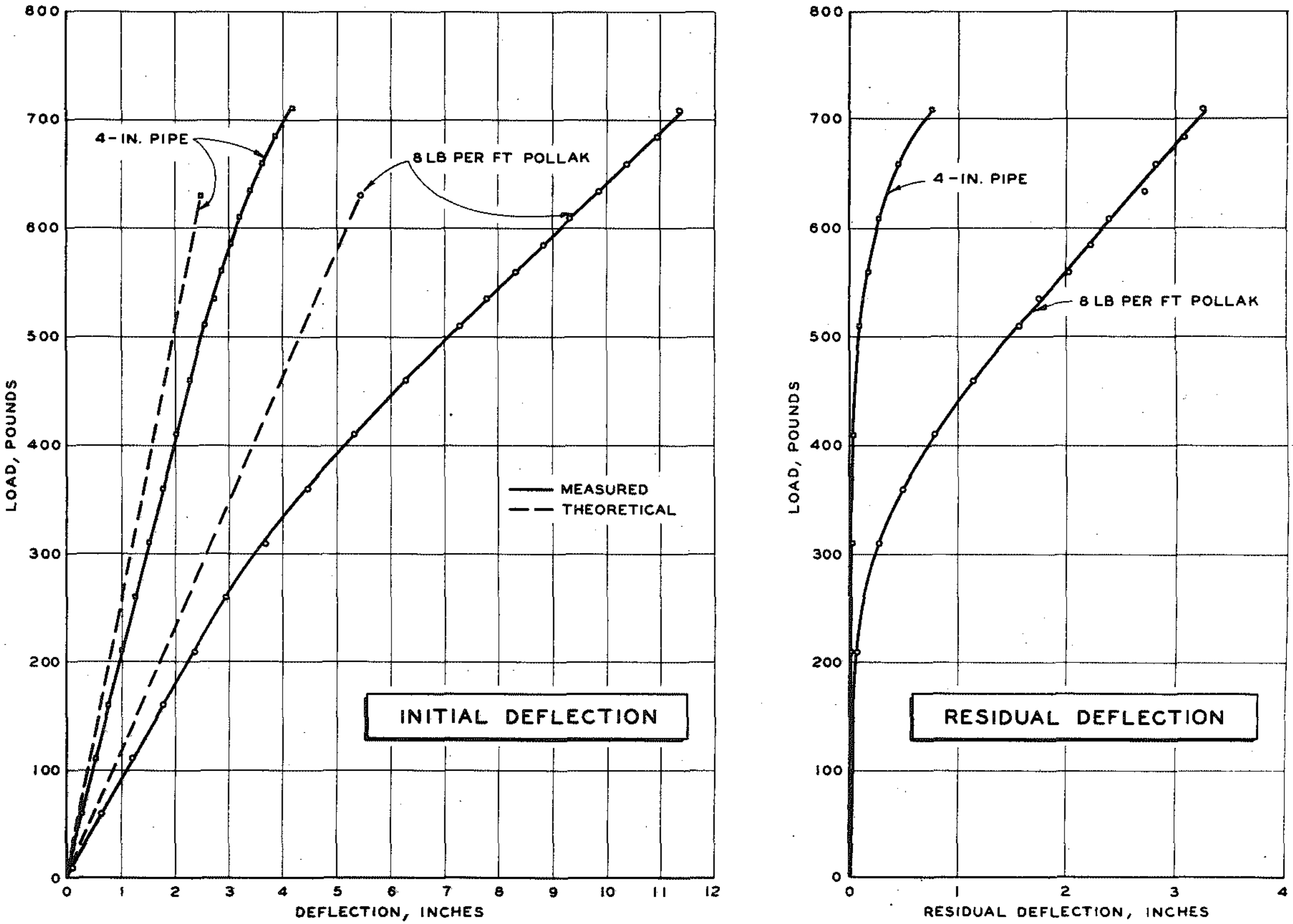


Figure 8. Load-deflection curves (second group).