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MICHIGAN
STATE HIGHWAY DEPARTMENT
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INVESTIGATION OF PREFABRICATED PLYWOOD WALLS FOR CONCRETE COLUMN CONSTRUCTION

(For the Bridge Division)

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INVESTIGATION OF PREFABRICATED PLYWOOD WALES FOR CONCRETE COLUMN CONSTRUCTION

The present practice on column construction is to use wales made out of ordinary structural timber supplemented by tie bolts through the wales to provide adequate bracing for the plywood forms. In this work, three tie bolts per side of column are used and the center rod or tie bolt passes through the column, requiring a threaded rod and subsequent patching of the hole in the concrete left by the coupling rod when the forms are removed. Figure 1 shows standard wales being used in form work for concrete column construction. A contractor in the Detroit area has presented for investigation a laminated plywood wale for which it is claimed that there is sufficient additional strength so that it is permissible to use only the end tie rods.

Mr. Paul Ueberhorst, District Bridge Engineer, has supplied the Research Laboratory with wales of laminated plywood with the request that they be tested in some manner to determine their suitability for the purpose intended.

The lateral pressure in forms for walls and columns is not easy to determine and it is affected by many factors. However, the Portland Cement Association Bulletin on "Pressure of Concrete on Form Work" gives 750 lbs. per sq. ft. on forms for hand-placed concrete at a rate of pour of six feet per hour, at a temperature of 70° F.

This investigation was conducted to simulate the conditions of pressure on wales used for 3'0" concrete columns in concrete piers for the Detroit Expressway bridges. Vertical 2" x 6" studs at 12" centers support the plywood forms and the studs are in turn supported by horizontal wales at approximately 2'0" centers. On this basis, the area contributing pressure to one wale is 6 sq. ft., and therefore, for this area and a pressure of 750 lbs. per sq. ft., the total load on a wale

would be 4500 lbs. This load is considered as the test load for the wales. The specimens shown in Figure 2 were analyzed on the basis of the measured deflections and the calculated stresses.

The testing arrangement used for measuring deflections is shown schematically in Figures 3A and 3B. Figure 4 illustrates the method used for application of load. All specimens were tested with end supports, simulating end tie rods only, and with a loading arrangement duplicating field conditions. Loads were applied at b and c in Figure 3A and then at a and d. Deflections were observed for each set of loads and by superposition the total deflection for loads at a, b, c, and d was obtained. Specimen D, 2" x 6" standard timber, was tested with three rigid supports simulating three-tie-rod support and with the same loading arrangement. Deflections were measured at mid-span and at the supports by means of 0.001-inch dial gages. Corrections for slight settlement of supports were applied to the measured mid-span deflections.

The extreme fiber stresses at mid-span for the wales using end tie rods only, under a total load of 4500 lbs. (design load) and for the ultimate load are as follows:

		Calculated Unit Stress p.s.i. at 4500# Load	Calculated Unit Stress p.s.i. at Breaking Load
A.	Fabricated plywood (3-1/8" x 7-15/16")	1100 p.s.i.	6100 p.s.i.
*B.	Fab. plywood with metal edge (3-3/4" x 7-15/16")	946 p.s.i.	4960 p.s.i.
C.	Standard timber (two 2" x 8")	1270 p.s.i.	7260 p.s.i.
D.	Standard timber (two 2" x 6")	2560 p.s.i.	9450 p.s.i.

* This specimen failed at ultimate load through bolts connecting the plywood panels.

Since the working stress should be limited to 1800 p.s.i., Specimens A, B, and C would be satisfactory without center tie rods. The stress in Specimen D would not be satisfactory with end ties only; therefore, the vertical spacing should be restricted to 16" to keep the stresses below 1800 p.s.i. However, this specimen with three-tie-rod support, which is present practice, has a stress of only 288 p.s.i.

The results of the load deflection study are shown in Figure 5. All specimens were tested as shown in Figure 3A and Specimen D (standard timber, 2" x 6") was also tested as shown in Figure 3B to simulate present practice. If the deflection of the wale using only end tie rods is to be limited to the very small deflection obtained with the present 2" x 6" standard timber wales with three-tie-rod support, then the cross-section of the wales, assuming the same materials, would have to be of two 2" x 8" at 8-inch centers. This is impractical but if a somewhat greater deflection of wales is permissible, then specimens A, B, or C may be used at reasonable spacings. The observed modulus of elasticity (E) for the plywood wales was 0.9×10^6 p.s.i. and 1.0×10^6 p.s.i., while the douglas fir wales had an observed E of 1.6×10^6 p.s.i. and 1.7×10^6 p.s.i. Therefore, for a given cross-section a much smaller deflection may be obtained by using standard timber of douglas fir.

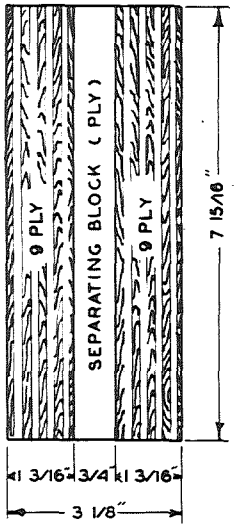
Figure 6 gives the vertical spacing of wales which must be used for any specified limiting deflection. When the graph is shown as a dotted line the stress in the extreme fibers exceeds the allowable limit of 1800 p.s.i. This graph is based on a pressure of 750 pounds per sq. ft. as obtained for hand-placed concrete at a rate of pour of 6 ft. per hour at 70° F.

In evaluating the results of this study certain limitations should be clearly understood. Only one specimen of each type of wale was presented for testing and therefore these results are based on only these single specimens. If a greater number of specimens of each type had been tested, variation in results for specimens of a given type could be expected, but it is believed this variation, due chiefly to variation in seasoning of the wood, would be more pronounced in the douglas fir specimens than in the plywood specimens.

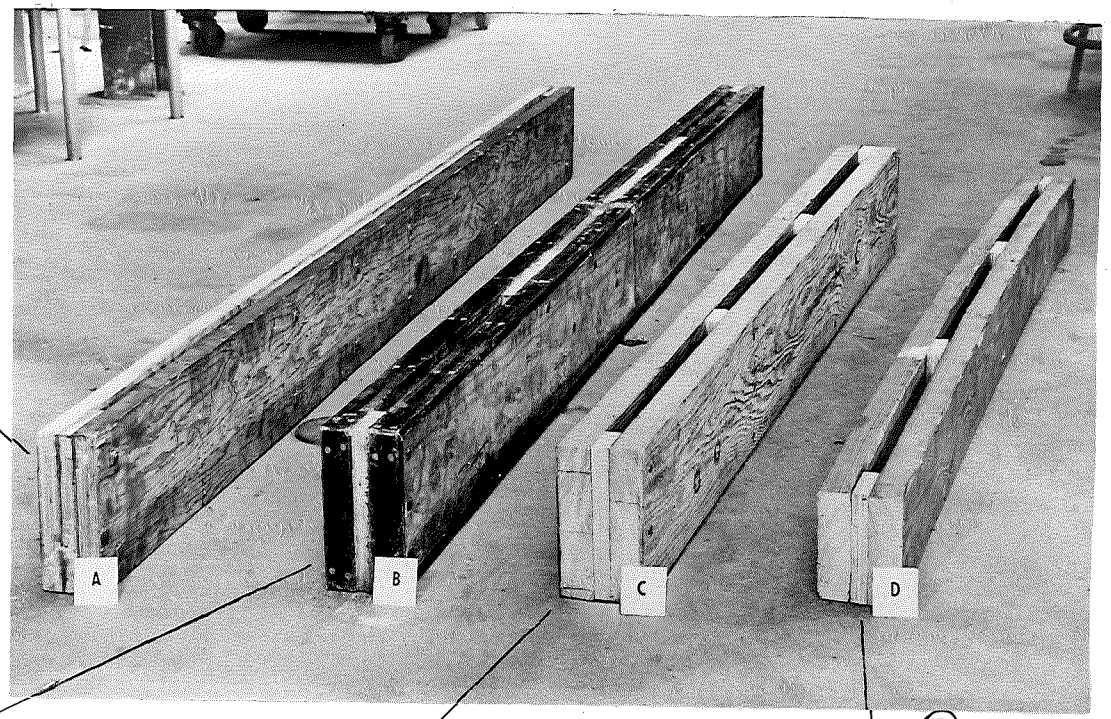
Form work under present practice using standard timber wales for concrete column construction.

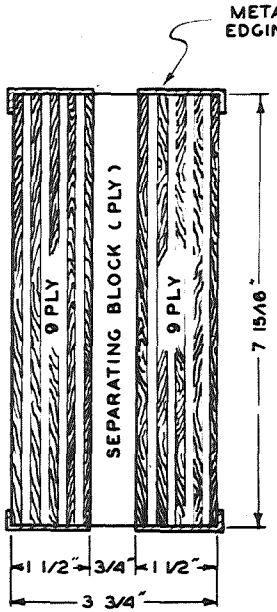
Detailed view of standard timber wales used under present practice with three tie bolts per wale.

Figure 1



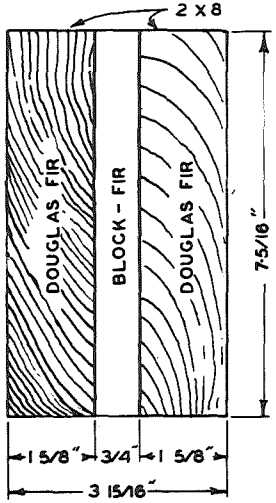
(A)
FABRICATED PLYWOOD
OBSERVED:
E=0.9 X 10^6 LBS. P.S.I.



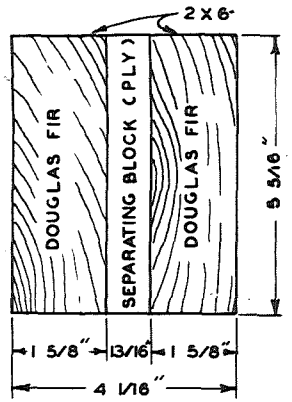


(B)
FABRICATED PLYWOOD
WITH METAL EDGE
OBSERVED:
E=1.0 X 10^6 LBS. P.S.I.

(C)
STANDARD TIMBER
OBSERVED:
E=1.6 X 10^6 LBS. P.S.I.



(D)
STANDARD TIMBER
OBSERVED:
E= 1.7 X 10^6 LBS. P.S.I.



CROSS SECTIONS OF TESTED WALES

FIGURE 2

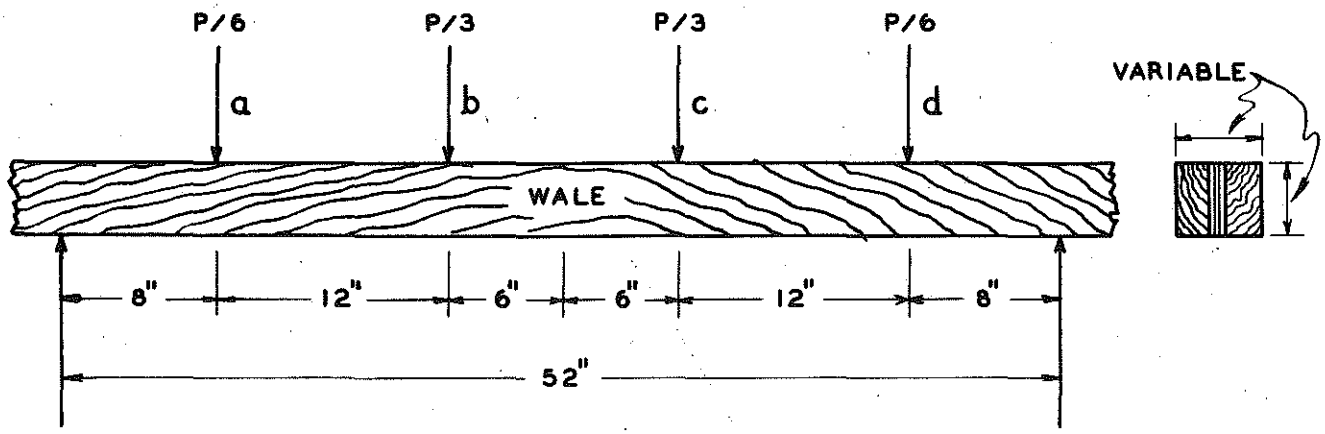


FIGURE 3A

LOADING USED FOR ALL SPECIMENS
SIMULATING END TIE RODS ONLY

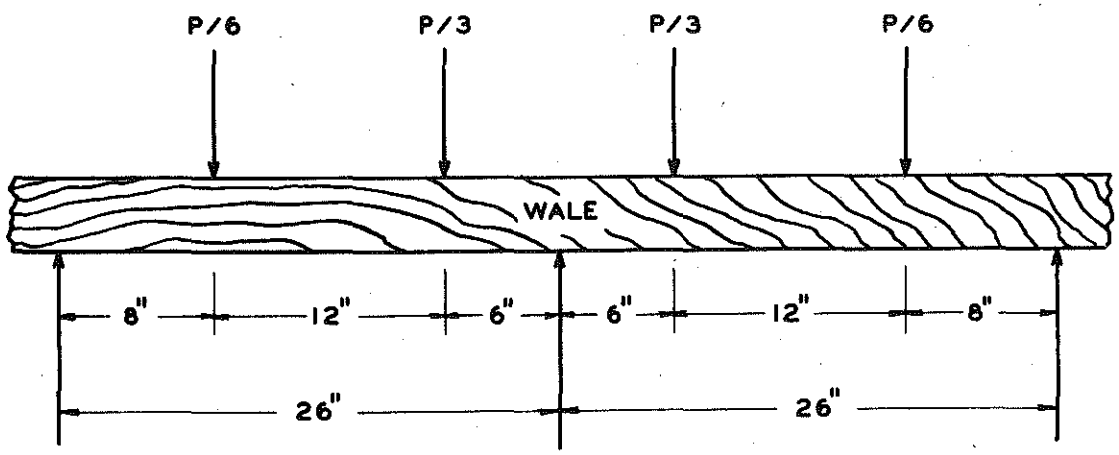
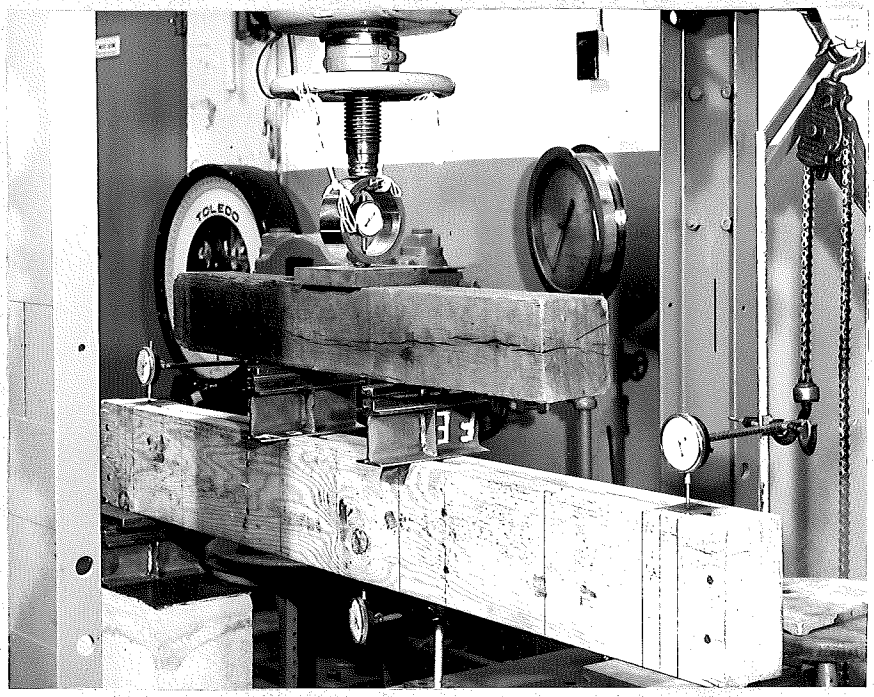


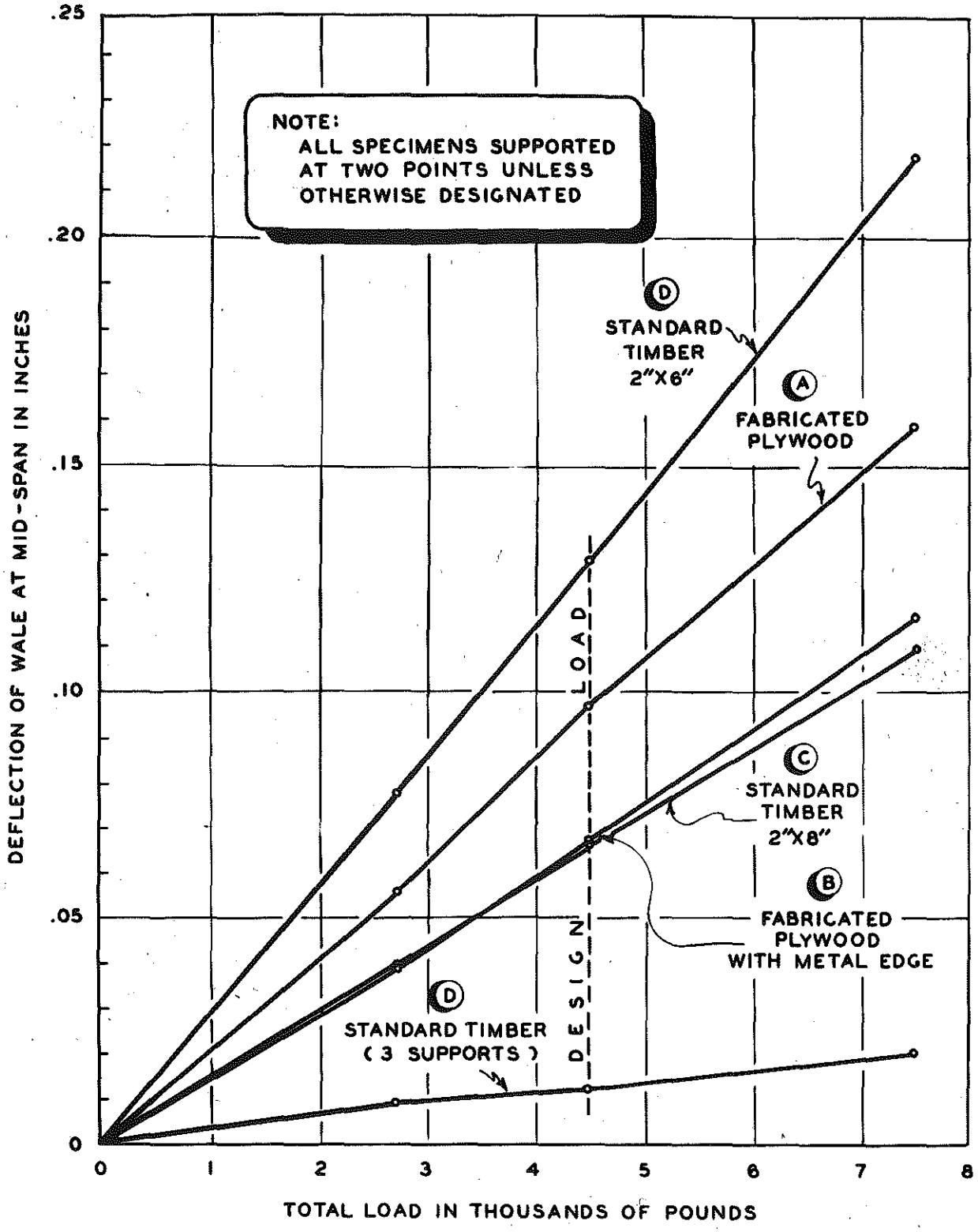
FIGURE 3B

LOADING USED FOR STANDARD SPECIMEN
SIMULATING THREE TIE ROD SUPPORT



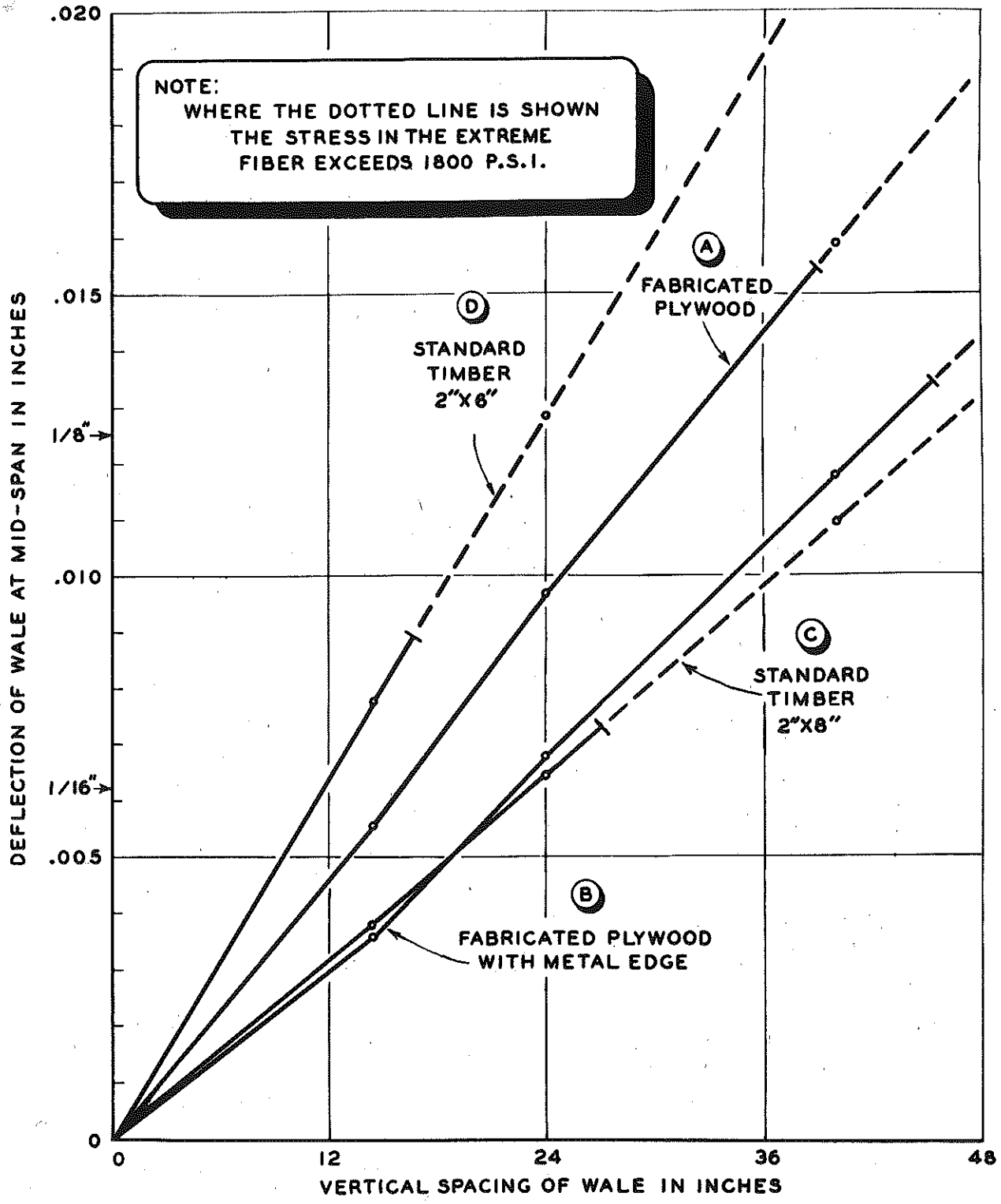
Testing arrangement for applying load to the wale.

Figure 4



DEFLECTION OF PREFABRICATED WALES

FIGURE 5



LIMITING VERTICAL SPACING OF WALES FOR 3'-0" CONCRETE COLUMNS FOR A GIVEN DEFLECTION USING ONLY END TIE RODS

FIGURE 6