1950

# Portal frame tests proposal

L. S. Beedle

E. R. Johnston Jr.

LEHIGH UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING
FRITZ ENGINEERING LABORATORY
BETHLEHEM, PA.

August 25, 1950

PHONE
BETHLEHEM 7-5071
FRITZ E. L. OFFICE EXT. 258
HYDRAULICS LAB. EXT. 279

File No. 205D

To: Members, Lehigh Project Subcommittee
Structural Steel Committee
Welding Research Council

PORTAL FRAME TESTS

Gentlemen:

It is the purpose of this letter to present to the Lehigh Project Subcommittee recommendations for certain frame tests to be conducted as a part of the current five-year investigation on the "Ultimate Strength of Welded Continuous Frames and Their Components"*

## INTRODUCTION

Sufficient information has been obtained from phases of the investigation already completed or nearing completion to permit the testing of complete welded frames. A test program of frame components (beam, columns, and connections) has been partially completed; two reports for publication are to be finished during the next two months. Full scale and miniature portal frames tested at Cambridge University, England, have confirmed the accuracy of methods for the prediction of the ultimate carrying capacity of frames for the particular sec-
1. tions tested. However, the prediction of plastic deformations
2. and the effect of frame connections are still uncertain. It
is hoped that the recommended tests will help to fill these
gaps in present knowledge and at the same time demonstrate the
3. carrying capacity of frames in which wide-flange sections are
used.

## PURPOSE

Therefore, the present frame tests have two major objectives:

(1) to check the behavior of various frame components (such as connections, columns and beams) with the numerous isolated tests which have been performed.

- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -

*For readers who may wish to review previous frame test proposals reference is made to the following:

(1) May 12, 1948, Proposal to Welding Research Council. This describes initial plans and objectives of the entire program.

(2) May 7, 1948, Proposal to Office of Naval Research. This describes in more detail than the above the frame test as originally planned.

(2) to check actual deformations and internal forces with those predicted by various analytical treatments. One such treatment has been proposed by Mr. Weiskopf;* another is a method analogous to the usual conjugate beam procedure. Methods of numerical integration have been used, and it is hoped that additional methods can be devised.

A particular comparison under item (1) is with a recent continuous beam test in which a portal frame was simulated.

## PROGRAM OF TESTS

The components of the frame tests recommended at this time are as nearly identical to the isolated tests as practical.

Three frame tests are proposed; loads will be applied through the plastic region to collapse. The frames are identical in overall dimensions (Fig. 1); in two frames equal loads will be applied at the three-eighths points; and in one frame a concentrated load will be applied at the center line.

The physical details are as follows:

| MODEL | SPAN | COLUMN HEIGHT | LOADING | BEAM | COLUMN | CONNECTION TYPE | COMPLETED |
|---|---|---|---|---|---|---|---|
| A | 14' | 7' | 3/8 pt. | 8WF40 | 8WF40 | 8B | Feb. '51 |
| B | 14' | 7' | centerline | 8B13 | 8B13 | 8B | April '51 |
| C | 14' | 7' | 3/8 pt. | 4WF13 | 4WF13 | 2B | Remains. (10/1/51) |

Funds presently available may permit the testing of only two of the above frames. Unless the committee has recommendations to the contrary the frames will be tested in order listed.

## DIMENSIONS AND LOADING CONDITION OF THE FRAMES

The overall dimensions of the frames are the same as have been used in the simulated frame tests of the continuous beam program. Vertical loads in two of the tests will be applied at points three-eighths of the span length from each knee. Third point loading, originally planned for these tests, introduces plastic shear failure in the 8WF40 section. It appears desirable to avoid such a shear failure over any significant portion of the span. Shear failure also could have been eliminated by the use of a different rolled section or by increasing the span length. However, it is considered desirable to use sections which have been used in earlier portions of the project. A standard span length of 14', which has been used in the previous tests, is maintained in this program.

---

*Mr. Weiskopf's paper was forwarded to members of the Lehigh Subcommittee by Mr. Higgins on November 23, 1949. The paper was discussed in Progress Report H, issued to the Subcommittee February 20, 1950.

It is known from previous tests that the 8B13 section possesses very poor lateral buckling qualities in a region of constant moment. For this reason the center line loading condition has been chosen for Model B.

The initial tests are to be kept as simple as possible from the viewpoint of analysis. For this reason special precaution is taken to prevent side away and a column section is chosen which should develop the required moments without lateral buckling. In addition lateral support is provided at several points along the beam.

## SELECTION OF SECTION

Three sections have been selected: 8WF40, 8B13, and 4WF13. The 8" sections have been tested in numerous beam, column, and connection tests; and the 4WF13 section has been used in the most recent column tests.

The 8WF40 and 4WF13 sections do not have the usual proportions of portal frame columns. However, the objectives of these tests can best be pursued by their use. Both sections will eliminate some undesirable lateral and local buckling tendencies; for these initial tests this is desirable, since the deformation theories being checked do not include these effects. Previous column tests indicate that for the loading encountered in these frames both sections will develop their plastic strength without inelastic buckling.

The 8B13 section is selected because its proportions resemble those in common use for portal frame columns and also because the section was used in most of the isolated connection tests. It is considered desirable to obtain a direct comparison between the behavior of an isolated connection and the behavior of the same connection in a frame.

As mentioned above the 8B13 section has poor buckling qualities especially in the plastic range. Since currently used portal frame sections have similar proportions, this test has a certain "negative" quality; it should show that sections used efficiently in the elastic range are not necessarily efficient in the plastic range.

## SELECTION OF KNEE

Two types of knees which have shown desirable characteristics in isolated tests have been chosen. Connection type 8B (Fig. 2) has moment rotation characteristics which closely approximate an equivalent length of beam; in the elastic range its rotations are approximately 30% greater than an equivalent length (Fig. 3); in the plastic range, the strength of the rolled section is completely developed. Type 8B connection tests did not differentiate between full-depth and half depth stiffeners. The former has been chosen.

Since in many instances the aesthetic as well as the structural qualities of a knee are of importance, it is recommended that the second knee be one of the commonly used haunched or curved knees. Connection type 2B (Fig. 2) is recommended. On a 14' span it is impractical to use a haunched connection with an 8" rolled section since the end of the knee will fall very near a point of contra-flexure. Therefore, connection type 2B is used with the 4" rolled section. Previous tests indicate that the type 2B is both stiffer (approximately 100%) and stronger than an equivalent length of beam (Fig. 3).

When tested as isolated units with an 8B13 rolled section the failure of the knees under consideration was precipitated by local buckling. The rolled sections recommended for Models A and C are less susceptible to local buckling than the 8B13 section.

Any change in the moment rotation characteristics due to the use of a different rolled section will be determined by direct measurements on the frames. Since each frame will have two identical knees, it is felt that the knee can be adequately investigated without resorting to additional isolated tests.

As shown in Fig. 4 the loading of the frame connection is not identical to that of the isolated test. It is felt that this will have a minor effect on the characteristics of the knee and it is hoped that the effect can be evaluated from the frame tests.

## TEST PROCEDURE

The arrangement for application of loads is shown in Fig. 1. Loads will be applied and measured with hydraulic jacks and aluminum tube dynamometers. In Model A and C equal loads will be applied at the three-eights points; in Model B one load will be applied at the center line. Lateral support and sideway support will be provided as shown in Fig. 1. The testing procedure will be similar to that employed in the past on isolated components.

The shape of the deformed structure will be determined by means of dial gages and level bars. Moment rotation characteristics of the connections and rolled sections will be measured by means of SR-4 gages and level bars located at certain critical sections.

GENERAL

Arrangements are being made for the conduct of tests except that any needed material will not be ordered until the proposal is approved. Provisions has already been made in the budget for the cost of these tests.

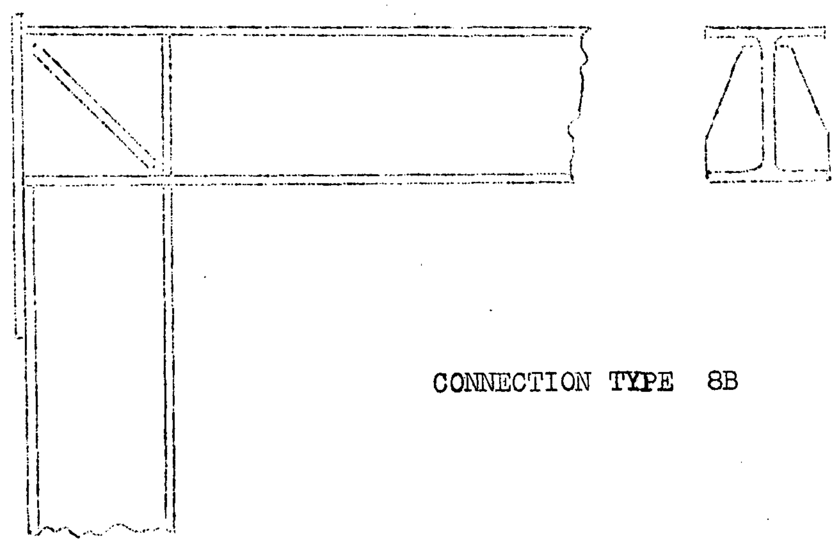
Your comments are solicited on the attached postcard.

Sincerely,

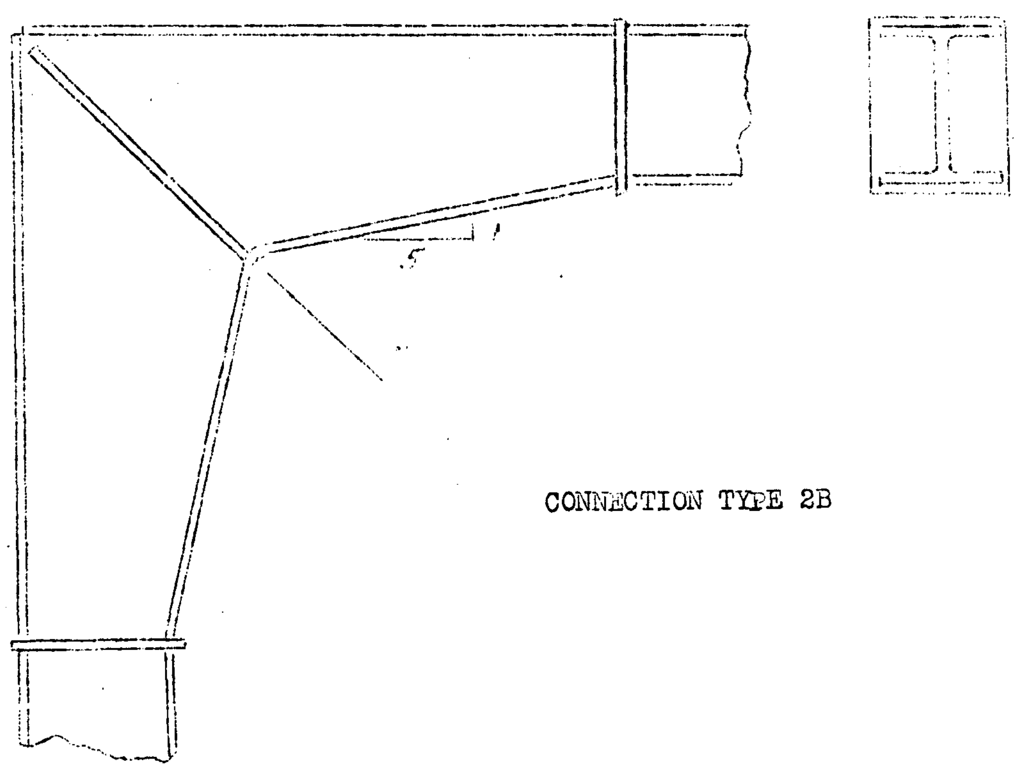
E. Russell Johnston, Jr.
Assistant Professor of C.E.

Lynn S. Beedle
Project Director

ERJ:LSB:jff
Cc: J.F. Baker
LaMotte Grover
J.D. Griffiths
William Spraragen
ONR Scientific Section (NY)
Armed Forces Special
Weapons Project



CONNECTION TYPE 8B



CONNECTION TYPE 2B

<u>FIGURE 2</u>

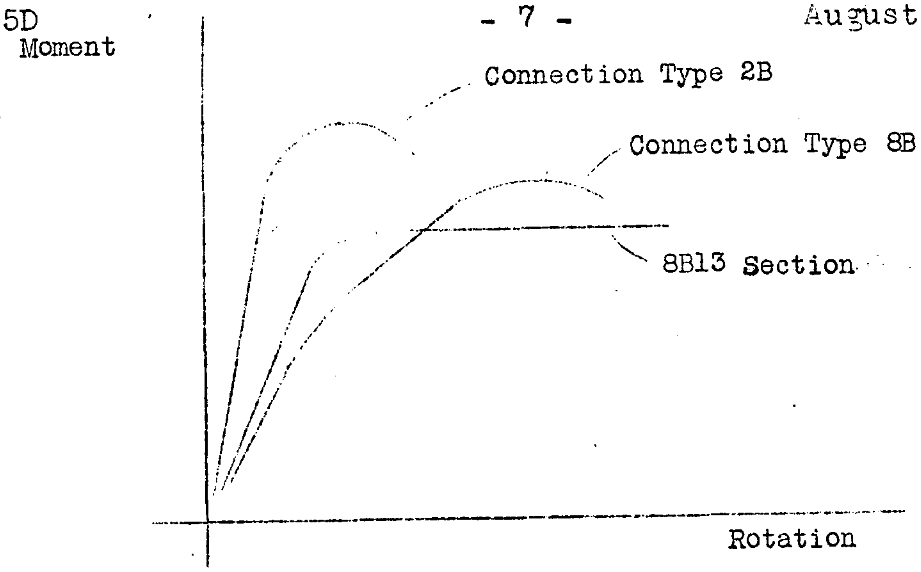
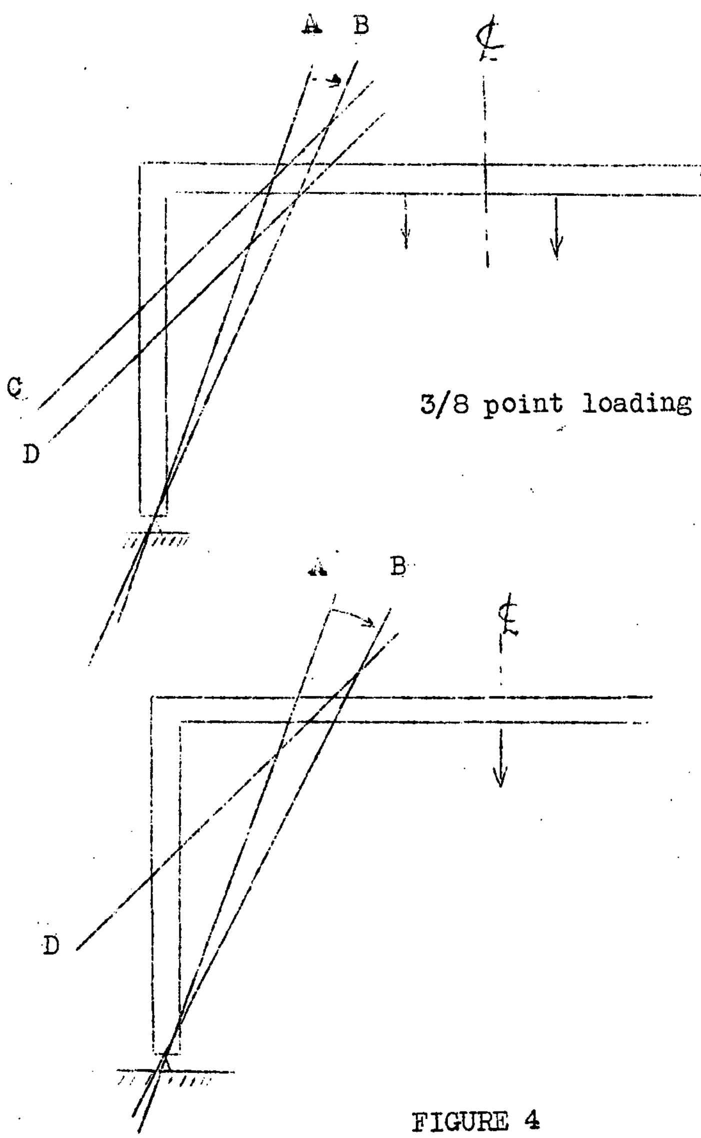



FIGURE 3




A - Load Line Frame Test (elastic)*

B - Load Line Frame Test (plastic)*

C - Equivalent Load Line, Isolated Connection Test, Type 2B

D - Equivalent Load Line, Isolated Connection Test, Type 8B

(Load line will shift from A to B as test progresses)

FIGURE 4

SKETCH OF FRAME TESTING ASSEMBLY

FOR MODELS A and C

| | |
|---|---|
| SKETCH OF FRAME TESTING ASSEMBLY | FL 20 |
| 7-9-1950 | J-M-R |

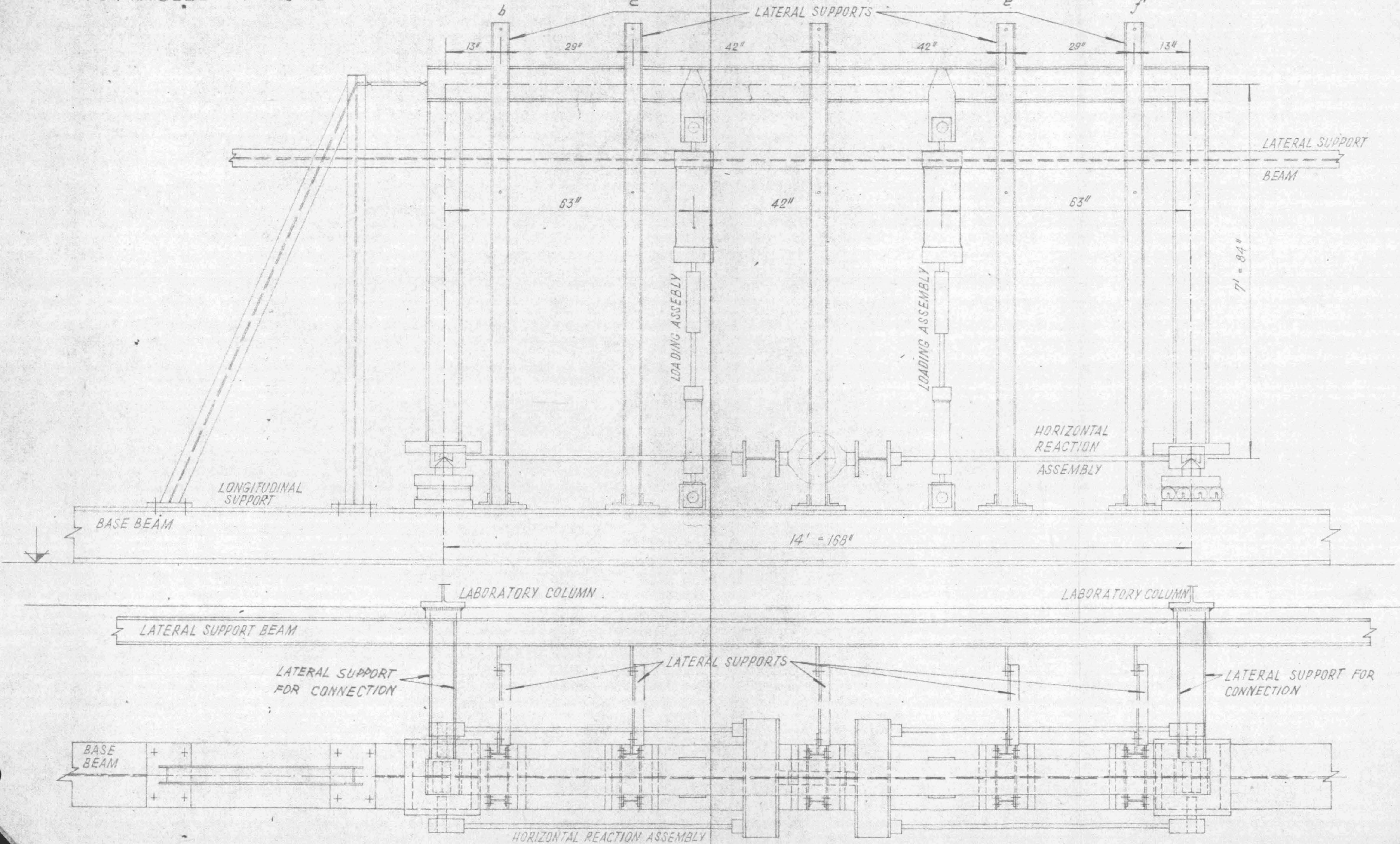



FIG. 1.