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Column testing procedure, June 1969

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European Column Studies

COLUMN TESTING PROCEDURE

FRITZ ENGINEERING
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by
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Fritz Engineering Laboratory Report No. 351.1

European Column Studies

COLUMN TESTING PROCEDURE

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June, 1969

Fritz Engineering Laboratory Report No. 351.1

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351.1

ABSTRACT

This report describes the instrumentation and testing procedure proposed for the project "European Column Studies" underway at Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania.

The purpose of this study is to gain experience in the testing procedure and recording needed for the project sponsored by the European Convention for Constructional Steelwork Association, the National Science Foundation, and the Welding Research Council. Some preliminary tests on U.S. heavy shapes similar to the European manufactured heavy sections were undertaken as part of the study.

This report summarizes the final proposal of the instrumentation and testing procedure for the columns to be tested to furnish information to be used in the preparation of design specifications of the European Convention.

1. INTRODUCTION

The European Convention of Constructional Steelwork Associations (ECCSA) is studying the conditions by which the results from their basic research program on column shapes with small dimensions and light weights can be extended to heavy columns.

According to the Test Program on Experimental Studies of Buckling undertaken by Subcommittee 8.1 of ECCSA as described in Ref. 1, the application of the column curve obtained from the statistical test program may not be valid for sections of large dimensions and with heavy thickness, nor for certain types of sections built-up by welding. "Heavy sections" refer to columns larger than the section HE 280 (equivalent to U.S. 12 WF 133) and "heavy thickness" refer to the order of 30mm (1 1/8 inch) and higher.

Fritz Engineering Laboratory of Lehigh University is conducting the program on the heavy shapes. To obtain conclusive experimental evidence with the minimum costs the program was restricted to the shape HEM 340 (equivalent to the U.S. 12 WF 161) and to two slenderness

ratios, 50 and 95. The two slenderness ratios were chosen on the basis that they belong within the most critical range according to theoretical and practical considerations. A total of 24 columns (12 per slenderness ratio) will be tested.

In order to gain experience with the new procedure and instrumentation as required by ECCSA, some complementary tests were conducted at Fritz Engineering Laboratory on a U.S. shape 12 WF 161. The method of testing proposed for the European Columns⁽¹⁾ differs from that used in the recent past at Lehigh University. This prompted the investigation of the test methods; conclusions and recommendations from the comparison study are given in Ref. 2.

For the tests on the European columns the required instrumentation and procedure⁽¹⁾ will be used to avoid introducing any new variables which may affect the statistical evaluation.

However, the experience from the pilot tests on the 12 WF 161 columns, the results of which are discussed in Ref. 2, indicates some clarifications and adjustments.

These, together with a description of the instrumentation and testing procedure, are discussed below.

2. INITIAL MEASUREMENTS AND ALIGNMENT

The following data will be collected for each column. The ECCSA requirements are presented within quotation marks.

2.1 Out-of-Straightness

"Initial flexural curvature of the test specimen will be measured in the two planes of symmetry of the section."

Figure 1 shows the method for measuring initial out-of-straightness using the theodolite and the movable carpenter's frame square with a strip scale attached to it.

Out-of-straightness (x) about the weak axis is obtained from four readings - one with reference to each tip surface of the flange (Fig. 1b). For the theoretical evaluation, the values for each flange may be obtained separately. The average of the four readings is taken as the out-of-straightness of the whole section.

Out-of-straightness (y) about the strong axis is obtained from the two readings (Fig. 1c). The average

of the two readings is taken to be used for theoretical prediction.

In Fig. 2, a plot of the readings obtained for a typical column from the Comparative Study⁽²⁾ is shown.

The flexural curvature is obtained from the measurements made at nine levels, each spaced at one-eighth of the column length.

2.2 Cross-Sectional Dimensions

"Cross-sectional dimensions as shown in the figure below* at preferably five sections (but at least 3 sections) along the column: the two ends, in the middle and possibly at the quarter and three-quarter points."

The cross-sectional dimensions are measured at five locations - the two ends, the quarter, the middle, and the three-quarter points. The measuring tools used are:

Thickness and depth - vernier caliper ($\frac{1}{1000}$ in. sensitivity)

Web thickness - depth micrometer ($\frac{1}{1000}$ in.

sensitivity, Fig. 4 shows how

* Figure 3 of this report.

the web thickness is
determined)

The recorded dimensions for one of the columns tested for the Comparative Study are tabulated in Table 1.

It may be appropriate to note that function errors such as angles between the flanges and the web as shown in Fig. 5 are not measured. Such deformations, however, are not usual for rolled steel sections.

Possible preparation errors as the angle α between end plates, and center line deviation Δ , which are assumed to be zero in both cases (Fig. 6) also are not measured.

2.3 Alignment of Specimen

"The alignment of the specimen will be through the center of web and not through the real center of gravity of the section, even if the section shows a dissymmetry due to unusual tolerances. The alignment will not be corrected during the test."

The required alignment procedure is very simple and time saving, since the end plates can easily be welded

with reference to the center of the web, and consequently the end plates can be positioned with reference to the center line of the testing machine without much difficulty. It should be mentioned, however, that a new variable is introduced for sections with the center of gravity not at the center of the web. Such sections have been observed in other investigations.

The column ends may not always be machined to have parallel surfaces, thus one flange will be loaded more than the other. It is recommended, therefore, to use at least two strain gages at the center of the flanges or preferably four at the flange tips at mid-height of the column as shown in Fig. 7. The possible difference may be reduced by adjusting the leveling plates at the sensitive cross-head of the testing machine.

3. INSTRUMENTATION

The instrumentation for the column tests consists of $\frac{1}{1000}$ inch graduation dial gages, 4 inch and 1 3/8 inch stroke potentiometers (with sensitivities of 4/1000 inch and 1/1000 inch respectively (Fig. 8) to measure lateral deflections about both axes, and the angle of twists at the five levels described earlier. In addition to the practice suggested by ECCSA, measurements of lateral deflection and angle of twists of both ends will be taken for the purpose of using a reference. A possible condition for the case of mid-height deflection is shown in Fig. 9. A layout of the instrumentation is shown schematically in Fig. 10. Figure 11 shows the instrumentation of the column.

4. TESTING PROCEDURE

The loading will be carried out as required by ECCSA with only minor modifications:

- a) The required loading rate of 1.42 ksi/min. (1 kp/sq. mm. per min.) will be established by adjusting the valve setting of the testing machine when the column is within its elastic range. The established valve setting will be kept fixed and will be used until the ultimate load is reached. It is noted that the speed of loading will not be kept constant after the column starts yielding, and that the rate will depend on the type of testing machine used.
- b) The column is loaded continuously up to the dynamic ultimate load which will be recorded on the X-Y plotter (Fig. 12) and the Brush multichannel oscillograph (Fig. 13) and is indicated by the stopping of the follower pointer of the dial on the testing machine. All other

deflection characteristics will be recorded automatically. Typical plots are shown in Fig. 14.

- c) The static ultimate load will be obtained immediately after the dynamic ultimate load is reached. This information is not required by ECCSA. The value of the static load will be obtained from the method of column testing used at Lehigh University⁽³⁾ by closing the loading valve and taking a reading when no further movement of the sensitive cross-head is observed. To confirm stabilization, a plot of the load change and cross-head movement versus time is shown in Fig. 15. Stabilization usually takes place after about 15 minutes.
- d) After the static load is recorded the test will be continued using the valve setting established originally until a mid-height deflection of 2 to 3 inches is reached. Continuation of testing is

not required by ECCSA. A sketch of the complete P- Δ curve resulting from such a test will be similar to that shown in Fig. 16.

5. SUMMARY

The testing of the European columns will follow the required European Convention procedure, described in Ref. 1, with additional instrumentation and recordings.

The required alignment is simple and time saving. Strain gages are recommended to be used for columns with large preparation errors.

All deflection characteristics will be plotted using automatic plotters.

The required loading rate of 1.42 ksi/min. (1 kp/sq. mm. per min.) will be established when the column is loaded within its elastic range. The established valve setting will be used up to the end of the experiment.

Loading on the column will be stopped immediately after the ultimate dynamic load has been reached. The ultimate static load will be determined using the Lehigh method of testing after which the test will be continued using the valve setting established originally.

6. ACKNOWLEDGEMENTS

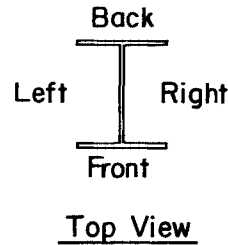
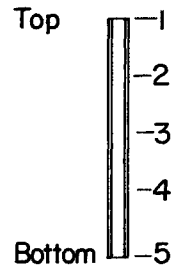
This progress report presents the column testing procedure proposed for a series of column tests to be conducted for the European Convention of Constructional Steelwork Association.

The investigation is being conducted at Fritz Engineering Laboratory, Lehigh University, Bethlehem, Pennsylvania. The European Convention, National Science Foundation, and the Welding Research Council jointly sponsor the study.

The guidance of Task Group 11 of the Column Research Council, under the chairmanship of Lynn S. Beedle, is gratefully acknowledged. Special thanks are due to Duiliu Sfintesco, Director of Research, Centre Technique Industriel de la Construction Metallique, Paris, for his advice in the initiation of the study.

7. TABLES AND FIGURES

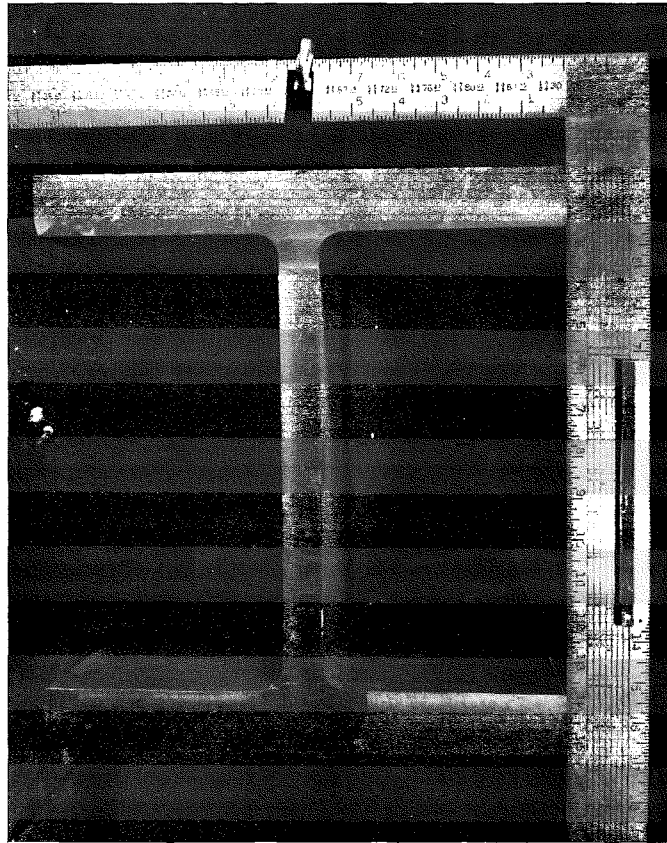
TABLE I: CROSS SECTION DIMENSION



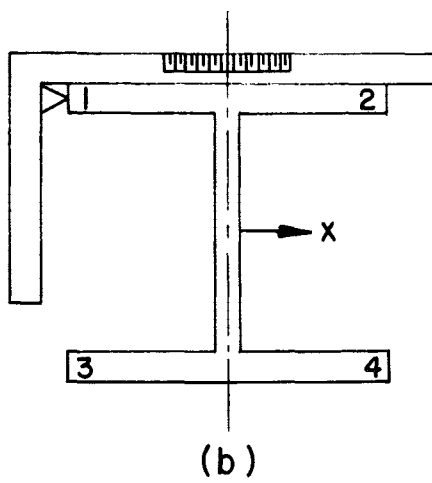
Proj. No: 351
 Steel Grade: A36
 Shape: 12W161
 Col. No: 01
 Length: 13'-4 1/2"
 Recd: P.M. & N.T.
 Date: 2/9/69

Section	h _l	h _r	b _f	b _b	t _{fr}	t _{br}	w _f	w _b	c _{fr}	c _{br}	Area (in ²)
					t _{fl}	t _{bl}			c _{fl}	c _{bl}	
1	13.765	13.829	12.613	12.596	1.464 1.460	1.440 1.460	.978	.993	5.789 5.846	5.804 5.799	47.432
2	13.771	13.856	12.604	12.594	1.464 1.447	1.432 1.460	.973	.990	5.785 5.845	5.815 5.789	47.266
3	13.795	13.818	12.603	12.577	1.469 1.452	1.432 1.471	.975	.982	5.773 5.855	5.801 5.794	47.323
4	13.780	13.832	12.618	12.596	1.471 1.451	1.427 1.439	1.034	1.006	5.784 5.800	5.804 5.786	47.615
5	13.763	13.845	12.608	12.598	1.472 1.455	1.433 1.436	1.025	1.006	5.788 5.795	5.800 5.792	47.599
Average	13.775	13.836	12.609	12.592	1.461	1.443	0.997	0.995	5.806	5.798	47.450

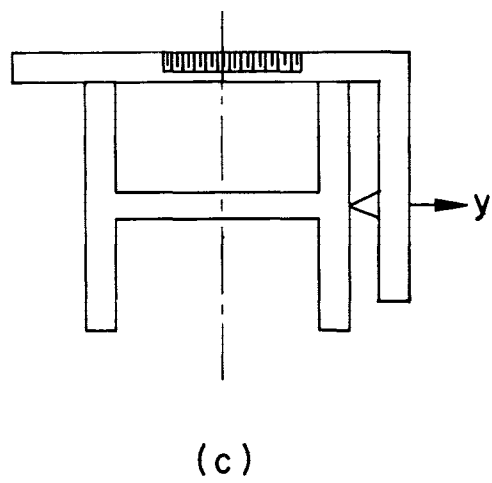
See Fig. 3 for Notation



(a)



(b)

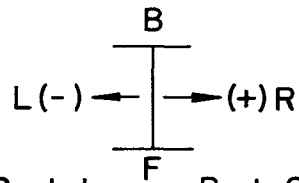


(c)

Fig. 1 Instrumentation for Initial Out-of-Straightness Measurements.

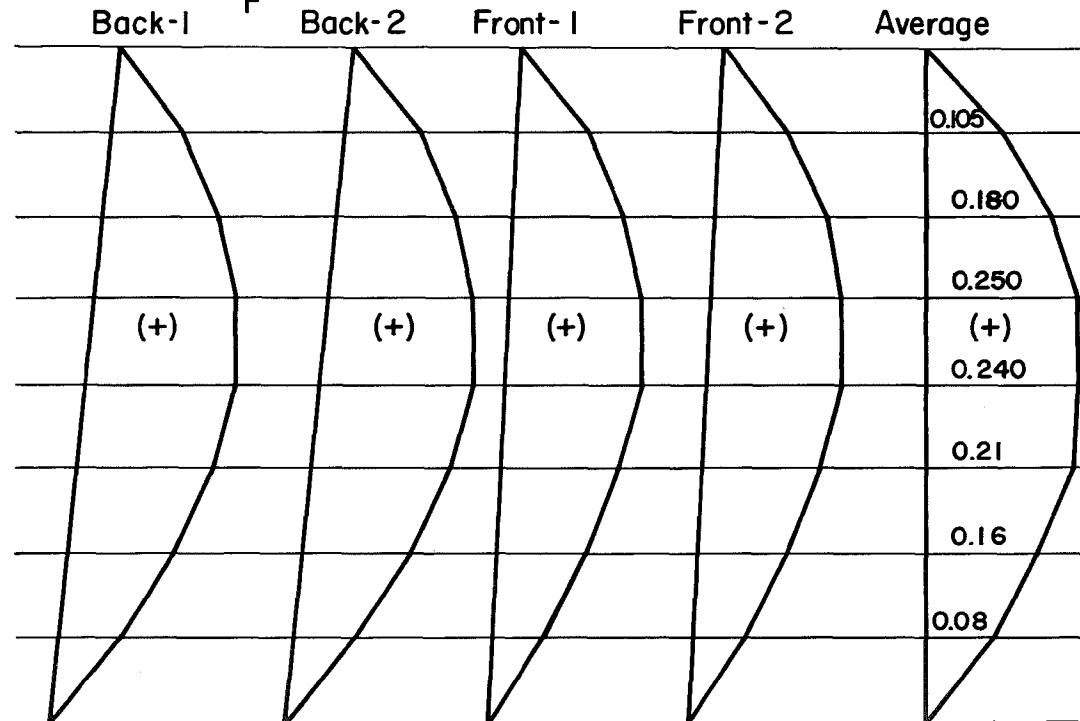
WEAK AXIS, INITIAL OUT-OF-STRAIGHTNESS

Right
Left



Proj. No: 351
Shape: 12WF161
Col. No: 01

	Front	Back
1	3.50 1.60	2.320 4.280
1'	3.40 1.50	2.42 4.34
2	3.30 1.40	2.44 4.35
2'	3.26 1.34	2.46 4.38
3	3.24 1.32	2.44 4.34
3'	3.28 1.38	2.40 4.30
4	3.36 1.44	2.33 4.25
4'	3.46 1.55	2.23 4.14
5	3.54 1.62	2.12 4.04



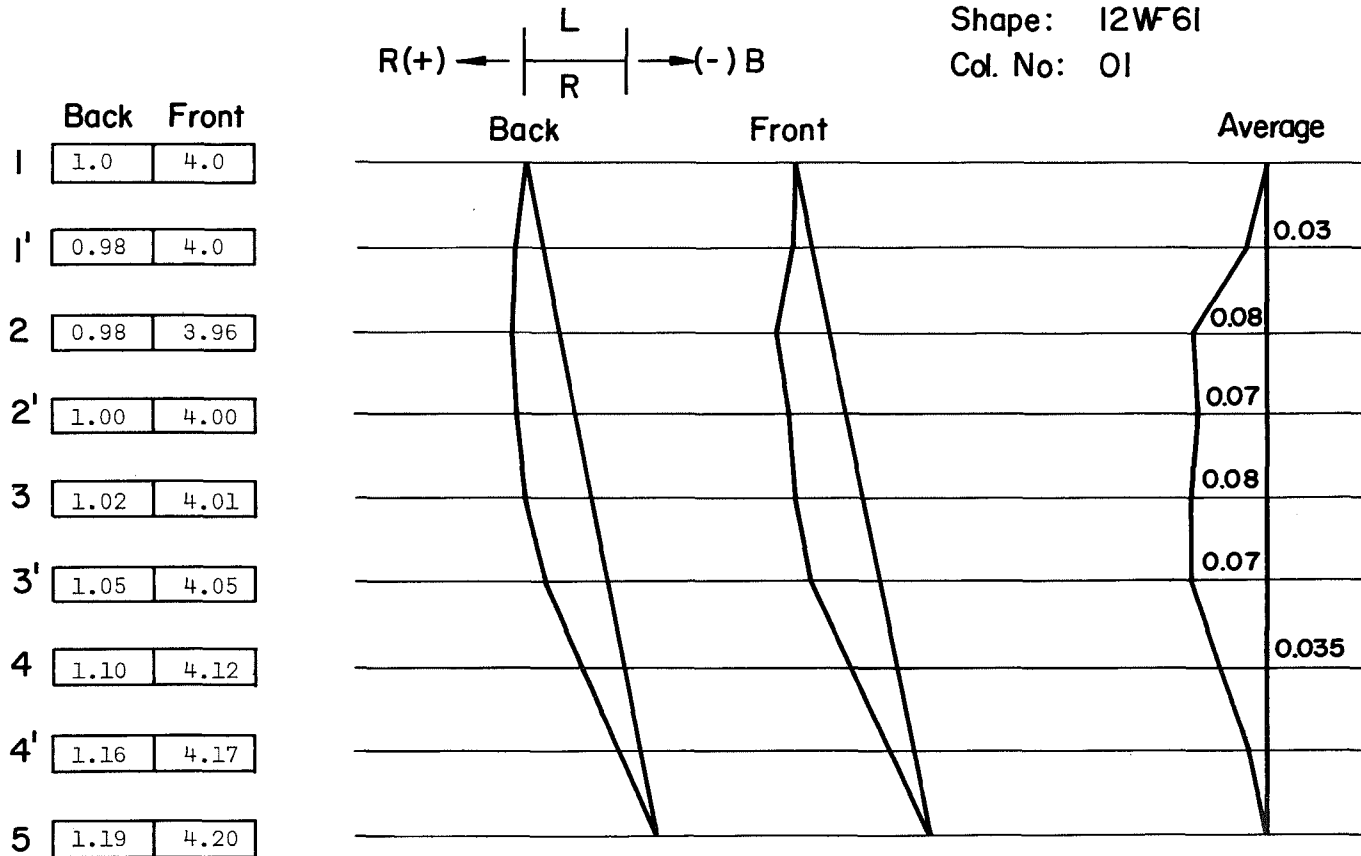
Read and Recd: P.M. & N.T.
Date: 2/9/69

Fig. 2a

Measurements of Initial Out-of-Straightness
(Weak Axis).

STRONG AXIS, INITIAL OUT-OF-STRAIGHTNESS

Proj. No: 351
 Shape: 12W61
 Col. No: 01



Read and Recd: P.M. & N.T.
 Date: 2/9/69

Fig. 2b

Measurements of Initial Out-of-Straightness
 (Strong Axis).

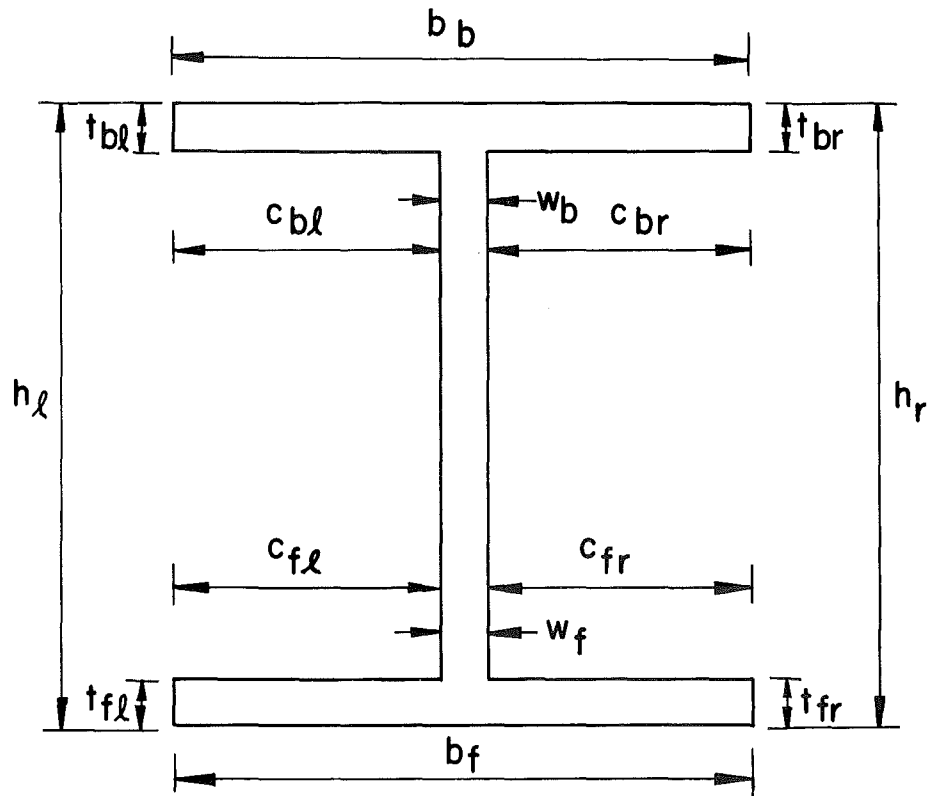
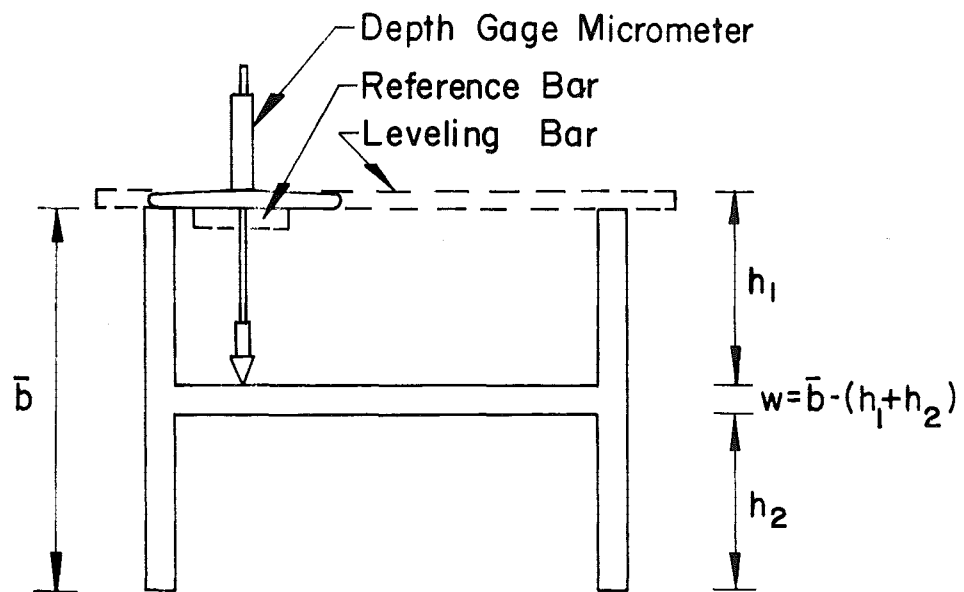
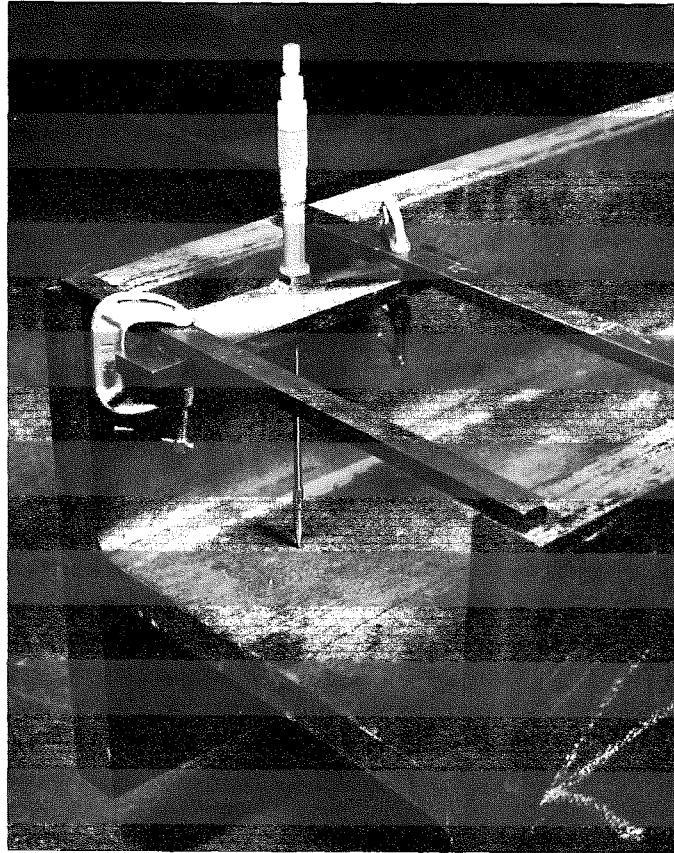


Fig. 3 Required Measurements of Cross-Sectional Dimensions.



(a)

Fig. 4

Determination of Web-Thickness Using the
Depth Micrometer.

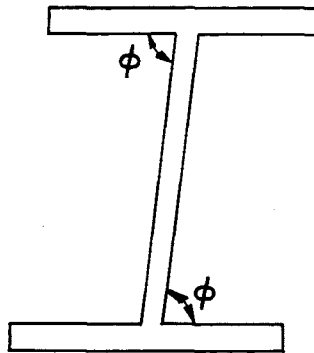
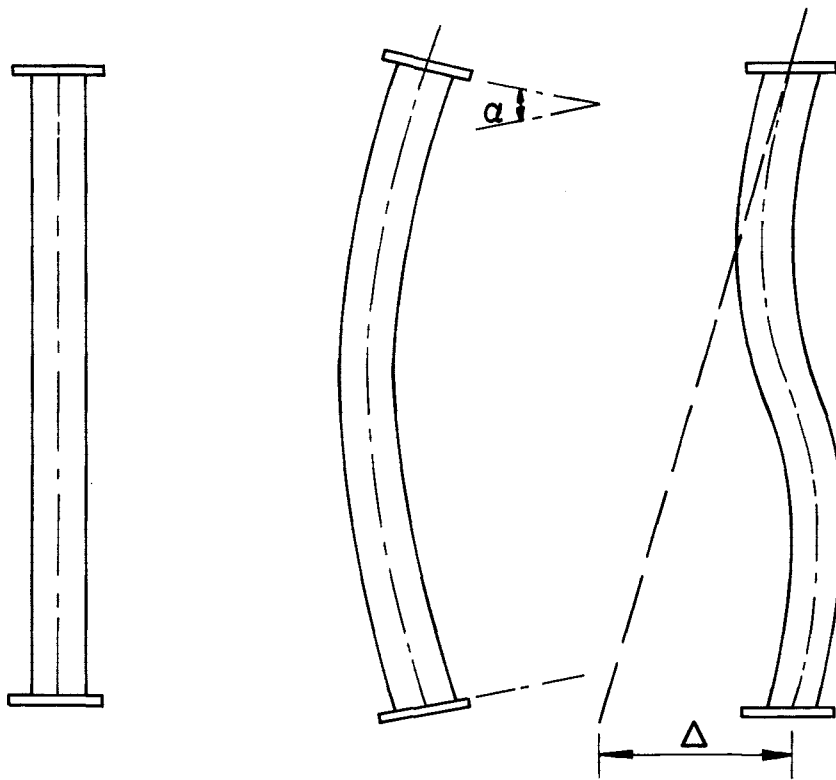


Fig. 5 Possible Fabrication Error.



(a) Ideal Case

(b) Non-Parallel End-Plates

(c) Deviation of Center Line

Fig. 6

Possible Preparation Errors Not Taken Into Consideration.

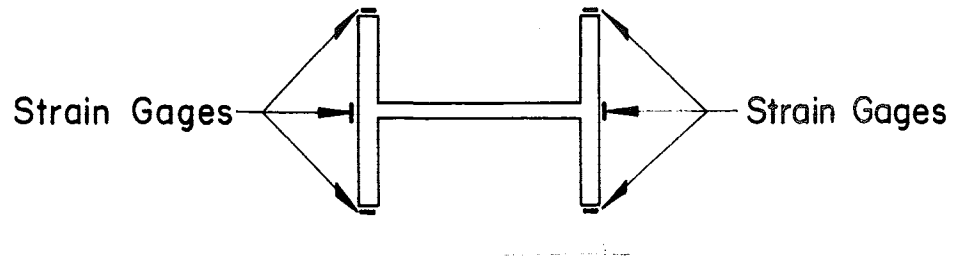


Fig. 7 Strain Gages for Preliminary Alignment.

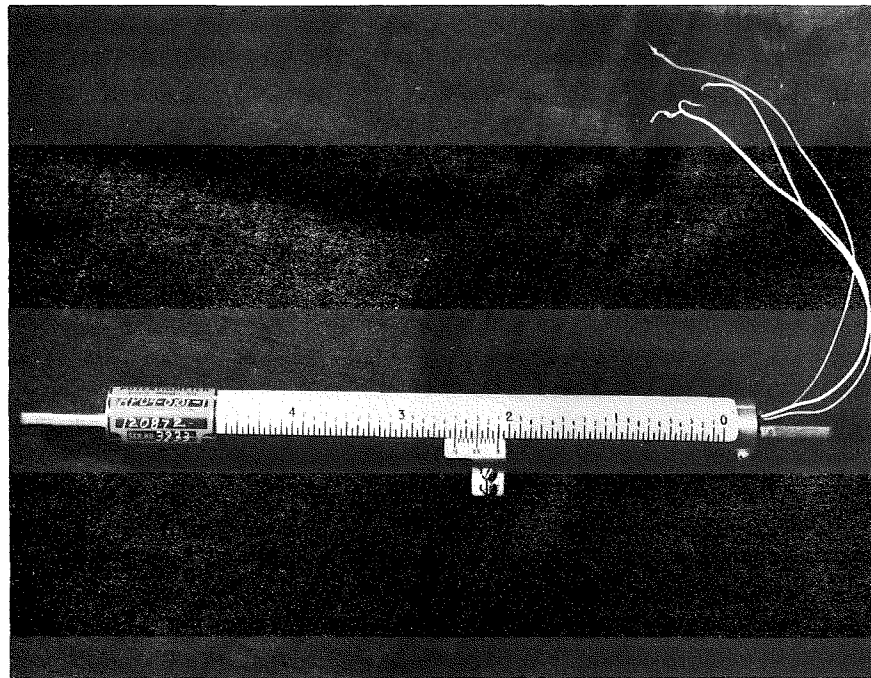


Fig. 8 A 4-inch Potentiometer.

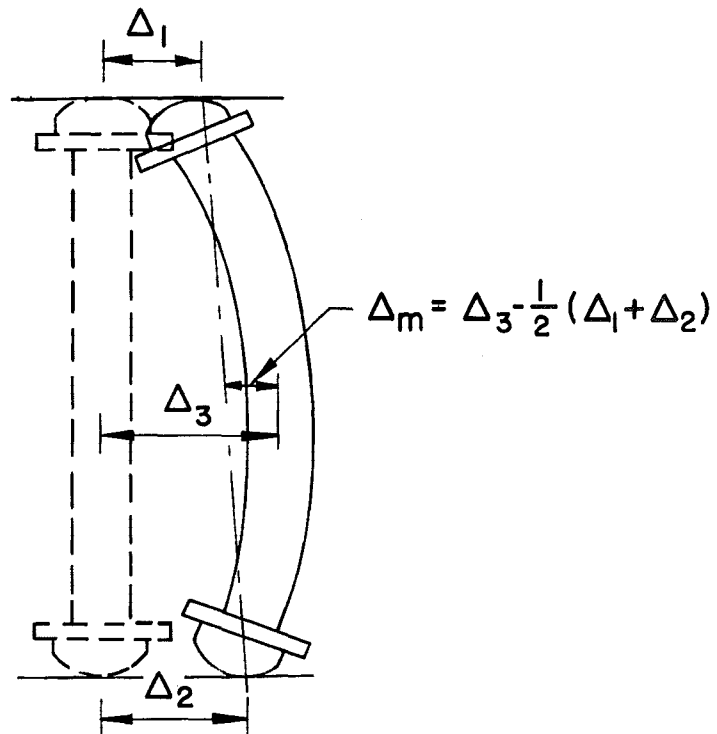


Fig. 9 Deflection Measurements at Ends for Correct Mid-Height Deflection.

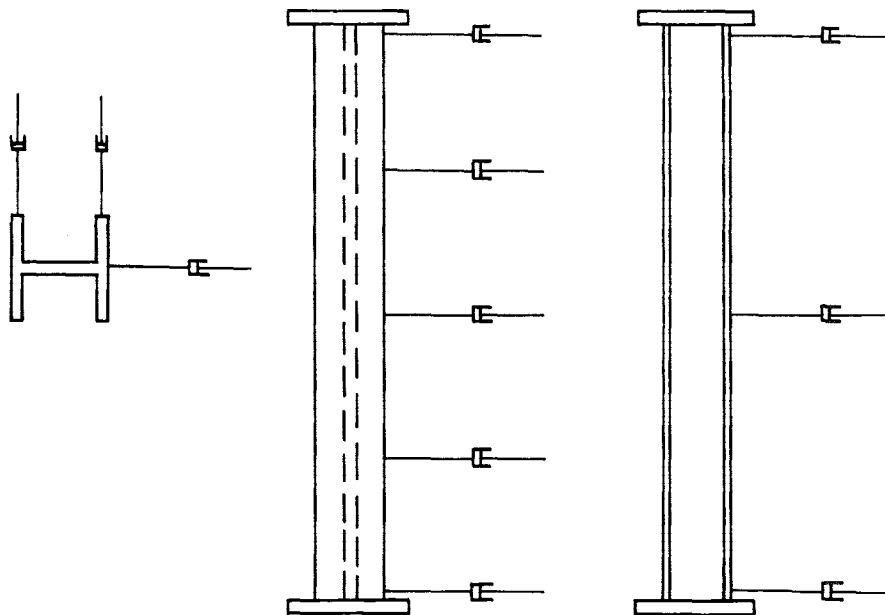


Fig. 10 Schematic Drawing of Instrumentation.

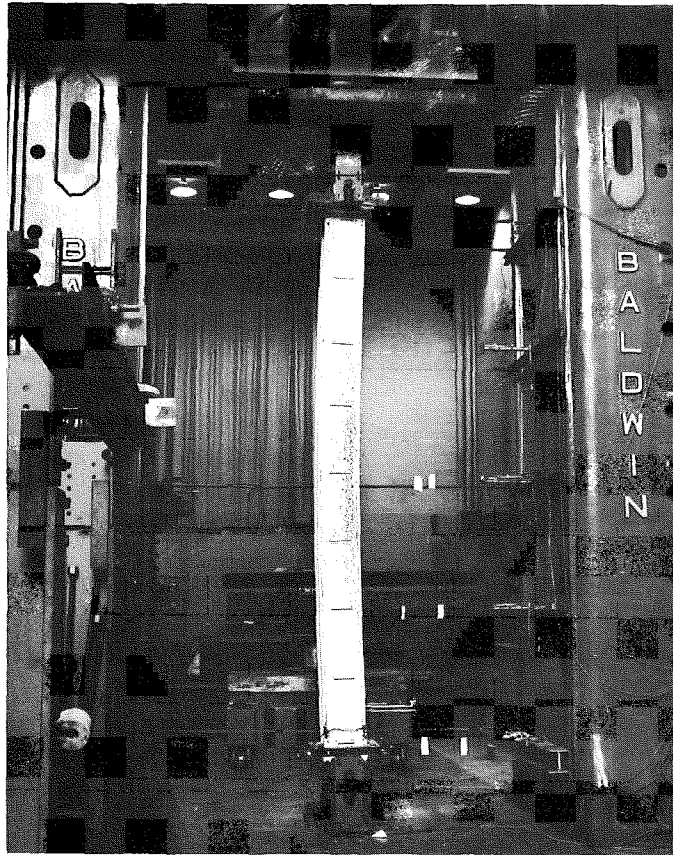


Fig. 11 Instrumentation of Column.

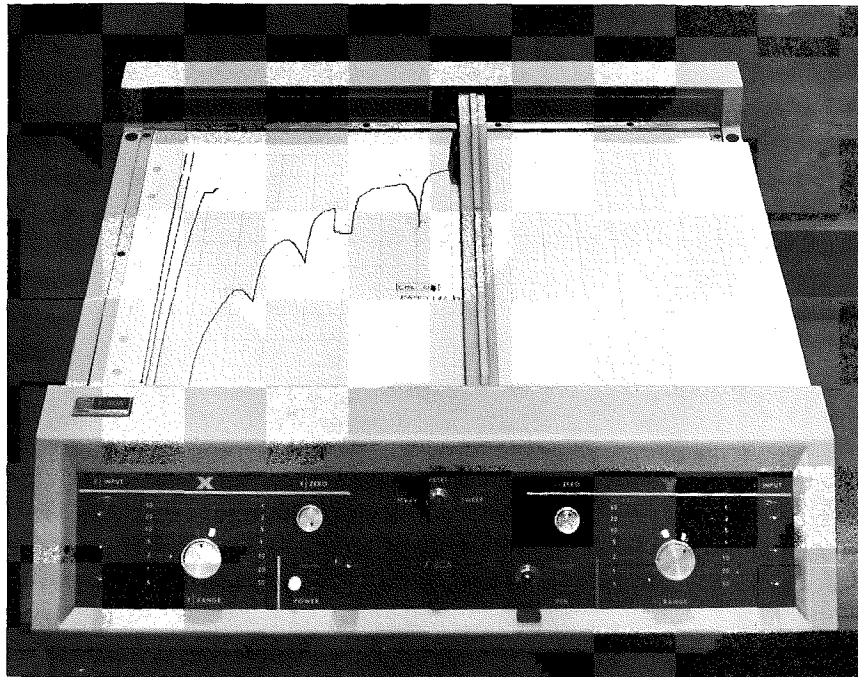


Fig. 12 The X-Y Plotter.

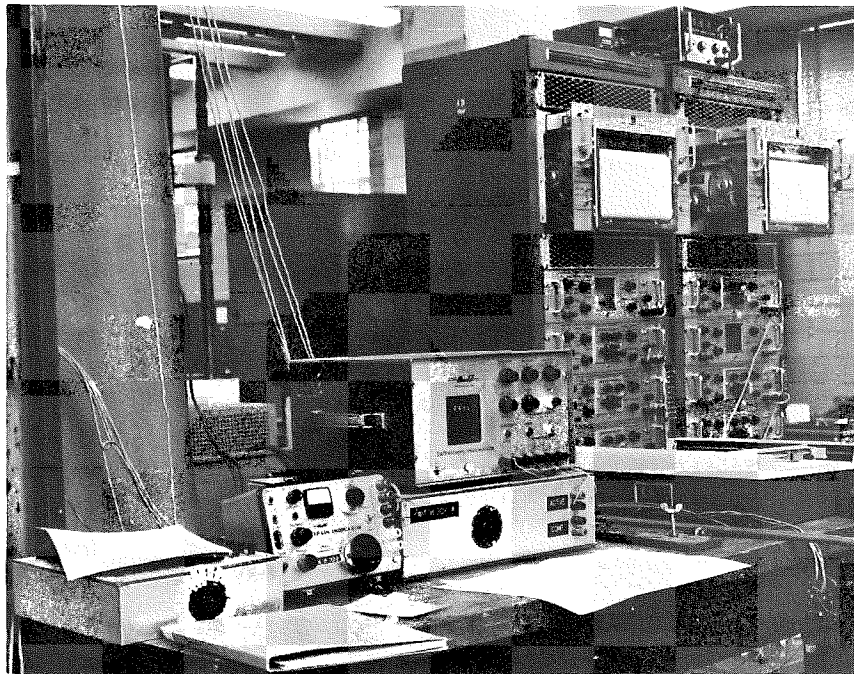
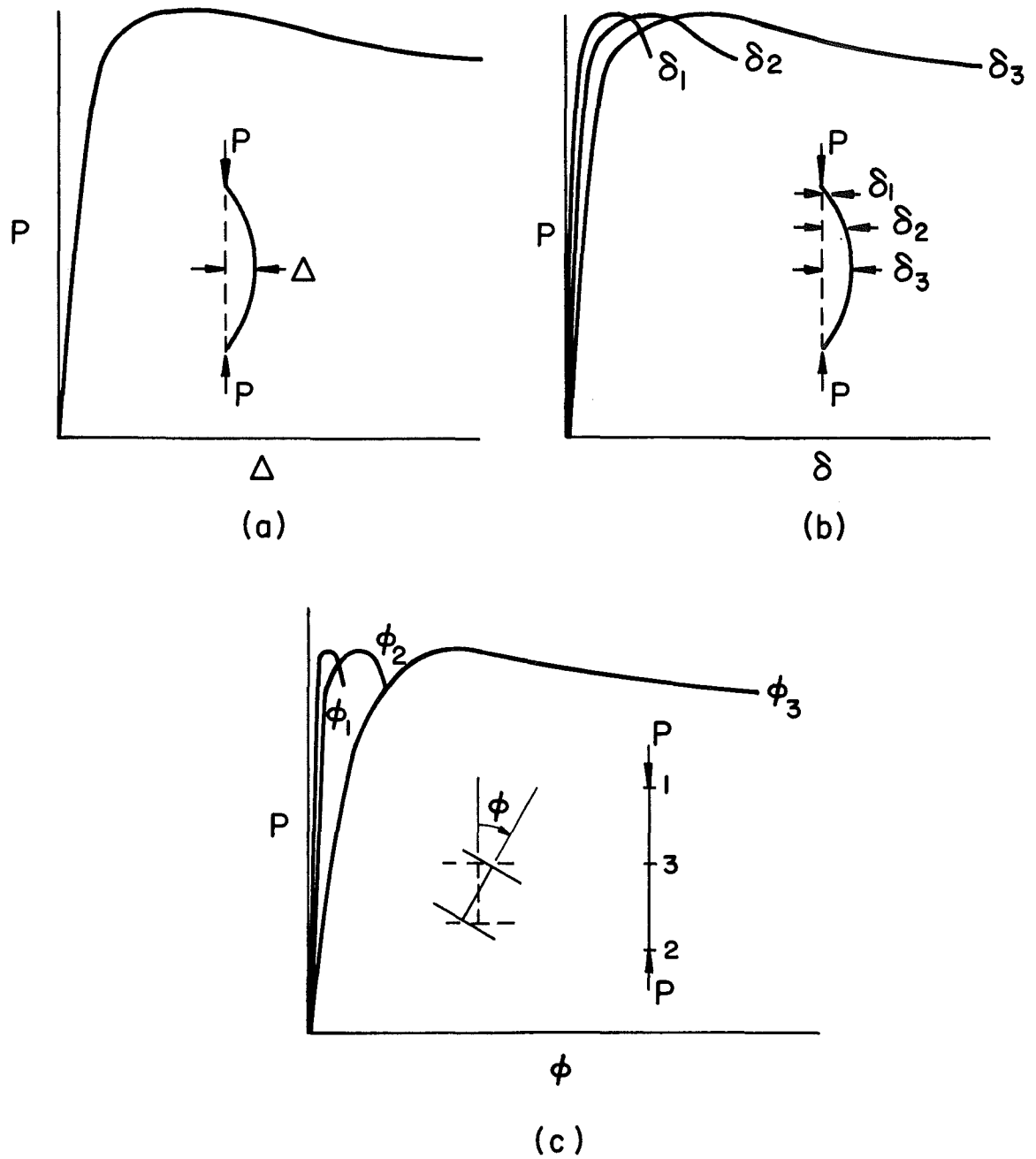


Fig. 13 The Brush Multichannel Oscilloscope.



(a) Results from X-Y Plotter

(b) Lateral Deflection from a Brush Multichannel Oscillograph

(c) Torsional Angle from a Brush Multichannel Oscillograph

Fig. 14 Load-Deflection Characteristics Curves.

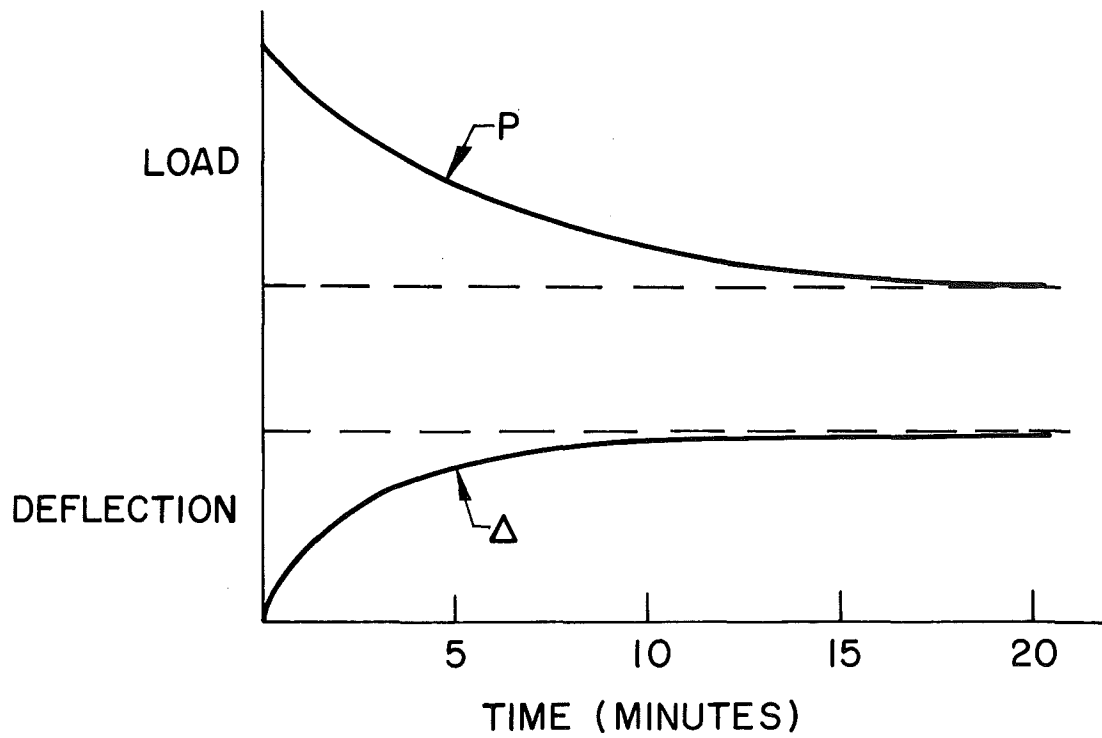


Fig. 15 Typical Load-Relaxation Curves.

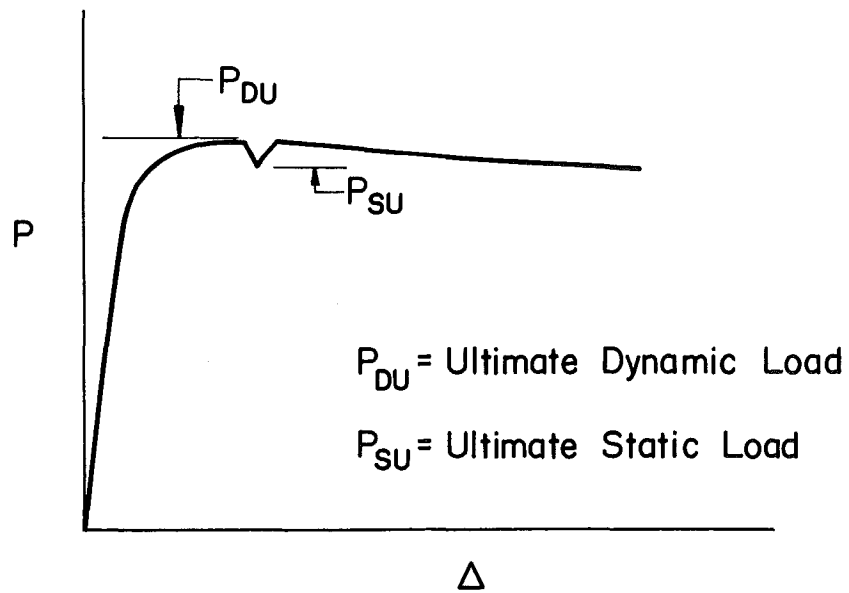


Fig. 16 Typical Load-Deflection Curve.

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