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LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

FRITZ ENGINEERING LABORATORY
DEPARTMENT OF CIVIL ENGINEERING

File No. 205.4
January 18, 1956

Mr. Wm. Spraragen, Director
Welding Research Council
29 West 39th Street
New York 18, New York

Re: ONR Status Report
No. 22
NR 064-345

Quarterly Report
(10/1/55 - 12/31/55)

Dear Mr. Spraragen:

Attached is our quarterly report including a financial
statement submitted by request of the Welding Research Council.

Sincerely yours,

Lynn S. Beedle

LSB:plt

Enc.

CC: Mr. T. R. Higgins
Mr. LaMotte Grover
Members, Lehigh Project Subcommittee, WRC
ONR Scientific Section (New York)
Professor J. F. Baker
Armed Forces Special Weapons Project

Welded Continuous Frames and Their Components

General (Lynn S. Beedle)

A majority of the work on the project during the quarter has involved analytical work and the preparation of reports. Part of this work is discussed in the separate reports that follow.

A paper entitled, "Practical Applications of Plastic Design in Structural Steel" was presented at the annual meeting of the Structural Engineers Association of California, October 6-8, 1955. This report described some of the essential features of plastic analysis and included the solution of several design problems.

Prof. Bruno Thurlimann presented the paper "Analysis of Frames for Ultimate Strength" at the Engineering Mechanics Division session during the annual meeting of the A. S. C. E., October 26, 1955. The principles, methods, and application of plastic analysis included. The manuscript is nearing completion.

During the next quarter work will continue on the "Rules of Practice" phase of the project. In considering the practical application of plastic design, three documents seem desirable:

- (1) a "commentary" on plastic design (the "rules" and justification therefore)
- (2) a set of design examples, and
- (3) a specification.

Item (1) is intended as an extension of the report "Rules of Practice in Plastic Design" (Interim Report No. 26). When completed it should constitute a justification of the provisions and procedures of the plastic methods.

Summer Course Demonstrations (George C. Driscoll)

A rough draft of the summary report on the demonstration tests conducted in the Summer Course in Plastic Design in Structural Steel has been written. Preparation of figures for the final report has begun, and the report is expected to be ready soon.

Figure 1 shows a summary of the results of the tests compared to predicted ultimate loads calculated by simple plastic theory and also compared to present A.I.S.C. working loads and to plastic design working loads. It will be noted that all specimens either reached or very nearly reached the predicted ultimate loads. In a couple of the cases where the predicted load was considerably exceeded, extensions to the simple plastic theory would have shown the tendency toward these higher loads.

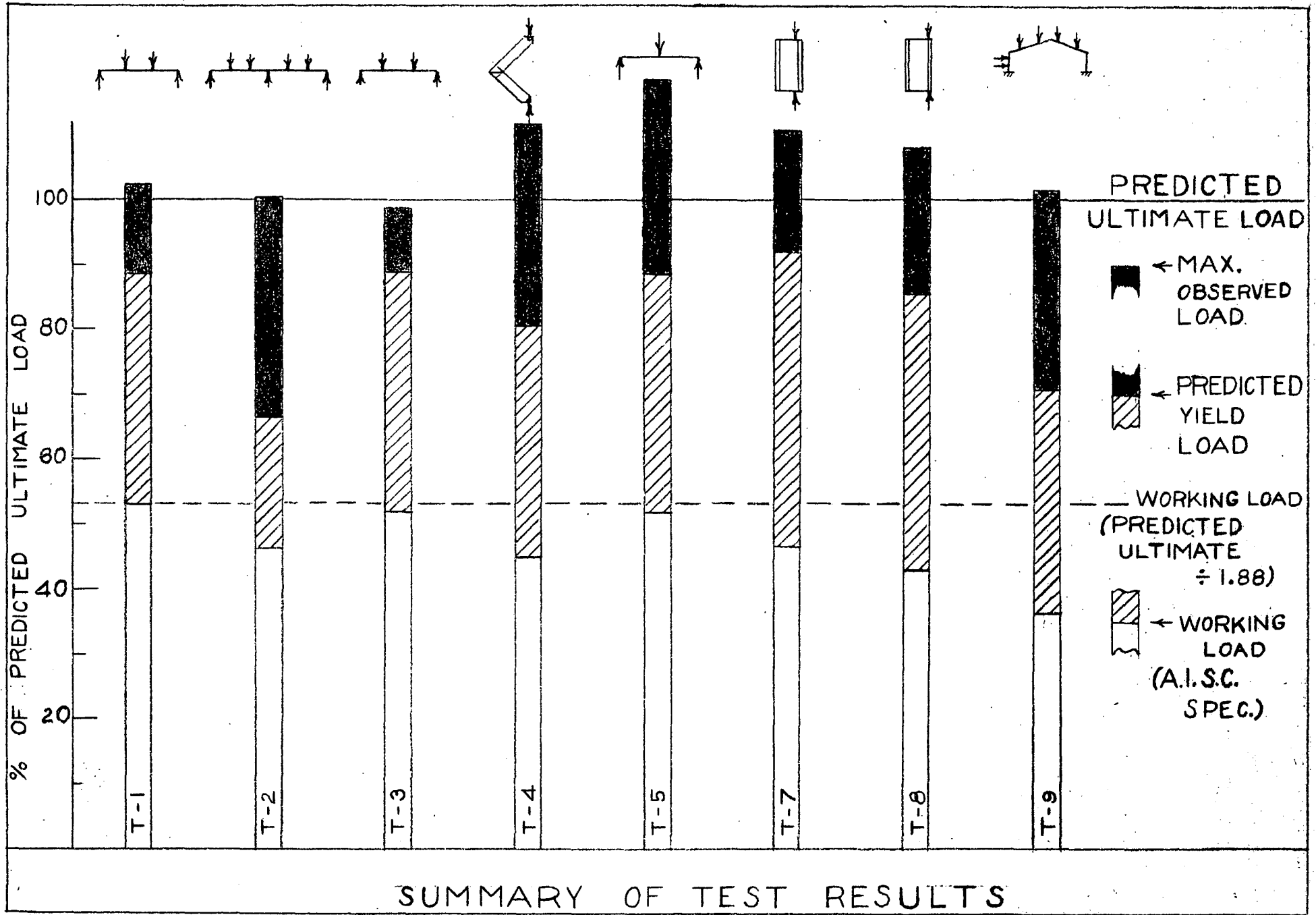


Figure 1

Design Examples and Techniques (Robert L. Ketter)

In using the mechanism approach to the analysis and design of frames according to plastic theory, there are for a given structure a certain number of possible plastic hinge combinations that will result in failure of the structure. The correct solution then is the one that results in the lowest critical load. In preparing for one of the lectures of the summer school that was held in September, it was observed that generalized solutions for the single span gable frame could be obtained. These solutions (for the pin-based frames) were presented in graphical form in the lecture notes. Similar curves for the fixed-base have since been developed.

A direct solution of the type referred to above was attempted for the generalized multi-span gable frame problem but due to the complexity of the resulting equations had to be abandoned. It was therefore necessary to develop a new method or procedure for obtaining a solution. The essence of this new method is the dividing of the structure into parts more easily solved. By giving the results in graphical form, it has been possible to solve quite complex problems in a relatively short amount of time. Solution as to minimum weight will be a direct result of this study.

Columns (Robert L. Ketter)

Study on the behavior of columns during the past quarter has been restricted to a review of the results of two graduate student projects on the strength of bi-axially loaded, model, steel columns. An extension of the analytical parts of these studies was carried out. Also a check of the material properties of certain of the test specimens was performed. The correlation between predicted strength and observed carrying capacity is shown in the attached Figures 2 and 3.

Two series of tests were carried out. The first of these was a study of the strength of square cross-section columns (3/4", annealed, mild-structural steel) where the members was constrained to rotate about a diagonal axis at each end. Tests were made for five slenderness values ($L/r = 40, 60, 80, 100, \text{ and } 120$) and two eccentricity ratios ($ec/r^2 = 0$ and 0.25).

The second study was concerned with the strength of a rectangular cross-section column (1/2" x 3/4"), eccentrically loaded and forced at each end to bend about an axis 30° inclined to the major principal axis of the member. Five tests were carried out at various slenderness ratios for one eccentricity value ($ec/r^2 = 0.5$).

Work during the next quarter will be concerned with the preparation of a report describing the results of these studies.

A paper titled "Stability of Beam-Columns Above the Elastic Limit" by Robert L. Ketter (A.S.C.E. Separate No. 692) was presented at the annual meeting of the A. S. C. E. in October.

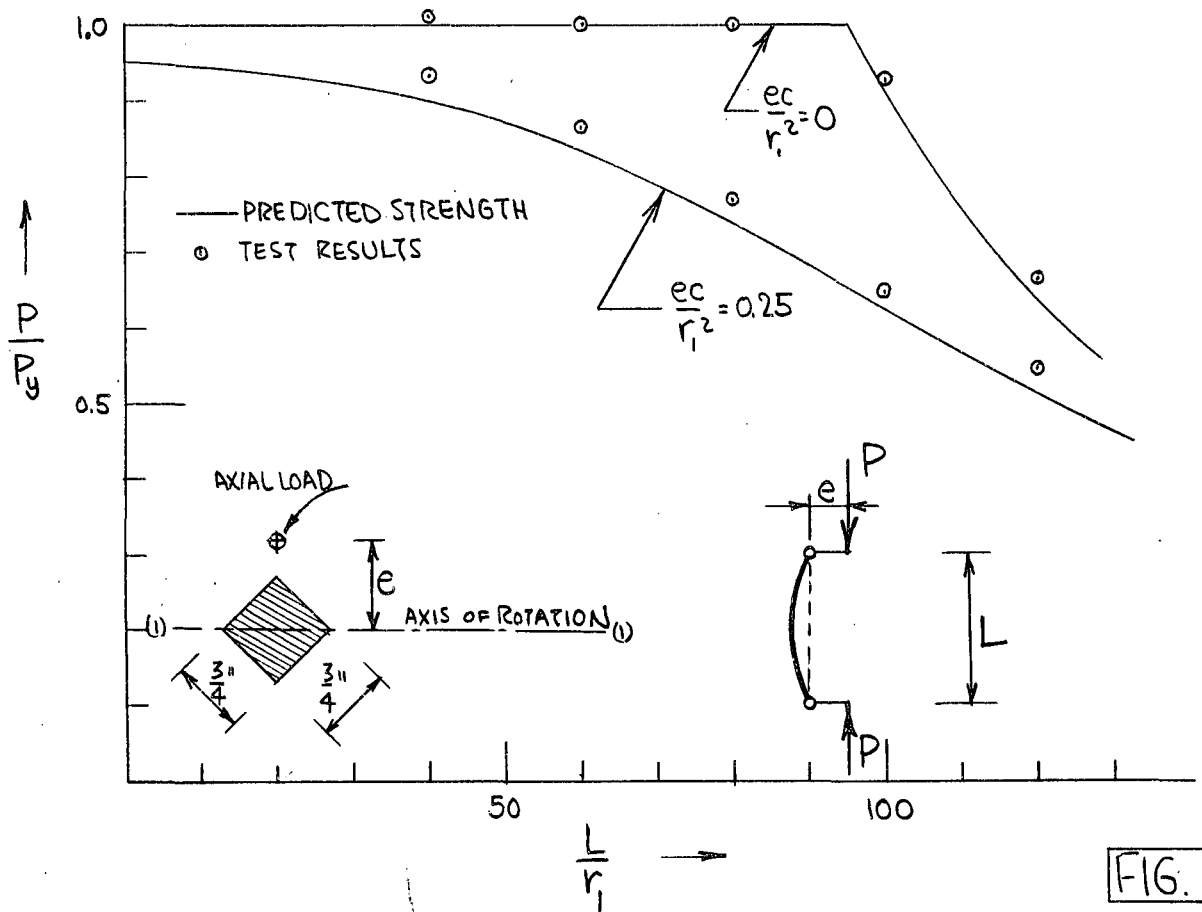


FIG. 2

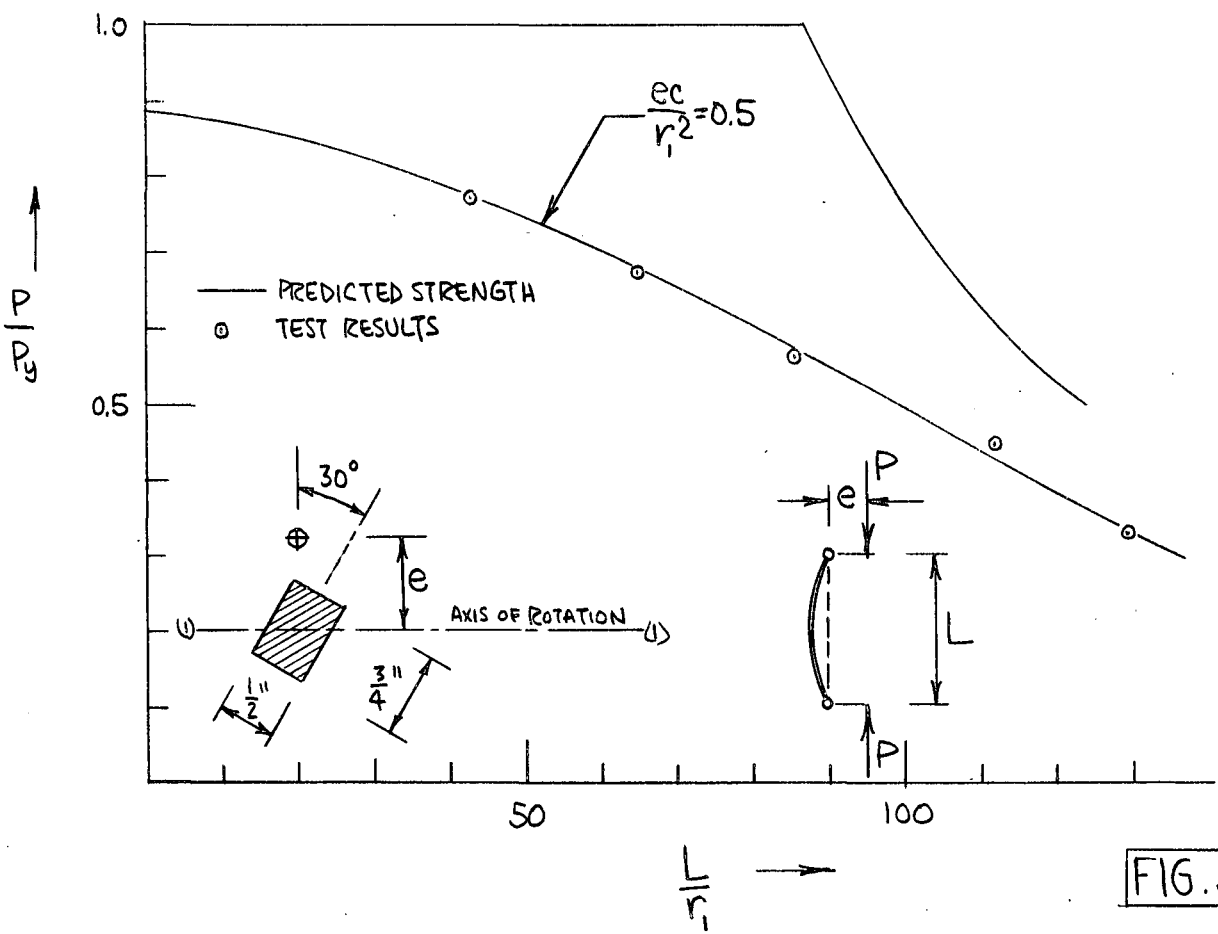


FIG. 3

Haunched Connections (Jerome E. Smith)

The determination of the relationship between the required thickness of flange and the geometry of the haunched knee is being continued. It has been found that in some cases it would be uneconomical to increase the thickness of only one flange. It is also undesirable when the possibility of tension loading of the knee occurs.

For knees with a ratio of length of one leg to depth of connecting rolled section of about 3.5 both flange thicknesses must be increased by about 50 per cent if the plastic moment is applied at the beginning of the haunch. This percentage increases rapidly if the critical section in the haunch occurs at the beginning of the haunch (angle between top and bottom straight flanges less than about 11 degrees).

Immediate plans are to continue to investigate the effect of the variables encountered.

Portal Frames (Bryan Chapman and George C. Driscoll)

Work continued on the write-up of the report on the forty foot span gabled portal frame which was tested in the summer session on Plastic Design in Structural Steel.

Progress Report No. 17 "Behavior of Welded Single-Span Frames Under Combined Loading" by C. G. Schilling, F. W. Schutz, L. S. Beedle was completed and distributed to the committee and sponsors.

Influence of Shear on Plastic Moment (Yuzuru Fujita and Bruno Thurlimann)

The final draft of the report on influence of shear on the full plastic moment of beams is completed. Preparation of a report for committee distribution will be started in the near future.

The results of the investigation can be summarized as follows:

1. High shear reduces considerably the plastic moment value at the beginning of the plastic range. However, after some rotation, θ , has taken place the moment value "catches up" with the value for pure bending.
2. Fair agreement was obtained between test results and theoretical predictions.
3. It can be stated that under ordinary conditions the influence of shear can be neglected.

Inelastic Instability-Local Buckling (Geerhard Haaijer and Bruno Thurlimann)

The analytical work on the local (plate) buckling problem following the outline mentioned in the last quarterly report is completed. The problem has been approached by assuming orthotropic behavior of the material after it has been compressed into the strain-hardening range. Next the moduli corresponding to this type of behavior were estimated from the incremental theory of plasticity with the second invariant of the deviatoric stress tensor, J_2 , as the loading function.

The expected agreement between theoretical estimates and test results was indeed found. A final report on the findings of the local buckling investigation is pending.

Inelastic Instability-Lateral Buckling (Maxwell W. White and Bruno Thurlimann)

The results of tests completed earlier were examined further. A brief summary of these results can be seen in Table 1.

In the coming quarter attention will be primarily on analytical work leading to the solution of beams under general moment gradient and with part of the beam in the strain-hardening range.

Table I - Lateral Buckling Tests Under Constant Moment and Built-In Ends

	L1	L2	L3	L4
1. Section (a) Size	10WF29	10WF29	16WF36	10WF29
(b) b/t	11.6	11.6	16.4	11.6
(c) d/w	35.3	35.3	46.8	35.3
2. Length of test (a) Actual* Section in inches	30.5	60	32.5	96
(b) L_{cr} ex- pected from theory with $E_{st}=1000$ ksi $G_{st}=2500$ ksi	40.5	40.5	42	40.5
3. Plastic Moment predicted from coupon tests = $\sigma_y Z$. in. kips.	1130	1130	2400	1130
4. Maximum Moment reached in tests. in. kips.	{ 1072 (yield) 1536	1132	2387	1090
5. Point of Lateral Buckling $\frac{\phi_{av}}{\phi_p}$ **	>30	2.2	>15	1.35
6. Mode of Failure	Combined Local & Lateral Buckle	Lateral Buckle	Local Buckle	Lateral Buckle
7. Curvature $\frac{\phi_{av}}{\phi_p}$ at which actual ϕ_p Moment fell to 95% of plastic moment	Not determ.	14.5	12.2 (Local)	1.65

*In tests L1 and L3 an attempt was made to test the critical length. However, low values of E_{st} used in the calculations (from coupon tests) gave theoretical critical lengths too small.

**Approximate value of ϕ_{av}/ϕ_p at strain-hardening is 12.

Deflection Stability (A. T. Gozum and Bruno Thurlimann)

Further analytical work was carried out to include the influence of strain-hardening on the deflection stability ("shakedown") of a two-span continuous beam.

The results of the investigation are presented in Interim Report No. 28 "Deflection Stability ('Shakedown') of Continuous Beams" by Alfredo T. Gozum and Geerhard Haaijer, F. L. Report No. 205G.1, December 1955, completing work on this phase of the problem.

Lateral Bracing Requirements (Maxwell W. White and Bruno Thurlimann)

No further work has been done on this project during the last quarter.

In view of the proposed work and developments in Project 205E-V, it is planned that the more fundamental analytical work on lateral buckling should be completed before further work on this project is done.

Financial Statement

Cash Deficit, September 30, 1955 \$ 9,317.71

Income

A. I. S. C. (WRC)	\$ 8,000.00
A. I. S. C. (WRC)	2,500.00
U. S. Navy	<u>3,749.86</u>

Total Income 14,249.86

Net Balance \$ 4,932.15

Expenditures

Salaries and Wages	\$ 4,650.00
Overhead	1,404.91
Expenses	<u>826.42</u>

Total Expenditures \$ 6,881.33

Deficit, December 31, 1955 \$ 1,949.18

Unpaid Invoices 5,166.75

Book Balance, December 31, 1955 \$ 3,217.57

Additional Contract Funds to be Received

WRC (AISC)	\$ 8,000.00	(June)
U. S. Navy	<u>16,495.93</u>	(As Billed)
Total	\$ 24,495.93	

Research Committee A
Project No. 3.3.A

Residual Stress and Compressive Properties of Steel

Lehigh University
(July 1, 1955 - September 30, 1955)

Sponsored jointly by the Pennsylvania Department of Highways and Bureau of Public Roads, by the National Science Foundation and the Engineering Foundation (Column Research Council).

Tests Conducted and Results:

An 8WF67 and a 12WF65 column free to bend in the weak direction, were tested under axial loading. These tests have concluded the program of Part One of the general investigation. The results of the column control tests of Part One of the program are shown in the attached figure and compared with theoretical results.

Reports:

The rough draft of a paper on residual stresses scheduled for publication in the Welding Journal has been completed. A report entitled "The Magnitude and Distribution of Residual Stress" has been distributed.

Further Work:

The study on the influence of cold-bending on column strength has been studied theoretically and the first tests will be made in the coming quarter. The order for welded and riveted built-up columns is being processed. Shipment of steel for subsequent tests has been received.

Finances:

	<u>220A</u>	<u>249*</u>
Total Budget	\$ 12,000.00	\$ 6,000.00
Deficit, January 1, 1955	1,761.98	---
Expenditures	<u>5,414.05</u>	<u>25.60</u>
Balance, August 31, 1955	\$ 4,823.97	\$ 5,974.40

A. W. Huber

Lynn S. Beedle

*Built-up Columns

LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

FRITZ ENGINEERING LABORATORY
DEPARTMENT OF CIVIL ENGINEERING

File No. 220A
November 8, 1955

Dr. Bruce G. Johnston
Chairman, Research Committee A
Column Research Council
301 W. Engineering Building
University of Michigan
Ann Arbor, Michigan

Progress Report
(7/1/55 - 9/30/55)

Dear Dr. Johnston:

Attached is our progress report summarizing
the work and progress made in the last three-month period.

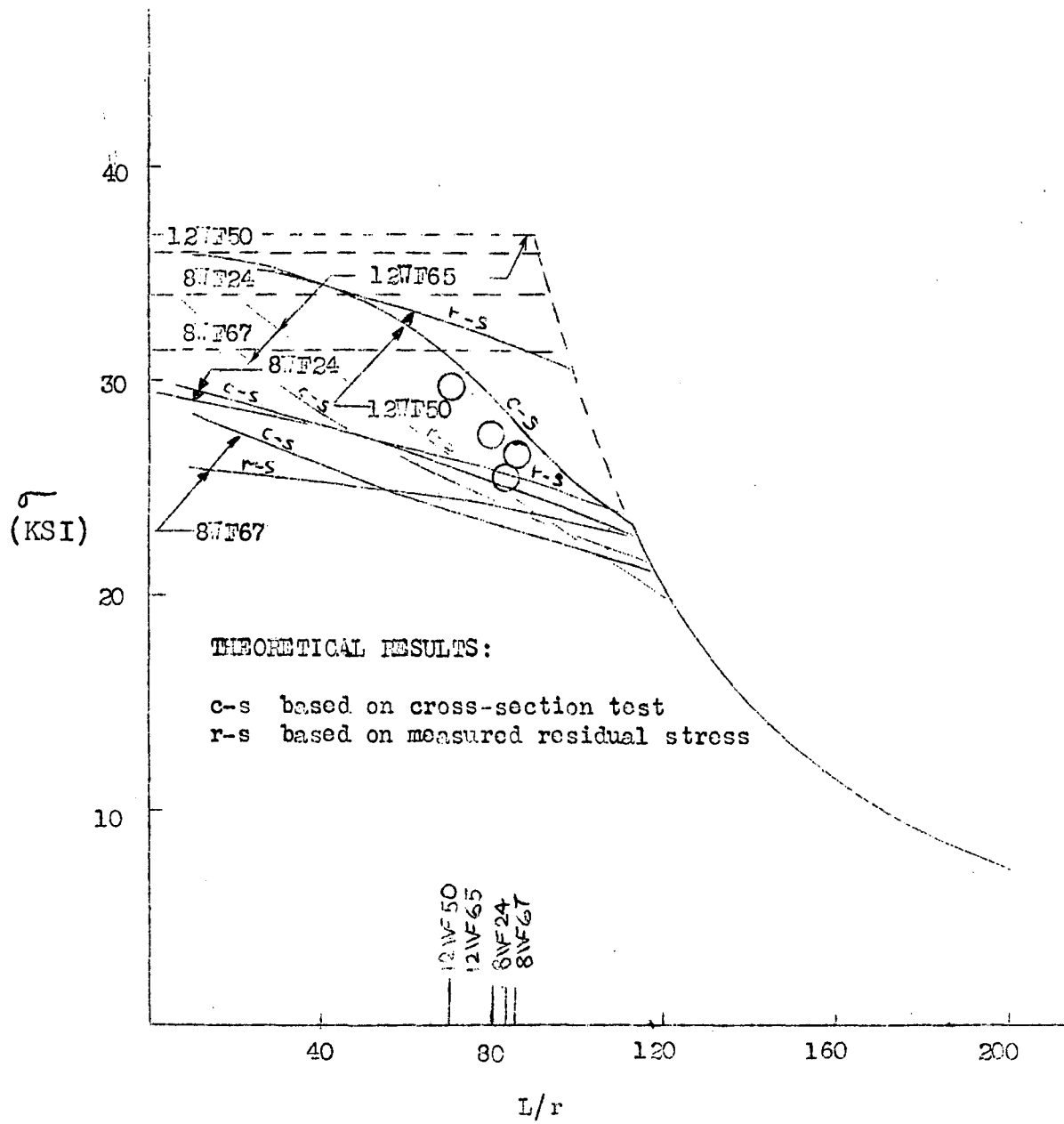
Sincerely yours,

A. W. Huber
Research Instructor

Lynn S. Beedle
Chairman
Structural Metals Division

AWH:plt
Enc.

CC: Members, Research Committee A, CRC
Members, Executive Committee, CRC
Members, Lehigh Project Subcommittee
Pennsylvania Department of Highways
Messrs.: H. G. Van Riper
A. Wiesenberger
Bureau of Public Roads, Mr. L. T. Stinson
National Science Foundation, Dr. G. H. Hickox
Mr. Shortridge Hardesty



WEAK AXIS COLUMN CURVES AND COLUMN TEST RESULTS

File No. 220A
August 10, 1955

Dr. Bruce G. Johnston
Chairman, Research Committee A
Column Research Council
301 W. Engineering Building
University of Michigan
Ann Arbor, Michigan

Progress Report
(1/1/55-6/30/55)

Dear Dr. Johnston:

Attached is our progress report summarizing the
work and progress made in the last six-month period.

Sincerely yours,

A.W. Huber
Research Instructor

L.S. Beedle
Assistant Director

AWH:bk
Enc:

CC: Members, Research Committee A, CRC
Members, Executive Committee, CRC
Members, Lehigh Project Subcommittee
Pennsylvania Department of Highways
Messrs.: H.G. Van Riper
W.H. Herman
Bureau of Public Roads, Mr. L.T. Stinson
National Science Foundation, Dr. G.H. Hickox
Mr. S. Hardesty

Research Committee A
Project No. 3.3.A

Residual Stress and Compressive Properties of Steel

Lehigh University
(January 1, 1955 to June 30, 1955)

Sponsored jointly by the Pennsylvania Department of Highways and Bureau of Public Roads, the Engineering Foundation (Column Research Council) and by the National Science Foundation.

Tests Conducted and Results:

The study of residual stress magnitude and distribution of six specimens has been concluded and a separate report has been prepared on the results. The enclosed figure was taken from that report and summarizes schematically the measured stresses. There is a large variation between individual stress patterns, but all flanges have a similar pattern, namely compression stresses at the tips (average about 12 ksi) and tension stresses in the flange center.

The special column end fixtures were delivered in May and used on the test of a 12WF50 column (one of three still to be tested in Part I of the program). At first the column was tested elastically with a 1/2" eccentricity. End rotations for loading and unloading checked the theoretical solution very closely indicating satisfactory pin-ended condition for the lower load ranges. The fixtures permitted a very good centering in the axial column test. The maximum load was about 5% below the predicted value from residual stress measurements.

The deletion of a latticed column test in the program on built-up sections was approved by Committee A.

Reports:

The technical report entitled "Material Properties, Residual Stresses, and Column Strength" was distributed in May. Another report entitled "The Magnitude and Distribution of Residual Stress" has been presented at a meeting of Research Committee A and will be distributed shortly.

A paper on residual stress is being prepared for publication in the Welding Journal.

Further Work:

The two remaining columns of Part I in the program will be tested within the next quarter. The cold bending study will follow immediately. At the same time the first test of built-up columns will be conducted.

Personnel and Finances:

Mr. Yuzuru Fujita who has been assigned as Research Assistant on the project almost a year ago is working now exclusively on the built-up column part of the program. Mr. A. Huber has resumed his duties on the project June 1, 1955. Mr. T. Kawai has been assigned to the project as half-time research assistant.

The financial statement is as follows:

Total Budget	\$12,000.00
Total Expenditures (since Jan. 1, 1955 and deficit at that date)	<u>\$ 4,423.58</u>
Balance June 30, 1955	\$ 7,576.42

The Pennsylvania Department of Highways and the Bureau of Public Roads has granted a request for an additional \$6,000.00 for the initial study of built-up members.

A.W. Huber

L.S. Beedle

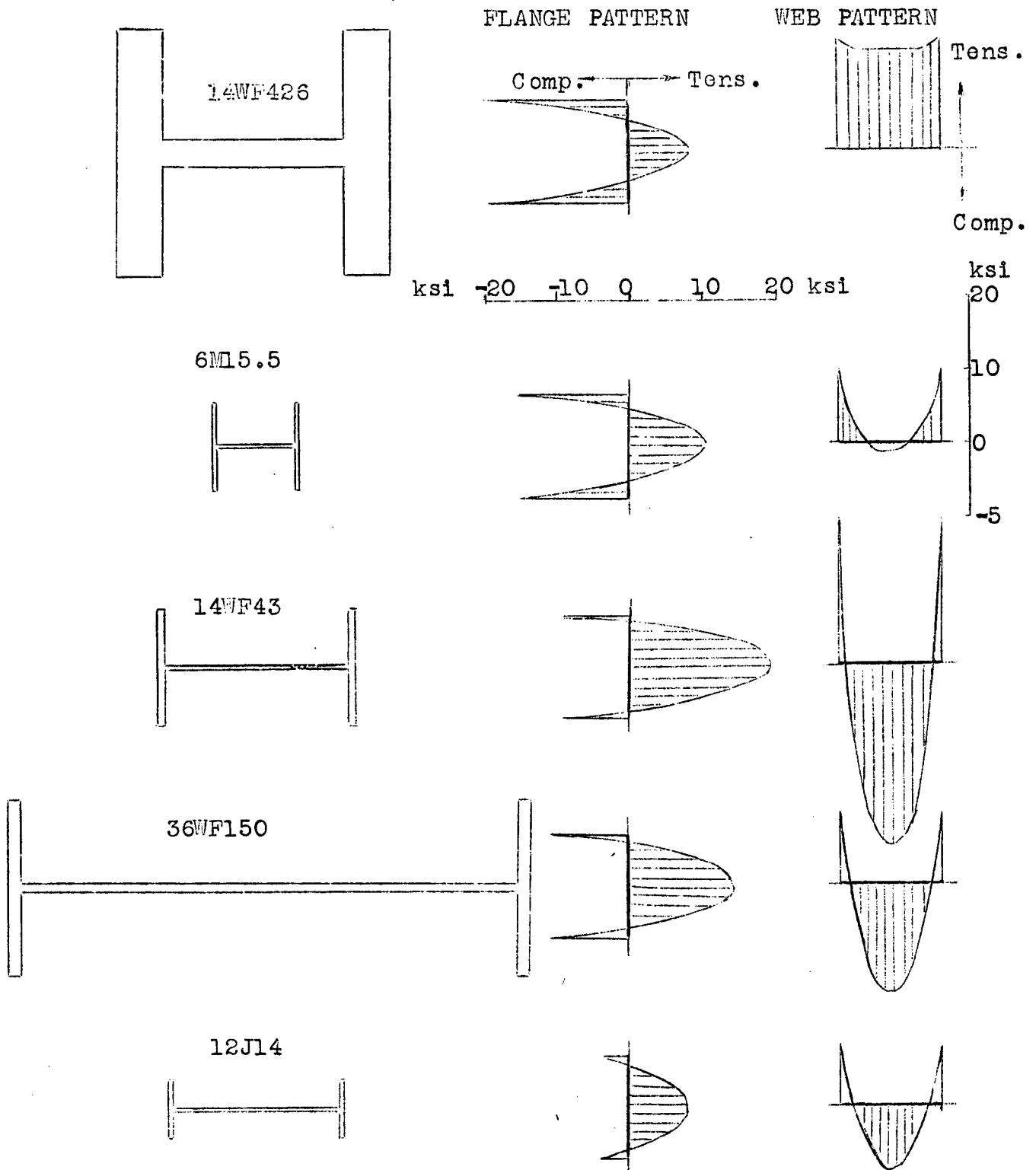


Fig. 9 RESIDUAL STRESS DISTRIBUTION
(Schematic Diagram)

LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

FRITZ ENGINEERING LABORATORY
DEPARTMENT OF
CIVIL ENGINEERING AND MECHANICS

File No. 220A
11 February 1955

Dr. Bruce G. Johnston
Chairman, Research Committee A
Column Research Council
301 W. Engineering Building
University of Michigan
Ann Arbor, Michigan

Progress Report
(7/1/54-12/31/54)

Dear Dr. Johnston:

Attached is our progress report summarizing
the work and progress made in the last six-month period.

Sincerely yours,

Lynn S. Beedle
Assistant Director

LSB:plt
Enc.

CC: Members, Research Committee A, CRC
Members, Executive Committee, CRC
Members, Lehigh Project Subcommittee
Penna. Department of Highways
Mr. H. G. Van Riper
Mr. W. H. Herman
Bureau of Public Roads, Mr. T. L. Stinson
National Science Foundation, Dr. G. H. Hickox
Mr. Shortridge Hardesty

RESEARCH COMMITTEE A: RESIDUAL STRESSES

Project No. 3.3.A

Residual Stress and Compressive Properties of Steel

Lehigh University

(July 1, 1954 to December 31, 1954)

Sponsored jointly by the Engineering Foundation (Column Research Council), Pennsylvania Department of Highways and Bureau of Public Roads, and by the National Science Foundation.

1. Tests Conducted and Results

Special column end fixtures, necessary for the testing of columns with a maximum strength greater than 360,000 pounds, are currently being fabricated and will be available within a short while. This will make it possible to complete the three column tests (8WF67, 12WF50, 12WF65) that remain in Part I of the program.

Tests have been started on Part II of the program*. These tests cover the following phases:

1. Influence of cold-straightening on column strength.
2. Variation in magnitude and distribution of residual stress for different proportions and weights of WF shapes.
3. Cross-section tests and ASTM acceptance tests.

Material has been procured from item 1 (above) and present emphasis is on item 2.

Coupons taken from the as-delivered 5WF18.5 were tested in tension. Further, the residual stress distribution has been determined and the cross-section has been tested. These tests are "control" for the study of cold-straightening.

Residual stresses were measured in two 14WF43 shapes, to follow up the recommendation made at the last committee meeting that it be determined if there is a significant influence of cooling rate in the mill. The procedure was to measure residual stresses in a piece which had gone through the normal cooling operation (close-packed with the other pieces); the other piece (from the same rolling) was coiled in a portion of the hot bed isolated from the rest of the steel.

- - - - -

* See Technical Proposal May 26, 1954, revised August 26, 1954.

The results of these residual stress measurements are shown in Fig. 1. The solid line is for a beam cooled in the ordinary manner (together with many other beams), while the dotted line is for the beam allowed to cool separately. The results suggest that position of the piece on the cooling bed is not particularly critical. Separate cooling produces somewhat higher web stresses, but does not affect the flange much -- and the flange distribution is the most critical insofar as column strength is concerned.

The compressive stresses measured in the web are the highest yet observed (30,000 psi in piece 1 and 42,000 psi in piece 2). The latter probably approached the yield stress level.

Residual stress measurements have also been completed on the 6WF15.5 shape. The study thus far is confirming the findings of the Pilot Investigation.

Some additional attention has been given to the influence of strain rate on the yield stress level. In the Final Report on the Pilot Program(1) it was possible to explain most of the difference between the strength of cross-sections tested in the laboratory and the yield stress of acceptance-type tension coupons -- except for about 5%. A controlled series of tests were started (at no cost to the project). These tests are not yet completed, but the results to date confirm the findings reported in the last progress report (July, 1954). The difference of yield level between weighted average laboratory coupons and cross-section tests is a function of testing machine strain rate rather than a size and shape effect.

Reports

The Final Report (Pilot Program) has been published in the Welding Journal(1) and copies have been distributed to committee members.

A further technical report summarizing findings on Part I and on the strain rate study is nearing completion.

Further Work

Preparations have been made to measure the residual stresses in the remaining sections which were selected for that purpose (14WF426, 12B14, 36WF150). The "cold bending" study will follow.

Personnel and Finances

Mr. A.T. Gozum, Research Assistant on the project since February, 1954, completed his studies at Lehigh in September. Mr. Yuzuru Fujita has been assigned as Research Assistant on the

- - - - -
(1) Huber and Beedle, "RESIDUAL STRESS AND THE COMPRESSIVE STRENGTH OF STEEL", Welding Journal, 33(12), Dec. 1954, p. 589-s.

project. Mr. Alfons Huber, Research Instructor, has returned to his home in Austria for a few months, and will return by April.

The financial statement is as follows:

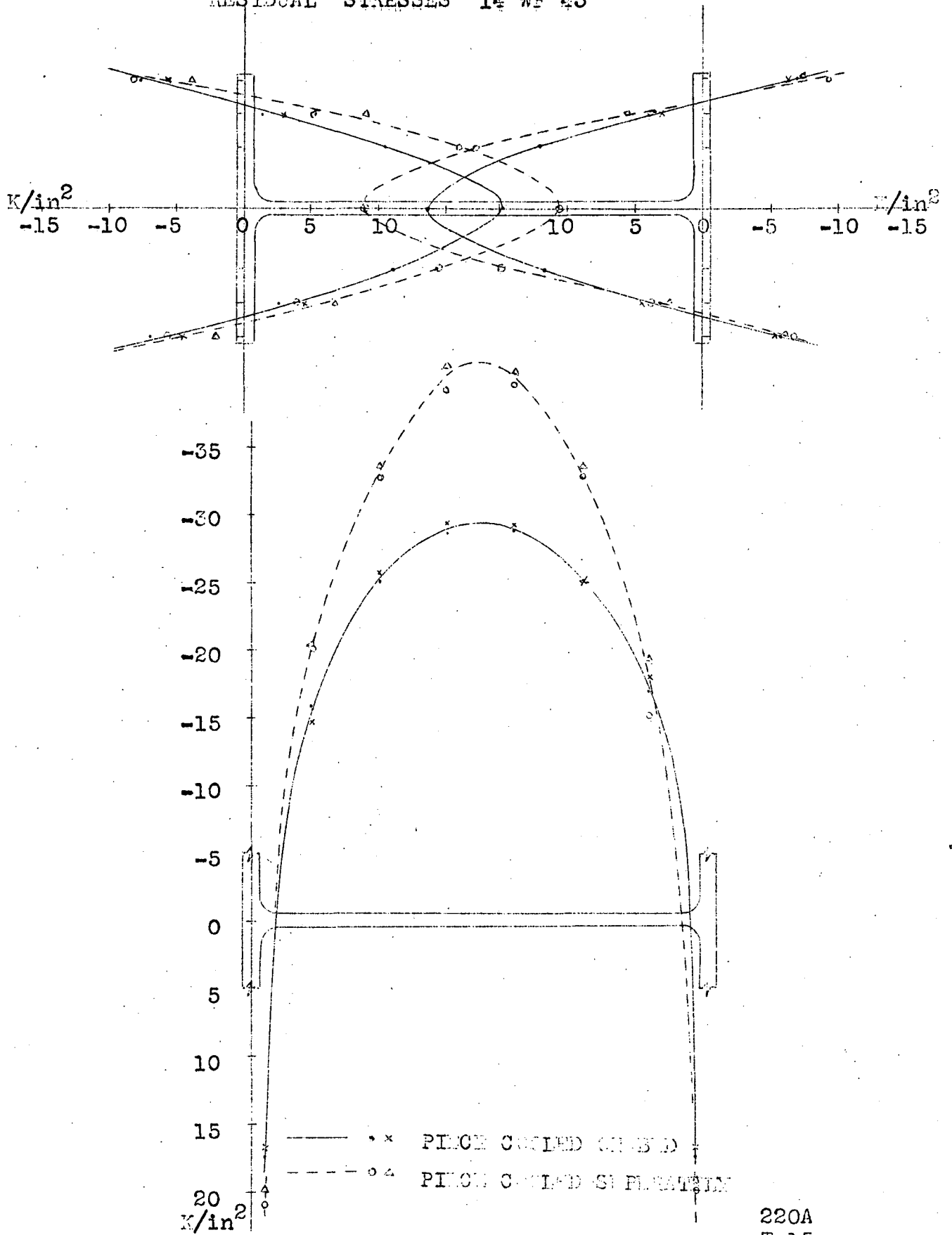
Total Budget	\$ 12,000.00
Total Expenditures (since September 1953)	<u>13,761.98</u>
Balance, Dec. 31, 1954	\$ -1761.98

A request has been submitted for an additional \$6000.00 to cover the initial study of built-up members and members of low-alloy steel. This program was approved at the annual meeting of the C.R.C.

s/Lynn S. Beedle

Enc: Residual Stresses of 14WF143

RESIDUAL STRESSES 14 WF 43



220A
T-15

File No. 220A
22 July 1954

Dr. Bruce G. Johnston
Chairman, Committee A
Column Research Council
301 W. Engineering Bldg.
University of Michigan
Ann Arbor, Michigan

Quarterly Report
(4/1/54-6/30/54)

Dear Dr. Johnston:

Attached is our quarterly report summarizing
the work and progress made in the last three-month period.

Sincerely yours,

Lynn S. Beedle
Assistant Director

Enc.
LSB:plt

CC: Members, Committee A, CRC
Members, Executive Committee, CRC
Pennsylvania Department of Highways
Messrs.: H. G. Van Riper
W. H. Herman
Bureau of Public Roads, Mr. T.L. Stinson
National Science Foundation, Mr. R.A. Morgen
Mr. Shortridge Hardesty
Mr. F. M. Masters
Mr. E. L. Erickson

Quarterly Report
(4/1/54 - 6/30/54)

Research Committee A: Residual Stress and
Compressive Strength of Steel
(Project No. 3.3.A)

Sponsored jointly by the Engineering Foundation (Column Research Council), Pennsylvania Department of Highways and Bureau of Public Roads, and by the National Science Foundation.

1. General:

The investigators met with Committee A of the Column Research Council on May 27, 1954. The future test program was discussed in detail and approved. An order for part of the required material has been placed.

Column end fixtures with a capacity of 2×10^6 # were designed in order to test the heavier columns under pin-ended condition.

2. Tests Conducted:

Tests on part I (8WF24, 8WF67, 12WF50, 12WF65) have been completed with exception of the column tests of the three heavier shapes and a few compression coupons. An additional 8WF24 cross-section test was performed in a hydraulic machine to study the problem of differences in yield stress level between coupons and cross-sections.

3. Results:

There is indication that the difference of the yield stress level between coupons and cross-section tests is a function of testing machine strain rate rather than size and shape affect. Curves will be shown in a later report.

The enclosed figures show results for strong and weak axis tests of three cross-section specimens and the axial column test for the weak axis of the 8WF24 shape.* The enclosed table compares the yield stress as determined by different types of tests.

4. Financial Statement:

Total Budget	\$12,000.00
Total Expenditures (since Sept. 1953)	8,504.87
Balance May 31, 1954	\$ 3,495.13

* The dashed curves are the parabolic and straight-line approximations based on average values.

COMPARISON OF YIELD STRESSES

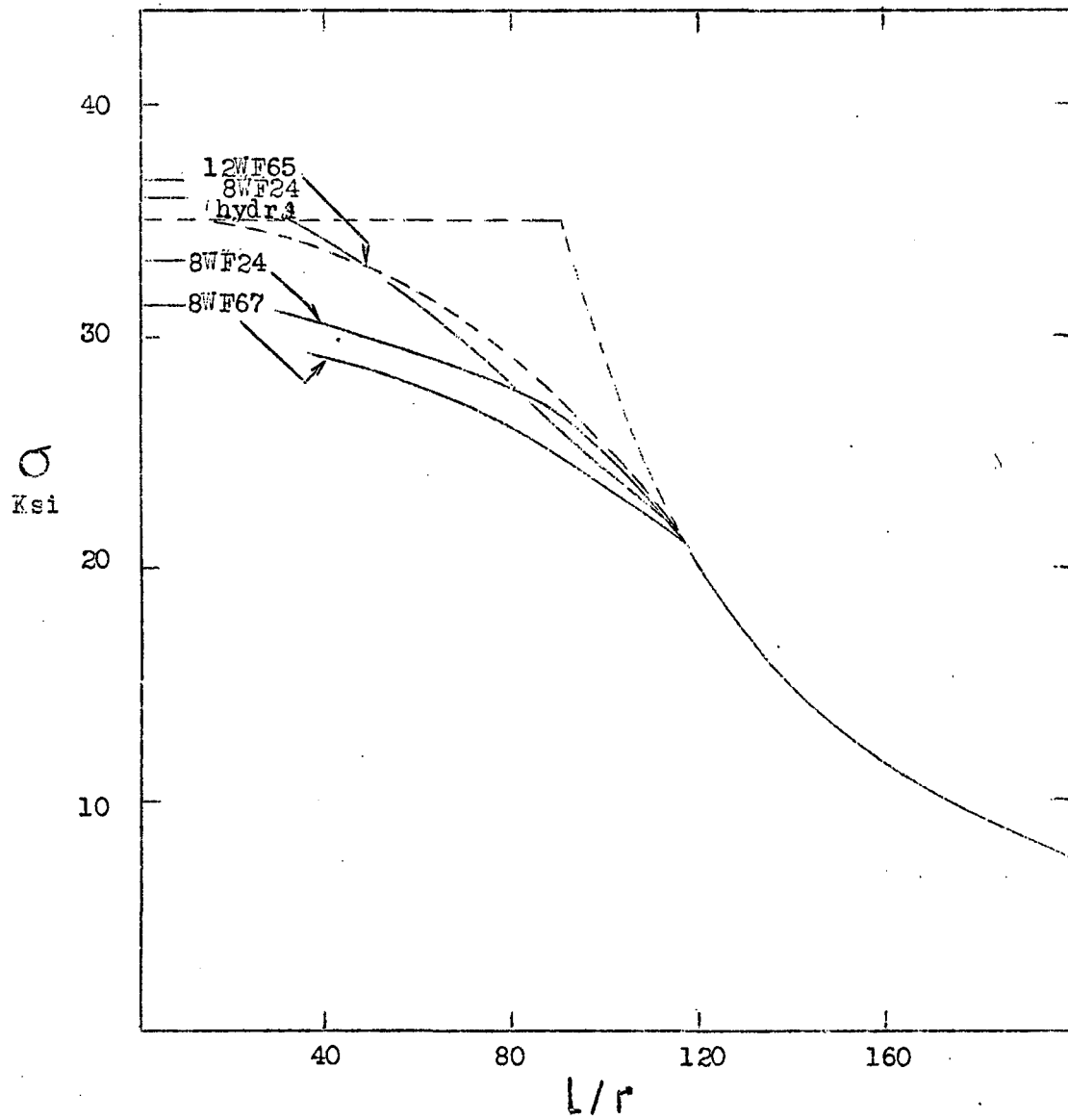
Shape	M Mill Test	SM Simulated* Mill Test	$\frac{M}{SM}$	C Web Tension** Coupon	$\frac{C}{SM}$	C-S Cross-Section Test	$\frac{C-S}{SM}$
8WF24	39.84	40.75	.978	36.75	.902	34.30	.841
8WF67	43.02	37.50	1.146	35.60	.950	31.40	.837
12WF50	42.61	41.30	1.032	38.40	.930	36.20	.876
12WF65	39.73	42.40	.937	39.90	.942	36.60	.864
8WF31	43.30	-		38.90		37.00	
Average	41.70	40.49		37.91		35.12	

* Rate of strain same as tested in the mill approx.
40 micro in/in sec.

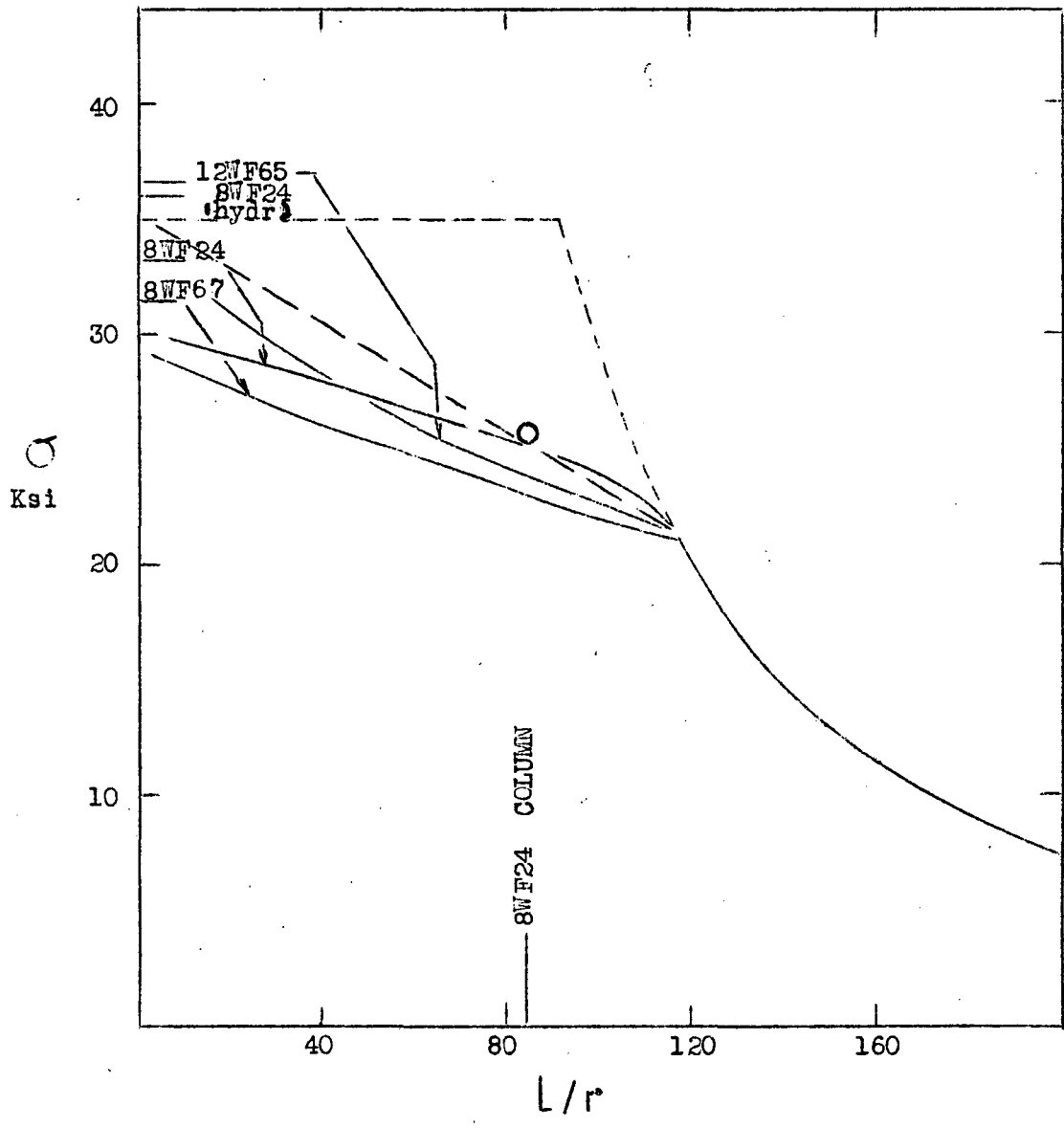
** Laboratory rate of strain approx. 1 micro in/in sec.

Alfons Huber

Lynn S. Beedle



CROSS-SECTION COLUMN CURVES - STRONG AXIS



CROSS-SECTION COLUMN CURVES - WEAK AXIS

LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

FRITZ ENGINEERING LABORATORY
DEPARTMENT OF
CIVIL ENGINEERING AND MECHANICS

File No. 220A

21 April 1954

Dr. Bruce G. Johnston
Chairman, Committee A
Column Research Council
301 W. Engineering Bldg.
University of Michigan
Ann Arbor, Michigan

Quarterly Report
(1/1/54 - 3/31/54)

Dear Dr. Johnston:

Attached is our quarterly report summarizing the
work and progress made in the last three-month period.

Sincerely yours,

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Lynn S. Beedle
Assistant Director

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Pennsylvania Department of Highways
Messrs.: H. G. Van Riper
W. H. Herman
Bureau of Public Roads, Mr. T.L. Stinson
National Science Foundation, Mr. R.A. Morgen
Mr. Shortridge Hardesty
Mr. F. M. Masters
Mr. E. L. Erickson

RESEARCH COMMITTEE A: RESIDUAL STRESSESProject No. 3.3.A

Lehigh University

March 31, 1954

1. General

The Pilot Investigation (Project No. 3.1.A) was completed towards the end of last year. The final report was distributed and approved for publication. It will be published in the Research Supplement of the Welding Journal in the near future.

Work on the General Investigation continued. The first part of the program includes a study of four wide-flange shapes (8WF24, 8WF67, 12WF50, 12WF60). The following series of tests are being made on all shapes: coupon tests, residual stress measurements, cross-section and axial column tests.

The investigators met with Committee A of the Column Research Council on March 30th, 1954. The final report and the program of the General Investigation were discussed.

2. Tests Conducted

Tests have been completed on the 8WF24 series during the quarter with exception of the column test. Coupon tests and residual stress measurements have been started on the remaining sections.

3. Results

The results will be described in the next report together with the 8WF24 column test result. Generally the trends are the same as observed in the Pilot Program.

4. Funds

For the first year \$12,000 have been made available by the joint sponsors (Column Research Council, Pennsylvania Department of Highways and Bureau of Public Roads, and National Science Foundation).

The financial statement is as follows:

Total Budget	\$12,000.00	
Salaries and Wages		\$ 2,373.36
Overhead		775.18
Expenses		<u>418.03</u>
Total Expenditures (since Sept.1953)		\$ 3,566.57
Balance	\$ 8,433.43	

s/Alfons W. Huber

s/Lynn S. Beedle

LEHIGH UNIVERSITY
DEPARTMENT OF CIVIL ENGINEERING AND MECHANICS
BETHLEHEM, PA.

ADDRESS REPLY TO:
FRITZ ENGINEERING LABORATORY

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

30 October 1953

File No. 220A

Members, Research Committee A, CRC
Members, Executive Committee, CRC
Messrs. W. H. Herman, H. G. Van Riper,
L. A. Porter and T. L. Stinson
of Pennsylvania State Highway
Department and Bureau of
Public Roads.

Re: Quarterly Report

Gentlemen:

Attached is our quarterly report submitted for your
information.

Sincerely yours,

Lynn S. Beedle
Assistant Director

LSB:plt
CC: Mr. Shortridge Hardesty
Mr. F. M. Masters
Mr. C. H. Yang
Mr. K. de Vries
Enc.

Quarterly Report

Residual Stresses in Columns

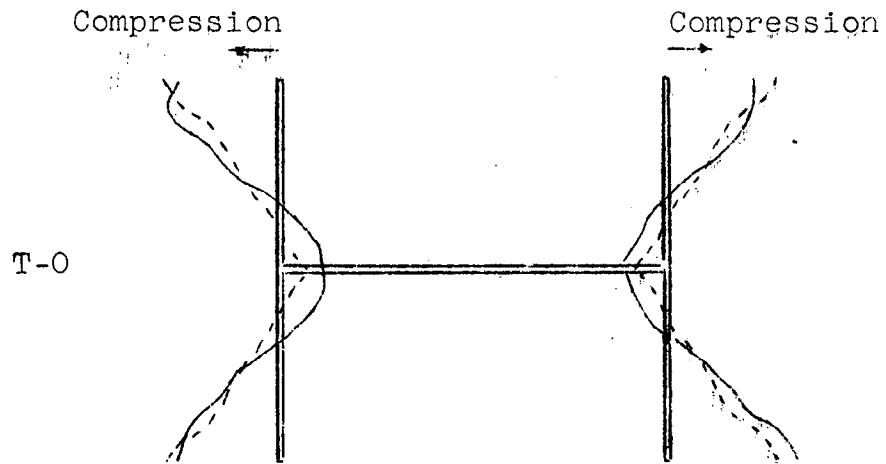
C.R.C. Project No. 3.3.A
Lehigh University
October 1953

A draft of the final report on the Pilot Investigation has been rewritten. It is anticipated that the report will be ready for distribution early next month.

An interesting relationship has been observed recently which enables one to calculate the residual stress distribution in the flanges from the stress-strain curves of cross-section tests. The enclosed figure compares the measured residual stresses (solid lines) with the calculated stresses (dashed lines). Some of the irregularities in the calculated stress distribution are due to the errors involved in determining the tangent modulus which is required for the analysis.

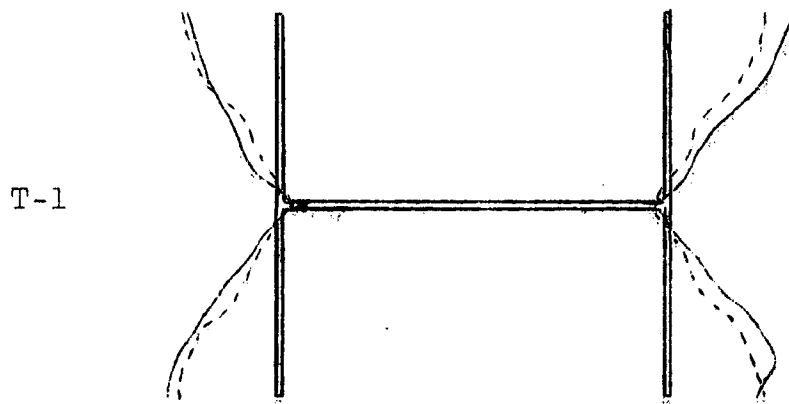
A. W. Huber
Research Instructor

Lynn S. Beedle
Assistant Director



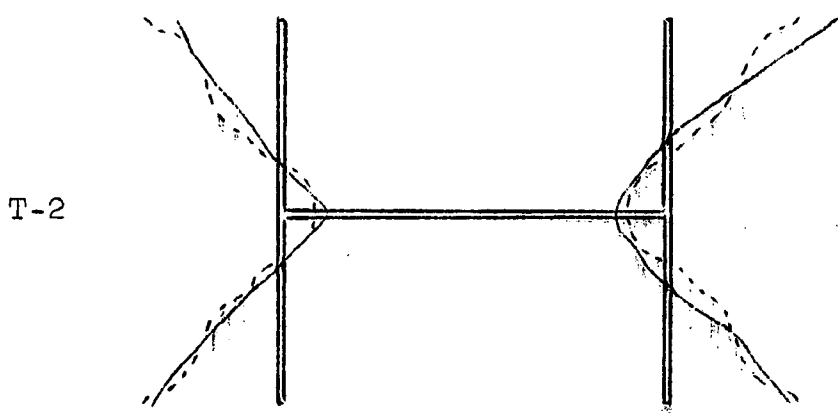
10 Ksi

10 Ksi



10 Ksi

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— Measured Residual Stresses
 - - - - - Computed from cross-section Tests

COMPARISON OF MEASURED RESIDUAL STRESSES WITH STRESSES COMPUTED FROM CROSS-SECTION TESTS