

1940

# Memorandum to members of the ASCE subcommittee, 1940

B. G. Johnston

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MEMORANDUM TO MEMBERS OF THE A.S.C.E. SUB-COMMITTEE ON  
"DESIGN STRESSES IN RELATION TO ULTIMATE STRENGTH,  
YIELD POINT STRENGTH AND RELATED PHYSICAL PROPERTIES OF METALS"

by Johnston

1940

The following memorandum outlines the present status of the research work at the Fritz Laboratory related to the work of this sub-committee. This memorandum is being distributed to members of the sub-committee and to others who through their interest in this work may desire to attend the meeting of this sub-committee, scheduled for 10:00 A.M. Thursday, January 18, 1940, in Room 1105 of the Engineering Societies Building. As an outline for discussion the following is proposed.

- (1) Review of purposes and progress of the research work now going forward.
- (2) Discussion of the revised program of tests which is attached to this memorandum.
- (3) Suggestions for other tests simulating structural behavior.

Review of Proposed Research Work at Fritz Laboratory.

During the winter of 1938 a Fritz Engineering Research project was proposed with the purpose of correlating the physical properties of structural metals as determined by standard tension, torsion, and compression tests with their behavior in structural models involving various types of localized, variable, and multi-axial stress distributions. Mr. Leon S. Moisseiff had proposed tests along the same line and it also became apparent that this Sub-Committee had similar aims. It was therefore proposed that the research work be done in cooperation with the Sub-Committee.

During the summer of 1939 a tentative program of tests was distributed to the members of the sub-committee and to several others. Letters of comment and criticism were received from the following: R. Templin\*, A. Nadai, Wilbur Wilson (and associates), Paul Ffield, F. B. Seely, Jonathan Jones, E. F. Kenney\*, R. E. Davis, and Inge Lyse\*.

Many helpful suggestions were received regarding the details of the tests proposed in the tentative program. These suggestions have been studied carefully and a revised program is attached to this memorandum. The writer wishes to express his sincere appreciation to those who volunteered their advice in this work.

Although most of the reviewers of this tentative program expressed the belief that the tests would be of value there were a number who questioned their relation to the actual behavior of structures. It is probable that the intended scope of the program was not outlined with enough clarity in the tentative program. The proposed tests will naturally reveal nothing regarding such important structural problems as the buckling strength of columns, the fatigue strength of structural units, or the general structural behavior of a bridge, building, or built-up structural units of any kind. The final specification of unit stresses for any particular type of structural use may require a special series of tests as well as the consideration of a group of engineers familiar with the particular field of design.

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\* Members of the Sub-Committee.

Rather than attempt to solve any new structural problems the proposed research will attack the fundamental question of design stresses only insofar as the choice is affected by the physical properties of materials. One of the motivating factors behind the formation of this sub-committee was the limitation in the A.R.E.A. Bridge Design Specifications that the yield point of alloy steels be limited to not more than seventy per cent of the ultimate strength. The study of the relations between yield point, ultimate strength, and ductility as revealed in a simple tension test are an important part of the work.

In an actual structure the stresses are no longer uniaxial as in a tension test, but exist in any direction or combination and to a more or less rapidly varying degree, depending on shape and load characteristics. The possible importance of combined stresses has been emphasized by the recent brittle failure of a steel Viereendeel bridge in Belgium. Combined stresses may or may not have been the cause of the brittle type of fracture which was noted in the plates of this structure, but the facts remain that simple tension tests of the same material showed good ductility, and that it is possible to get brittle type fractures under states of combined stress acting on a material which shows ductility in a simple tension test. Another type of brittle fracture in steel is familiar to steel mill operators who have experienced the brittle shattering of heavy rolls or thick plates. Zones of tri-axial tension stress set up by cooling are probably a factor in producing such failures.

It is possible in small models to obtain conditions of combined stress and varying stress similar to those obtaining in various parts of actual structures. Such model tests give no information regarding general structural behavior or structural theory but they may yield information as to the relation between the physical properties of the material and the behavior of the material under states of stress similar to those obtaining in structures. The results of the investigation may show that certain tests other than the simple tension test reveal properties of materials which are important in considering them for structural use.

The following progress has already been made in this investigation:

1. Survey of literature and previous tests related to this investigation. This survey has been in progress for some time. It would be appreciated if members of this sub-committee would send in any references available to the chairman.

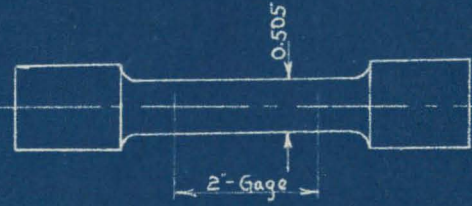
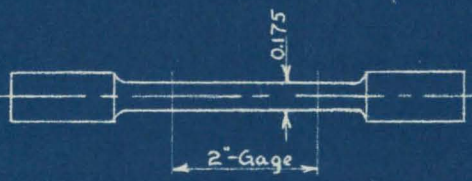
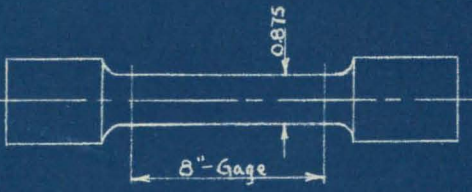

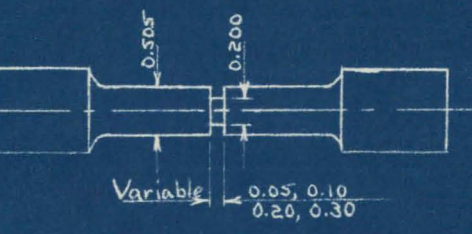
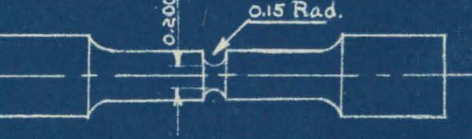

2. Tension tests are now in progress on a number of different alloys. Automatic load deformation curves are being recorded graphically on these specimens, with high-magnification up to a completely plastic stage and low-magnification from initial load to final failure. The load-deformation recording gives the modulus of elasticity, upper and lower yield points, and ultimate strength. These preliminary tension tests will be used as a basis for selecting between five and ten typical materials having well-defined differences in physical properties. These selected materials will be used in the following program of tests which is a revision of the program previously distributed.



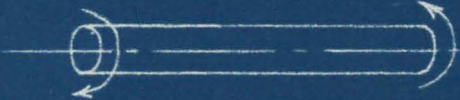
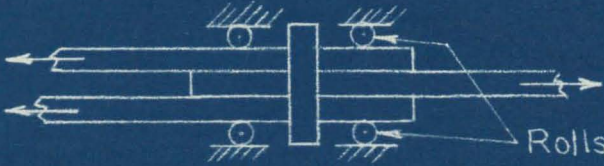

The following is a limited reading list related to the subject under consideration:

1. Notes on The Tensile Test,  
by E.C.Bain, in mimeographed form.
2. Strength of Machine Elements as Dependent  
on Their Shape, by A. Thum and W. Gautz,  
Stahl und Eisen, September 26, 1935,  
translation to English by General Electric Co.
3. Mechanical Testing and Applicability of Materials,  
by Wilhelm Kuntze, January 1939, Archiv fur  
das Eisenhüttenwesen,  
translation to English by Welding Research Comm.
4. Strength Under Tri-Axial Systems of Stress,  
by W. Kuntze, November 1937, Stahlbau,  
translation to English by Welding Research Comm.
5. The Structural Significance of Stress,  
by Bruce Johnston,  
Civil Engineering, May 1939
6. The Symposium on Structural Applications  
of Steel and Light Weight Alloys,  
Transactions, A.S.C.E. 1937
7. Some Observations on the Yield Point of  
Low Carbon Steel  
by Joseph Winlock and Ralph W. E. Leiter  
A.S.M.E. Transactions, October 1939

# REVISED TEST PROGRAM

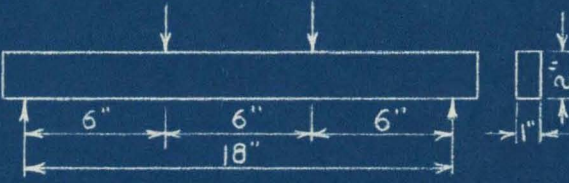
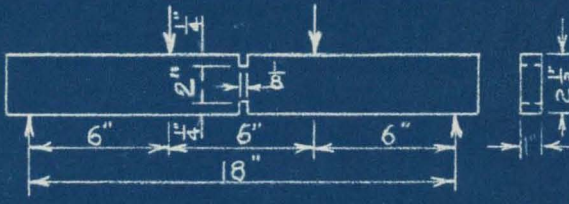

## I-Tension and Compression Tests

<p>(a)</p>	 <p>Standard size for autographic recording-high magnification</p>	<p>Tension test on round bar to determine yield point, ultimate strength, per cent area reduction, per cent elongation, and modulus of elasticity.</p>
<p>(b)</p>	 <p>Small size for autographic recording-low magnification</p>	<p>Tension test on round bar to determine yield point, ultimate strength, per cent area reduction, per cent elongation,</p>
<p>(c)</p>		<p>Tension test on round bar to determine modulus of elasticity, proportional limit, and Poisson's Ratio.</p>
<p>(d)</p>		<p>Tension test on round bar with threaded surface.</p>
<p>(e)</p>		<p>Tension test on round bar with groove to determine effect of stress concentration. Four tests with variable groove width.</p>
<p>(f)</p>		<p>Tension test on round bar with circular groove.</p>
<p>(g)</p>		<p>Alternate tension and compression beyond yield point to study Bauschinger effect.</p>

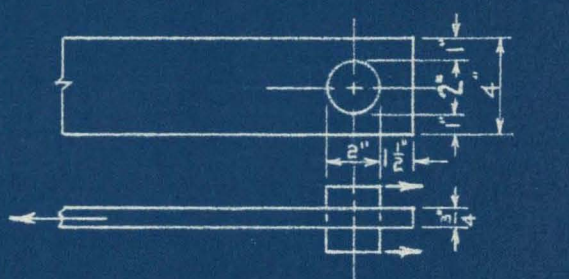
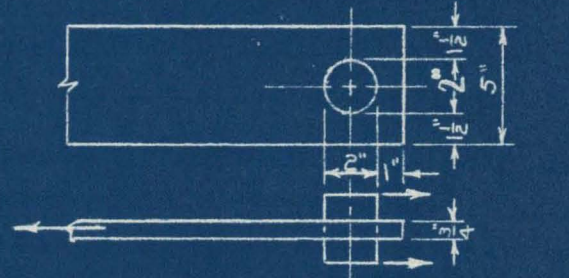
h		Standard compression test of a round bar.
i		Behavior of an elementary column using $\frac{l}{r} = 40, 70,$ and $100.$
<h2>II Torsion and Shear Tests</h2>		
a		Round bar torsion test to determine stress-strain properties in shear.
b		Shear test of round stock. Rolls to prevent spreading
c		Shear test with stress-concentration and variable stress distribution.

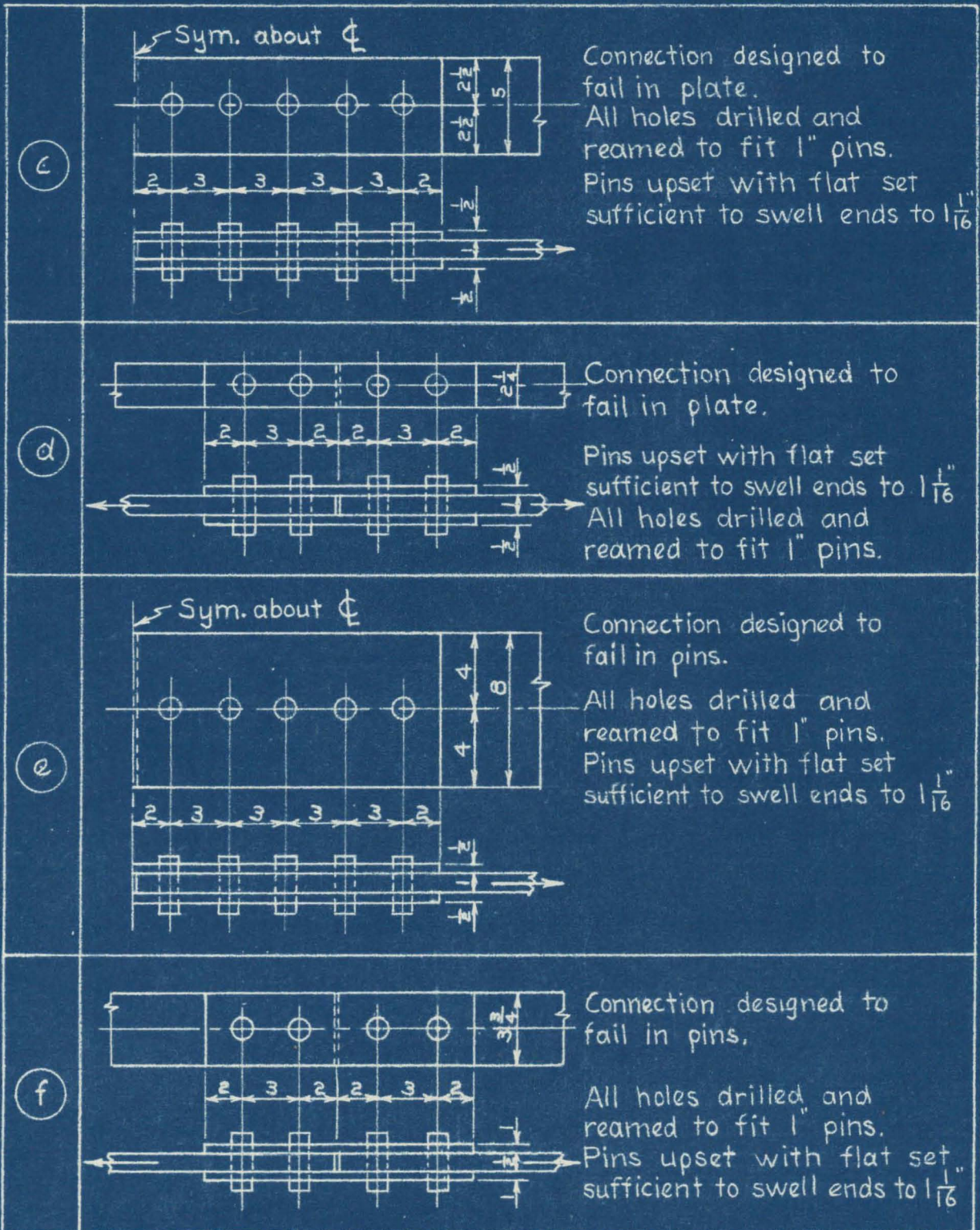


### III Bending Tests

(a)		Third point load, rectangular cross section.
(b)		Third point load, rectangular cross section, with stress raiser.
(c)		Cold bend test of flat piece for ductility.

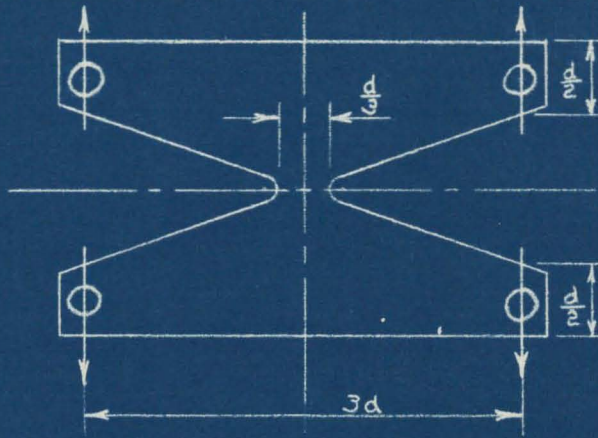
### IV-Connection Tests

(a)		Pin-connected plate designed to fail in net section across pin-hole.
(b)		Pin-connected plate designed to fail by tearing behind pin-hole.



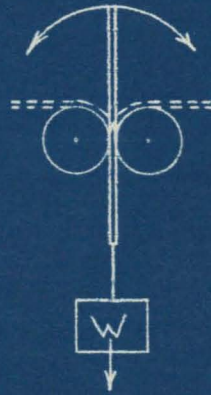
# V-Special Tests

(a)



Combined bending and tension test involving stress-concentrations, local constrictions, and bi-axial tension.

(b)



Special test to determine cold working and toughness