BOLTED HIGH STRENGTH-STEEL JOINTS

SUMMARY REPORT TO COMMITTEE 10+23
OF THE RESEARCH COUNCIL ON
RIVETED AND BOLTED
STRUCTURAL JOINTS

by

Project Staff
(Not for publication)

This work has been carried out as part of the Bolted-High Strength Steel Joints Project sponsored financially by the Pennsylvania Department of Highways, the Department of Commerce - Bureau of Public Roads, and the American Institute of Steel Construction. Technical guidance is provided by the Research Council on Riveted and Bolted Structural Joints.

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September, 1965

Fritz Engineering Laboratory Report No. 317,1
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# BOLTED HIGH STRENGTH STEEL JOINTS, PROJECT 288
## Lehigh University Status of Various Phases

<table>
<thead>
<tr>
<th>Phase and Topic</th>
<th>Remarks</th>
<th>Tests Performed</th>
<th>Tests to Be Completed</th>
<th>Analytical Work</th>
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</thead>
<tbody>
<tr>
<td>I. Compact Joints of <strong>A440 Steel and A325 Bolts</strong>, E Series</td>
<td>Authorization: Committee 10 Minutes 4/19/60 Completed</td>
<td>6 Joints E41a, E41b E41c, E41e E41f, E41g</td>
<td>None</td>
<td></td>
<td>288.4 (IABSE) 288.7 288.7A 288.10 288.17 288.31</td>
</tr>
<tr>
<td>III. Inspection of <strong>Bolts</strong> Tightened by the turn-of-nut method E Series</td>
<td>Authorization: Committee 9 Minutes 1/30/60 Committee 10 Minutes 1/30/62 Dormant</td>
<td>Torque Measurements with a hand torque wrench on bolts of phase II</td>
<td>Tests to determine the &quot;breakway&quot; and kinetic torque</td>
<td></td>
<td>288.1 288.2</td>
</tr>
<tr>
<td>IV. (a) Calibration of <strong>A325 Bolts</strong> E and F Series</td>
<td>Authorization: Committee 10 Minutes 1/30/62 Committee 10 Minutes 11/7/62 Completed</td>
<td>Direct and Torqued Tension tests of 170-A325 bolts</td>
<td>None</td>
<td></td>
<td>271.21 (ASCE) 288.5 (ASCE)</td>
</tr>
<tr>
<td>Phase and Topic</td>
<td>Remarks</td>
<td>Tests Performed</td>
<td>Tests to Be completed</td>
<td>Analytical Work</td>
<td>Reports</td>
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<tr>
<td>IV. (b) Calibration of A354 and A490 Bolts J&amp;K Series</td>
<td>Authorization: Committee 10 Minutes 1/30/62 11/7/62 Completed</td>
<td>Direct and Torqued Tension tests of 7/8&quot; and 1&quot; dia. bolts</td>
<td>None</td>
<td></td>
<td>288.9 288.11 288.19</td>
</tr>
<tr>
<td>VI. Joints of Constructional Alloy Steel Connected with A325 Bolts F Series</td>
<td>Authorization: Committee 10 Minutes 11/7/62 Active</td>
<td>Pilot Studies 5 Joints F42a, F42b, F42c, F42d, F42f</td>
<td>See Proj. 317 Prediction of the behavior of T1 plates with holes</td>
<td>None</td>
<td>288.13 288.13A</td>
</tr>
<tr>
<td>VII. Joints of Constructional Alloy Steel Connected With A490 Bolts J Series</td>
<td>Authorization: Committee 10 Minutes 11/7/62 Active</td>
<td>4 Joints J42a, J42b, J42c, J42d</td>
<td>See Proj. 317 Prediction of the behavior of T1 plates with holes</td>
<td></td>
<td>288.13 288.13A</td>
</tr>
<tr>
<td>VIII. Joints of A440 Steel Connected With A490 Bolts K Series</td>
<td>Authorization: Committee 10 Minutes 11/7/63 Active</td>
<td>K42a, K42b, K42c, K42d</td>
<td>Long joints specified in proposal to Committee 10, September 28, 1964 Computer analysis of the effect of pitch, joint length and $A/A_s$ on joint strength. Based on method given in 288.10. This is now in progress</td>
<td></td>
<td>288.7A 288.13 288.13A 288.30 288.31</td>
</tr>
<tr>
<td>Phase and Topic</td>
<td>Remarks</td>
<td>Tests Performed</td>
<td>Tests to Be Completed</td>
<td>Analytical Work</td>
<td>Reports</td>
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<tr>
<td>IX. Co-operative Study with the University of Illinois Calibration of A490 Bolts</td>
<td>Authorization: Committee 15 Minutes: 2/14/63 Completed</td>
<td>50 tests of 7/8&quot; x 5-1/2&quot; and 7/8&quot; x 9-1/2&quot; A490 bolts, in direct and torqued tension</td>
<td>None</td>
<td></td>
<td>288.14 288.15 288.23</td>
</tr>
<tr>
<td>X. Joints of A440 Steel Connected With High-Strength Rivets H Series</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Completed</td>
<td>3 Shear tests of Rivets in A440 Steel</td>
<td>None</td>
<td>Computer analysis of the effect of pitch, joint length, and $A_s/A_n$. Comparisons to be made to the behavior of A440 steel fastened with high strength bolts</td>
<td>288.27 288.30</td>
</tr>
</tbody>
</table>
Project 288
Summary of Reports - To September 1965

Fritz Lab Report

*288.1 Project Staff
"Summary Report to Committees 9 and 10"
January, 1962

+288.2 Project Staff
"Summary Report for RCRBSJ"
March 1962

288.3 Project Staff
"Large Bolted Joints Project 288-Manual"
(Contains the "File system, Summary and Phases,
Test Preparation and Procedure, Standard Data
Forms and Standard Project Forms" of Project 288.

#288.4 J. W. Fisher, P. O. Ramseier, L. S. Beedle
"Static tension tests of A440 Steel Joints Connected
With A325 Bolts"
(Reports on results of six pilot tests, five long
joint tests and three wide joint tests fabricated
at a tension shear ratio of 1/1.0. Published,
Publications, IABSE, Vol. 23, 1963 Fritz Lab
Reprint No. 245).

#288.5 J. L. Rumpf, J. W. Fisher
"Calibration and installation of A325 Bolts"
(Revision of Report 271.11 plus additional studies
on the heavy head A325 in conjunction with the
tests of large joints. Published, Journal of the
Structural Division, ASCD, Vol. 89, St. 6, 1963.
Fritz Lab Reprint No. 232).

*288.6 Project Staff
"Summary Report to Committees 9 and 10"
November 1962.

*288.7 J. W. Fisher, L. S. Beedle
"Criteria for Designing Bolted Joints (Bearing Type)"
February 1963.
J. W. Fisher, L. S. Beedle
"Criteria for Designing Bolted Joints (Bearing Type)"
July 1964
(Published, Journal of the Structural Division,
ASCE, Vol. 91, St. 5, 1965).

Project Staff
"Summary Report for RCRBSJ"
March, 1963

R. J. Christopher, J. W. Fisher
"Calibration of A354 Bolts"
March, 1963 (Preliminary Report)

J. W. Fisher
"The Analysis of Bolted Place Splices"
Ph.D. Dissertation, Lehigh University, 1964

R. J. Christopher
"Calibration of Alloy Steel Bolts"
Master of Science Thesis, June, 1964

J. J. Wallaert,
"The Shear Strength of A325 and Alloy Steel Structural
Bolts"
Master of Science Thesis, June, 1964

J. J. Wallaert, G. H. Sterling, J. W. Fisher
"The History of Internal Tension in Bolts Connecting
Large Joints"
December, 1964
(This report, which was distributed in February,
presents the results of measurements of changes in
b Bolt tension during tests of large joints.)

J. J. Wallaert, G. H. Sterling, J. W. Fisher
"What happens to Bolt Tension in Large Joints?"
May, 1965
(This report was submitted for publication in the
magazine of the Industrial Fasteners Institute.)

Project Staff
"Summary Report to Committee 10 of RCRBSJ"
December, 1963

G. H. Sterling, J. W. Fisher
"Test of A490 Bolts"
February, 1964 (Preliminary Report)

Project Staff
"Summary Report to RCRBSJ"
March, 1964
J. W. Fisher, J. L. Rumpf
"The Analysis of Bolted Butt Joints"
September, 1964
(Published, Journal of the Structural Division, ASCE, Vol. 91, No. St.5, 1965.)

J. W. Fisher
"On the Behavior of Fasteners and Plates with Holes"
December, 1964
(This report presents the development of the mathematics models used to predict the behavior of plates and bolts throughout the elastic and inelastic ranges. The report has been accepted for publication by the ASCE.)

R. J. Christopher, J. W. Fisher
"Calibration of Alloy Steel Bolts"
September, 1964

R. J. Christopher, G. L. Kulak, J. W. Fisher
"Calibration of Alloy Steel Bolts"
July, 1965
(This report is a revision of 288.19. The report will be distributed to members of committee 10 for their approval.)

J. J. Wallaert, J. W. Fisher
"The Shear Strength of High-Strength Bolts"
July, 1964
(This report was published by the ASCE in the Journal of the Structural Division, Vol. 91, No. St.3, June, 1965)

R. J. Christopher, J. J. Wallaert
"Project Summary Report"
June, 1964
(This report gives the location of various material, status of various phases, etc. It is intended only for internal use.)

J. W. Fisher, L. S. Beedle
"High Strength Bolting in the U. S. A."
August, 1964
(A talk given at the 7th Congress of IABSE in Rio de Janeiro. Presents a summary of American design concepts and summarizes tests of bolted connections and the development of installation procedures.)

"Calibration Tests of A490 High-Strength Bolts"
August, 1964
(This report, written in co-operation with the University of Illinois, includes all the data contained in Fritz Laboratory Report 288.15 and the University of Illinois SRS No. 280. It will be published in the Journal of the Structural Division, ASCE, Vol. 91, No. St.5, 1965.)
288.24  J. W. Fisher  
"Bolted Joints of High Strength Steel"  
October, 1964  
(A talk given at the Structural Connection Session  
at the Annual Meeting of ASCE in New York,  
October 22, 1964)  

288.25  Project Staff  
"Summary Report to Committee 10 of "RCRBSJ."
November, 1964  

288.26  G. H. Sterling, J. W. Fisher  
"Tests of Long A440 Steel Bolted Butt Joints"  
February, 1965  

288.27  G. H. Sterling  
"A440 Steel Butt Joints Connected with High-Strength  
Bolts or Rivets"  
Master of Science Thesis, June, 1965  

288.28  Project Staff  
"Summary Report to the RCRBSJ"  
March, 1965  

288.30  G. H. Sterling, J. W. Fisher  
"A440 Steel Joints Connected by A490 Bolts"  
August, 1965  
(This report will be a revised and condensed version  
of 288.2. It will be distributed to members of  
Committee 10 for their approval.)  

288.31  J. W. Fisher, G. L. Kulek, L. S. Beedle  
"Behavior of Large Bolted Joints"  
August, 1965  
(This report summarizes the work on large bolted  
connections conducted at Lehigh University. It is  
tended for submission to the HRB. The report will  
be distributed to members of Committee 10 for their  
approval.)  

* Indicates distribution to sub group, Pennsylvania Department of Highways, Bureau of Public Roads and certain interested parties.  
+ Indicates distribution to RCRBSJ, Pennsylvania Department of Highways, Bureau of Public Roads and certain interested parties.  
# Indicates published reports. Reprints distributed to RCRBSJ, Pennsylvania Department of Highways and Bureau of Public Roads.
Phases Now Completed

Phases I, II
Joints of A440 steel and A325 bolts. E Series

Phase IV (a)
Calibration of A325 bolts. E and F series.

Phase IV (b)

Phase V

Phase VIII
Joints of A440 Steel connected with A490 Bolts. K Series.

Phase IX
Co-operative study with the University of Illinois. Calibration of A490 bolts.

Phase X
Joints of A440 steel with high-strength rivets. H series.

Phases Not Initiated

Series C
Static tests of single joints fastened with A325 bolts.

Series S
Tests of large diameter bolts.
**BOLTED HIGH-STRENGTH STEEL JOINTS, PROJECT 317**
**LEHIGH UNIVERSITY STATUS OF VARIOUS PHASES**

<table>
<thead>
<tr>
<th>Phase and Topic</th>
<th>Remarks</th>
<th>Tests Performed</th>
<th>Tests to Be Completed</th>
<th>Analytical Work</th>
<th>Reports</th>
</tr>
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<tbody>
<tr>
<td>I. Quenched &amp; Tempered Steel (ASTM A514) Joints Fastened with A490 Bolts</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td>None</td>
<td>Tests to be specified</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Hybrid Connections</td>
<td>Two or more different grades of steel are joined</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td>12 shear jig tests of A36-A314 steels with A325 and A490 bolts, and A36-A440 steels with A325 bolts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Quenched and Tempered Steel Joints Fastened with A325 Bolts</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td>None</td>
<td>Tests to be specified</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Project 317

Phases Now Active

Phase I
Analysis and confirming static tests of quenched and tempered steel (ASTM A514) joints fastened with A490 bolts.

Phase II
Analysis and confirming static tests of connections in which two or more different grades of steel are joined (hybrid connections).

Phases Inactive

Phase III
Analysis of quenched and tempered steel joints fastened with A325 bolts.
<table>
<thead>
<tr>
<th>Phase and Topic</th>
<th>Remarks</th>
<th>Tests Performed</th>
<th>Tests to Be Completed</th>
<th>Analytical Work</th>
<th>Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Out-of-Flat Large Joints</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td>None</td>
<td>Purposely warped plates with both A325 &amp; A490 bolts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>II. Effects of the Variation of the faying surface on the slip resistance of the joints</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td>None</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III. Effect of slotted and oversize holes upon joint behavior</td>
<td>Authorization: Annual proposal to the Pennsylvania Department of Highways Active</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
Phases Now Active

Project 318

Phase I
Analysis and pilot tests of large joints which are out-of-flat. Test pieces of large plates, some of which have been purposely warped from true flatness, will be used. Both A325 and A490 bolts would be used in conjunction with these pieces.

Phase II
Analysis and pilot tests of smaller joints to determine the effect of controlled variation of the faying surface on the slip resistance of the joints.

Phase III
Analysis and pilot tests of the effect of slotted and oversize holes upon joint behavior.