Preliminary report on restrained column tests, September 1963

M. G. Lay

T. V. Galambos

Follow this and additional works at: https://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports

Recommended Citation
https://preserve.lehigh.edu/engr-civil-environmental-fritz-lab-reports/1800

This Technical Report is brought to you for free and open access by the Civil and Environmental Engineering at Lehigh Preserve. It has been accepted for inclusion in Fritz Laboratory Reports by an authorized administrator of Lehigh Preserve. For more information, please contact preserve@lehigh.edu.
PRELIMINARY REPORT ON RESULTS OF RESTRAINED COLUMN TESTS

M. G. LAY
T. V. GALAMBOS
September, 1963.
Fritz Engineering Laboratory,
Department of Civil Engineering,
Lehigh University.

This report briefly presents the results of seven restrained column tests conducted at Fritz Laboratory between January and August, 1963.

I. HISTORY

The tests were proposed in Fritz Laboratory Report 278.6 (Proposal for Restrained Column Tests) in 1962 and accepted at the 1962 Lehigh Project Subcommittee meeting. A report on the novel testing technique is now (September, 1963) in the final stages of preparation and will be distributed as Fritz Laboratory Report 278.7. A report on the seven test results will follow.

II. TEST SET-UP

The test set-up is shown diagramatically on page 3.

III. TEST VARIABLES

The Table 1 on page 4 presents the variables introduced in the seven tests.

IV. TEST RESULTS

The results are presented in graphical form on pages 5 to 11. A summary of the results is given in Table 2 on page 12.

DEPARTMENT OF CIVIL ENGINEERING
FRITZ ENGINEERING LABORATORY
LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA
V. CONCLUSIONS

1) For all $P/P_y$, except 0.8, the column deflection curve approach provides close and slightly conservative estimates of the behavior of structural frameworks containing significant axial forces.

2) There are no instability effects associated with the unloading portion of the column curve. This region can be used in design to effect a further increase in load capacity estimates.

3) Care must be taken in using standard design methods in those situations in which the columns meeting at a joint are markedly less flexible than the beam. In such a situation compatibility and deformation must be considered.
Tests conducted in 5 mil lb machine. Loads on stub beams applied by hydraulic jack. Beam-to-column connections are welded.

Diagram of test set-up

Deflected shape & bending moment diagram
<table>
<thead>
<tr>
<th>TEST NO.</th>
<th>$P/P_y$</th>
<th>$h/r$</th>
<th>$s/d$</th>
<th>NOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC-1</td>
<td>0.4</td>
<td>60</td>
<td>38.4</td>
<td>$P/P_y$ increased from 0.4 to 0.53</td>
</tr>
<tr>
<td>RC-2</td>
<td>0.4</td>
<td>60</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td>RC-3</td>
<td>0.4</td>
<td>60</td>
<td>19.2</td>
<td></td>
</tr>
<tr>
<td>RC-4</td>
<td>0.6</td>
<td>40</td>
<td>38.4</td>
<td></td>
</tr>
<tr>
<td>RC-5</td>
<td>0.6</td>
<td>40</td>
<td>28.8</td>
<td></td>
</tr>
<tr>
<td>RC-6</td>
<td>0.8</td>
<td>30</td>
<td>28.8</td>
<td>High axial load test.</td>
</tr>
<tr>
<td>RC-7</td>
<td>0.4</td>
<td>60</td>
<td>28.8#</td>
<td>Sway test, $\theta_{sway} = \frac{1}{2} \theta_{joint.}$</td>
</tr>
</tbody>
</table>

$P_y = \text{Area} \times \text{yield stress}$

$r = \text{radius of gyration (column)}$

$d = \text{depth (beam)}$

# top beam omitted

**TABLE I**
RC-2
p = 0.4
a = 60
\theta = 25.8

MOMENT
kip-in

800

600

400

200

0

0.01

0.02

0.03

0.04

J OINT

ROTATION (RADIAN)

FIRST YIELD IN COLUMN

FIRST YIELD IN BEAM

MAXIMUM STRUCTURE MOMENT

MAXIMUM COLUMN MOMENT

BEAM

COLUMN

local buckle
RC-3

\( p_{\text{cr}} = 0.4 \)

\( p_{\text{cr}} = 60 \)

\( \frac{A}{b} = 19.2 \)

Moment (kip-ft)

Joint Rotation (radian)

Maximum Structure Moment and Column Moment

Beam Yields

Column Yields

Local Buckle
RC-4

$P_{c} = 0.6$
$P_{y} = 40$
$P_{y} = 38.4$

Moment (kip-in)

Maximum Column Moment
Maximum Structure Moment
Beam Yields
Beam Hinge
Column Yields
Column
Beam
Local Buckling

Joint Rotation (radian)
MOMENTS (kip-in)

<table>
<thead>
<tr>
<th>RC-5</th>
<th>p, = 0.6</th>
</tr>
</thead>
<tbody>
<tr>
<td>η, = 40</td>
<td></td>
</tr>
<tr>
<td>d, = 28.8</td>
<td></td>
</tr>
</tbody>
</table>

Maximum Structure Moment

Maximum Column Moment

Joint Rotation (radian)

Beam Hinge

Local Buckle

Columns Yields

Beam Yields

Structure

Column

Beam

Joint Rotation (radian)
Joint Rotation (Radian)

Maximum Column Moment
Maximum Structure Moment
Beam Yields

Column Yielded Before Moments Were Applied

MOMENT
KIP-IN

 behavioral

0.01
0.02
0.03
0.04

RC-6
\( p_{Rc} = 0.8 \)
\( \rho = 30 \)
\( s_0 = 28.8 \)
TABLE II

<table>
<thead>
<tr>
<th>Test</th>
<th>Max. Frame Load</th>
<th>Axial Load</th>
<th>Pred. I</th>
<th>Test I</th>
<th>Pred. II</th>
<th>Test II</th>
<th>Pred. III</th>
<th>Test III</th>
<th>Pred. IV</th>
<th>Test IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>RC-1</td>
<td>625</td>
<td>139 to 184</td>
<td>630</td>
<td>0.99</td>
<td>785</td>
<td>0.80</td>
<td>(a)</td>
<td>(a)</td>
<td>383</td>
<td>1.63</td>
</tr>
<tr>
<td>RC-2</td>
<td>880</td>
<td>139</td>
<td>880</td>
<td>1.00</td>
<td>895</td>
<td>0.98</td>
<td>313</td>
<td>2.81</td>
<td>509</td>
<td>1.73</td>
</tr>
<tr>
<td>RC-3</td>
<td>940</td>
<td>139</td>
<td>910</td>
<td>1.03</td>
<td>895</td>
<td>1.05</td>
<td>313</td>
<td>3.00</td>
<td>526</td>
<td>1.79</td>
</tr>
<tr>
<td>RC-4</td>
<td>575</td>
<td>208</td>
<td>550</td>
<td>1.04</td>
<td>775</td>
<td>0.74</td>
<td>(a)</td>
<td>(a)</td>
<td>381</td>
<td>1.51</td>
</tr>
<tr>
<td>RC-5</td>
<td>750</td>
<td>208</td>
<td>630</td>
<td>1.19</td>
<td>775</td>
<td>0.97</td>
<td>(a)</td>
<td>(a)</td>
<td>437</td>
<td>1.72</td>
</tr>
<tr>
<td>RC-6</td>
<td>330</td>
<td>278</td>
<td>325</td>
<td>1.02</td>
<td>595</td>
<td>0.56</td>
<td>(a)</td>
<td>(a)</td>
<td>238</td>
<td>1.38</td>
</tr>
<tr>
<td>RC-7</td>
<td>630 top 210 bot.</td>
<td>139</td>
<td>660</td>
<td>0.95</td>
<td>645</td>
<td>0.98</td>
<td>326</td>
<td>1.93</td>
<td>243</td>
<td>1.84</td>
</tr>
</tbody>
</table>

Pred. I:-

**Prediction I** Use of column and beam deflection curves together with equilibrium and compatibility, i.e. "exact" analysis.

Pred. II:-

**Prediction II** Plastic design without considering rotation capacity or compatibility.

(c) Assuming C.D.C.s are used to find maximum column moment.

Pred. III:-

**Prediction III** AISC Specifications (1) assuming all axial load applied first.

(a) Axial load alone greater than allowable capacity.

Pred. IV:-

**Prediction IV** AISC Specifications (1) assuming axial load and moment are proportional.

(b) No moment in column.