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Design of Laterally Unsupported Columns

TEST OF SUBASSEMBLAGE "S-1"
(A brief report prepared for CRC Task Group 10)

by

Lee C. Lim

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TEST OF SUBASSEMBLAGE 'S-1'

1. Test Specimen

As shown in Fig. 1, subassemblage 'S-1' was fabricated of three 8W35 columns and two beams framing into the columns at the upper and lower joints respectively. The upper beam was made of a 10W21 section and had a span of 20'0". The lower beam was a 12B16.5 section and its span was 17'0". The column height was 10 ft. 2-3/8 in. and the calculated slenderness ratio about the strong axis for each column was 34.8 and that for the weak axis was 60.0.

2. Test Arrangement:

In Fig. 2 is shown a schematic diagram of the test setup. The ends of the columns and those of the beams were pinned. The axial load was applied to the columns by the five million pound universal testing machine. Vertical loads were applied to each beam at its quarter points by the tension jack of a gravity load simulator through a spreader beam.

3. Description of Test

Initially axial load was applied to the column at an increment of 20 kips until a total of 175.5 kips was reached. This load corresponded
to a value of 0.534 for the \( \frac{P}{P_y} \) ratio for each column. With the column load being maintained at this level, vertical loads of the same magnitude were then applied simultaneously to both beams. The maximum total load that could be applied to the upper beam was 37.4 kips. When this situation occurred, the hydraulic supply to the tension jack for the upper beam was then blocked and more oil was pumped into the tension jack for the lower beam in an attempt to force the lower beam to fail. As the load on the lower beam was increased, that on the upper beam began to drop gradually. The maximum total load that could be applied to the lower beam was 42.0 kips. At this stage the vertical load on the upper beam dropped to 35.2 kips, and there was no noticeable sign of failure in the columns even though the carrying-capacities of both beams were totally exhausted. The next thing to do was to apply more axial load to the columns. The maximum load on the column applied by the 5 mm pound machine was 244 kips before unloading was observed. The vertical load on the upper and lower beams was approximately 30 kips each when unloading occurred in the columns.

4. Modes of Failure

The various modes of failure for the subassemblage are shown in Fig. 3. Briefly there were four locations at which excessive yielding was observed: two in the upper beam; one in the lower beam and the fourth at the top of the lower column. There was lateral-torsional buckling in every column and beam. In addition to the lateral-torsional buckling, the lower column also exhibited local buckling at about its midheight.
5. Test Results

The applied moment-rotation curve for the upper joint is shown in Fig. 4. The maximum applied moment was 859 kip-in, as against the predicted moment carrying-capacity of the upper joint of 966 kip-in. Figure 4 indicates that the beam was never stressed to strain-hardening. The applied moment was less than the value calculated on the basis of full plastification of the beam section at the vicinity adjacent to the upper joint.

In-plane and out-of-plane measurements were taken at the midheight of the middle column. The analysis of these data resulted in a load-twist curve given in Fig. 5. It is apparent that twisting occurred even before any beam load was applied.

6. Summary

One significant point emerged from this test is that lateral and torsional deformations were present at early stage of loading but they did not seem to impair the resisting moment capacity of the column. A considerable amount of analytical work on the test data has to be made before any conclusions can be drawn. However, based on the available information, it appears that:

(1) the current design procedure for laterally unsupported columns is conservative;

(2) we need not have to consider the strain-hardening effect in the beam when designing columns; and

(3) for gradually applied axial load, failure is likely to occur in the beam.
FIG. 1 SUBASSEMBLAGE S-1

\[ \frac{h}{r_x} = 35 \]

\[ \frac{P}{P_y} = 0.540 \]

\[ 8\, W = 35 \]

\[ 10\, W = 21 \]

20'

0.600

12 B 16.5

17'

0.660

S-1
FIG. 2 TEST SETUP
FIG. 3 MODES OF FAILURE
FIG. 4  MOMENT-ROTATION CURVE FOR THE
UPPER JOINT
FIG. 5 LOAD-TWIST CURVE FOR MIDDLE COLUMN