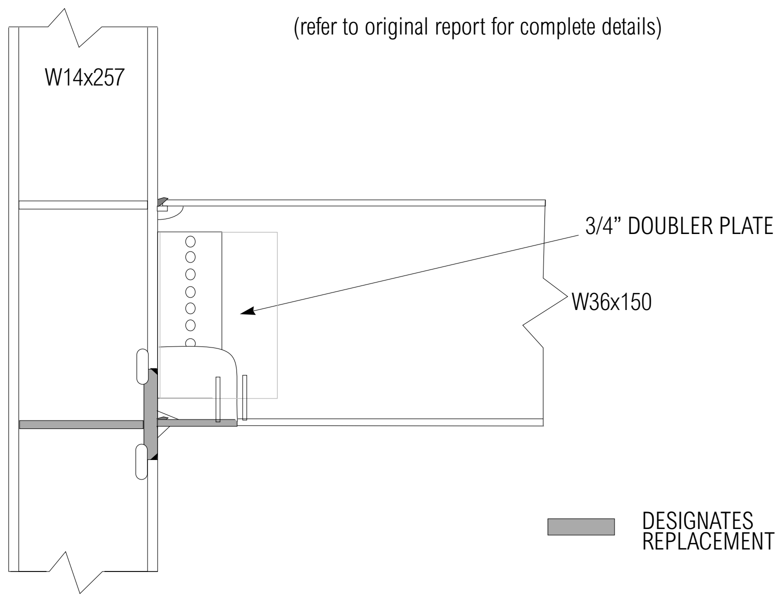
**SAC Steel Project** | **Test Summary No. 22**

**the FEMA Program to Reduce the Earthquake Hazards of Steel Moment Frame Structures**

| | |
|---|---|
| Specimen ID: | UTA-2R |
| Keywords: | Repair, beam and column splice plates, web doubler plate, vertical stiffeners beam and web doubler plate connection fractures, low rotation capacity |
| Test Location: | University of Texas, Austin |
| Test Date: | October 4, 1995 |
| Principal Investigator: | Michael D. Englehardt; with Bradley D. Shuey and Thomas A. Sabol |
| Related Summaries: | 8 |
| Reference: | "Experimental Investigations of Beam-Column Subassemblages", *Report No. SAC 96-01*, March 1996. |
| Funding Source: | FEMA / SAC Joint Venture, Phase I |

## CONNECTION DETAIL

(refer to original report for complete details)




## MATERIAL PROPERTIES AND SPECIMEN DETAILS

| Member | Size | Grade | Yield Stress (ksi) | | Ultimate Strength (ksi) | |
|---|---|---|---|---|---|---|
| | | | mill certs. | coupon tests * | mill certs. | coupon tests * |
| Beam | W36x150 | A36 | 58.5 | 42.3 flange<br>47.7 web | 67.5 | 61.1 flange<br>63.4 web |
| Column | W14x257 | A572 Gr. 50 | 53.5 | 48.7 flange | 72.5 | 69.0 flange |
| Web doubler plate | 3/4" plate | A572 Gr. 50 | N.A. | N.A. | N.A. | N.A. |
| Column flange splice | 2" plate | A572 Gr. 50 | N.A. | N.A. | N.A. | N.A. |
| Beam flange splice | 1" plate | A572 Gr. 50 | N.A. | N.A. | N.A. | N.A. |
| Vertical stiffeners | 3/4" plates | A572 Gr. 50 | N.A. | N.A. | N.A. | N.A. |

| | |
|---|---|
| Welding Procedure Specification | Original: see Test Summary No. 7<br>Modifications: All welds FCAW-SS using 0.072" diameter AWS E71T-8 electrode. (Repair to top flange uses AWS E70T-8.) |
| Shear tab | 5/8"x30"x5" plate, added 3/4" beam web doubler plate welded to beam web and column flange |
| Panel zone | No doubler plates |
| Continuity plates | 1/2" plates with c.p. weld, replace bottom plate, add 3/4" plate at bottom of haunch with c.p. weld |
| Boundary conditions | Single-sided test, no floor slab, axial force in lower half of column equal to beam shear force, specimen tested in upright position |
| Other detailing | Backup bars removed at top flange, weld root back-gouged and replaced |

N.A. = not available

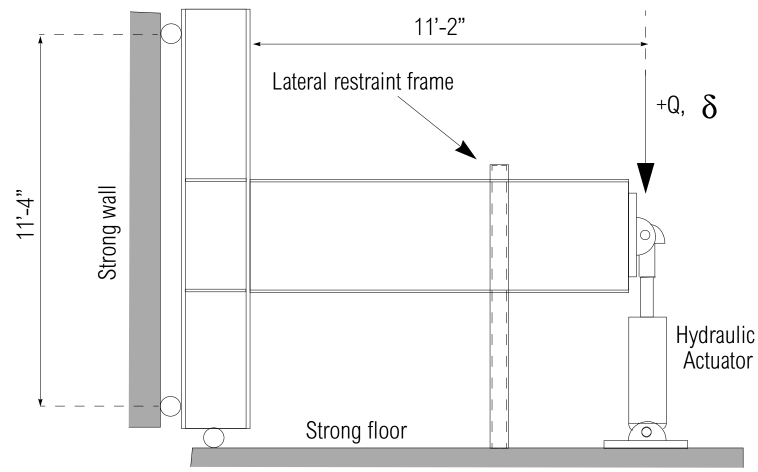
* dynamic stresses; see reference for additional details of coupon tests

## BACKGROUND

This was a test of a repairs to specimen UTA-2 (Test Summary No. 8) which was originally tested on March 24, 1995. The original specimen failed in the first half of the second displacement cycle to $2\delta_y$ without undergoing any significant plastic deformation. Both halves of the bottom flange connection experienced separate divot fractures into the column flange.

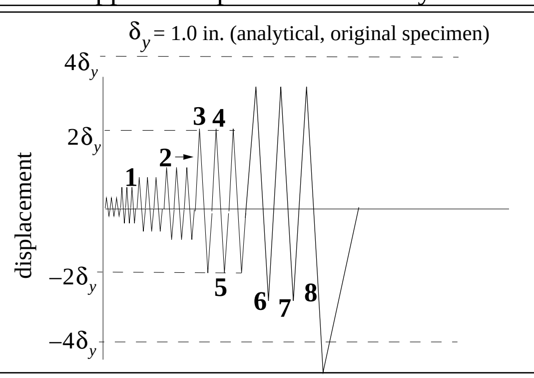
The repair schedule consisted of removing the beam material adjacent to the fractured weld, removing the existing bottom continuity plate, cutting two column web access holes, removing a piece of the column flange where the divot fractures had occurred, removing the shear tab bolts, inserting a new plate as a column flange splice, welding the column splice plate to the column flange and web, installing a new continuity plate, inserting a beam flange splice plate, welding the beam flange splice plate to the column flange splice plate and to the existing beam flange, removing all weld tabs, installing a web doubler plate on the side of the beam opposite the existing shear tab and welding this to column the flange and the beam bottom flange splice plate and beam web, and installing short vertical beam web stiffeners. The displacement history followed the standard SAC/ATC-24 protocol. The reference displacement ($\delta_y$) was selected to be 1.00 in. to be consistent with that used in the original test.

## TEST SET-UP




## DISPLACEMENT HISTORY AND KEY EXPERIMENTAL OBSERVATIONS

**Applied Displacement History**




**Key Observations of the Test**

| Point | Description |
|---|---|
| **1** | Yielding of beam bottom flange splice plate |
| **2** | Top flange yielding |
| **3** | Panel zone and continuity plate yielding |
| **4** | Spot yielding of the web doubler plate |
| **5** | Fracture of beam top flange to column connection |
| **6** | Another top flange fracture, pulling away of beam top flange from column exposing divot into column flange |
| **7** | Further exposure of column flange divot fracture of web doubler plate at the column face |
| **8** | Rapid reduction in load carrying capacity |

## DETAILED TEST RESULTS

| Quantity (see Introduction for definitions used in UTA tests) | | Maxima |
|---|---|---|
| Force/Displacement Properties | Peak actuator force prior to first fracture (kips): | ~200 |
| | Beam tip displacement prior to first fracture (in.): | 2.0 |
| | Experimental yield displacement (in.) | NA |
| Rotation Capacity | Maximum plastic rotation prior to first fracture (% radian): | 0.5 |
| | Cumulative plastic rotation (% radian): | NA |
| Energy Dissipation Properties | Cumulative energy dissipated (k-in.): | NA |

Mode of failure: Fracture of the welded beam top flange to column flange connection during the second $4\delta_y$ displacement cycle.

## DISCUSSION

Specimen UTA-2R failed in the second half of the second displacement cycle to $2\delta_y$ at a tip displacement of -1.69 in. After failure , the remaining $2\delta_y$ cycles were completed, and the specimen was then subjected to two-and-a-half displacement cycles to $3\delta_y$, followed by a single excursion to a tip displacement of -5.3 in. in the last half cycle. The beam bottom flange splice plate first experienced yielding during the $0.5\delta_y$ cycles and yielding was observed in the beam top flange during the $1\delta_y$ cycles. Slight yielding of the panel zone, continuity plates, and the beam doubler plate were observed in the first displcament cycle to $2\delta_y$, followed by a sudden fracture in the weld between the beam top flange and the column flange. The fracture appeared to be along the weld-column interface. As the loading was continued, during the third displacement cycle to $2\delta_y$, the specimen experienced more yielding in the beam flanges and web. During the first $3\delta_y$ cycle, another sudden fracture occurred as the beam top flange pulled away from the column, exposing a divot in the column flange. In the next cycle, more of the column flange divot was exposed. In addition, the beam web doubler plate fractured along the face of the column. During the last loading cycle to -5.3 in. the load began to drop rapidly as the doubler plate-to-column weld fracture propagated. The maximum plastic rotation of the connection prior to the initial failure of the top flange was 0.5% radian. Approximately 1/3 of this rotation was associated with deformation in the beam, with the remaining 2/3 contributed by inelastic behavior in the column panel zone.