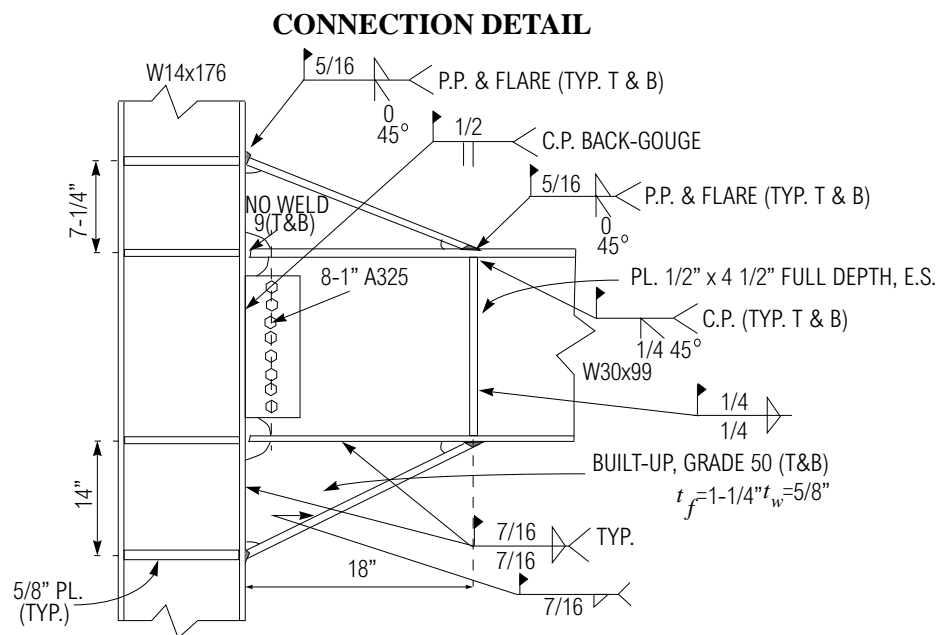


Specimen ID: EERC-RN2
 Keywords: Repair, top and bottom triangular haunch, beam flange not welded, flange local buckling, web distortion, large strains, medium rotation capacity
 Test Location: Earthquake Engineering Research Center, University of California at Berkeley
 Test Date: June 29-30, 1995
 Principal Investigator: Vitelmo V. Bertero; with Andrew S. Whittaker and Amir S. Gilani
 Related Summaries: 2
 Reference: "Experimental Investigations of Beam-Column Subassemblages", Report No. SAC 96-01, March 1996.
 Funding Source: FEMA / SAC Joint Venture, Phase I



MATERIAL PROPERTIES AND SPECIMEN DETAILS

Member	Size	Grade	Yield Stress (ksi)		Ultimate Strength (ksi)	
			mill certs.	coupon tests *	mill certs.	coupon tests *
Beam	W30X99	A36	54.1	48.6 flange 57.4web	73.4	70.9 flange 72.9 web
Column	W14X176	A572 Gr. 50	56.5	48.6 flange 53.5web	74.5	68.9 flange 70.8web
Triangular Haunch	Built-up WT $t_f=1-1/4", t_w=5/8"$	Gr. 50	N.A.	N.A.	N.A.	N.A.
Vertical stiffener	1/2" plate	N.A.	N.A.	N.A.	N.A.	N.A.
Welding Procedure Specification	All welds FCAW-SS in accordance with AWS D1.1-94. Haunch groove and fillet welds and welds between beam web and column flange performed with 0.072" diameter AWS E71T-8 electrode.					
Shear tab	Arc off existing shear tab; CJP groove weld between beam web and column flange					
Panel zone	No doubler plates					
Continuity plates	3/8" plates with c.p. weld, add 5/8" plates at haunches 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	Existing top and bottom flange groove welds removed; CJP groove welds applied between haunch flanges and beam and column flanges, backup bars removed, weld back-gouged, reinforcing fillets added					

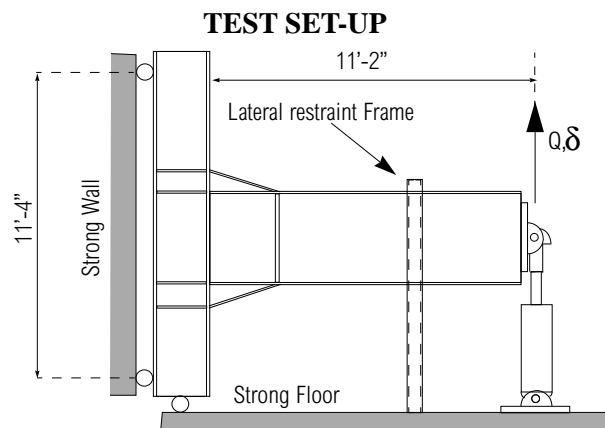
N.A. = not available

*Coupon locations per ASTM

BACKGROUND

This was a test of repairs to specimen EERC-PN2 (Test Summary No. 2) that was originally tested on March 14-15, 1995. The original specimen failed when the weld between the beam top flange and the column flange fractured prior to undergoing any significant plastic deformations or rotations. The fracture occurred during the third negative displacement excursion to $2\delta_y$, (where, $\delta_y = 1.40$ in., was obtained from analytical studies of the original specimen). The failure of the specimen was preceded by shear yielding in the panel zone, first observed during the displacement cycles to $0.75\delta_y$. Visual observation of the specimen following testing suggested that the beam did not yield over its full depth. The cyclic tests were performed quasi-statically.

The specimen repair procedure consisted of realigning of the beam column assembly to 90 degrees, removing the fractured top flange weld material, removing the undamaged bottom flange weld material, adding built-up T-shaped top and bottom haunches at the beam-column connections, groove welding the haunch flanges to the beam and column and fillet welding of the haunch webs to the beam and column, back-gouging the root pass of the groove welds and placing reinforcing fillet welds in the back-gouged zones, groove welding the beam web to the column flange, and installing additional continuity plates and vertical web stiffeners. The standard SAC/ATC-24 loading history was used in the quasi-static testing of the repaired specimen.



DISPLACEMENT HISTORY AND KEY EXPERIMENTAL OBSERVATIONS

Applied Displacement History	Key Observations of the Test	
	Point	Description
	1	Local buckling in beam bottom flange outside of haunch
	2	Local buckling in beam top flange outside of haunch
	3	Peak load in this cycle was less than 80% of the previous maximum load
	4	Substantial local buckling and web distortion in the beam top flange adjacent to the haunch
	5	Fracture of beam top flange, with the crack propagating into the beam web

DETAILED TEST RESULTS

Quantity (see Introduction for definitions used in EERC tests)		Maxima
Force/Displacement Properties	Peak actuator force (kips):	153
	Beam tip displacement (in.):	3.8
	Experimental beam yield displacement (in.):	1.1
Rotation Capacity	Maximum plastic rotation (% radian):	2.8
	Cumulative plastic rotation (% radian):	NA
Energy Dissipation Properties	Cumulative energy dissipated (k-in.):	5,223

Mode of failure: The load-carrying capacity of the specimen dropped below 80% of the recorded maximum load during the displacement cycles to $3\delta_y$ due to local buckling of the beam flanges outside of the haunch. Fracture of the beam top flange due to severe local buckling was observed in subsequent cycles.

DISCUSSION

The capacity of specimen EERC-RN2 dropped below 80 percent of its maximum during the third negative displacement cycle to $3\delta_y$. At the peaks of the cycles, the amplitude of flange buckling was approximately 2.5 in. Although there were no material or weld fractures observed at this displacement, such a loss of load carrying capacity was specified as failure according to the SAC Phase 1 test protocol. However, the test was continued, and the beam ultimately developed a plastic rotation of 0.06 radian during the cycles to $5\delta_y$, but with a reduction in the load carrying capacity of approximately 50 percent. The material fracture resulted from substantial local buckling of the beam flanges just outside the haunch zone. The fracture of the top flange of the specimen occurred at a displacement of approximately -5.5 in. during the third negative displacement excursion to $5\delta_y$. The fracture was likely caused by high strains resulting from large curvatures in the buckled flange. The maximum moment delivered to the column was 36 percent higher than in the original specimen. The maximum plastic rotation of the connection prior to the 20 percent drop in load-carrying capacity used to define failure was approximately 0.028 radian, consisting of 0.001 radian from the panel zone, and 0.027 radian from the beam. The beam plastic rotations for this specimen were much larger compared to the original specimen.

DISCLAIMER

This summary has been prepared from the cited reference. The SAC Joint Venture has not verified any of the results presented herein, and no warranty is offered with regard to the results, findings, and recommendations presented, either by the Federal Emergency Management Agency, the SAC Joint Venture, the individual joint venture partners, their directors, members, or employees. These organizations and individuals do not assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any of the information, products, or processes included in this publication. The reader is cautioned to carefully review the material presented herein. More detailed information is available in the cited reference.