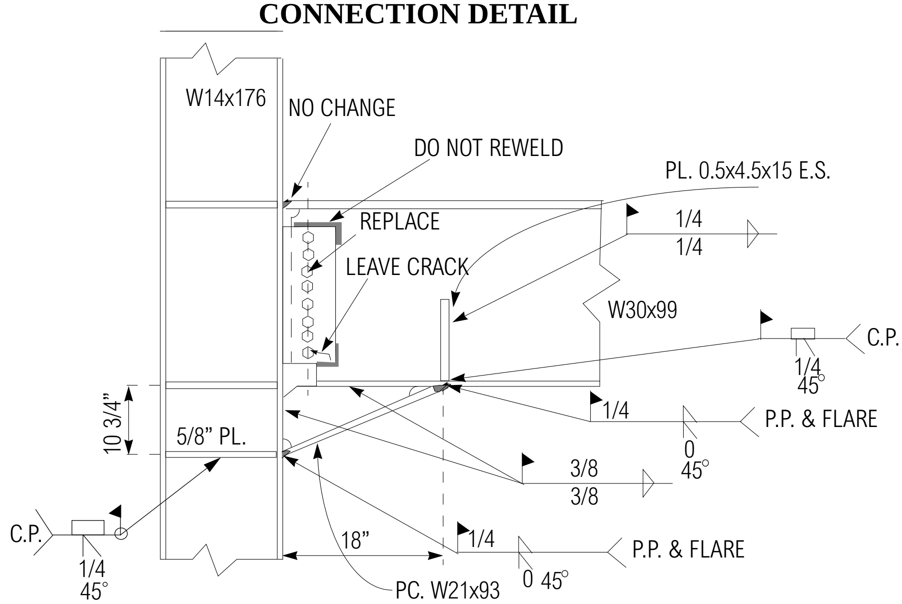
SAC Steel Project — Test Summary No. 17

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

Specimen ID:	UCSD-1R
Keywords:	Repaired, bottom haunch, unconnected beam bottom flange, local and lateral torsional buckling, haunch yielding, medium rotation capacity
Test Location:	University of California, San Diego
Test Date:	March 31, 1995
Principal Investigator:	Chia-Ming Uang; with Duane Bondad
Related Summaries:	4
Reference:	"Experimental Investigations of Beam-Column Subassemblages", *Report No. SAC 96-01*, March 1996.
Funding Source:	FEMA / SAC Joint Venture, Phase I

CONNECTION DETAIL



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	49.3	46.5 flange 57.1 web	71.8	67.7 flange 72.5 web
Column	W14X176	A572 Gr. 50	55.0	52.5 flange 51.2 web	74.5	68.2 flange 67.2 web
Haunch	W21X93	A36	N.A.	39.0 flange 39.8 web	N.A.	64.0 flange 69.2 web
Vertical Stiffener	1/2" plate	A36	N.A.	45.2	N.A.	66.9

Welding Procedure Specification	All welds FCAW-SS in conformance with AWSD1.1-94, performed with 0.120" diameter AWS E70T-4 electrodes. Preheat and interpass temperature per Table 4.3. Fillet weld of shear tab to beam web performed with 0.072" diameter AWS E71T-8 electrode. All repairs performed using 0.072 in. diameter AWS E71-T8 electrode.
Shear tab	3/8 x 5" plate with eight 7/8" A325 bolts, do not repair fillet weld to beam web
Panel zone	No doubler plates
Continuity plates	3/8" plates with c.p. weld ; add a 5/8" plate at the haunch level with 1/4" c.p. weld
Boundary conditions	Single-sided test, no floor slab, axial load in lower half of column equal to shear in beam, specimen tested in upright position
Other detailing	Bottom beam flange not welded to column flange

N.A. = not available

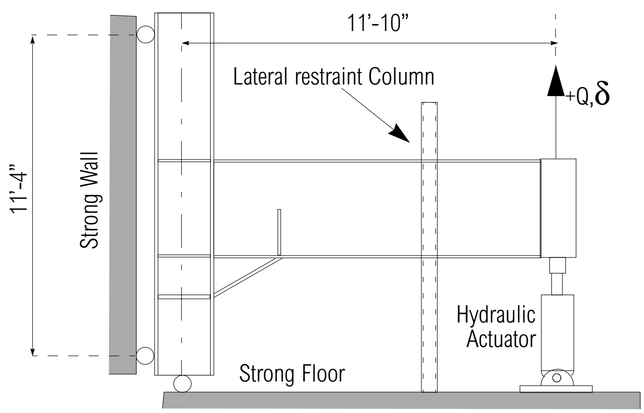
* Coupon locations per ASTM

BACKGROUND

This was a test of a repairs on specimen UCSD-PN1 (Test Summary No. 4) that was originally tested on February 16, 1995. The original specimen experienced a sudden fracture of the welded beam bottom flange to the column flange before undergoing significant plastic deformations or rotations. The failure occurred in the first displacement excursion to $2\delta_y$ (where δ_y = 1.40 in., obtained from analytical studies of the original specimen). The failure of the specimen was preceded by minor shear yielding in the panel zone. The cyclic tests were performed quasi-statically.

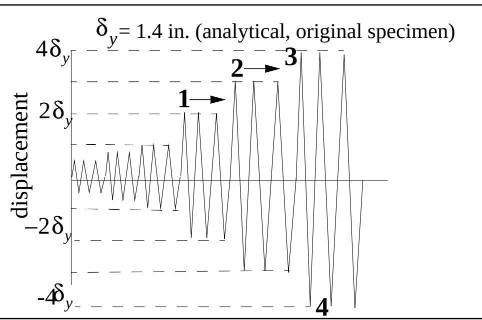
The objective of adding a haunch to the connection was to force plastic hinging in the beam to occur away from the column face. The specimen repair procedure consisted of realigning the connection to 90 degrees, replacing of the shear tab bolts, removal of the beam bottom flange from the column face to the back of the access hole, installing a haunch (cut from W21x93) by welding the haunch flange to the column and beam flanges and fillet welding the haunch webs to the column and beam flanges, installing an additional continuity plate at the haunch level, and installing a vertical stiffener at the end of the haunch extending halfway through the beam depth. The beam top flange was not repaired or strengthened, because ultrasonic tests revealed no unacceptable defects. The standard SAC/ATC-24 loading history was used in the quasi-static testing of the repaired specimen, and a yield displacement (δ_y) of 1.40 in. was assumed to provide the consistency with previous tests.

TEST SET-UP



DISPLACEMENT HISTORY AND KEY EXPERIMENTAL OBSERVATIONS

Applied Displacement History



Key Observations of the Test

Point	Description
1	Minor local buckling beam top flange
2	Local buckling of beam top and bottom flanges, yielding of the haunch and vertical stiffeners, lateral torsional buckling of bottom flange near haunch
3	Severe buckling and fracture of the top side of the beam top flange due to buckling
4	Fracture of the underside of the beam top flange adjacent to the backing bar

DETAILED TEST RESULTS

Quantity (see Introduction for definitions used in the UCSD tests)		Maxima
Force/Displacement Properties	Peak actuator force (kips):	~140
	Beam tip displacement (in.):	5.75
	Experimental yield displacement (in.)	1.51
Rotation Capacity	Maximum plastic rotation (% radian):	3.8/2.5 prior to strength degradation below $0.8M_p$
	Cumulative plastic rotation (% radian):	47.6(including degraded portion)
Energy Dissipation Properties	Cumulative energy dissipated (k-in.):	6235 (including degraded portion)

Mode of failure: Fracture of the underside of the beam top flange in two locations during the $4\delta_y$ cycle. Significant strength degradation occurred prior to this

DISCUSSION

Minor local buckling in the beam top flange was observed during displacement cycles of $2\delta_y$. During the excursions to $3\delta_y$ local buckling was observed in the beam top flange next to the column and in the beam bottom flange outside the haunch. The haunch and beam vertical stiffeners yielded and lateral torsional buckling of the beam near the end of the haunch was also observed. Due to the interaction of these two types of buckling, the specimen strength deteriorated rapidly. During the first $4\delta_y$ cycle, the beam top flange buckled severely. The resulting curvature caused the top side of the flange to fracture. The underside of the flange fractured during the reverse cycle at the root of the beam web cope and just outside the backing bar . In the panel zone, the inelastic action was primarily present in the upper part, due to presence of the bottom haunch. The maximum plastic rotation of the connection was approximately 3.8% radian, consisting of N.A. radian. The majority of the rotation was in the beam. The repair scheme significantly improved the performance of the connection by moving the critical section away from the column face, and the inelastic action in the panel zone was reduced. To further improve the response of the connection, and minimize the occurrence of lateral torsional buckling, the investigators suggest that the fractured bottom beam flange should be connected to the column flange.