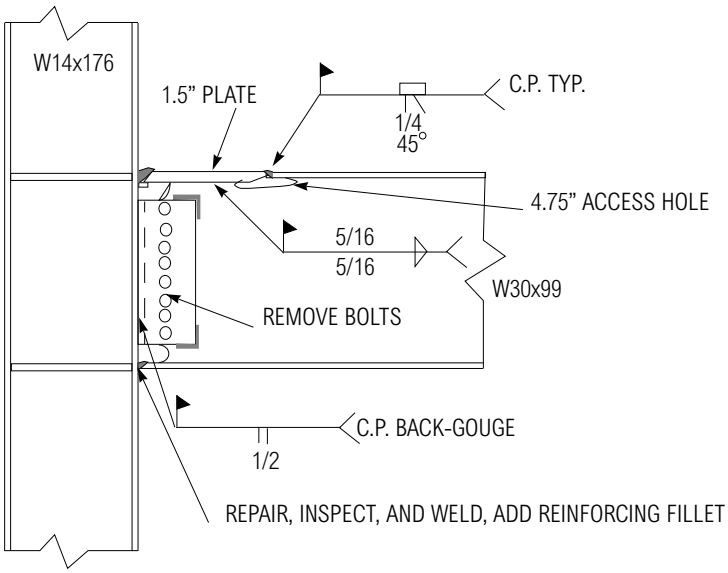
SAC Steel Project

Test Summary No. 18

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

Specimen ID:	UCSD-2R
Keywords:	Repaired, replacement plate for beam top flange, shear tab to column weld, web buckling, flange fracture, low rotation capacity
Test Location:	University of California, San Diego
Test Date:	April 21, 1995
Principal Investigator:	Chia-Ming Uang; with Duane Bondad
Related Summaries:	5
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	51.8	46.5 flange 57.1 web	46.5	67.7 flange 72.5 web
Column	W14X176	A572 Gr. 50	51.9	52.5 flange 51.2 web	52.5	68.2 flange 67.2 web
Replacement Plate	1.5" thick	A36	NA	42.2	NA	71.4

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, remove bolts, groove weld beam web to column flange
Panel zone	No doubler plates
Continuity plates	3/8" plates with 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	Repair beam bottom flange groove weld

N.A. = not available

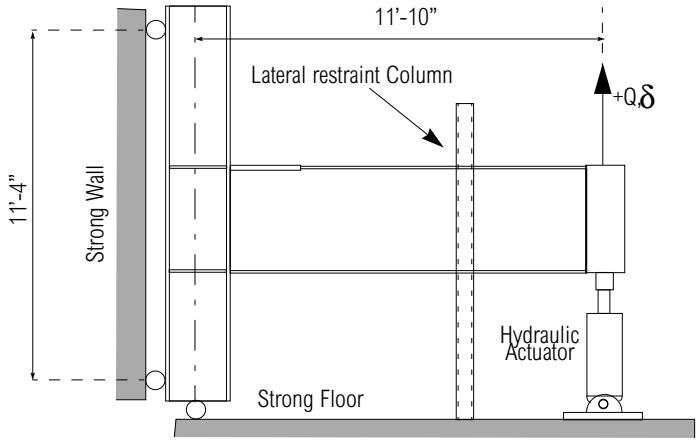
* Coupon locations per ASTM

BACKGROUND

This was a test of a repairs on specimen UCSD-PN2 (Test Summary No. 5) that was originally tested on February 23, 1995. The original specimen experienced sudden failure in the heat affected zone of the beam top flange during the first negative displacement excursion to $3\delta_y$ (where δ_y = 1.40 in., obtained from analytical studies of the original specimen). The failure of the specimen was preceded by shear yielding in the panel zone. Additionally, the specimen experienced local buckling in the beam top flange, fracture at the top and bottom ends of the shear tab, and cracking in the top beam flange-groove weld interface during the cycles to $2\delta_y$. The cyclic tests were performed quasi-statically.

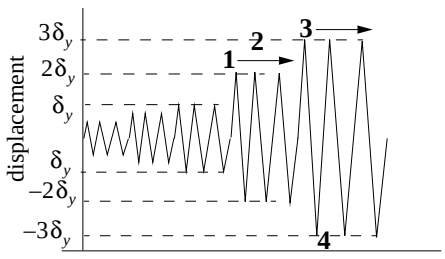
The specimen repair procedure consisted of torch cutting and removing a 20-in. long portion of the beam top flange which had buckled, torching a 4.75 in. wide inclined access hole, replacing the cut beam top flange with a 1.5" thick plate, welding the replacement plate to the column and beam flanges, fillet welding the plate to the beam web, removing the backup bars and running a final weld pass, removing the shear tab bolts, groove welding the beam web to the column flange, and repairing the beam bottom flange to column flange groove weld. 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 consistency with the previous test.

TEST SET-UP



DISPLACEMENT HISTORY AND KEY EXPERIMENTAL OBSERVATIONS

Applied Displacement History



Key Observations of the Test

Point	Description
1	Yielding and minor local buckling of beam flanges
2	Out of plane buckling of the beam web below top access hole
3	Significant local buckling of beam top flange next to flange replacement plate and tearing at both ends of access hole at top repair
4	Fracture of groove weld between beam top flange and replacement plate at access hole

DETAILED TEST RESULTS

Quantity (see Introduction for definitions used in UCSD tests)		Maxima
Force/Displacement Properties	Peak actuator force (kips):	127
	Beam tip displacement (in.):	4.22
	Experimental yield displacement (in.)	1.53
Rotation Capacity	Maximum plastic rotation (% radian):	2.6/~2.0 prior to strength degradation below $0.8M_p$
	Cumulative plastic rotation (% radian):	34 (including degraded portion)
Energy Dissipation Properties	Cumulative energy dissipated (k-in.):	4475 (including degraded portion)

Mode of failure: Fracture of the groove weld at the beam top flange above the access hole for the replacement plate during the $3\delta_y$ cycle.

DISCUSSION

Yielding and minor local buckling in the beam flanges of specimen UCSD-2R were observed during displacement cycles of $2\delta_y$. When the top half of the beam web was in compression, the web below the 4.75 in. wide access hole buckled out of plane. This resulted from the transformation of the beam web from a stiffened to an unstiffened element, due to the presence of the access hole. During the excursions to $3\delta_y$, significant local buckling of the beam top flange next to the flange replacement plate was observed, while the buckling of the beam bottom flange was limited. During the first positive excursion to $3\delta_y$, the out-of-plane web buckling caused tearing at both ends of the access hole. Once the tearing initiated, it propagated rapidly in the next cycle. The beam top flange above the access hole fractured completely in the subsequent excursion. In the panel zone, plastic shear deformations only developed when the top flange was subjected to tension; local buckling limited compression force transfer in the beam top flange. The maximum plastic rotation of the connection was approximately 2.6% radian. The repair scheme did not significantly improve the performance of the connection, as is noted from the nearly equal plastic rotation capacity of the original and the repaired specimens, although the plastic zone was moved away from the column face. It is important that the large weld access hole in the repair be stiffened to achieve better performance.

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.