International Journal of Offshore and Polar Engineering
Vol. 12, No. 3, September 2002 (ISSN 1053-5381)

Testing of Beam-to-RHS Column Connections Without Weld-access Holes

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ABSTRACT

This paper presents 3 full-scale tests of beam-to-RHS column connections without weld-access holes. The aim of the tests was to investigate the plastic deformation capacity and ultimate strength of these types of beam-to-column connections. The ultimate moment capacities of the welded beam-to-column connections were predicted by simple formulas based on elementary plastic analysis. In all the specimens, the connections had sufficient overstrength to allow formation of plastic hinges at the beam ends, although one specimen failed through brittle fracture starting from the toe of the weld between the beam flange and the horizontal haunch.

NOMENCLATURE

A_w	:	cross-sectional area of beam web
b_b	:	width of beam flange
b_c	:	width of column
d_j	:	inner distance between top and bottom diaphragm
E	:	elastic modulus
E.L.	:	elongation
G	:	shear modulus of elasticity
H_b	:	height of beam
H_d	:	outer distance between top and bottom diaphragm
I	:	moment of inertia
j_b	:	distance between centroids of beam flange
L	:	distance between loading point and column face
l_e	:	effective weld length
L_{haunch}	:	length of haunch
L_{fracture}	:	length of fracture path
$M_{f,u}$	:	ultimate moment carried by beam flange
M_m	:	moment at column face
$M_{\max}$	:	maximum moment
M_p	:	full plastic moment of beam
M_u	:	ultimate moment of beam-to-column connection
$M_{w,u}$	:	ultimate moment carried by beam web connection
S_h	:	space between edge of diaphragm and beam flange
S_r	:	vertical space of beam cope
t_c	:	thickness of column
t_d	:	thickness of diaphragm
t_f	:	thickness of beam flange
t_{pl}	:	thickness of flange plate
t_s	:	thickness of shear tab
u_1, u_2	:	horizontal displacements
v_1, v_2	:	vertical displacements
Y.R.	:	yield ratio
$Z_{w,pe}$	:	plastic modulus of effective cross-section of beam web
α	:	ratio of $M_{\max}$ and M_p
η	:	cumulative plastic deformation factor
$\sigma_{c,y}$	:	yield strength of column material
$\sigma_{f,u}$	:	ultimate tensile strength of beam flange material
$\sigma_{s,y}$	:	yield strength of shear tab material
$\sigma_{s,u}$	:	ultimate tensile strength of shear tab material
θ_m	:	rotation of connection between beam and column
θ_p	:	elastic beam rotation at M_p

INTRODUCTION

Both the 1994 Northridge and 1995 Hyogoken Nanbu (Kobe) earthquakes took structural engineering professionals by surprise in that many of the welded connections in modern steel-building frames showed brittle fractures. Before these earthquakes, engineers commonly assumed that the connections between the beam flanges and columns using complete joint penetration (CJP) groove welds satisfied overstrength criteria to allow formation of plastic hinges in beams (CEN 1994, ICBO 1994). These fractures most frequently occurred in regions around the beam bottom flange groove welds. In Northridge, brittle fractures initiated at a very low level of plastic demand and, in some cases, while structures remained nearly elastic. In Kobe, however, the majority of

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Received November 28, 2001; revised manuscript received by the editors June 26, 2002. The original version (prior to the final revised manuscript) was presented at the 11th International Offshore and Polar Engineering Conference (ISOPE-2001), Stavanger, Norway, June 17–22, 2001.

KEY WORDS: Beam-to-column connection, cyclic load, field welding, full-scale test, seismic design, tubular steel structure, weld-access hole.