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Failure Modes and Limit States of Longitudinal Plate to RHS Connections

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ABSTRACT

The use of Rectangular Hollow Sections (RHS) in different structures has been expanded dramatically, and longitudinally-oriented plates have been used widely to connect braces and other attachments to RHS members. Since plate-to-RHS connections are very flexible, some factors have to be considered in the design of this connection type, such as large deformations on connecting faces and non-uniformly distributed stresses in plates. The existence of an axial load on an RHS member also affects the strength of a plate connected to the RHS member.

Based on an investigation of different failure modes of plate-to-RHS connections under different loading cases, a tentative design method is proposed for the connections. Two deformation limits are used to control the deformation of the connecting face in an RHS member. The deformation under the ultimate load is limited to 3% of the RHS member width and the deformation under the service load is limited to 1% of the RHS member width. The effective width of the plate, effective length of the welds, and the influence of the axial load in the RHS member should also be considered.

Four 90° longitudinal plate-to-RHS column connections have been tested under different axial loads on the column. The connections were tested to rupture and the load-displacement behaviour of the column faces and stress distributions in the plates were obtained. The test results generally confirm the proposed design method for plate effective width and connection to the column face.

KEY WORDS: Rectangular Hollow Sections, joints, connections, tubes, deformation and serviceability limits, longitudinal gusset plate, pre-loading

NOMENCLATURE

A_0	cross sectional area of RHS
a	weld throat thickness
b_0	width of RHS
b_1	plate thickness
f(n)	reduction factor, taking the effect of RHS pre-loading into account
f_{y0}	yield strength of RHS
f_{y1}	yield strength of plate
h_0	depth of RHS
h_1	plate width
P_Q	connection strength for general punching shear
P_Y	connection strength for yield line mechanism
P_u	ultimate connection strength
$P_{s,1\%}$	load corresponding to $1\%b_0$ serviceability limit
$P_{u,3\%}$	load corresponding to $3\%b_0$ deformation limit
t_0	RHS wall thickness
w	weld leg length
β	brace width to column width ratio = b_1/b_0
Δ	out-of plane deformation of the RHS wall at connection centre
Δ_u	out-of plane deformation of the RHS wall at connection centre at failure
σ_1	stress in gusset plate

INTRODUCTION

As a common means of connecting a brace member to a column member, for example in braced frames, a gusset plate is typically welded in the longitudinal direction to the column wall. When the column is an RHS, the connection is extremely flexible to a load or a load component perpendicular to the column axis because of the flexibility of the RHS connecting wall, unless so called through-plates are used, the fabrication of which is expensive, or the plate is welded to the RHS corner, which requires the RHS to be orientated at a 45° angle. Whereas stiffeners are easily placed on open sections, this is not possible inside the RHS. At the present time, the longitudinal plate-to-RHS connection is recommended only as a pure shear connection.

However, the increasing use of RHS columns in braced structures and therefore the demand for design guidelines stands in contrast to the lack of research on this connection type.