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Thin-Walled Structures 42 (2004) 1013–1033
THIN-WALLED STRUCTURES
www.elsevier.com/locate/tws

Experimental investigation into the structural behaviour of lapped connections between cold-formed steel Z sections

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Received 16 June 2003; received in revised form 5 March 2004; accepted 5 March 2004

Abstract

This paper presents an experimental investigation on the structural behaviour of lapped cold-formed steel Z sections. A total of 26 one point load tests on lapped connections between Z sections with various lap lengths and test spans were carried out, and both the strength and the deformation characteristics of these connections were examined in detail. Among all tests, section failure at the end of lap under combined bending and shear was always found to be critical in the connected Z sections. Moreover, the moment resistances of lapped connections with lap lengths equal to 1.2 times section depth were found to develop only 80% of the moment capacities of connected sections. For lapped connections with lap lengths equal to six times section depth, their moment resistances were found to be significantly increased to about 140% of the moment capacities of connected sections. Similar results in the flexural rigidities of the lapped connections were also found. Consequently, it is shown that the degree of structural continuity in lapped connections against bending depend on not only the load levels, the lap length to section depth ratios, but also the lap length to test span ratios. Hence, the widely adopted assumption of full strength and stiffness connections in lapped sections is not always correct. The research work aims to provide understanding to the structural performance of lapped connections between cold-formed steel Z sections, and hence, to develop a set of rational design rules for multi-span purlin systems with overlaps in modern roof construction. The analysis and design method will be fully presented in a complementary paper.

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doi:10.1016/j.tws.2004.03.022

Keywords: Multi-span purlins with overlaps; Bolted moment connections; Lapped cold-formed steel Z sections; Combined bending and shear

1. Introduction

Cold-formed steel sections are lightweight building materials with high strength to self weight ratios, and they are suitable for building construction owing to their versatility in applications, and ease of fabrication and installation. In general, both cold-formed steel C sections and Z sections are widely used in building construction, and the section depths typically range from 100 to 350 mm while the section thicknesses typically range from 1.2 to 3.0 mm. Cold-formed steel sections with yield strengths at 280, 350 and 450 N/mm^2 are common while thin cold-formed steel profiled sheetings with high yield strength at 550 N/mm^2 are also readily available.

In general, design rules on section capacities and member resistances for cold-formed steel sections may be found in various codes of practice [1–4]. However, for connection design, only design rules on the load carrying capacities of individual fasteners are provided while little guidance may be found on the structural behaviour of bolted moment connections.

2. Modern roofs with cold-formed steel purlins

In single storey industrial buildings, and low to medium rise offices and warehouses, cold-formed steel sections are widely used as secondary structural members such as purlins to support roof cladding. Four different types of purlin systems may be found in modern roofs with different degrees of continuity:

(i) single span,
(ii) double span,
(iii) multi-span with sleeves, and
(iv) multi-span with overlaps.

The load carrying capacities of these purlin systems depend on many factors, such as steel grades, section shapes and sizes of purlin members, restraints provided by attached roof cladding and intermediate bracing members, and connection configurations at purlin–rafter supports. In practice, multi-span purlin systems with overlaps are the most popular owing to their high structural efficiency and simple installation of purlin–rafter connections. The general member arrangement of multi-span purlin systems with overlaps is illustrated in Fig. 1. Up to the presence, there is little technical guidance for engineers to assess the structural behaviour of bolted moment connections between cold-formed steel sections for general applications, in particular, of lapped sections in multi-span purlin systems. Design based purlin systems are often found to be very conservative with low market competitiveness. In fact, most modern roof systems with cold-formed steel purlins