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Nonlinear buckling analysis of 2-D cold-formed steel simple cross-aisle storage rack frames

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ABSTRACT

Industrial storage racks are among the most important structures made from cold-formed steel sections. They are widely used due to the increasing need for rational space utilization in warehouses, and other facilities used to store goods. Pallet rack is a material handling, storage aid system designed to store materials on pallets. Although there are many varieties of pallet racking, all types allow for the storage of palletized materials in horizontal rows with multiple levels. Rack systems are widely used in warehouses where they are loaded with valuable goods. The cold-formed steel columns usually have open cross-sections and are thin walled, making them vulnerable to torsional-flexural buckling and local buckling. The loss of goods may be greater than the total cost of the rack on which the goods are stored, which can indirectly affect the owner. Therefore, understanding the stability of rack structures is very important. This paper deals with numerical linear and nonlinear buckling analysis of 2-D cold-formed steel simple cross-aisle storage rack frames. The main focus of the study is to ascertain the stability of 2-D frames of a pallet racking system. With this objective, a pallet racking system with cold-formed steel sections is simulated by three-dimensional models using shell elements in ABAQUS, a general purpose finite element analysis software. Linear and nonlinear buckling analyses are carried out on these frames. Results are obtained from finite element analysis of frames with 12 types of column sections. Spacer bars and channel stiffeners are used to improve the torsional strength of original open cross sections. Results show that spacer bars and channel stiffeners are very effective in enhancing the strength of cold-formed steel pallet rack structures.

1. Introduction

The performance of 2-D frames of rack structure is very complex due to perforations in column sections and nature of the connections. The performance of storage rack structures depends on how the individual components, like beam column, braces perform uniquely with each other through a designed connection. The analysis and design of thin-walled structures with perforations in open upright cross sections gives many challenges to the structural engineers. Therefore, a thorough understanding of the structural behaviour of rack structures is very important. Presently, only a limited number of design standards, such as the BS EN-15512 [1], Australian code AS4084 [2], AISI [3], SEMA [4] and the specifications published by the RMI [5] provide some guidelines for the analysis and design of rack structures.

Ellifrit et al. [6] studied the flexural strength and deflections of discretely braced cold-formed steel channel and zee sections at the University of Florida. Typical channel and zee sections were tested in flexure with various types of bracing. The load was applied at the junction of web-top flange, i. e. not in the shear centre. Therefore, this is a case of the combined bending and torsion acting on an unbraced beam. However, the effect of torsion was not considered in the analytical modelling. Pi and Trahair [7] developed a finite element model for the nonlinear large-deflections and rotation analysis of beam-columns. Bogdan et al. [8] studied the buckling behaviour of cold formed steel (CFS) channel beams. The buckling test was carried out on simply supported unbraced CFS sections of two different cross sections. The lateral buckling test results showed that the CFS sections failed catastrophically by local and distortional buckling of most compressed elements of the cross section after large deformations. Schafer and Pekoz [9] focused on the performance of the compression flange and did not provide definitive evaluations of the design expressions for the web due to the incomplete restriction of the distortion mode, arrangement of the specimens back to back versus toe to toe, and a

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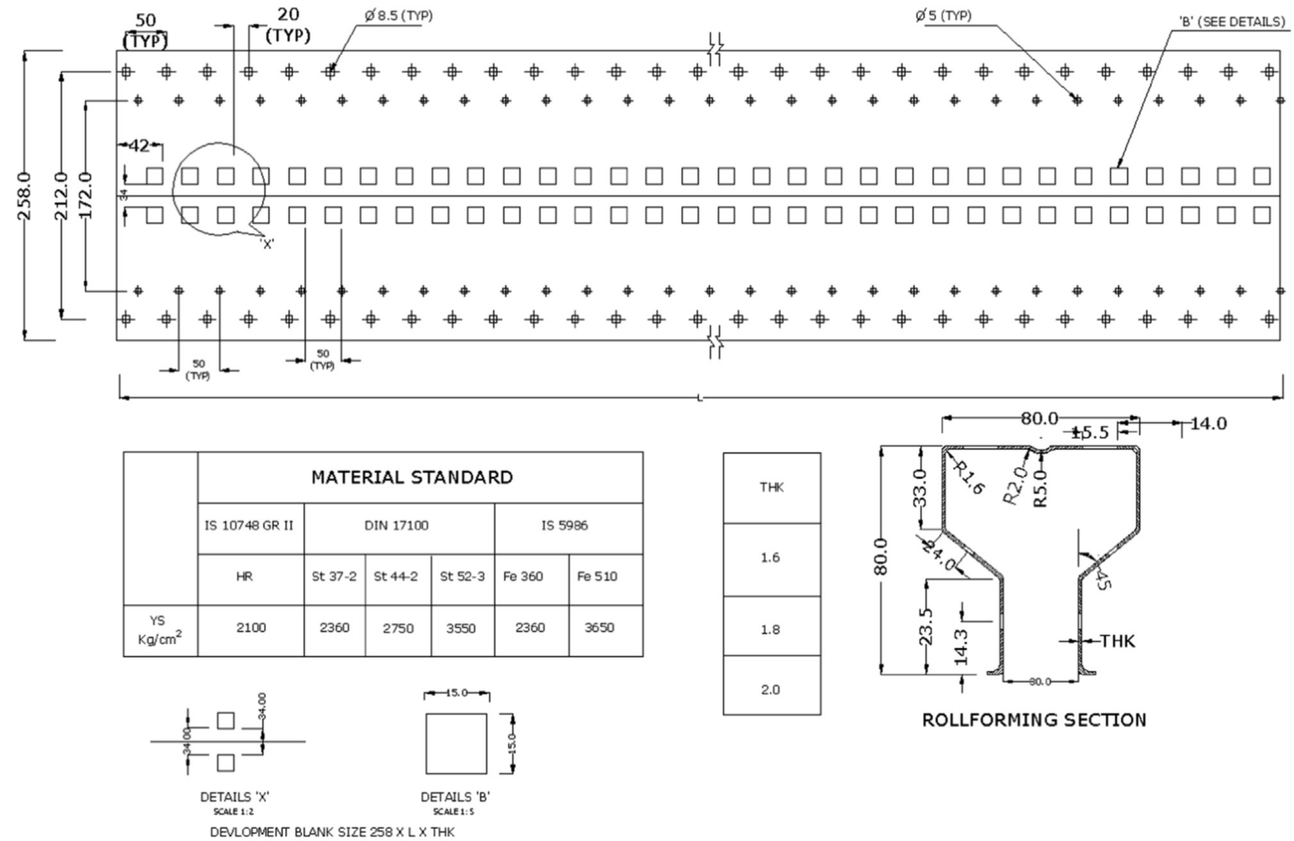
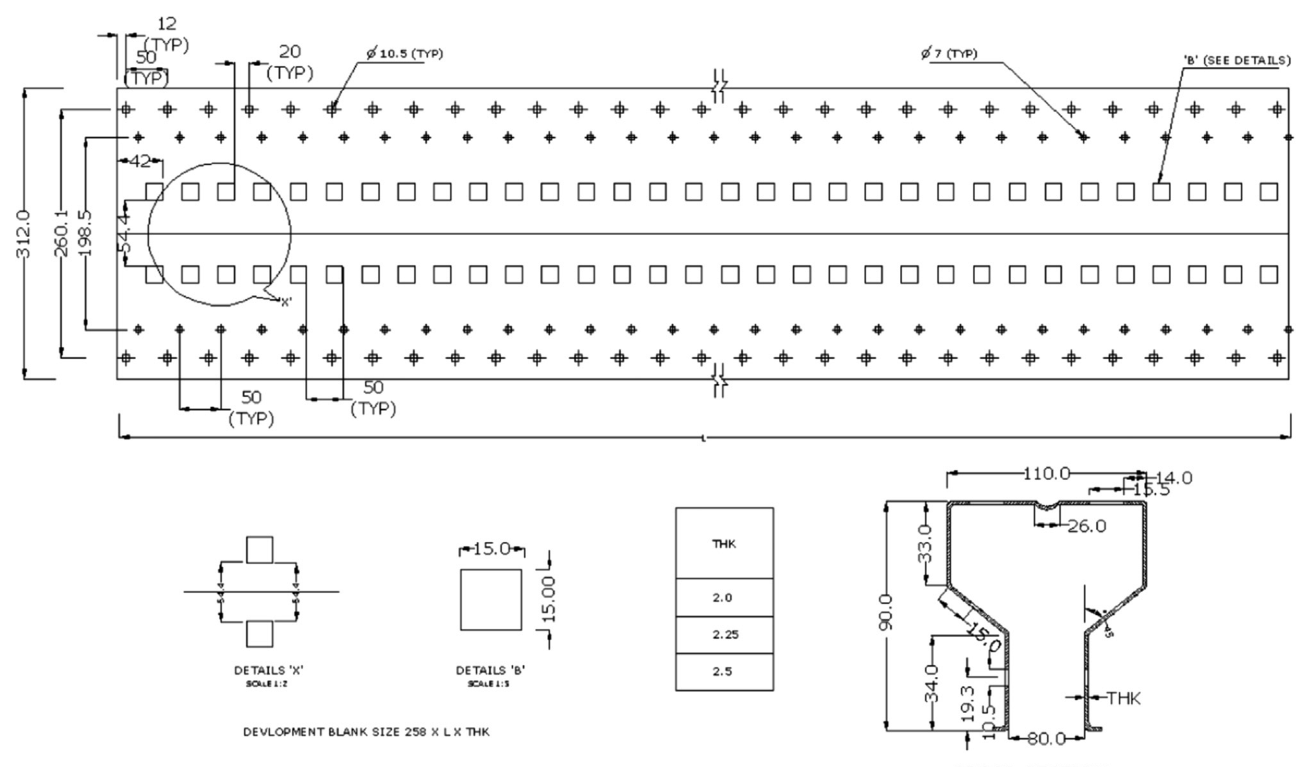


	MATERIAL STANDARD					
	IS 10748 GR II	DIN 17100			IS 5986	
	HR	St 37-2	St 44-2	St 52-3	Fe 360	Fe 510
YS Kg/cm^2	2100	2360	2750	3550	2360	3650

THK
1.6
1.8
2.0

Fig. 1. Medium weight column upright section 1.6 mm, 1.8 mm and 2.0 mm thick.



THK
2.0
2.25
2.5

Fig. 2. Heavy weight column upright section 2.0 mm, 2.25 mm and 2.5 mm thick.