Structural performance and design of cold formed steel Sigma sections

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The aim of the project is to develop a plastic design model for Sigma purlins with continuous/semi-continuous connections at internal supports and to improve the design method in EC3 for Sigma purlins partially restrained by sheeting.

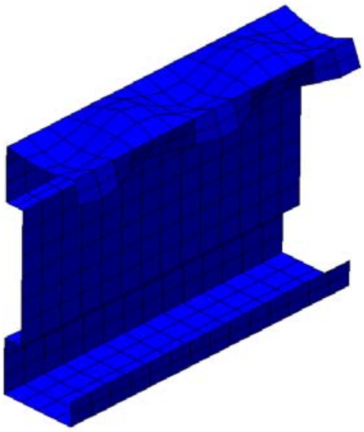
The objectives of this project include:

1) To study the moment-rotation relationship of Sigma sections at the internal support with both continuous and semi-continuous connections by conducting extensive range of experiments.
2) To develop FEM-based models for continuous/semi-continuous purlins and the purlin-sheeting system.
3) To investigate the ductility and the plastic support moment resistance of Sigma sections with the aim of developing a simple plastic design method.
4) To characterize the effect of sheeting on Sigma purlins under both gravity and uplift loading and therefore to improve the design method for sheeted purlins in Eurocode 3.

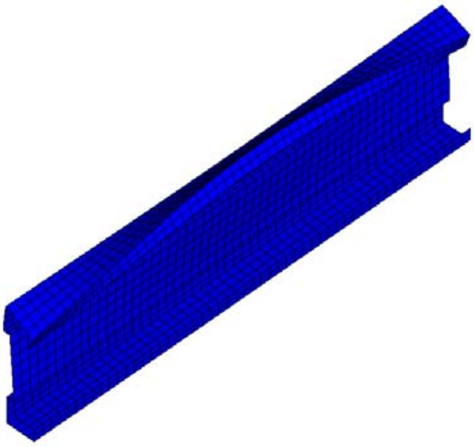
Background

Plastic design method has been deemed as a more economic design method for continuous and semi-continuous (sleeved) purlins. It is only applicable for the case where plastic hinges can be developed and hence moment redistribution may take place. To accommodate the moment redistribution, sufficient rotational capacity at the plastic hinge point is requisite. In the case of hot-rolled section, the rotational capacity has not been a concern due to the high ductility of steel materials. However, for light-gauge cold-formed steel sections, local buckling (see Fig.1 a), distortional buckling (see Fig.1 b) and lateral torsional buckling (see Fig.1 c) will lead to an unstable post-failure behavior and therefore the ultimate failure load can not be used as plastic moment resistance. The actual plastic moment resistance needs to be studied.

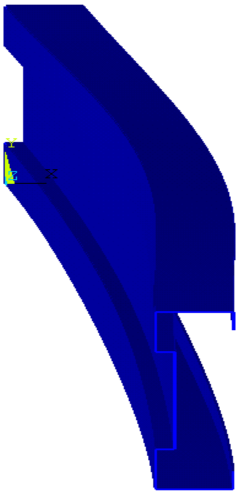
In practice, purlins are normally laterally restrained by roof sheeting in service states. The interaction between purlins and sheeting is a very complicated topic. Literature review indicates that very little research has been carried out on the structural performance of Sigma purlins partially restrained by sheeting. More thorough investigations are therefore required to characterize the Sigma purlin-sheeting system in different loading cases.



(a) Local buckling mode



(b) Distortional buckling mode



(c) Lateral torsional buckling mode

Figure 1 Typical buckling modes for a Sigma section under bending

Methodology

The project is to focus on the investigation of the structural performance of Sigma steel sections with/without sheeting by using experimental and numerical methods. A series of samples will be tested, from which the loading-deflection and moment-rotation relationship will be established and the ultimate failure modes and associated loads will be identified. This will be followed by a thorough numerical analysis (FEA) through which testing results will be reproduced. Results through both studies will lead to a rational design model which can be readily adopted by engineering practitioners.

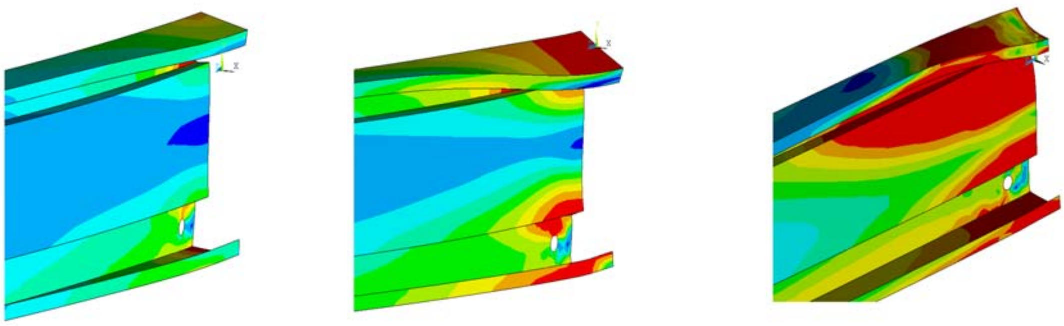
Figure 2 Material strength test

Figure 3 Internal support test

(a) Loading case: gravity load (b) Loading case: uplift load

Figure 4 sheeted purlin test

At present, material strength tests, internal support tests and purlin/sheeting interaction tests had been completed (see Fig.2 to 4) and the structural performances of both single purlins with internal supports and purlin/sheeting system have been preliminarily investigated. A FEM-based numerical model has also been developed and can be adopted to predict the structural behavior of Sigma sections with internal support (see Fig. 5).



(a) Pre-buckling stage (b) At peak load (c) Post failure stage

Figure 5 Deformations predicted by the developed numerical model for a tested sample at internal support

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