Investigation of distortional buckling of cold-formed steel sections

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Aims and Objectives

Thin-walled, cold-formed steel sections are widely used in buildings as sheeting, decking, purlins, rails, mezzanine floor beams, lattice beams, wall studs, storage racking and shelving. Among these products, roof purlins and cladding rails have been considered to be the most popular products and account for a substantial proportion of cold-formed steel usage in buildings.

With the increasing use of high strength steels it is inevitable to reduce the thickness of the section. Based on the strength design criterion, the cold-formed steel member can have a very thin thickness. However, the thinner the section, the easier the member can buckle. Efforts have been made to increase the buckling resistance by designing sections that have intermediate folds in the flange and/or in the web. The use of intermediate folds can increase the critical stress of local buckling, but it is questionable whether it can also increase the critical stress of distortional buckling.

The purpose of this research is to investigate the distortional buckling behaviour of cold-formed steel sections using both analytical (closed-form solutions) and numerical methods (finite element methods). The individual measurable objectives are listed below:

- Investigate the distortional buckling behaviour of cold-formed steel sections subjected to pure bending.
- Investigate the distortional buckling behaviour of cold-formed steel sections subjected to transverse uniform loading.
- Investigate the post-distortional buckling behaviour of cold-formed steel sections subjected to pure bending.
- Investigate the post-distortional buckling behaviour of cold-formed steel sections subjected to transverse uniform loading.
- Investigate the interaction between local and distortional buckling of cold-formed steel sections subjected to pure bending.
- Investigate the interaction between local and distortional buckling of cold-formed steel sections subjected to transverse uniform loading.

Background

Local, distortional and lateral-torsional bucklings are three different types of buckling (see Fig.1.) which a cold-formed steel member may occur. Compared to the local and lateral-torsional buckling, the distortional buckling is a relatively new concept, has a very short history and occurs only in cold-formed steel sections. Although there has been substantial research work published literature on distortional buckling of various section members, there are still some problems which are not fully understood and need be investigated, particularly in the following aspects:

1. The importance of the distortional buckling is not generally recognized. This is partly because the distortional buckling was not addressed in existing BS5950-Part 5 for cold-formed steel sections design and partly because most sectional profiles made by the UK manufacturers were designed based on old steel grade (S275) for which the section failure is dominated by the local buckling and/or material yield. However, with significantly improved steel grade in recent years, the cold-formed steel yield strength can now reach to 550 MPa. This leads the distortional buckling to be as critical as the local buckling.

2. The distortional buckling has been addressed in recently published EN 1993-1-3, but it is only for channel and zed sections. Also the design formula provided in the codes is too complicated and involves too many parameters although the model used for calculating the critical stress of distortional buckling itself is very simple. This makes it difficult to apply and modify the codes to other types of sections, for instance, the sigma section which is also widely used in industries.

3. There are very limited research results on the interaction between the distortional buckling and other failure modes such as local buckling, lateral torsional buckling and material yield (see Fig.2.). How the interaction affecting the design load is a topic which need be investigated for various types of sections.

4. The current research on distortional buckling focuses on cold-formed steel sections themselves. However, in practice, most sections are used to support the roof or wall sheeting which will provide lateral restraints to the sections. There are experimental evidences that showed the influences of the sheeting on the local, distortional and lateral-torsional buckling are different. The restraints of sheeting lead the section to be different in distortional buckling for gravity and uplift loads. The latter has never been addressed in literature.

The present study will address some of the above problems. By using numerical methods (finite element methods and finite strip methods) the distortional buckling problems of zed and sigma sections will be investigated. Interaction of distortional buckling with other failure modes will also be studied. Influence of sheeting on the distortional buckling of restrained flange and free flange will also be examined.

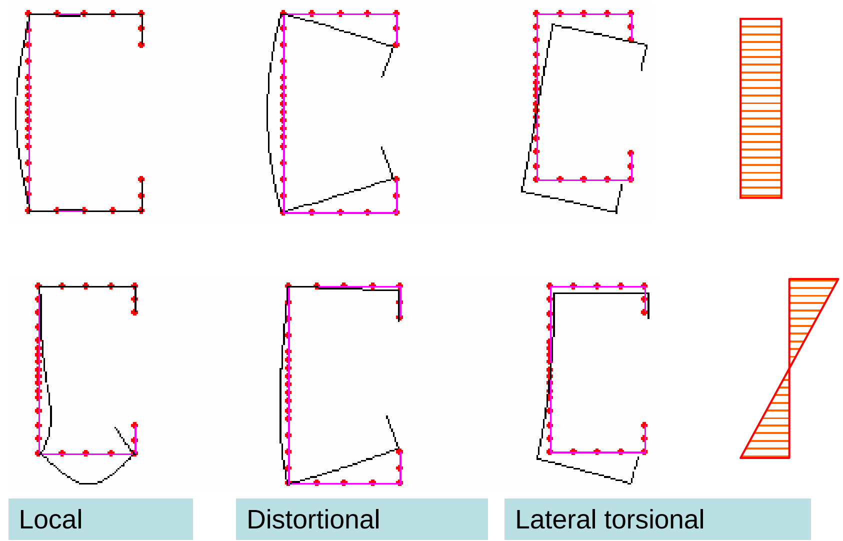

Figure 1. Three bucking types subjected to compression and bending.

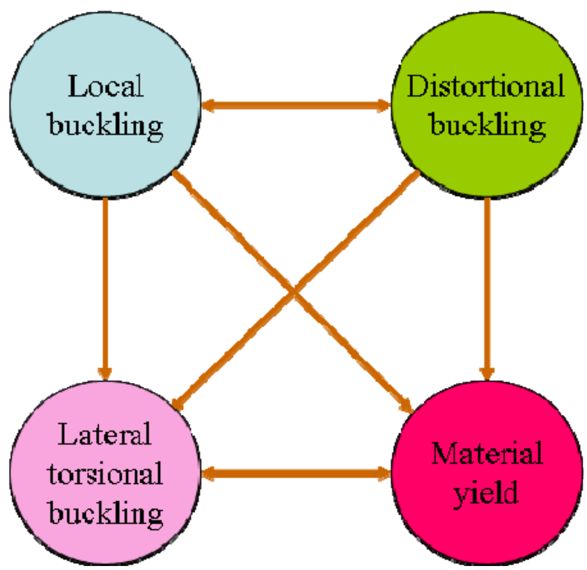

Figure 2. Interaction between different buckling and failure modes.