

Optimal Cross Sections for Cold Formed Steel Members under Compression

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Abstract

Cold formed steel has many advantages over other construction materials. CFS members are lightweight. They weigh up to 35-50% less than their wood counterparts. High strength and stiffness to weight ratio is another advantage. This makes CFS members economical and the same time very easy to erect and install (almost no framework is needed). CFS is very durable, is not combustible, is easy to transport and handle, and can be easily recycled. One of the most desirable features of CFS members, however, is that they may be shaped (cold-bent) to nearly any open cross section. This allows for the use of formal optimization strategies to find optimal shapes for the members' cross sections.

Cold-formed steel members are usually thin-walled and have open cross sections. They are therefore prone to local, distortional, and global (Euler) buckling. The goal of this work is to examine the role of boundary conditions on optimal column cross sections, i.e. cross sections that maximize compressive capacity of a column with a given length, coil width, and sheet thickness. In addition, we discuss the choice of longitudinal basis functions in the context of Finite Strip Method (FSM), the computational strategy used to explore different instability modes of a given cross section. As far as the optimization algorithm is concerned, the available options are: algorithms based on formal mathematical programming or those that are based-on principles of stochastic search. Gradient descent based solutions are highly sensitive to the initial design, but lead to more practical cross sections (e.g. symmetrical). The stochastic search algorithms, on the other hand, are computationally expensive but do a better job in exploring the design space while being relatively insensitive to the initial design. In this paper we choose a somewhat hybrid approach. We first start exploring the design space via a stochastic search algorithm. To arrive at practical designs we put constraints on the geometrical properties of the optimal cross section. We finally refine the near-optimal folding of the cross section through a few steps of the gradient descent optimization.