

**Stress-Strain Behaviour of Cold-Worked Materials in Cold-Formed
Stainless Steel Sections**

by

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Abstract

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The forming process of cold-formed steel sections induces cold work in structural members, and such cold work can enhance the strength but reduce the ductility of materials. The enhanced strength of cold-worked materials, e.g. corner materials (materials in the corner region of cold-formed sections) and flat materials (materials in the flat portion of cold-formed sections), has been traditionally determined using semi-empirical equations. These semi-empirical models for the cold-worked materials are only applicable to the prediction of the enhanced yield strength (or 0.2% proof stress), but are neither capable of predicting the stress-strain behaviour nor able to account for the difference in the mechanical behaviour of the cold-worked materials under tension and compression. To overcome these limitations, a simple finite element approach has been previously developed and presented elsewhere (Qiu 2008) by the author to predict the initial stress-strain behaviour of cold-worked materials. This simple finite element approach is employed in the present study to examine the effect of forming parameters and testing setup on the initial stress-strain behaviour of cold-worked materials. Numerical results of this parametric study are presented in the thesis.

The accurate prediction of the reduced ductility of cold-worked materials is not yet available. In order to enable the prediction of the reduced ductility, an advanced finite element approach is then proposed in the present study for predicting the full-range stress-strain behaviour of cold-worked materials (including both corner materials and flat materials) in cold-formed stainless steel sections. Thus, the proposed advanced

method can predict not only the enhanced strength but also the reduced ductility of cold-worked materials. In this method, the effect of cold work on the stress-strain behaviour of cold-worked materials is accounted for by means of a numerical simulation of the forming of cold-formed steel sections, with the resulting residual stresses and equivalent plastic strains specified as the initial state in subsequent finite element simulations of coupon tests. The necking of thin sheet metals is also taken into account in the finite element simulation of coupon tests, in order to quantify the ductility.

Under uni-axial tensile loading in coupon tests, diffuse necking occurs in a thin sheet coupon when ultimate stress is reached. The diffuse necking spreads over a length of the order of the width. At the end of the diffuse necking, localized necking starts to develop over a length of the order of the sheet thickness and rapidly leads to fracture. As the nominal strain at the onset of localized necking is close to the nominal strain at fracture, the ductility of thin sheet metals including cold-worked materials can be characterized by the strain at the onset of localized necking in the present study.

In this study, an experimental investigation on the stress-strain behaviour of corner materials was also carried out to verify the accuracy of the proposed finite element approach. A series of uni-axial tensile tests on both flat materials and corner materials were performed. Three different testing methods (i.e. 1) single corner-coupon tests, 2) twin corner-coupon tests with larger eccentricity, and 3) twin corner-coupon tests with smaller eccentricity) for the stress-strain behaviour of corner coupons were examined for their validity. A series of stub column tests on cold-formed channel sections were also performed to examine the enhanced cross-sectional strength due to cold work.

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