Numerical prediction of residual stresses distribution in thin-walled press-braked stainless steel sections

ABSTRACT

Stainless steels are increasingly used in construction today, especially in harsh environments, in which steel corrosion commonly occurs. Cold-formed stainless steel structures are currently increasing in popularity because of its efficiency in load-bearing capacity and its appealing architectural appearance. Cold-rolling and press-braking are the cold-working processes used in the forming of stainless steel sections. Press braking can produce large cross-sections from thin to thick-walled sections compared to cold-rolling. Cold-forming in press-braked sections significantly affect member behaviour and joints; therefore, they have attained great attention from many researchers to initiate investigations on those effects. This paper examines the behaviour of residual stress distribution of stainless steel press-braked sections by implementing three-dimensional finite element (3D-FE) technique. The study proposed a full finite element procedure to predict the residual stresses starting from coiling-uncoiling to press-braking. This work considered material anisotropy to examine its effect on the residual stress distribution. The technique adopted was compared with different finite element techniques in the literature. This study also provided a parametric study for three corner radius-to-thickness ratios looking at the through-thickness residual stress distribution of four stainless steels (i.e., ferritic, austenitic, duplex, lean duplex) in which have their own chemical composition. In conclusion, the comparison showed that the adopted technique provides a detailed prediction of residual stress distribution. The influence of geometrical aspects is more pronounced than the material properties. Neglecting the material anisotropy shows higher shifting in the neutral axis. The parametric study showed that all stainless steel types have the same stress through-thickness distribution. Moreover, R/t ratios' effect is insignificant in all transverse residual stress distributions, but a slight change to R/t ratios can affect the longitudinal residual stress distribution.

Keyword: Stainless steel; Finite element; 3D-FE; 2D-FE; Residual stress; Compressive stress; Tensile stress