ABSTRACT

Cold-formed steel sections are predominantly used in modern steel construction, because of their high strength to weight ratio. The main objective of this study is to investigate the behaviour of cold-formed steel plain channel sections subjected to axial and eccentric compression. Four different slenderness ratios were considered for plain channel sections with six cross sections. The effect of eccentricity on the load carrying capacity was studied theoretically, analytically and also experimentally.

In the first phase, experimental investigations were carried out to study the behaviour of cold-formed steel plain channels. Two cross sections of size CFC 150x50x2 mm and CFC 200x50x2 mm were chosen for the study with a slenderness ratio of 40. The end conditions of the columns were chosen as fixed- fixed. The eccentricity chosen were 40 mm on the positive and 40mm on negative axis. Five tests were conducted and validated with the numerical study. All the specimens were tested until their failure. The effect of slenderness ratio, the effect of flat width to thickness ratio and the effect of eccentricity on the load carrying capacity were studied. The load versus axial shortening behaviour, the load versus strain behaviour and the load versus lateral deflection behaviour under the elastic as well as in the plastic ranges of loading were studied. The ultimate load carrying capacity of axially loaded plain channel obtained from tests was found to be twice compared to the section loaded with 40mm positive eccentricity. The initial stiffness decreased
drastically for specimens with slenderness ratio 40 and beyond this slenderness ratio up to 120 the drop in initial stiffness was marginal. For the concentrically loaded specimens, the contribution of web element to the load carrying capacity was nine times higher than that of eccentrically loaded specimens. Specimens loaded through centroid and through positive eccentricity, failed due to interaction of flexural and local buckling. It was also observed that in the case of eccentrically loaded specimens the local buckling occurred in the flanges only.

In the second phase, the provisions prescribed in the various International codes of practice were reviewed and the experimental results were compared with the codal predictions. The standards included, were the Indian Standard code of practice for use of Cold-formed Light Gauge Steel structural member: IS 801 – 2005, the British Code of practice for Design of Cold-formed sections: BS5950 (Part-5) – 2002, the North American Standard for Cold-formed Steel Design Manual: NAS Manual – 2007. The provisions included were the effect of cold-forming, effect of buckling coefficient, uniform and non uniform compression and the concentric and eccentric load carrying capacity. The load carrying capacity obtained from the experimental investigations was also compared with the loads predicted by the different codes of practice.

In the third phase, numerical investigations were carried out by using a commercial finite element analysis code, ABAQUS. The thin shell element was used and the mesh used in the model was investigated by varying the size of the elements. The final finite element mesh chosen was arrived at
after conducting a series of studies to satisfy the convergence criteria. The element meshes were refined until the acceptable converged solution was obtained. The scaled value of linear buckling mode shape was used to create an initial geometric imperfection for the non-linear post buckling analysis. The degree of imperfection was assumed as the maximum amplitude of the buckling mode shape and considered as a percentage of the element’s thickness. Geometric imperfections were sorted into two categories namely maximum local imperfection in a stiffened element and maximum deviation from straightness in an unstiffened flange. The material nonlinearity was included by specifying the true values of stresses and strains and the geometric imperfections were included by using a linear perturbation analysis. The displacement control loading method was used which was identical to the loading method used in the tests. For each incremental step of axial-shortening, the total load or reaction at the end was obtained. Deformation patterns and stress contours obtained from ABAQUS were compared with the experimental results. The numerical model developed using ABAQUS to predict the behaviour of the plain channels under axial and eccentric loading with different slenderness ratios was found to stimulate the behaviour very closely.

Based on the experimental, the theoretical and the analytical investigations conducted on cold-formed steel plain channels subjected to axial and eccentric loading, the effect of slenderness ratio, the effect of eccentricity and the effect of flat width to thickness ratio on the load carrying capacity were established.