# Elastic and Plastic Buckling of Steel Arches under In-plane Loadings

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**Abstract**. The paper studies the buckling behaviour of steel arches under vertical in-plane loadings. The arches have uniform rectangular sections and their shapes are defined by various mathematical functions. The shapes of some of these arches are frequently encountered in bridge or other ancient constructions built with masonry materials. The study includes the effect of change in height-to-span ratios for the range (0.01, 0.5), with a constant span and fixed end-supports. The stability analyses include both linear and nonlinear steel materials. For the box section under study and for most of the designed sections in arch bridges, plastic buckling could occur earlier than elastic buckling. The studies show that the buckling behaviour of the arch varies with its shape. The results indicate that each arch type should be utilized in a dedicated particular situation for the optimization of the structure.

**Keywords.** steel arches; stability of arches; in-plane buckling; elastic-plastic buckling;

**1. Introduction.** The linear and nonlinear buckling of the circular arches are studied under various support and other geometric conditions. In this section a summary of the results of previous research carried out in this regard is given. Timoshenko and Gere (1961), studied the elastic buckling behaviour of the arches. Schreyer and Masur (1996) obtained the elastic buckling loads and curves resulted from loads for arches. Their research produced exact solutions for shallow circular arches having a rectangular section. They studied buckling of the arches under concentrated, symmetrical and asymmetrical loadings. The arch resists the loading by combining axial compression and bending effects. These combined actions have been studied by Pi and Bradford (1996) by non-elastic analysis. They have, also studied in-plane plastic buckling of steel arches with I-sections. They also studied the effect of the initial defects and imperfections, height-to-span ratio, residual stresses, plastic stability of steel plane arches. Pi and Trahair (1998), studied the nonlinear buckling and post-buckling behaviour of arches with I-sections. Also, Pi and Bradford (2002) studied symmetrical and asymmetrical plastic buckling of shallow arches with various sections. Furthermore, they indicated that the classic buckling theory correctly anticipates plane asymmetrical bifurcation buckling load in non-shallow arches, but it overestimates the plane symmetrical bifurcation buckling load of shallow arches.

An analytical study on the arches with elastic supports has been provided by Pi and Bradford (2006). They proposed solutions for asymmetrical bifurcation of arches using a virtual work formula and found that elastic supports had a serious effect on the buckling load of the arches. These studies are mostly restricted to I-sections and a uniformly distributed radial loading. In the mean time, some criteria have also been provided to estimate of the non-linear behaviour of arches and a formula has been suggested for the estimation of non-linear buckling loading. Furthermore, the effects of different factors such as initial imperfections, the height to span ratio and boundary conditions on the strength of arches have been studied.

Dimopoulos and Ganete (2007), carried out research on the elastic and plastic behaviour of arches with a circular section, and the authors studied the effect of design parameters such as boundary conditions, height-to-span ratio, on their strength of the structure. They also, studied the effect of