Ultimate load of cylindrically curved panels under uniform compression at straight edge and the influence of curvature

Hui Guo[1, 2], Zhibin Zeng[1, 2], Xiaoguang Liu[1, 2], Xiaochen Ju[1, 2], Xinxin Zhao[1, 2]

[1]*Railway Engineering Research Institute, China Academy of Railway Sciences, Beijing, China*

[2]*State Key Laboratory for Track Technology of High-speed Railway, Beijing, China*

Contact: superhugo@163.com

Abstract

Curved panels are widely used in modern novel steel bridges and buildings. Stability shall be considered for these structures under compressive loads. While it still has many challenges on how to consider stability since there are no guidelines in specifications. In this paper, ultimate load of the cylindrically curved panels were studied. First, accuracy of numerical model was verified by theory and model test. Then the influence of curvature on ultimate load at the straight edge of curved panel was studied. Results showed that the deformation of curved panel was obvious in the direction perpendicular to the panel. The position of maximum deformation was located near the central region and perpendicular to the curved panel. Ultimate load of curved panel is smaller than the straight one. And the ultimate load decreases as the curvature increases with a linear relationship between the reduction factor of local stability and the curvature.

Keywords: curved panel; stability; steel pylon of cable-stayed bridge; elasto-plastic buckling; full-scale model test; ultimate load; curvature; reduction factor; empirical formula.

1 Introduction

Curved panels have been used widely in steel bridges and buildings, etc. Stability design of those structures often encounters difficulty by a lack of specifications. Research on stability of curved panels mainly deals with the axial or external compression of cylindrically curved panels or shells, as shown in Figure 1a and 1b. Tran et al. carried out series of numerical simulations to study the characteristics of curved panels' elasto-plastic behavior and derived the semi-empirical formulae for predicting the elastic buckling and ultimate strength[1]. It appeared that the behavior of cylindrically curved panels usually depended on its curvature, its slenderness and its imperfection[1]. Martins et al. also studied the ultimate load of simply supported cylindrically curved panels subjected to pure compression and in-plane bending by numerical method. Results showed that the ultimate behavior of cylindrically curved panels was similar to flat plates (similar ρ-$\overline{\lambda}$ curves) [2]. Xu et al. derived approximate solutions by shallow shell theory and Galerkin method for buckling stress of curved web plate of a steel bridge under wheel compression. Solutions of straight plate as the special case were then proved to be reasonable compared to the calculated value from Japan's structural stability handbook[3]. Research group from Institute of Mechanics, China Academy of Sciences had carried out theoretical study and test on buckling of stiffened cylindrical shells under external pressure. Model tests for stiffened cylindrical shells subjected to external pressure by gas cell were conducted and it

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