ABAQUS FE software. The shear behavior, shear resistance and failure mechanism of the two mentioned cases were calculated and compared with each other. In addition, the effects of the placement of girders in bridges, and the interaction of secondary components, such as cross-frames on the behavior of the curved girders were investigated. Results demonstrated that the shear behavior, ultimate shear resistance and shear buckling resistance of the single-girders and the bridge system are similar; whereas the initial stiffness of two approaches differs. Furthermore, the equivalent single girders are not capable of predicting the correct mechanism of the shear failure in some panels of the interior girders in the bridge system because of neglecting the vertical stiffness of the cross-frames and the interaction of girders.

In this study, the effect of the geometric imperfection on the shear behavior of I-girders with different radius of curvature is studied and the results showed that the imperfection has insignificant effect on the ultimate shear resistance of the curved I-girders; whereas the ultimate shear resistance of the straight I-girders reduces by increase of the imperfection magnitudes. The AASHTO provisions do not require the consideration of the geometric imperfection on the ultimate shear resistance of I-girders.

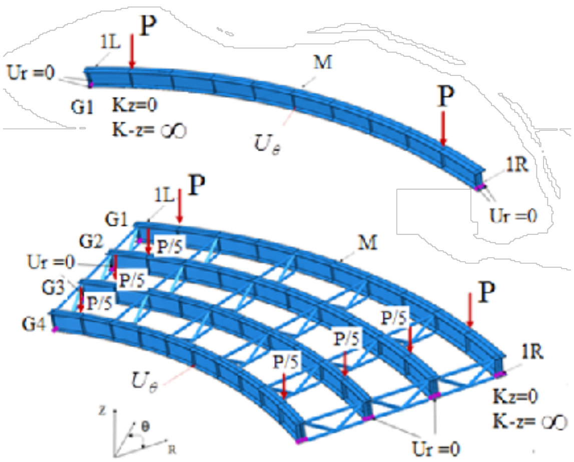

Figure 1. FE modelling of curved I-girders

3- Conclusions

- The shear behavior, ultimate shear resistance and shear buckling resistance of the curved I-girders in the bridge system and the equivalent single girders are similar. Thus, single-girders can be utilized to investigate the effect of the various parameters such as geometric imperfection on them.
- The elastic stiffness of the bridge system and the equivalent single girders are different. The reason is the method of simulating the cross-frames in the single-girders. Cross-frames are simulated as radial restraints. Such simulation does not represent the true radial and vertical stiffness of cross-frames. Thus, it is recommended to simulate the cross-frames with a combination of thee linear and nonlinear springs. Such a procedure has its own complications, and needs further investigations.
- Equivalent single girders are not capable of predicting the correct mechanism of the shear failure in some panels of the interior girders in the bridge system because of neglecting the vertical stiffness of the cross-frames and the interaction of girders in the single girders.
- Given a specified geometric imperfection pattern, the ultimate shear resistance of the curved I-girders are insensitive; whereas the ultimate shear resistance of the straight I-girders reduces with increasing of the imperfection magnitudes. The AASHTO provisions do not require the consideration of geometric imperfection on the ultimate shear resistance of I-girders.
- The AASHTO provisions limits the to the 0.1. In this investigation I-girders having is studied which results that there is no difference in the shear failure and shear behavior of them.

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The Shear Loading Capacity and Behavior of Horizontally Curved Steel I-girder Bridges, and the Imperfection Effect

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ABSTRACT: In this study, horizontally curved steel I-girder bridges having various radii of curvatures in practical dimensions, and designed via the AASHTO standards are modeled and analyzed via the finite element software ABAQUS. The aim of these material-geometric non-linear analyses are to characterize the shear behavior, the shear failure mechanism and the shear resistance of steel I-girders in the complete bridge systems and in their equivalent single girders. Results demonstrated that the shear behavior, the ultimate shear resistance, the shear buckling resistance of single-girders and bridge system are similar; whereas the initial stiffness of the two approaches differ. Furthermore, the equivalent single-girders are incapable of predicting the correct mechanism of the shear failure in some interior panels of the bridge system; due to the negligencs of the true horizontal and vertical stiffness of cross-frames, and also due to the interaction of girders. In addition, it is shown that under a specified geometric imperfection pattern, the ultimate shear resistance of curved I-girders is insensitive to the imperfection magnitudes; whereas, the ultimate shear resistance of straight I-girders reduces with the increase of imperfection magnitudes. The AASHTO provisions however, do not require the consideration of geometric imperfections on the ultimate shear resistance of I-girders.

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1- Introduction

Due to the need to augment traffic capacity in the urban highways and the constraints of existing land use, there has been a steady increase in the use of curved bridges in the past 25 years. In many cases, these bridges are located in on- and off-ramps with very tight radii of curvature and are characterized by complex vertical and horizontal geometries. For this application, curved steel girders are the preferred choice because of the simplicity of fabrication and construction, speed of erection and serviceability performance. Although the horizontally curved steel bridges constitute roughly one-third of all steel bridges being erected today, their structural behavior is not well-understood [1].

Because of their inherent three-dimensional response, the analysis, design and construction of the horizontally curved steel I-girder bridges are quite challenging. Due to the horizontal curvature, the bridge and its component members are subjected to coupled torsion and bending. Furthermore, due to the horizontal curvature, horizontal deflections and reactions can be important in addition to the vertical deflections and reactions. The interaction among the curved girders in the bridge cross-section is typically larger than among the straight bridges without skewed supports [2].

Primary studies on the curved bridges started with a project called CURT in 1960's in the USA [3]. This project led to the publication of "AASHTO Guide Specifications for Horizontally Curved Highway Bridges" [4]. In Japan, widespread researches were performed on curved steel bridges. Results of those investigations were published as guidelines for the design of the horizontally curved girder bridges by Hanshin expressway public corporation and steel structure study committee in 1988 [5]. Later in 1992 Federal Highway Administration (FHWA) started vast researches on the behavior of steel bridges and their components. The main purpose of that project called CSBRP was a fundamental study on the behavior of curved girders using real dimension experiments of the bridge systems [3]. Using the results obtained from the above-mentioned investigations, AASHTO LRFD Bridge Design Specifications was published [6].

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2- Methodology, Results and Discussion

Due to the high slenderness of webs, they buckle at early stages of the loading. Therefore, one important design aspect of the girders is the shear behavior, shear buckling and shear failure of the web elements of the curved I-girders.

This nonlinear FE parametric study investigate: (1) the shear failure mechanism, loading capacity and the shear behavior of the curved steel I-girders in the two cases of complete bridge systems and their equivalent single-girders and, (2) Effect of the geometric imperfection on the ultimate shear resistance of the curved and straight I-girders.

Dimensions of the curved girders and the features of the parametric study were set with respect to a base bridge system designed via the AASHTO Specifications. Figure 1 illustrates the overall FE modeling of the curved I-girders.

Curved girders were analyzed in two cases of the bridge systems and their equivalent single girders using the