Finite Element Model Updating Using GA and Static Data for Studying Joints Behavior in Double Layer Grid

Mohammad Reza Davoodi[1], Amin Mostafavian[2]

1- Assistant professor, Faculty of civil engineering, Babol University of Technology
2- PhD student, Faculty of civil engineering, Babol University of Technology

a.mostafavian@stu.nit.ac.ir

Abstract

Double layer grids are one of the most popular types of precast space structures that are assembled and erected in construction site using bolted joint systems. If joints behavior was not considered in analytical model of these structures, there would be considerable discrepancy between analytical and experimental results. In order to predict more accurate analytical responses, joint behavior must be considered in the analysis. In the present work, with the aim of studying the behavior of the ball joint system that was utilized in construction of a double layer grid, the method of inverse problem and in particular indirect finite element model updating technique has been used. An appropriate finite element model capable of modeling joints behavior was build for a double layer grid that the results of its static displacement measurements were available. An optimization problem is defined in which the objective function contains difference between experimental and analytical responses of the double layer grid, and using the genetic algorithm this objective function was minimized. Consequently an approximation of the joint behavior that has been considered as optimization variable was obtained. The obtained results show a very good correlation between responses of the updated model and experimental responses. Also, obtained relationship for the behavior of ball joint system shows a nonlinear behavior with two specific zones, including initial lack of fit zone and then ideal behavior zone.

Keywords: Model updating, Genetic algorithm, Double layer grid, Ball joint system

1. INTRODUCTION

One type of space structures that are widely used in civil engineering constructions are double layer grids. Previous studies show that a considerable difference exists between experimental and analytical responses of the grids resulting from neglecting the joint effects in analysis [1, 2, 3]. Since in double layer grids axial force is the main internal force and non-axial effects have secondary significance [4], in order to consider joint behavior in analysis, the axial force-displacement relationship of joint should be determined. To achieve better analytical responses for structure, Ghasemi et al. [5] obtained experimental force-displacement relationship of the ball joint system that was used in [2]. While the relationship is linear in the beginning of loading, the joint stiffness will be reduced when some of its components yield, and the relationship will be nonlinear after that. They utilized the experimentally obtained force-displacement relationship of joint in analytical model of a double layer grid that its actual responses were on hand. Their studies showed that the analysis of grid considering joint effects yield better approximation of actual behavior (experimental responses) of the grid. However, considerable discrepancy exists between analytical and experimental deflections of the grid and overall form of load-deflection curves are different too. The cause of this inconsistency in the analytical and experimental behavior of the grid is related to the difference between actual behavior of joint when it is used in a structure and its behavior when it is separated and detached from the structure. This difference in joint behavior is due to some uncertainties that will develop during assembly of the structure, such as initial lack of fit of the joints and different degrees of bolt tightness in the joints.

Considering the above mentioned uncertainties, the experimental force-displacement relationship of an individual and separate joint do not represent the actual behavior of joint as in the structure and this relationship must be obtained from study of the whole structure. To do so, the finite element model of double layer grid can be adjusted through a Finite Element Model Updating (FEMU) technique. Chuna et al. [6] identified the rotational and translational stiffness of bolted beam-to-column joints by using model updating technique. The test structure consisted of a beam and a column made from GFRP pultruded profiles. Türker et al. [7] investigated semi-rigid connections in steel structures using two columns and a 2D frame. Members welded directly together and semi-rigidity of connections was modeled using linear elastic springs in finite element model used for updating. Wu and Li [8] identified various parameters, including Young's modulus,