Optimum Shape Design of Double-Layer Grids by Particle Swarm Optimization Using Neural Networks

S. Gholizadeh[1], P. Torkzadeh[2], S. Jabbarzadeh[3]
1- Assistant Prof. of Civil Engineering Department, Urmia University, Urmia, Iran
2- Assistant Prof. of Civil Engineering Department, University of Kerman, Kerman, Iran
3- M.S. Student of Kerman Graduate University of Technology, Kerman, Iran

torkzadeh@mail.uk.ac.ir

Abstract

In this paper, an efficient method is proposed for optimum shape design of double-layer grids. In optimization process, the weight of structure is considered as objective function. The design variables are the number of spans divisions of grid in two directions, the height of between two layers and the cross sectional area of elements. The design constraints are considered as limitations of the stress and slenderness of elements and the displacement requirements of joints. The optimization is carried out by particle swarm algorithm that is suitable for discrete and continuous variables. To reduce the computational time of optimization process, the structural responses are predicted using properly trained radial basis function neural network. This network is a robust network for predicting the structural responses. The numerical results demonstrate the robustness and high performance of the suggested method for the optimum shape design of double-layer grids in.

Keywords: Optimum shape design, Double-layer grid, Particle swarm optimization, Neural network, Radial basis function.

1. INTRODUCTION

Space structures belong to special category of three dimensional structures with special forms. The most important kind of these structures are double layer grids, domes and barrel vaults [1]. These structures are widely used to cover large areas without intermediate columns such as hangars, supermarkets, stadiums, etc. Double-layer grids are one of the most popular types of space structures. In all such cases, it is desirable for the structure to have enough strength, provide displacement and other engineering requirements, while having minimum weight and cost [2]. Optimum design of space structures is one of the active branches of research in the optimization field. The optimum design of space structures is performed via three configurations as follows:

1. Sizing optimization, in which the cross-sectional areas are considered as design variables, while nodal coordinates and topology are fixed.
2. Shape optimization, in which nodal coordinates are considered as design variables [3].
3. Topology optimization, in which the state of joining the nodes are determined by elements [4].

In order to achieve structural optimization with fixed topology, it is necessary that the joints and elements specifications are simultaneously optimized. A great number of studies have been carried out for the optimum design of space structures, and some of them are referred to in this study.

Optimum design of double-layer grids was performed subject to static loadings by genetic algorithm [5]. In this study, variables such as the presence or absence of joints and the cross-sectional area of elements of double-layer grids were considered. Optimum design of space structures was proposed by an improved genetic algorithm and the structural responses were predicted by neural networks during optimization process [6]. Backpropagation algorithm was also employed for training efficient neural networks for evaluation of the maximum deflection, weight, and design of double layer grids [7]. A hybrid optimization algorithm was employed for the optimum design of space structures [8]. This optimization hybrid algorithm was compared to the other optimization methods including genetic algorithm, ant colony optimization, particle swarm optimization and harmony search. In the other study, optimum design of double-layer grids was presented with the design variables as the height of between two layers and the cross sectional areas of elements [9]. A combination of improved genetic algorithm and wavelet radial basis function neural network was also proposed to find the optimal weight of structures subject to multiple natural frequency constraints [10].

In this study, an efficient method is presented to find the optimum shape design of double-layer grids utilizing an evolutionary algorithm such as particle swarm optimization. The stochastic nature of the