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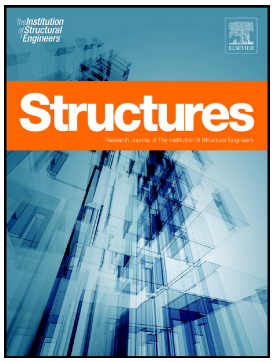

Reliability Analysis of Space Structures Using Monte-Carlo Simulation Method

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ACCEPTED MANUSCRIPT

Reliability Analysis of Space structures using Monte-Carlo Simulation Method

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ABSTRACT. The existence of initial imperfections in manufacturing or assemblage of real structures is inevitable. Many of these imperfections in double-layer space structures, such as the curvature and length imperfections, are random in nature. In this paper, the effect of initial curvature imperfection in the load carrying capacity of double-layer space structures is investigated. For this purpose, three different types of supports are considered. The curvature imperfection is considered as a random number by gamma distribution. The probabilistic model is used to distribute the random imperfections among all members of the structure. The collapse behavior and the ultimate capacity of the considered structures are determined using nonlinear analysis and this procedure is repeated by Monte Carlo simulation method. The results show that the collapse behavior of double-layer grid space structures is highly sensitive to the random distribution of initial imperfections.
Keywords: Steel structures; Reliability; Monte-Carlo Simulation; Imperfection; space structures

1. Introduction

Double-layer space trusses are frequently used in large open areas because they offer advantages such as high stiffness, relatively light weight, ease of erection, and ability to cover open areas [1]. Despite being known for their high degree of indeterminacy and absorption forces, space structures suffer from characteristic progressive failure after the collapse of one or several members. In such an event, the failure of even one member can lead the collapse of the whole structure. The factors that affect the behavior of these structures are quite diverse and depend upon the behavior of every single member and also their connecting system. Although these structures are manufactured industrially, the members of these structures behave inconsistently because of different mechanical and geometrical properties

Space truss structures have been the subject of many studies [2-11]. Schmidt et al. have indicated that space trusses may fail in a brittle and unstable manner, in which the buckling of one member due to overloading can trigger a progressive collapse of the whole structure, in which successive members fail in a rapid sequence [2-3]. Affan and Calladine have shown that the number of redundant bars that can be removed without affecting the stability of structure is about 15% to 25% of the total number of truss members [4-5]. It is not possible to attribute this characteristic to all space structures; the failure of the roof of the Hartford stadium in 1984 is a practical example of the possibility of progressive collapse. Researchers have noted imperfections in members as an important cause of this failure [6].

Space structures have a high degree of indeterminacy and typically contain hundreds of members which inevitably incorporate different types of imperfection. Initial curvature of a truss

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