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Transient Behavior of CFRP Tensegrity System in a Suspen-dome

IfeOlorun Olofin [a*], Ronggui Liu [a]

[a] *Departmentof Civil Engineering and Solid Mechanics, Jiangsu University, No301Xuefu Road, Zhenjiang,212013, China.*

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Abstract

In order to establish a conclusive result for the application of carbon fibre reinforced polymer (CFRP) cable as a tensegrity system for a suspen dome, the structural integrity assessment of the system, subjected to transient load, must be considered. This paper gives a preliminary assessment of the dynamic behavior of carbon fibre reinforced polymer cable in a suspen dome in comparison with that of the steel counterpart, using a small model of 4 m span and 0.4 m rise. A commercial finite element software namely ANSYS was used for the structure simulation in respect of the experimental design. The results from the simulation show that the carbon fibre reinforced polymer cable gives a reliable assessment as the steel counterpart. The natural frequencies of CFRP cables are higher than those of steel cables due to the CFRP cables' high stiffness-to-weight ratio and less curvature under gravity loads. CFRP cables influence the structure with good stiffness which provides good vibration resistance. The results also indicate that from a technical point of view, carbon fibre reinforced polymer cables can perform better than steel cables as tensegrity system for a suspen dome. It is concluded that CFRP cables can be applied to replace steel ones as tensegrity system for a suspen dome.

Keywords: Suspen dome; CFRP Tensegrity System; Steel Tensegrity System; Modal Analysis; Transient Analysis.

1. Introduction

A suspen dome is a fascinating structure, based on its architectural design and construction point of view [1].this new structure was created by Kawaguchi and his team. It is made up of a single-reticulated layer and a tensegrity system (Strut, hoop and radical cables) [2] as illustrated in Figure 1. The tensegrity system in this structure plays a salient role.With its high strength-to-weight ratio, a tensegrity system gives an outstanding appearance that provides opportunities for engineers to explore new innovation and ideas to produce an excellent structural form. Long span structures are becoming more popular because of their many advantages which include efficient load resistance, light weight and smaller cross-sections. These advantages can be improved on with better cable stiffness and strength-to-weight ratios.

The need for long span structures is trendy; hence the use of alternate materials that can enhance these qualities, other than steel, has to be taken into great consideration by researchers. Carbon fibre reinforced polymer cable is a new material that has demonstrated its efficiency in Bridge engineering. The use of CFRP cable is anticipated to improve the suspen dome performance in a different way. Firstly, its low weight can reduce sagging and increase stiffness which means that the Ernst modulus is higher than that of steel cable.

The formula for this equivalent modulus was developed by J.H Ernst and it is given as:

$$\frac{E_e}{E} = \frac{1}{1 + \frac{(\rho l)^2}{12\sigma^3}} E \tag{1}$$

* Corresponding author: y.shahbazi@tabriziau.ac.ir