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Parametric study of cable-stiffened single-layer cylindrical latticed shells with different supporting conditions

Pengcheng Li, Minger Wu *

Department of Structural Engineering, Tongji University, 1239 Siping Road, Shanghai, 200092, China

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ABSTRACT

Numerical investigations to the stability behaviour of novel cable-stiffened single-layer cylindrical latticed shells with different supporting conditions are presented. It is shown that the governing imperfection distribution that should be adopted within finite element analysis to capture the actual load carrying capacity does not always follow the lowest buckling mode for the type of element and assumptions implemented in the current study, which distinguishes it from the existed specification. The principle to determine the governing imperfection distribution is proposed in this study, this is followed by parametric analysis which aims to investigate the stability behaviour of cable-stiffened single-layer cylindrical latticed shell systematically. The parametric analysis shows that the stability behaviour of ordinary cylindrical latticed shell can be considerably enhanced by the pre-tensioned cable-stiffened system. It should be stressed that the introduction of cable-stiffened system decreases the sensitivity of the stability behaviour of ordinary cylindrical latticed shell to joint types, this would enable engineers to adopt scissor-type joints to cylindrical latticed shells. The effects of other parameters on the stability behaviour of cable-stiffened single-layer cylindrical latticed are also presented in this current work.

1. Introduction

Cable-stiffened single-layer latticed shells, which usually comprise an ordinary single-layer latticed shell and an external pre-tensioned cable-stiffened system [1,2], have been increasingly used as an efficient and lightweight structural solution to span a large distance [3]. Pre-tensioned cable-stiffened systems, three of which are presented in Fig. 1, have been proved to provide effective structural stiffness and enhance the load carrying capacity significantly [4]. For the type A cable-stiffened system (see Fig. 1(a)), only cables are adopted to stiffen the grids of the latticed shell diagonally to enhance the shear stiffness. For the type B (see Fig. 1(b)) and type C (see Fig. 1(c)) cable-stiffened systems, both cables and posts are introduced to stiffen the grids in order to increase the shear and bending stiffness. In type B cable-stiffened system, a post is attached to each joint of the grid and cables are used to connect the ends of the post diagonally. In type C cable-stiffened system, a post is placed in the middle of the grid and the two ends of which are connected to the joints of the grids by diagonal cables. In addition, parallel cables are placed in two directions through the ends of the posts.

As the first practical application of cable-stiffened single-layer latticed shell, Neckarsulm dome adopted the Type A cable-stiffened system (as shown in Fig. 1(a)) to enhance the structural stiffness and load carrying capacity [2]. In contrast, Kumagaya dome adopted the Type B cable-stiffened system (as shown in Fig. 1(b)) to improve the stability behaviour [5]. More practical uses of this type of structure can be found in the previous work [3]. Research works on the stability behaviour of cable-stiffened single-layer latticed shells have also existed since it was proposed, such as those investigating the effects of cable-stiffened systems [5,6], discussing the initial imperfection distributions [7], evaluating the buckling loads [8,9] and parametric studies [4,10].

Most of the existed research works concentrated on investigating the stability of cable-stiffened single-layer latticed domes [11–14], though few of them also aimed to study the behaviour of other types of cable-stiffened single-layer latticed shells, such as the cylindrical ones [6,9]. In addition, all of the previous research on cable-stiffened single-layer latticed shells only limited the ones with the Type A (as shown in Fig. 1(a)) and Type B (as shown in Fig. 1(b)) cable-stiffened systems except the work conducted in [4] as far as the authors are aware. To the knowledge of the authors, investigations into the behaviour of cable-stiffened single-layer cylindrical latticed shells with Type C cable-stiffened systems have hitherto not been attempted. Study of the stability behaviour of cable-stiffened single-layer cylindrical latticed shells with Type C (see Fig. 1(c)) cable-stiffened system is therefore becomes the subject of this current study. However, it should be noted that the cylindrical latticed shells can be supported along four edges or two longitude edges in practical. Thus, the stability behaviour of the cable-stiffened single-layer cylindrical latticed shells with these two different supporting conditions are investigated and compared in this current work.

* Corresponding author.
E-mail addresses: 2011_pchl@tongji.edu.cn (P. Li), wuminger@tongji.edu.cn (M. Wu).

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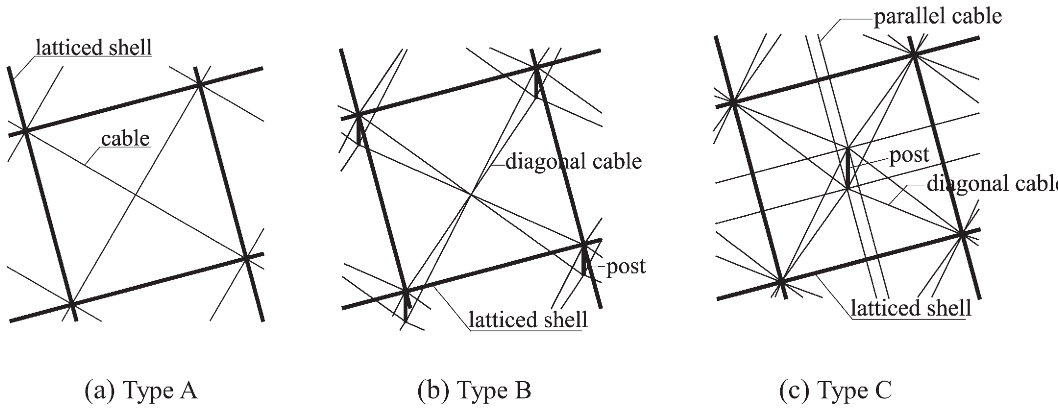

Fig. 1. Different types of cable-stiffened quadrangular grids.

The commercial code ANSYS was adopted to conduct the numerical analysis in this current work. The governing imperfection distribution which corresponds to the actual load carrying capacity of the latticed shell was investigated initially. Parametric analysis was conducted then to investigate the effects of different parameters on the stability behaviour of cable-stiffened single-layer latticed shell systematically.

2. Problem definition

As mentioned before, this current work focuses on a cable-stiffened single-layer cylindrical latticed shell with the Type C (see Fig. 1(c)) cable-stiffened system, the geometry of which is shown in Fig. 2. In this model, the height H and span B of the latticed shell are

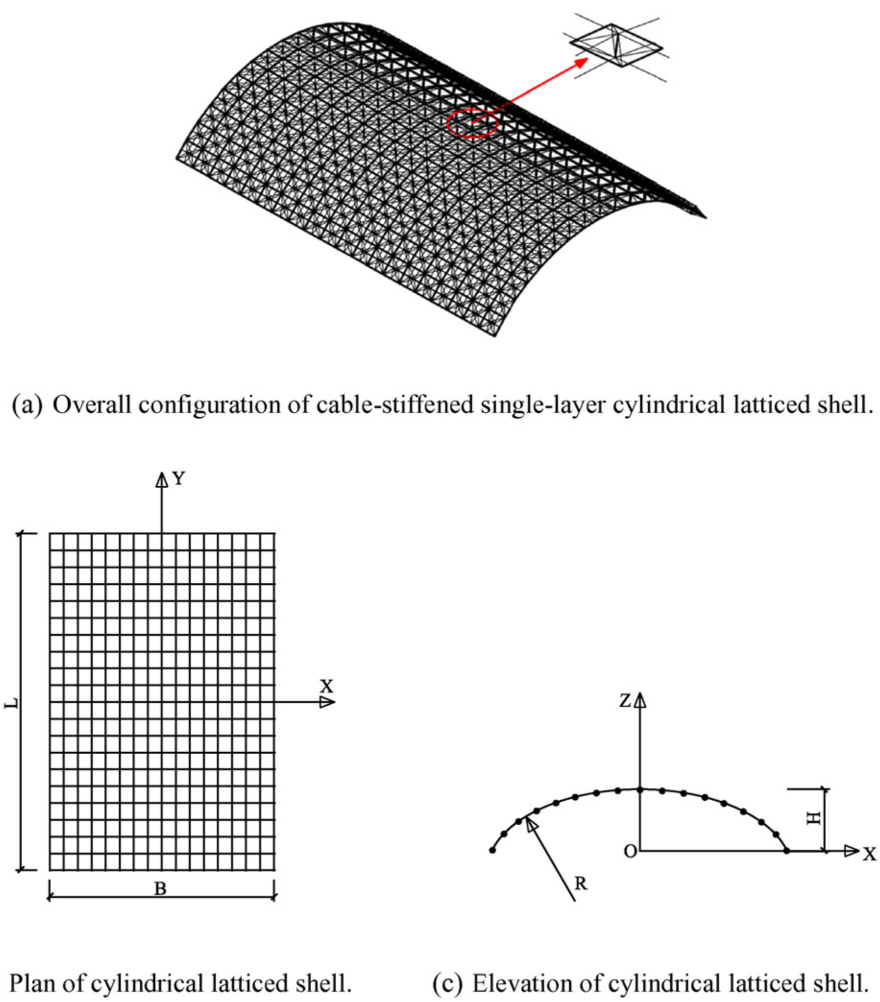

Fig. 2. Geometry principle of cable-stiffened single-layer cylindrical latticed shell. The cable-stiffened system is neglected in (b) and (c).