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Effects of geometrical factors on the buckling behaviour of free-edge single-layer gridshells

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Abstract

Gridshells are form-resistant lightweight structures usually designed to cover large spans. Gridshells are highly prone to buckling phenomena, as testified by catastrophic collapses such as the one of the Bucharest Exhibition Hall in 1963. A lot of research has been devoted to this issue in the last 20 years, in order to investigate the effects of different factors on the stability of gridshells [1, 2]. Stability studies on gridshell domes are usually carried out by referring to structures with a horizontal spring-plane and rigid supports, while gridshells with elastic boundaries have never been extensively studied. Therefore, a scatter exists between the scientific literature and the design practice, being the majority of built gridshells characterised by one or more free-edges. These elastic boundaries result from the need to trim the gridshell reference geometry to provide openings or to insert the gridshell within an existing building.

The buckling behaviour of free-edge gridshells is expected to be influenced by both mechanical and geometrical factors. The influence of mechanical factors, i.e. the flexural stiffness of the boundary structure and the in-plane stiffness of the gridshell, has been investigated in [3] through a parametric study on an ideal single-layer hybrid free-edge gridshell. The results of the cited study showed that the buckling of the structure could be boundary-driven or shell-driven, depending on the ratio between the flexural stiffness of the boundary and the in-plane stiffness of the gridshell.

This study, in prosecution of the preceeding one, aims at investigating the effects of geometrical factors on the stability of free-edge single-layer gridshells. In particular, two geometrical factors are considered: i. the orientation of the trimming surface with respect to the grid direction, to study the effects of anisotropy; ii. the location of the trimming surface, to study the influence of the ratio between the gridshell and free-edge spans. The parametric study is carried out through numerical simulations on an ideal single-layer free-edge steel gridshell, with two different grid topologies (quadrangular and hybrid). Results are discussed in terms of both load factors and buckling shapes, evaluated through linear buckling analysis and geometrically and materially non linear analysis on both the perfect and imperfect structure.

References

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[3] F. Venuti and L. Bruno, Influence of in-plane and out-of-plane stiffness on the stability of free-edge gridshells: A parametric analysis, *Thin-Walled Structures*, vol. 131, pp. 755-768, 2018.