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A comparative study of the structural performance of different types of reticulated dome subjected to distributed loads

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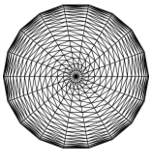
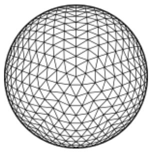
Abstract

Reticulated domes (i.e. domes composed of bars) with various patterns (figure 1) have been built to span large surfaces, demonstrating their material-efficiency. The geodesic dome is often assumed to be superior because its patent holder, Richard Buckminster Fuller, claimed that *the resulting framework will be characterized by more uniform stressing of the individual members than is possible with any construction heretofore known* (US patent 2,682,235A). This –unverified– claim implies that it is a fully stressed design, which is a measure for optimal material use under certain conditions.



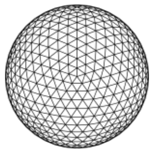
(a)

954 elements
w_{min} = 2653 kg



(b)

935 elements
w_{min} = 5610 kg



(c)

980 elements
w_{min} = 5733 kg

Figure 1: Common patterns for reticulated domes: a (a) Schwedler, (b) Kiewitt, and (c) geodesic dome

In the past decades, several authors have studied the optimal design of reticulated domes: Saka [1-2] minimized the weight of a geodesic dome under a vertical point load, Kaveh and Talatahari [3] addressed the optimization of Kiewitt domes, and Çarbas and Saka [4] performed a comparative study of different types of reticulated domes. However, these studies are not fully conclusive because the different types of dome were not subjected to the same loads. Moreover, often unrealistic loads were applied: distributed loads are either approximated or omitted, despite being the predominant load for reticulated domes.

This paper aims to determine which type of reticulated dome is superior through a comparative study of the minimized weight of Kiewitt, Schwedler and geodesic domes with a span of 16 m and a gravity load of 2 kN/m^2. The number of rings, subdivisions along each ring, and the sections of all bars are varied to minimize the total weight of each variant, taking into account stress and buckling constraints, as well as the constraint that the total number of bars cannot exceed 1000. Full enumeration is used for the discrete variables (number of rings, subdivisions along each ring,…), while a gradient-based algorithm is used for the continuous variables (member sections).

Although the Schwedler configuration generally outperforms the geodesic dome, the claim of uniform stressing in a geodesic dome is not entirely wrong: if all members are assigned the same size, a geodesic dome of 980 bars is more evenly stressed and up to 28% lighter than other dome types of similar size. However, if all members are sized individually, a Schwedler dome is 53% lighter than a Kiewitt dome, and 54% lighter than a geodesic dome.

References

[1] M. Saka, "Optimum geometry design of geodesic domes using harmony search algorithm", *Comput Struct*, 2007. 10(6): 595–606.
[2] M. Saka, "Optimum topological design of geometrically nonlinear single layer latticed domes using coupled genetic algorithm", *Comput Struct*, 2007. 85(21): 1635–1646.
[3] A. Kaveh and S. Talatahari, "Geometry and topology optimization of geodesic domes using charged system search", *Struct Multidisc Optim*, 2011. 43(2): 215–229.
[4] S. Çarbas and M. P. Saka, "Optimum topology design of various geometrically nonlinear latticed domes using improved harmony search method", *Struct Multidisc Optim*, 2012. 45(3): 377–399.