About the funicularity of Velaroidal Shells

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Abstract

One of the advantages of using thin double-curved shells for covering large areas is connected to their ability to carry applied loads mainly by membrane actions. However, this property is governed by the structural form, the actual configuration of applied loads and on boundary conditions represented by the presence and effectiveness of shell supports.

An infinite number of shell forms can be obtained numerically, either by solving the equilibrium equation associated to the membrane theory of shells or by alternative numerical approaches such as the Force Density Method or the Thrust Network Analysis. Among these shapes, the so called velaroidal surface has the useful property of being provided by an analytical expression. Its use, for design purposes, dates back to 1961, when Ramaswamy exploited it to solve the equilibrium equations of the membrane theory of shells, on a plane boundary of rectangular shape [1]. Such a shape was given the name of funicular shell due to its ability to carry applied load by compressive membrane actions only, equal in both directions and without shear stresses.

We discuss on the actual fulfilment of the funicularity condition for velaroidal shells. This is done by employing both analytical and numerical tools. In particular, the membrane theory of shells is used to compute membrane actions associated to shells whose mid surface is defined by a velaroid. A numerical solution to such a differential equation is then used to obtain a funicular shape generated by the same loading and boundary conditions. Obtained shape is compared with the analytical one to discuss about similarities and differences. Finally, both the analytical shape and the numerical solution are implemented within a finite element code in order to verify their R-funicularity [2], by computing the generalized eccentricity associated to several loading conditions.

References

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