CERIS : Civil Engineering Research and Innovation for Sustainability

Structural and experimental analysis for the usage of free form thin shells in prestressed precast concrete in large span roofs

PhD student
Bárbara Cardoso Gomes

PhD program
Civil Engineering (FCT, Nova University of Lisbon)

Supervisor
Eduardo Cavaco (FCT, Nova University of Lisbon; CERIS, IST, University of Lisbon)

Co-supervisors
Maria Elizabeth Tavares (FEN, Rio de Janeiro State Universiy) and Eduardo Júlio (CERIS, IST, University of Lisbon)

Period
2020-2024

Funding
FCT Project – Pre-Shell (POCI-01-0247-FEDER-039735)

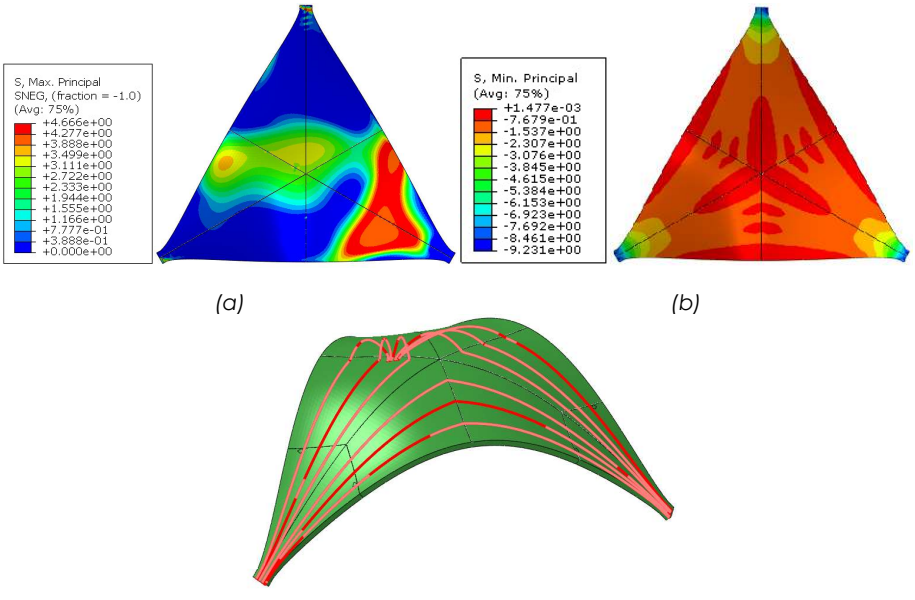
Summary

The work in course is part of the research project PRE-SHELL, that aims to increase the viability of precast thin concrete shells in large span roofs. Starting from a shell with double curvature of geometry obtained using a nonlinear analysis of the membrane subject to its own weight, this work includes the linear and non-linear structural analysis of the shell under the effect of normative loads, the effect of the prestress, as well as the division in modules and the experimental analysis of a reduced model. A parametric study with the variation of thickness and compressive strength of the material adopted is presented, with the aim of evaluating and optimizing its structural behaviour facing the loads and their combinations according to the Eurocodes. In this study, static loads are considered in persistent or transient and accidental combinations of the Ultimate Limit State.

The work is developed based on a numerical analysis of the structure using the ABAQUS software. For a shell of three supports and a span of 25m, thicknesses ranging from 100mm to 500mm, and compressive strength of concrete varying between 30MPa and 120MPa are adopted. The structural behaviour is evaluated in terms of stresses. Results show that the effect of uniformly applied loads, such as self-weight, imposed loads and non-drifted snow, do not decompress the shell structure, and generate relatively low compressive stresses. On the other hand, the persistent and accidental effect of drifted snow and the wind load, acting non uniformly against the shell surface, decompress the structure and generate significant tensile stresses, above the material strength, in particular when thickness is below 300mm. The analysis of the shell with unbonded prestress, given its geometry, is in progress. It is chosen to use 3/8" strands with the maximum stress allowed by the normative rules in 100mm thickness shell. Two models with one and three strands are proposed with dry joint between the modules. It is seen that with the application of prestressing, the shell increases its bearing capacity and resists to the non-uniform loads, due to the better stress distribution. Yet the shell still decompresses, in this case with tensile stresses under the resistance of the concrete. However, failure modes and local effects on the anchors, joints and cable region still in need to be studied. Finally, the production of a reduced prototype in modules with a span of 5m is in progress for the experimental analysis.

Keywords

Prestressed concrete, precast, thin shell, membrane, nonlinear analysis.



(a) *(b)*

(c)

Shell geometry obtained from the numerical model (a) Maximum principal stress diagram under the effect of accidental snow; (b) Minimum principal stress diagram under the effect of three prestressed strands; (c) Shell divided into modules with three prestress strands.