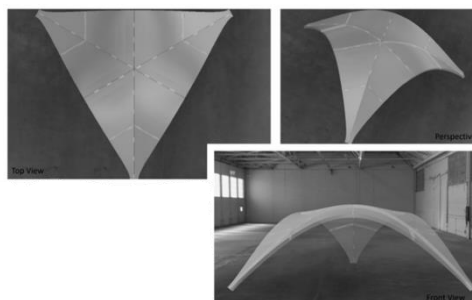
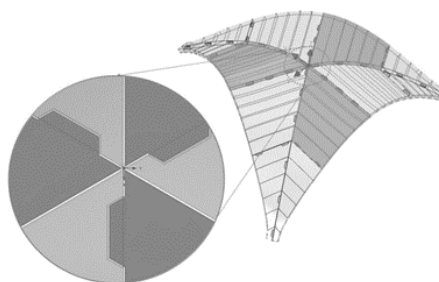


## Pre-Shell – Prefabricated Ultra Thin Concrete Shells

### Summary

Roofs and canopies composed of thin concrete shells are structural solutions that allow large areas to be covered, overcoming spans of considerable size. This structural typology is usually associated with emblematic works, not only because of its size, but also because it allows almost organic geometries, surprising from the architectural point of view, overcoming spans with very slender structures. It was in the 50's and 60's that the use of thin concrete shells became more popular, but since then, their construction has become almost residual, not due to the technical difficulties associated with their design, but mainly due to the slowness and higher costs related to the constructive process. Indeed, and in spite of significant advances in the field of structural mechanics, often supported by numerical methods and increased computational capacity, which have turned structural analysis easier, this type of structural solution is usually disadvantaged due to the construction extra costs compared with competing roofing solutions, resulting from the very specific, complex and non-reusable formwork molds, and the expensive falsework. The aim of this project is to guarantee technological, scientific and economic competitiveness to structural roofing systems made of thin concrete shells, through the development of a structural solution optimized from the geometric and material points of view, produced using pre-fabrication techniques. The shell geometry and form should be freely established, depending essentially on the architectural program and on a form optimization algorithm to be developed within the project context, and based on preliminary

studies, which promotes membrane, instead of bending efforts, being the latter critical for the structural typology. From a material point of view, specific formulations of ultra high strength concrete (tensile and compression), possibly reinforced with steel or composite fibers, will be developed to reduce the thickness of the shells to be used, as well as the amount of reinforcement required, without compromising the structure durability. With regard to the manufacturing process, the following steps are foreseen: (i) developing a process of discretizing the shape of the shell into sub-elements and optimizing its geometry, in order to minimize the number of different formwork molds; (ii) development of connection systems between shell panels with variable geometry; and (iii) design of prestressed solutions that contribute to improve the structural behavior of the shell during the constructive and exploration phases, also taking advantage of the high compressive strength of the material to be developed. The performance and safety of the proposed solution will be assessed throughout the project using prototypes subjected to load tests, global and local stability analysis, wind tunnel and seismic table tests, and numerical analysis. The development of a more industrialized and innovative solution in terms of geometry, material and construction will ensure the technical and economic competitiveness of thin concrete shells for structural roofs and canopies, which will allow SPRAL to conquer new national and international markets with emblematic structures as well as meet the increasing architectural demands for buildings of free and customizable shapes.



### Project Reference

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### Leading Institution

SPRAL – Sociedade de Pré-Esforçados de Aveiro Lda (Portugal)

### Partners

FCT NOVA – Nova School of Science and Technology (Portugal), IST-ID – Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento (Portugal), IPC – Instituto Politécnico de Coimbra (Portugal), FCTUC – Faculdade de Ciências e Tecnologia da Universidade de Coimbra (Portugal), IPLeI – Instituto Politécnico de Leiria (Portugal)

### CERIS Principal Investigator

Eduardo Cavaco  
([e.cavaco@fct.unl.pt](mailto:e.cavaco@fct.unl.pt))

### CERIS Research Team

Eduardo Júlio, António Moret Rodrigues, Ana Tomé, Luis Guerreiro, Jónatas Valença, João Almeida, António Costa, Ricardo Carmo, José Dinis Silvestre, Hugo Costa

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### CERIS

46 223.81€

### Project Website

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