

Nonlinear structural analysis of the Church's elliptical dome of the Laboral City of Culture of Gijón, Spain

Juan José del Coz-Díaz*, Alfonso Lozano Martínez-Luengas*, Mar Alonso-Martínez*, Maria-Pilar García-Cuetos† and Felipe Pedro Alvarez-Rabanal*

* GICONSIME Research Team - University of Oviedo
Viesques Departmental Building 7, Office 7.1.02, 33204 Gijón, Spain
e-mail: delcoz@uniovi.es, alozano@uniovi.es, alonsomar@uniovi.es and felipe@constru.uniovi.es
web page: <http://giconsime.grupos.uniovi.es/>

† Department of Art History and Musicology, Faculty of Philosophy
University of Oviedo
Email: gcuetos@uniovi.es

ABSTRACT

The Laboral University of Gijón was built between 1946 and 1956 being the most important architectural work in the twentieth century and the largest building in Spain with its 270,000 square meters [1]. The Church building is undoubtedly the most spectacular architectural ensemble of the Laboral University of Gijón. With an overall inside surface of 807 m², the Church is the world's largest elliptical roof: 40.8 meters and 25.2 meters of mayor and minor axis, respectively.

The interior of the church is covered by a dome with an estimated weight of 2,300 tons. The whole structure is supported with no columns using twenty pairs of masonry ribs crossing each other. The Church from the floor to the springing line is twenty-five meters high, and it is thirty-three meters high to the crown. In the crown, there is an oculus to illuminate naturally the interior of the Church. Currently, there is no natural lighting because the roof sagged slightly. For its construction, 450,000 bricks annealed in the province of León (Spain) were used.

The structural analysis of masonry structures, and in particular of domes, present several difficulties: the nonlinear numerical model due to the nonlinear properties of the material, with almost no tensile strength; the lack of experimental characterisation of the mechanical properties of masonry structural elements; and the complexity of the geometry in this particular case [2].

To solve this complex structural problem, refined mechanical models, which accurately predict the behaviour of masonry material and elements, have been proposed in the inherent literature [3]. Models use different strategies to consider the highly nonlinear behaviour of the material both in tension (low tensile capacity and consequent cracking phenomena) and in compression. Some of those models are also able to provide the structural response to large displacements. Unfortunately, current models are hardly applicable to the complete 3D analysis of complex structural systems due to the great number of parameters involved in the definition, and the large number of degrees of freedom required for structural meshing, which lead to untreatable data. Nevertheless, in this work a nonlinear static analysis of the 3D structural complex elliptical dome of the Church is developed. The most relevant results, in terms of maximum displacement, stress and, cracking and crushing phenomena are presented.

Finally, valuable information from the structural behaviour and the interaction among the elements of the structure of this site of cultural interest are discussed. Furthermore, the most important conclusions of the structural analysis are drawn, and a protection plan of the building is proposed.

REFERENCES

- [1] A.M. Rodríguez, J.J. del Coz-Díaz, et.al., *Los talleres de la Universidad Laboral de Gijón* 2th Edition, Ed. Cicees, 2007.
- [2] J.J. del Coz-Díaz, A. Lozano Martínez-Luengas, J.M. Adam, A. Martín Rodríguez., *Non-linear hygrothermal failure analysis of an external clay brick wall by FEM – A case study*
- [3] J.J. del Coz-Díaz, P.J. García Nieto, F.P. Álvarez Rabanal, A. Lozano Martínez-Luengas., *Design and shape optimization of a new type of hollow concrete masonry block using the finite element method.*