STRUCTURAL ANALYSIS OF A SPHERICAL STONE DOME OF VARIABLE THICKNESS IN GRANADA (SPAIN)

J. Suárez, I. Abellán

IB²MAC
16th International Brick and Block Masonry Conference

Corresponding Author:
J. Suárez, I. Abellán
email: fjsuarez@ugr.es

School of Architecture,
University of Granada (Spain)

Introduction

The paper aims to structurally analyse the dome of Encarnación church in Montefrío (Granada, Spain). The Encarnación church in Montefrío was designed and executed by the architect Domingo Antonio Lois Monteagudo between 1786 y 1802, when the Enlightenment ideas were booming, and it is a perfect example of neoclassic style in the kingdom of Granada. The temple both spatially and dimensionally is a copy of the Agrippa's Pantheon in Rome.

Objectives

According to Rankine's and Schwedler's hypothesis, the stresses generated by the loads are contained in planes tangent to the half-surface at the point of application; taking into account the axial symmetry of the charges we conclude that no shear stresses are generated; only normal stresses either compressive or tensile, are generated. Our objective is to apply Rankine's formulation, by calculating the numerical value of the derivative to determine meridian and parallel compression forces, and the colatitude's value in the areas under traction efforts.

Methodology

To obtain the colatitude's angle, the dome has been sectioned in horizontal levels, measuring the volume remaining from the highest point of it to the level. Applying the correct conversion factors, the weight of those volumes and the angle corresponding to each of the levels are obtained. All that data is then computed to obtain a mathematical expression that relates both groups, a funtion that is able to give back the exact weight with an angle given.

$$P = 21531{,}6\,\varphi^3 - 20152\,\varphi^2 + 5599{,}38\,\varphi - 422{,}11$$

$$\frac{dP}{d\varphi} = 64594{,}8\,\varphi^2 - 40304\varphi + 5599{,}38$$

Results and discussion

After obtaining the expression and its derivative it is possible to calculate the meridian compression (N1) and the parallel traction (R1).

$$N_1 = \frac{P}{2\pi R sin^2\varphi} \quad ; \quad R_1 = \frac{1}{2\pi R} * \left(cotg\,\varphi\,\frac{dP}{d\varphi} - \frac{P}{sin^2\varphi}\right)$$

Analysing the values obtained with the parallel traction expression , it is possible to affirm that, when those become negative, the remaining portion of the dome is working under traction efforts. That can be seen in the representation of both series of values in the 3D model (blue for compression and red for traction) like they appear representated on the graphic.

Remarks and conclusions

Considering the dome's weight and how it is distributed, it is possible to calculate the numerical value of the derivative, obtaining the following:

- Maximum value of meridian compression force per parallel unit of length: 470,6 kN
- Maximum value of parallel compression force per meridian unit of length: -470,6 kN
- Colatitude value at the beginning of the area submitted to traction forces: 71,4°

All this it is represented in the graphics shown.

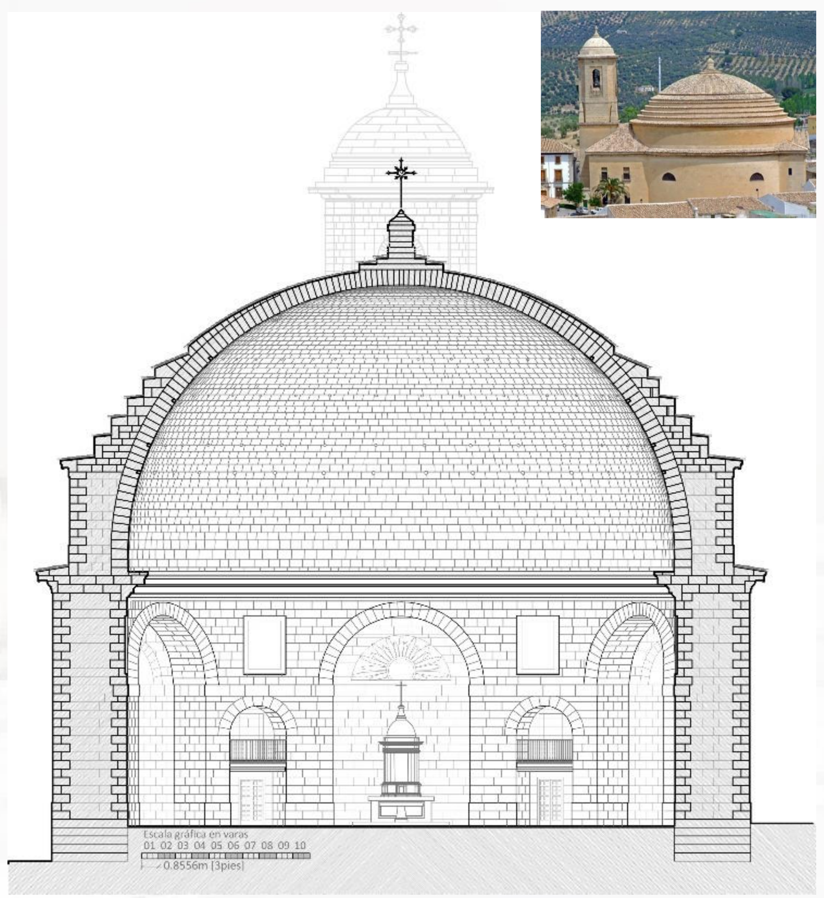

Figure 1: Actual image and constructive section of the dome

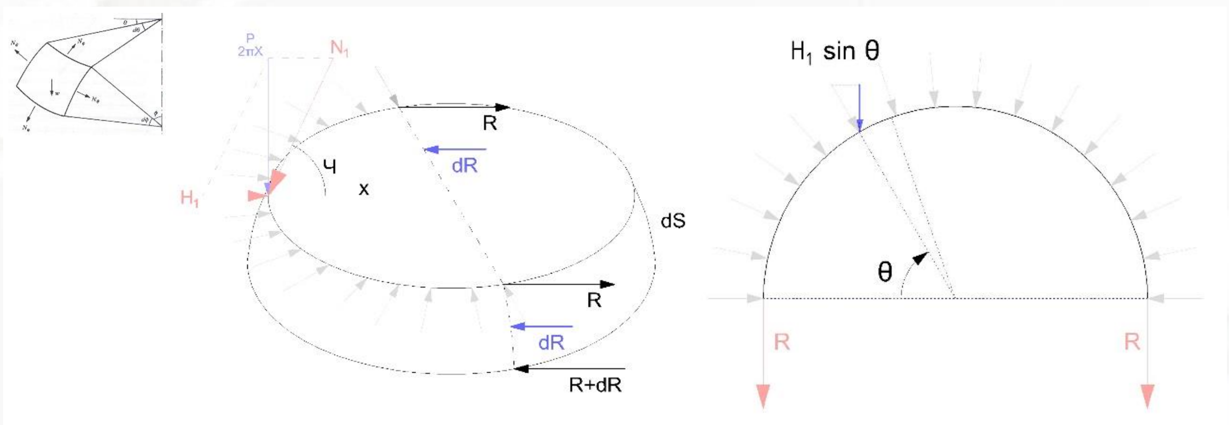

Figure 2: Equilibrium of forces according to Rankine's hypothesis

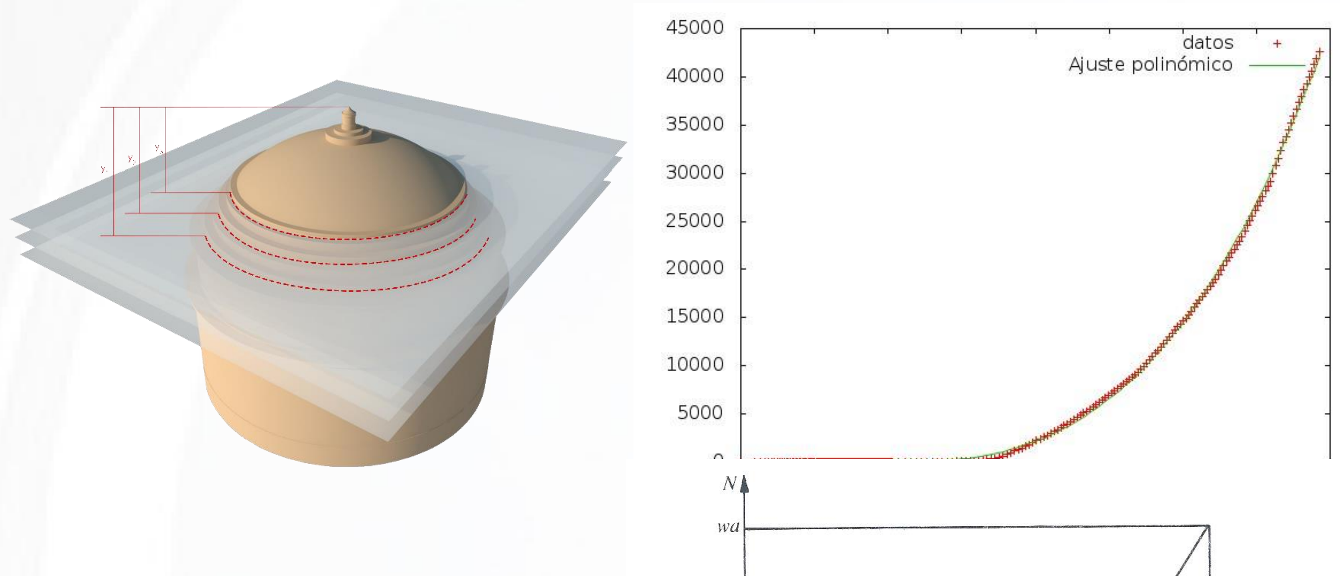

Figure 3: Estimate the dome's weight for each value of the colatitude and functional adjust of the data obtained

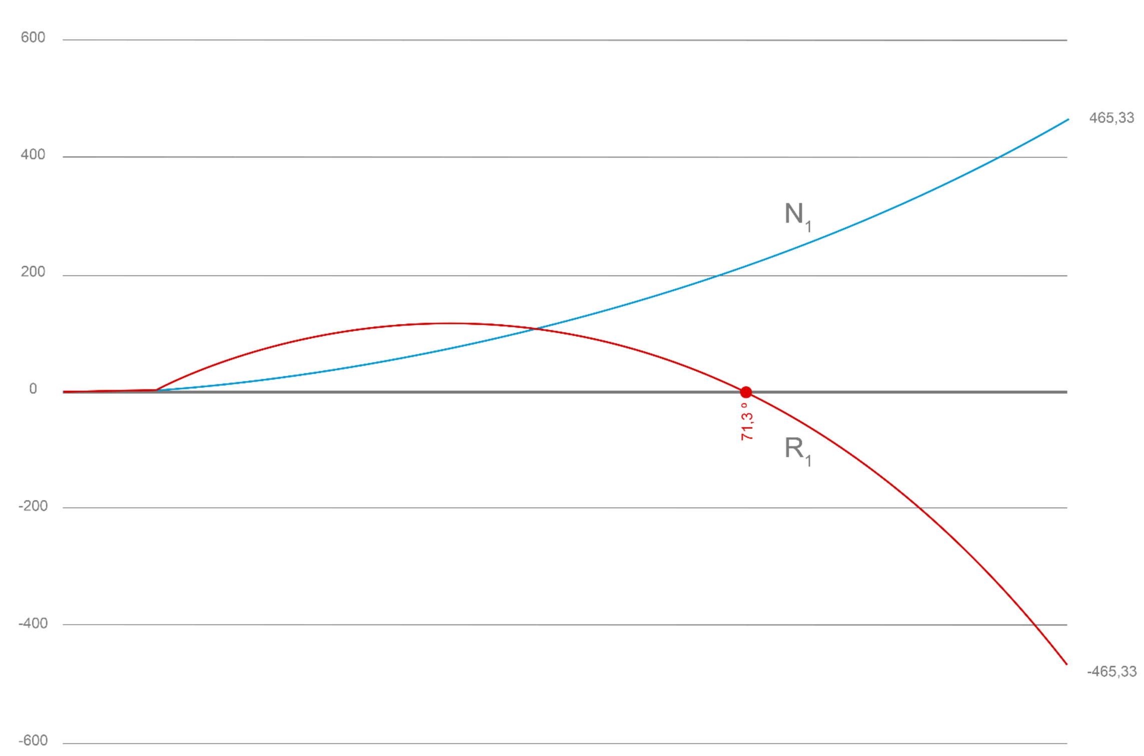

Figure 4:Graphic representation of meridian and parallel compression forces, depending on the colatitude

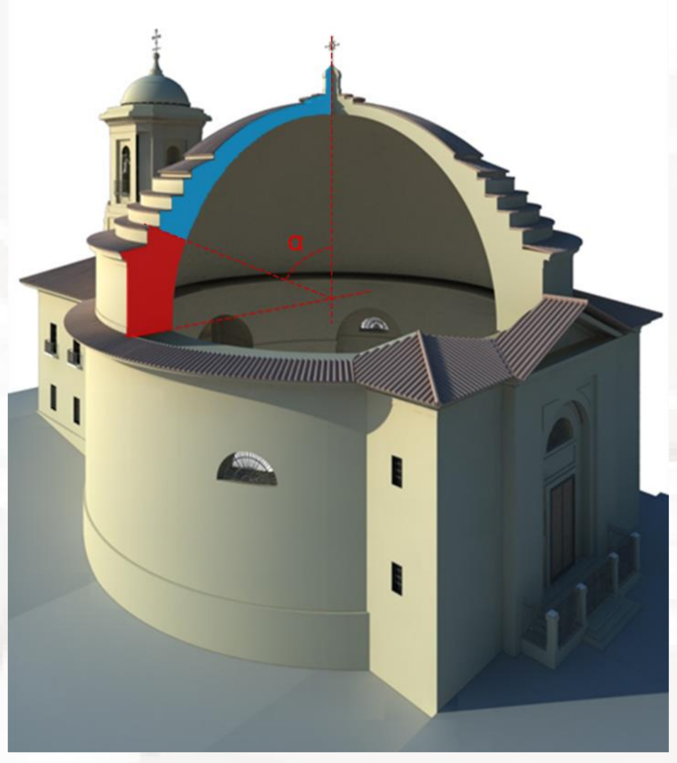

Figure 5: Graphic representation of the areas submitted to traction

Università degli Studi di Padova

ICEA