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Strengthening and Control of the Dome of Vicoforte Sanctuary

Renforcement et contrôle de la coupole du sanctuaire Vicoforte

Verstärkung und Kontrolle der Kuppel des Vicoforte-Heiligtums

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The elliptical masonry dome of the Sanctuary of Vicoforte near Mondovì, Italy, built in 1731 is the largest of its kind (major axis "37,15 m, minor axis 24,80 m, maximum height of the monument 84 m) and is in absolute the fith largest dome in the world. The original project of the monument is due to Ascanio Vitozzi (1539-1615) who was responsible of the early part of the construction.
The unfortunate selection of the site from a geothechnical view point is responsible of the structural damages that the monument suffered throughout his life. Only the north-east section is founded in fact on sufficiently consistent marls, whereas the remaining parts of the monument, and in particular the south-western sections, rest on compressible clay-silt layers of variable thickness (up to 3÷3,5 m). The monument was therefore exposed to the effects of large differential setlements during the various phases of its construction and life. Construction itself - started by Vitozzi in 1596 - after continuous compensation of initial settlements during the construction process and the establishment of a drainage system of clay layers, was practically abandoned at elevation 11,10 m in 1600, with a slow prosecution untill el. 19 m during the whole XVIIth century.
Architect Francesco Gallo (1672-1750), after new levelling of structures to compensate further settlements due to progressive consolidation of clay layers, as well as to unsufficient maintenance of the drainage system, started again construction works in 1701 and completed in 1731 the daring large elliptical dome, inspite of a negative opinion expressed by Filippo Juvarra asked for consultancy. New settlements due to immediate and delayed effects of large added loads, magnified in time by recurrent lack of maintenance of the drainage system, were responsible in the following centuries of statical disorders with the appearence of large cracks in the dome and in the lower parts of the monument. Maximum differential settlements of the west-side foundations with respect to the north-east side, developed during the whole history of the monument, were estimated in 1962 to be the order of 55 cm. Maximum amplitude of cracks measured at the base of the dome was 82 mm with a total amplitude of 413 mm on the dome perimeter. Total increment of major west side cracks (extending from el. 14 m to the top of the dome) was of 14 mm in the period 1935-60.
A monitoring, rehabilitation and structural strengthening program was started in 1976 with the following objects:
- consolidation and stabilization of foundations,
- structural strengthening of the dome through the formation of a post-tensio-

ning ring at the base of the drum,
- monitoring of the principal parameters characterizing the structural disorder and of the response of the monument after strengthening (with particular regard to the time-dependent stress response of the post-tensioning ring).

The post-tensioning ring is formed by 14 interconnected tangential tie-rods, each one consisting of 4 prestressing bars hidden in the drum masonry tensioned to a convenient limited fraction of the calculated circumferential stresses in the dome.

Diagrams of the variation in time of the stresses in the bars over 5 years (as obtained by the monitoring system) have been analysed and a separation between the relaxation of the stresses in the bars (due to plastic flow of the masonry) and parasite stress effects due to the differential thermal dilatation of masonry and steel bars has been tried. Maximum value of mean relaxation of stresses in the 56 tensioning bars has reached the order of 20% of initial values (stress decrease from 50 to 40 KN per bar) in the four years following initial tensioning. (fig.1)

Correlation of these data with monitored movements of the main cracks of the dome leads to the conclusion of the need for a recalibration of the stress levels in the post-tensioning system to be performed in 1993. The need of more reliable data on the internal temperatures in the dome masonry has led to a program for measuring and monitoring these parameters to be operative also in 1993.

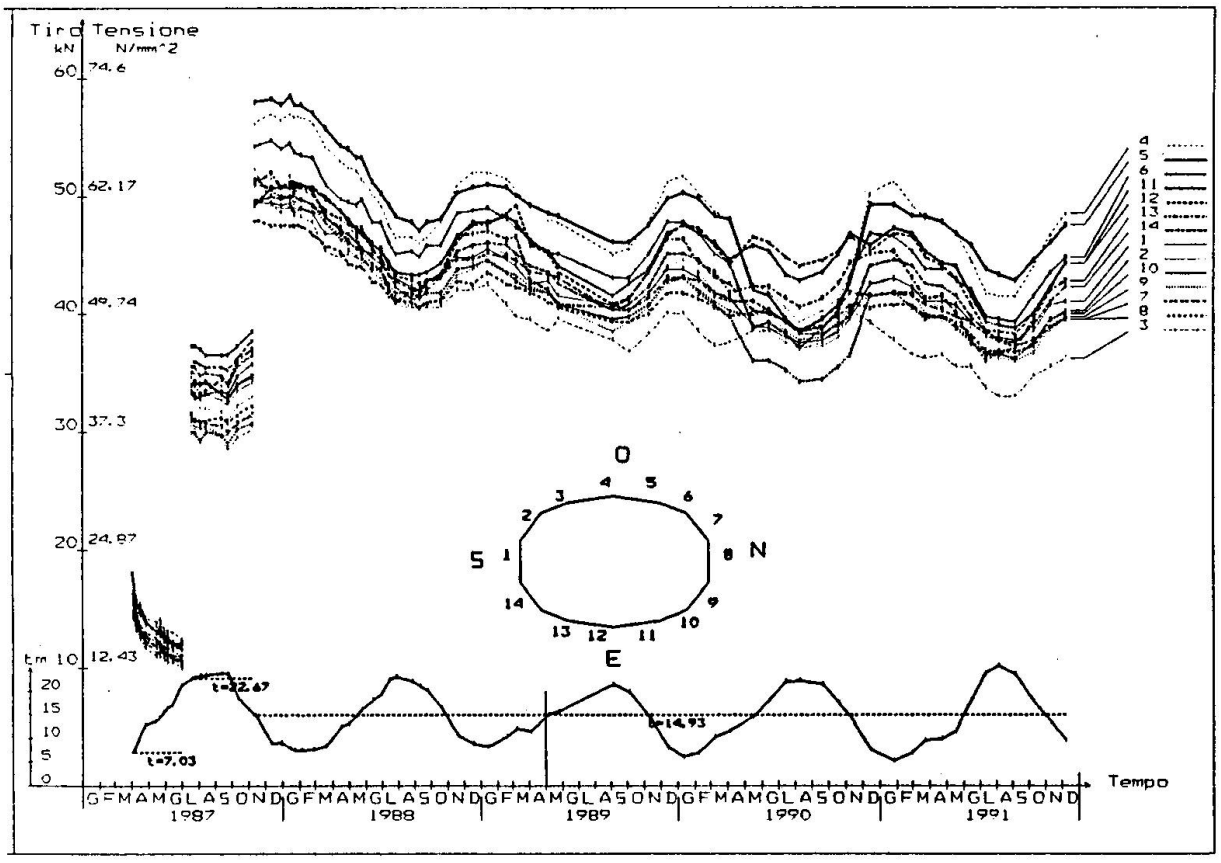

Fig.1 Variation in time of forces and stresses in the post-tensioning ring (mean values of 4 bars for each of the 14 sections of the ring) and variation of inside temperatures.