Structural analysis of the damage at the cathedral of Sibenik

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Structural Analysis of the Damage at the Cathedral of Sibenik

Calcul statique des dégâts de la cathédrale de Sibenik

Statische Berechnung der Schäden an der Kathedrale von Sibenik

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Structural analysis of the octagonaly shaped ribbed dome of cathedral of Šibenik, a masterpiece of the Croatian Quattrocento architecture, damaged by a bomb-shell in 1991. contains a condensed review of its structure, a brief art-historical analysis and the analysis of the mechanical characteristics as well as behavior of its structural mechanism. Special emphasis is placed on the spatial, formal and structural significance of its vaults erected with the peculiar technique, unique in its kind. The barrel vaults with the thin one-layer plates, shells, which also create the roof of the church, are constructed by mounting the large thin stone slabs on the relatively slender semi-circular stone arches tightened with iron ties. It is clearly a prefabricated structure. This structure, which seems formally Renaissance, but is structurally Gothic, for its plain skeleton, its clear distinction and hierarchy of primary and secondary structural elements, is used even for the dome structure. The dome, generally a spatial structure par exellance, here is carried out as a system of planar arches, converging into one point, and the envelope, acting as a covering, consists of stone slabs, like that one of the barrel vaults.

The main objective of this research was the FE computer modeling and analysis of the dome, demaged by a bomb- projectile explosion. The modeling and the static FE analysis was carried out using the COSMOS/M FE program. As we have suspected, the demage, a circular hole in the upper part of the stone slab-shell dome system has not much consequences on the carrying capacity of the dome. Luckily that it is on the part of the dome where the stresses are low, and the deformations extremely small. Fortunately, it is not a structurally dangerous injury which could jeopardize the stability of the Chatedral because only a secondary element was damaged. This could be seen on the presented screens. Only by chance the projectile has missed the rib: there could be done a devastating effect to the dome stability, if the rib has been hit and demaged.

We have had another objective before the 1991. and the well known aggression on Croatia: to build up a comprehensive FE model of the whole Cathedral. But with the war going on, and the drastically reduced foundings, as well as the damage done to the dome, the attention was shifted to the macroelement modeling of the damaged dome only.

Because of the peculiarity of the problem (nonhomogeneous masonry structure, nonresistant to tensile stresses), different variations of modeling have been made and examined, to approximate as close as possible the real behavior of the stone structure. Some of the most comprehensive classical approach to the stability and force-stress distributions was done by M. Šimunić in her M.Sc. thesis (in 1990.), and was accompanied by some limited FE model simulations of the dome's stone slabs (shell) behavior (using IBM v. ICES STRUDL2 and COSMOS/M). The structural role of some elements of the fabric is examined

in particular, creating alternative models of the structure by changing and eliminating those elements. The preliminary structural analysis of the whole structure have proved that the structure is very logical and purposeful and that every element, even the decorative ones, has a precisely determined structural function.

The further work on a more comprehensive analysis is still going on. Displayed are some of the obtained CAD/COSMOS/M screens of the work in progress.

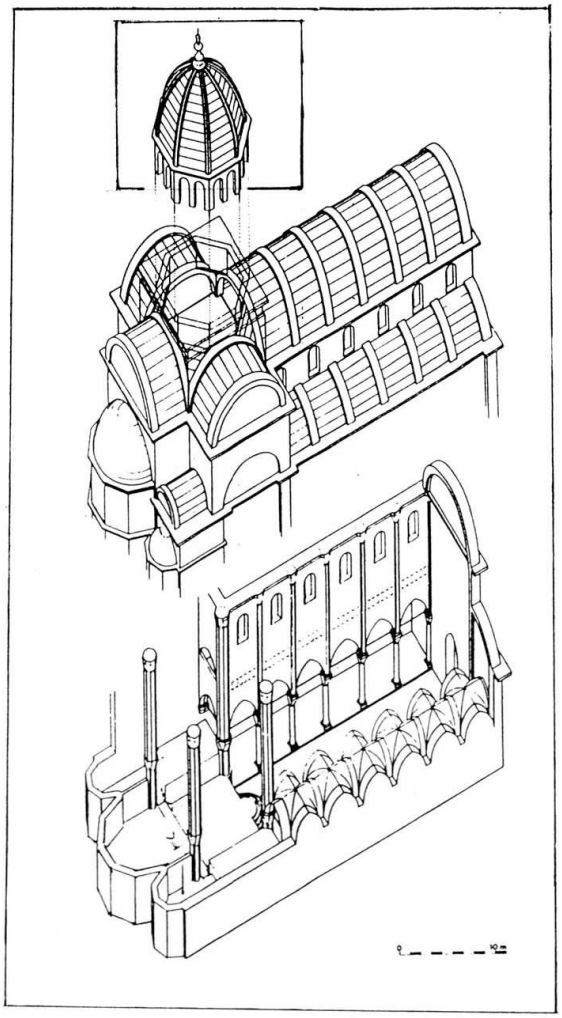

Fig. 1. Vaults of the Cathedral of Šibenik and the substructures.

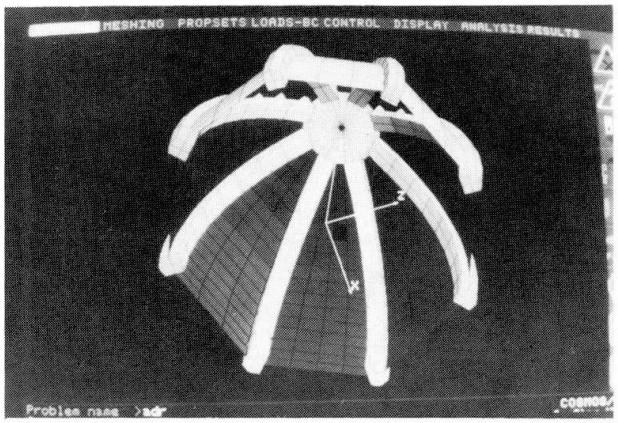

Fig. 2. The FE mesh of the dome-macroelement. The damaged part (a hole) is clearly visible.

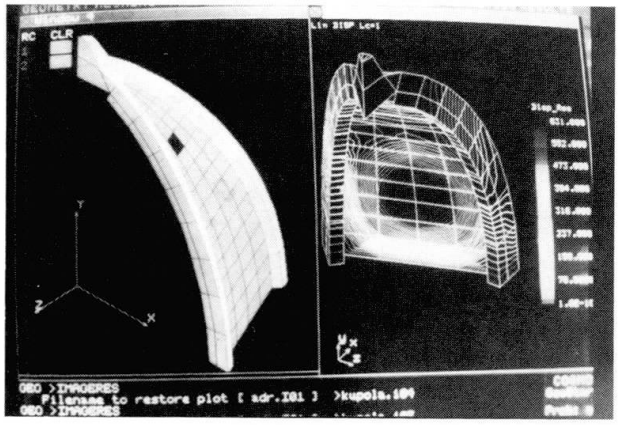

Fig. 3. The deflection lines of the substructure due to the selfeight.