Investigation and Monitoring of Historic Roof Structures During Conservation

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Abstract Because of their exceptional inherent heritage value, the preservation of historic roof structures is of utmost importance and requires investigations and monitoring carried out both before and after the conservation interventions proper. The ultimate goal is the interventions' efficiency; roof structure specialists want to be informed on the real behaviour of historic roof structures following interventions, comparing the outcome of 3D modelling with on-site measurements. The present paper focuses on the nave roof structure of the Lutheran Church A. C. in Bistrita. The Gothic roof structure was built between 1559 and 1563 and it has been recently conserved following a devastating fire that broke out in 2008.

Keywords investigation, monitoring, historic roof structure, intervention, restoration

1. INTRODUCTION

Of all the sub-units that compose the roof structure of the Lutheran Church in Bistrița, those of the tower, nave and choir were affected differently by the fire that broke out on June 11, 2008: while the Eclectic roof structure of the tower was completely destroyed, the Gothic roof structures of the nave and choir, in which the damage caused by the fire was less extensive, only required conservation.

The Gothic nave roof structure is made of 20 main trusses and 19 secondary trusses interposed, respectively of 8 longitudinal braces. It can be dated between 1559 and 1563, based on an archival general contractor agreement, the inscription recently discovered in the nave and the dendrocronologic study carried out in 2009. The span of the trusses is approx. 22.60 m.

2. MONITORING THE INTERVENTIONS ON THE NAVE ROOF STRUCTURE

Conservation interventions on the nave roof structure – following the fire that damaged a large quantity of tiles – inevitably required the dismantling and remaking of the roofing. Thus, a controlled conservation of the roof covering was possible, broken down into segments – preferably symmetric to the vertical axis that goes through the ridge. Because the modelling of the roof structure was made possible in certain stages of the partial load arising from the roof covering, as well as the placement of measuring devices on certain truss elements, it was possible to make a comparison between the results of the 3D computer modelling and the results of the measurements carried out while the roofing was being set.

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2.1. Placement of Measuring Devices on the Roof Structure's Trusses

Two pairs of trusses were chosen for monitoring the nave roof structure of the Lutheran Church A. C. in Bistrita. They are all part of those roof structure segments, which have returned, through conservation, to their original static scheme dating from the 16th century.

The first pair chosen is located near the tower, in an area where there is no joint connection between the tie-beam and rafters adjacent to the tower, most of its elements having been either replaced or prolonged. In this area, the displacement of the trusses from the tower's area is one of the elements that must be recorded, while monitoring to what extent the entire horizontal component of the trusses of the south support system is being transposed. The second pair chosen is located in an area, which also returned to its original static scheme. These trusses are symmetric ones and have less replaced or prolonged elements, as they are located further away from the destroyed area. So as to carry out measurements, seven comparators and five flexometers were placed on the four trusses.

2.2. Recording the Displacement and Deformation of Roof Structure Elements

Of all the four trusses, displacements have been recorded only in the case of the first pair (truss no. 2 and 3), adjacent to the tower. In the case of the trusses away from the tower displacements have been recorded crosswise on a north-south line (truss no. 2: flexometers F_4, F_5 and truss no. 3: flexometers F_1, F_2), respectively perpendicularly on this direction (truss no. 3: flexometer F_3).

Deformation has been recorded on three trusses: truss no. 3, respectively 29 and 30. The deformation of tie-beams was recorded on comparators C_1, C_2 (truss no. 3), respectively C_3, (truss no. 29) and C_4, (truss no. 30), and the deformation of compound rafters on comparators C_5 (truss no. 29, level I, lateral south), C_6 (truss no. 30, level I, lateral south) and C_7 (truss no. 3, level II, lateral south).

3. CONCLUSIONS

After the restoration, the trusses no 1 to 9 and 24 to 38 work again according to the original static structure diagram, even if the longitudinal beams mounted in 1897 – lacking usefulness after the recent intervention – were not removed in these areas. While monitoring the behaviour of the roof structure, after the restoration, we observed two pairs of trusses, all in the roof structure segments, where, following the restoration, the original static scheme from the 16th century is back into place. Both pairs are made of a main and a secondary truss.

For measurements, we installed 7 comparators and 5 flexometer on the four trusses. We determined the status of strain and deformations on an un-deformed geometry, although during their existence of approximately 450 years, the trusses suffered remanent deformations, both in their plane and perpendicularly to these planes. The deformations resulting from calculation are – in the case of complete truss pairs (T29, T30) – comparable with those determined experimentally. If larger differences are registered at some of the intermediate loading steps, this might be – according to our opinion – due to a late transmission of the loads. The trusses adjacent to the tower – lacking continuity joint between common rafter and tie-beam – have a chaotic behaviour, thus in the 7th stage a support movement was registered adjacent to the tower, probably at truss no. 3. The results show a transmission of axial efforts from the tie-beam preponderantly to the southern support.

REFERENCES

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