Analysis of Geometric Conception of the Historical Truss Church of All Saints in Vlčovice

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Abstract. Church of All Saints in Vlčovice was built likely in the second half of the XIV century and was consecrated in 1597 by catholic bishop Stanislav Pavlovs ký from Olomouc. The vault and nave of the church was built in Baroque. The truss of the church was dendrochronological dating to 1767/68. Some elements of structure were dendrochronological dating to 1586 when it was constructed primary truss structure. Today's appearance of the church is given by historicist modifications from the last quarter of the 19th century. Analysed truss has a rafter-collar tie structure with collar beams, pedestal struts. The roof structure has archaic form and we can include the structure into the earlier period by typology. These trusses were commonly used in this region and the wider cultural sphere at that time.

1. Introduction
Analysis of geometric conception is based on historical-structural, archival and dendrochronological research of the object as a whole. The method of geometrical analysis of the concept of the roof is based of acquiring information from period literature and from previous analyses. The Proportional Relationship of historic trusses was analysed mainly from Slovakia and Czechia. The results show further comparisons. Object of research is analysing the proportion of historical structure and relation into floor plan of building and layout of the building solution. Building space solution is also built on the concept of proportional relationships. Significant part of method is determining the roof height. The roof height is proportionally and geometrically derived from the ground plan of the building. This principle has also been identified in other historical roof trusses of Slovakia and Czechia, which we were analysing (eg. roof trusses on churches in the village of Bela Dulice, Abramova, Okolicne, Klímkovice and others [3,4,6]).

2. History of All Saints Church in Vlčovice
According to the archaeological research, the All Saints Church was built in the second half of the 16th century and consecrated by Stanislav Pavlovský, the Bishop of Olomouc, on 10 August 1597. The research did not confirm the hypotheses of previous authors that this masonry church is older. Dendro-dating also showed the older truss structures are of 1586 or later. At that time the truss contained the end stoppers; several pieces of them survived in a slightly transformed form at the attic of the southern sacristy. It was only in Baroque that the vault of the nave was added; the shape of the older vault is not known. The roof modifications are dendro-dated to 1767 - 1768. The sanctuary got its today's appearance during the several historicist alternations, the most important of which was performed in 1877. [1,2] (figure 1)
3. **Truss construction**

The roof structure of the church consists of two interconnected trusses above the nave and sanctuary. The turret on the eight-point star-shaped beam grid is also a part of the roof structure. The truss above the nave is a rafter and collar structure containing heel struts without longitudinal ties. The rafters are tenoned into the tie beams and supported by the heel struts. The heel struts are jointed with the tie beam using half-blind dovetail halving; with the rafter using full dovetail halving. The joints are fixed with wooden pins. The collar beam is jointed with rafters using full dovetail halving. The structure is made up of seven identical ties. The truss above the sanctuary is a similar structure without longitudinal ties, when compared to the truss above the nave, which has a smaller span and the same slope. Both cases are the archaic forms of the original truss of 1586, which were modified after the extensive renovation in 1767 - 1768d. (figure 2, figure 3)

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**Figure 1.** The researched object – The All Saints Church in Vlčovice

**Figure 2.** The inner view of the truss
4. Geometric concepts and proportional relationships within the truss

Previous examination of historic roofs, mainly in sacral buildings, indicates that one of the most commonly principles used to determine essential truss dimensions is the principle we named „n plus two“. It is used to determine the truss height on the basis of its width by the mutual comparison. The truss width is divided into 2n of x units and the truss height is then (n+2) of x units. This exact principle was used in the All Saints Church in Vlčovice. The basic concept of the truss above the nave is derived from the nave floor plan comprising the basic square (figures 4 and 5). If we divide the basic square into 4 parts, we get the ABCD square that is fundamental to the truss construction in a cross-section. If we divide the AB side of the basic ABCD square into thirds, we get positions of full truss bonds in a floor plan. The height of the truss above the nave is determined by the ABCD square. Its BC side stands for nx (the principle of "n plus two"). If we divide it into n-parts, we get the measure unit x (while n = 5 in this case). The height is determined by the principle (n+2)x, which means that the truss height is 7/5 of the BC side of the ABCD square. The truss width is widened by one x unit, probably due to the construction needs. The truss width/height ratio is, on the basis of this principle, 11:7. The position of the upper collar beam is determined by the position of the CD side of the ABCD square. The heel strut rests on a tie beam, at a distance of 2-times from the position of a rafter heel (2/11 of the truss width). The heel strut rests on a rafter in 1/3 of the length of the BC side of the ABCD square (figure 5). The height of the truss above the sanctuary is determined by the KLMN square. The LM side of the square stands for nx (the principle of "n plus two"). If we divide it into n-parts, we get the measure unit x (while n = 4 in this case). The measure unit x is the same as in the truss structure above the nave. The height is determined by the principle (n+2)x, which means that the truss height is 6/4 (3/2) of the LM side of the KLMN square. The position of the upper collar beam is defined by the MN side position in the KLMN square. The truss width here is equally widened by one x unit. The truss width/height ratio is, using this method, 3:2. The heel strut rests on a tie beam, at a distance of 1/4 of the KL side of the KLMN square from the K point (i.e. 1/6 of the truss width from the position of the rafter heel - see figure 6).

The truss above the sanctuary is similar. The floor plan of the sanctuary is located in the second basic square (figures 3 and 4). If we divide it into 4 parts, we get the KLMN square representing the basic construction conception of the truss above the sanctuary in the cross-section. The side of the ABCD square is just an x unit longer than the side of the KLMN square. The fact that the trusses above the sanctuary and the nave are tied together is also showed by the determination of a slope. As can be seen in figure 6, the slope is determined using the basic squares for the particular bonds, while maintaining the principle of "n plus two". Both slopes are identical (figure 7).
Figure 4. Floor plan: a - full bounds above nave, b - intermediate bounds above nave
a´ - full bounds above sanctuary, b´ - intermediate bounds above sanctuary

Figure 5. Section of the truss above nave
Figure 6. Section of the truss above sanctuary

Figure 7. Section of the truss above sanctuary
5. Conclusions

The examined roof shows a visible and identified method of geometric and proportional concept for truss designing in relation to the concept of a building’s floor plan. The basis is the use of the period way of designing the height and position of different truss members. Geometric and proportional analysis of the truss construction, as well as the object itself, may be useful for examining building’s historical development. [7] Identification of historical measures (based on division), proportions, and structures that were used may refer to the impact of cultural and socio-economic relations to the regional architecture. Acquired knowledge on geometric and proportional concept may be a guideline to the methodology for restoration and conservation of historic buildings. [8,9] The result obtained by the similar analysis of the truss proportional relations in the rural house in Vápenná [4,5] as well as in the Trinity Church in Klimkovice (also situated in Silesia) is the use of the similar principle to determine a truss height - the principle of "n plus one". The main difference is in the number of x units within the side of the basic square defining the truss structure. To understand the time and spatial relationship better, it is necessary to carry out more analyses and design concepts so that an extensive statistic database could be created and used for numerical analyses.

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