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Projekt „Rozvoj příhraniční spolupráce vysokých škol v oblasti historické architektury“

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PARAMETRIC ANALYSIS OF ROOF STRUCTURES OF HISTORICAL TRUSSES IN SELECTED REGIONS OF SLOVAKIA

PARAMETRICKÁ ANALÝZA STREŠNÝCH KONŠTRUKCIÍ HISTORICKÝCH KROVOV VYBRANÝCH REGIÓNOV SLOVENSKA

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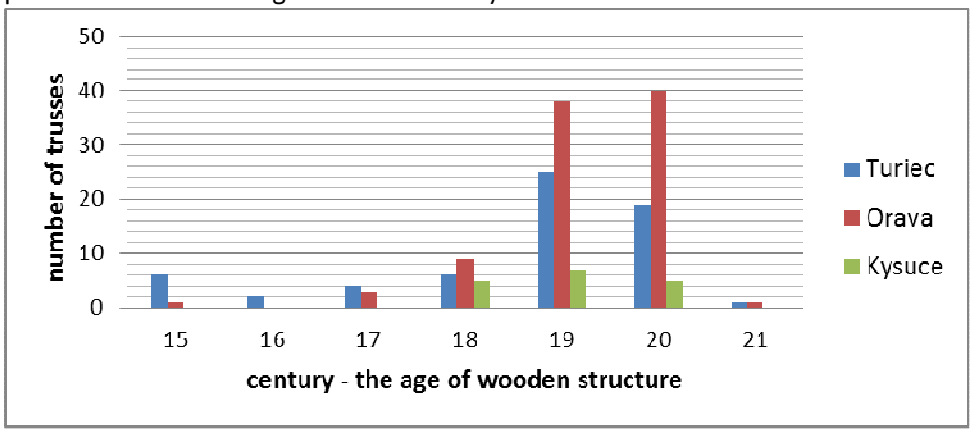
1 INTRODUCTION

Under the constructional and historical research of historical trusses, made in northern regions of Slovakia, the preliminary structural and technological research was also realized. Each of investigated objects is documented in detail, and all information connected with their technical condition, historical and typological classification, locations, and particular interventions was recorded. Information obtained from these studies is being subsequently processed into an overall database with running results processing. This article pays attention to under-roof spaces, and roof decks of historical trusses.

1 THE DEFINITION OF INTEREST

Historical roofs in northern regions of Slovakia, namely in regions of Orava, Kysuce, and Turiec [1, 2], are an item of interest of this paper. The entire research also deals with regions such as Liptov, Bytča, Žilina, and partially Upper Ponitrie as well as Gemer. Until now, about 460 historical trusses have been documented. These studies are chiefly carried out in sacral buildings; secular buildings, especially aristocratic residences, citizens´ houses or administrative buildings are smaller representatives of documented trusses .

Tab. 1 Historical trusses that were analyzed in selected regions of Slovakia alined according to the century (the age of wooden structure by dendrochronological dating)
Tab. 1 Analyzované krovy vo vybraných regiónoch Slovenska podľa storočia (vek drevenej konštrukcie podľa dendrochronologického datovania)



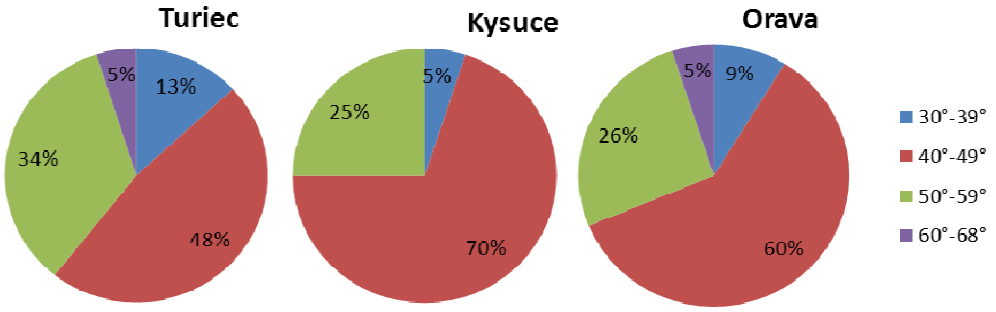


Fig. 1 Roof representation in selected regions according to the roof plane slope
Obr. 1 Zastúpenie striech vo vybraných regiónoch podľa sklonu strešnej roviny

In accordance with professional literature devoted to the problem of historical trusses, it is possible to suppose the certain dependence of a truss structure slope in the roof plane area, and the style period in which the particular truss was built, notably in relation to long-time climate changes, and to the development of structural systems [3]. The database obtained during our studies in selected regions also shows some dependences, while it is necessary to take into account time spread and the shift of typological and structural classification in respect to style periods.

3 THE UNDER-ROOF SPACE

The under-roof space is formed by a truss structure, bounded by a roof deck and ceiling structure over the last floor. In order to achieve state sustainability, it is needful to look into microclimate of under-roof space. It is to identify the impact of humidity on moisture of wooden structural members (prevention from arising critical humidity cases). Humidity in the under-roof space is significantly influenced by the space ventilating scheme [4, 6].

Important openings for air circulation are shown in Fig. 2. They are as follows:

B vent - openings in the lowest roof part having the shape of narrow slit, in eaves spot,
C vent - openings in gable walls (mostly opened to the outside),
D vent - openings in the sloping roof plane (roof windows - mostly closed),
E vent - openings in the sloping roof plane (dormer windows - mostly closed),
F vent - openings in the roof top (a sanctus bell),
G vent - the opening in the roof top (a ridge vent, continuous),
H vent - the opening in the lowest roof part having large dimensions - the opened section at a wall beam.

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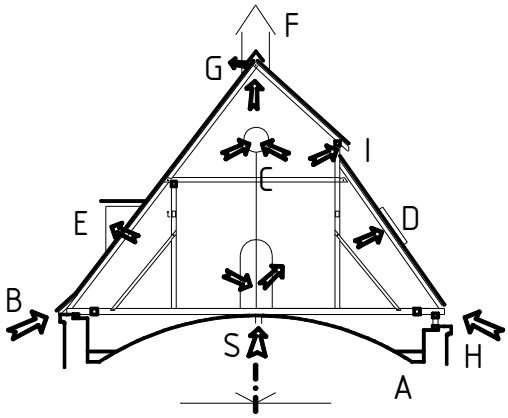

Fig. 2 Openings in the under-roof space of a truss that are essential for space air circulation

Obr. 2 Otvory do podstrešného priestoru krovu podstatné pre pohyb vzduchu v priestore.

Also various leak types are of great importance to air circulation in the under-roof space - e.g. in the joint of a gable wall and roof plane, at a ridge, at eaves, in a roof plane or at different penetrations through a roof plane, for example at a chimney - as well as openings for access to the under-roof space which can be situated in the vertical plane, mostly from a tower, or in the horizontal plane. Vents in the top church arches have also significant effect relating to the entire ventilating function, including the interior (they are assumed to have formed, or form the complete system). On the basis of dividing and combination of openings, there are several basic types of ventilating schemes of the under-roof space in historical trusses. These areas can be divided into various sorts, according to existing types of vents - see Fig. 3:

type a - without vents for an air intake or discharge,
type b - combinations of vents in the lowest and the top part of a truss / roof (BHFG),
type c - combinations of b type vents and vents in gable walls (BHFG C),
type d - combinations of b type vents and vents in a roof plane (BHFG DE),
type e - combinations of all vent types (BCDEFGH) - see Fig. 2.

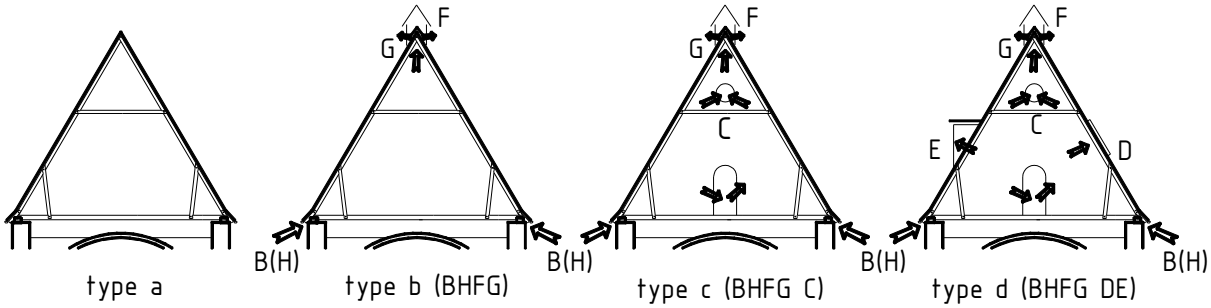

Fig. 3 Basic types of ventilating schemes in under-roof spaces

Obr. 3 Základné typy prevetrávacích schém podstrešných priestorov

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3 REPRESENTATION OF PARTICULAR TYPES OF UNDER-ROOF SPACES

On the basis of information processing regarding investigated historical trusses that were selected from the regions mentioned above, various ventilating schemes of under-roof spaces or vents in historical trusses were evaluated. This evaluation indicates that just the spaces without an air intake or discharge are the most frequent - see Fig. 5). And on the other hand, trusses with an air intake in the lowest point (at eaves), and with an air discharge in the highest point are quite rare.

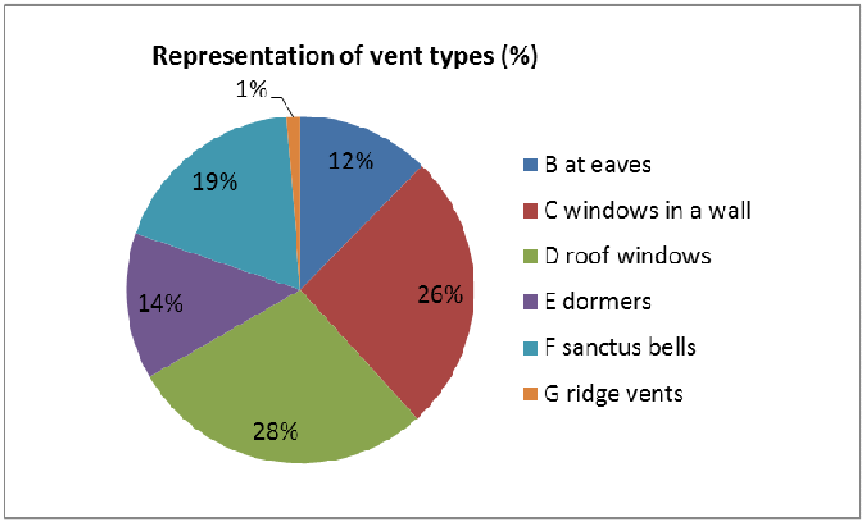

Fig. 4 Various types of vents in selected investigated trusses
Obr. 4 Zastúpenie jednotlivých vetracích otvorov vo vybraných skúmaných krovoch

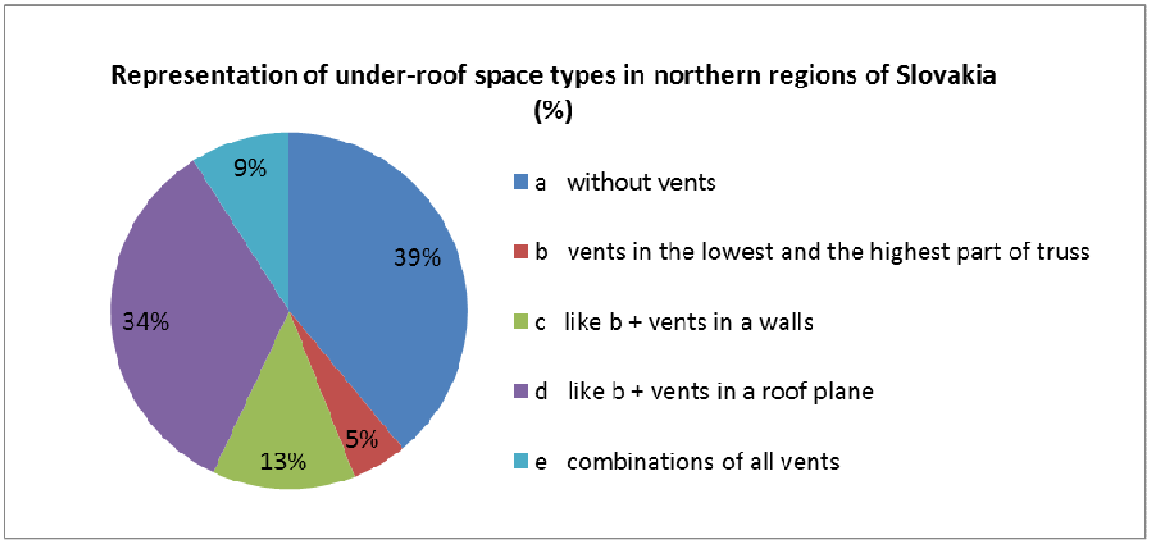

Fig. 5 Individual types of ventilating schemes used for under-roof spaces in historical trusses

Obr. 5 Zastúpenie jednotlivých typov vetracích schém podstrešných priestorov historických krovov vo vzorke skúmaných krovov.

2 REPRESENTATION OF PARTICULAR TYPES OF ROOF DECKS

The roof deck of a historical truss usually consists of roofing on an auxiliary structure. Currently, it is often applied an under-roof foil, which serves as additional water-proofing too, during its exchange. As for investigated trusses, roof foils were applied in 7.6% cases. But the foil was not used properly, often with faults at its realization, in almost 23% cases, which led into various defects .

Individual types of roofing are shown in Fig. 6. The figure also shows that galvanized sheet roofing is the most frequent. The copper sheet is in the second place, and a wooden shingle is the third one. Ceramic tiles are used in 7% of investigated trusses. Use of different types of floor structures was also documented in evaluated historical trusses. As seen in Fig. 7, heavy arches (brick, concrete) belong among the most frequent ones.

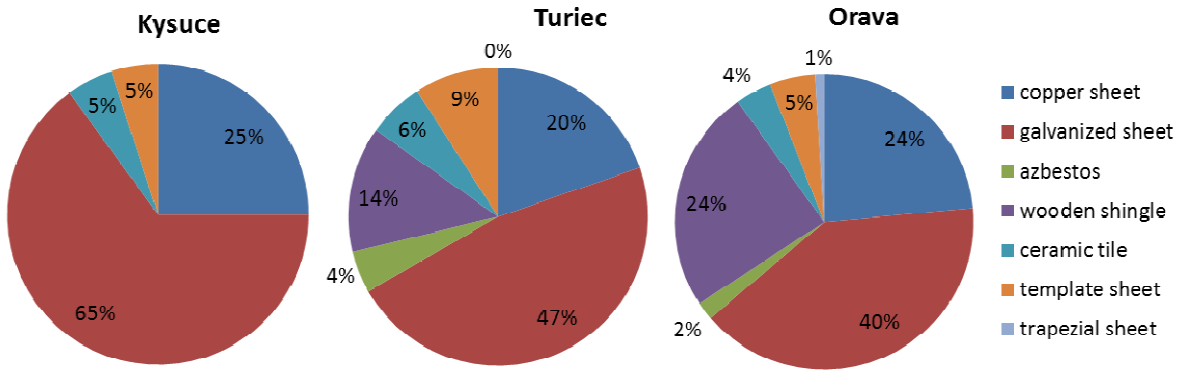

Fig. 6 Representation of roofing types used in selected regions - as a percentage
Obr. 6 Zastúpenie rôznych druhov krytín používaných vo vybraných regiónoch - precentuálne

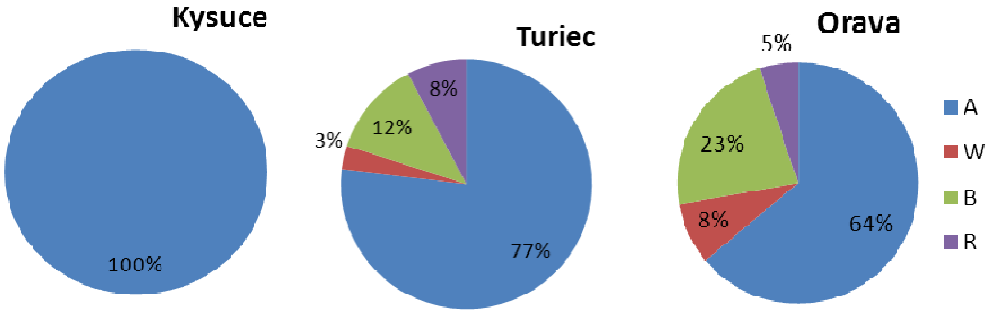

Fig. 7 Representation of floor structure types in selected regions: A - heavy arches,
W - wooden arches, B - ceilings of wooden beams, R - ceilings of reinforced concrete

Obr. 7 Zastúpenie rôznych druhov stropných konštrukcií vo vybraných regiónoch: A – ťažké klenby, W – drevené klenby, B – drevené trámové stropy, R – železobetónové stropy

After the lifetime of original roofing material ends, this is often replaced during the renovation of historical truss. The guidance for preservationists plays an important role in such a process, because they are authorized to choose suitable roofing considering the architectural and historical research. The financial capacity of an investor as well as his suggestibility by advices from "practitioners and

implementers" is also one of important points related to the renewal, due to unawareness of original system functions, sometimes with negative impacts on the structure itself.

4 CONCLUSION

Roofs in historical buildings are renovated very often. There are variety of disorder repairs and leakage eliminations. The leakage occurs as an effect of aging roofing materials, roofing details that are resolved inappropriately and improperly (penetrations through a roof plane, roof plane cracks etc.), wrongly designed details in all roof deck layers (e.g. improper under-roof foil finishing at eaves...). The design of roofing exchange without the project documentation is also very common. As it is obvious from cases brought above, a galvanized sheet is the most used roofing material in all selected regions of Slovakia at the present time.

Contemporary roofing materials are not those types that were used originally. In the past, wooden shingles strongly dominated, or burnt ceramic tiles and metals were used in a smaller measure. As late as in the end of 19th century, the cement-asbestos roofing began to be used. The interwar period is characterized by the significant usage of metal roofing, mainly galvanized sheets. Nowadays, the considerable proportion of galvanized sheets is probably associated with its price.

Regarding ceiling constructions over the last floors, heavy arches are used in most of them, which follows from the high proportion of religious buildings, as it was declared by the research of historical trusses (the access into truss spaces is influenced by approval of building owners). According to use of thermo-insulation on the upper side of ceiling structure in the under-roof space, the region of Kysuce is the area where its occurrence is the most frequent, and the youngest historical trusses that are found there, are those dated from the 18th century. The least of cases were recorded in the region of Turiec, where there are a lot of medieval structures.

The monitoring of under-roof space impact on the quality of wooden structures forms the separate part of this historical trusses research, thus, from this point of view, on its sustainability. The research in the field of under-roof spaces in historical trusses is focused on monitoring and analyzing the microclimate with the aim of achieving preservation of historical structures for future generations. Graphs show "paradoxical" the largest occurrence of ventilating schemes of under-roof spaces in historical trusses without vents - Fig. 5. The structural and historical research of these trusses leads to the conclusion that there is a mutual dependence between biotic damage of wooden structures (their extent and location) and the way of ventilating in under-roof spaces.

Obtained database will be an important groundwork for creating united assessment methodology as far as designed interventions into sights in Slovakia are concerned.

References

[1] SUCHÝ, L. a kol.: *Historické krovy v regiónoch Oravy a Kysúc*. Knižná publikácia. Vydal M. Gibala KNM 2010. ISBN: 978-80-970171-1-8

[2] SUCHÝ, L. a kol: *Historické krovy sakrálnych stavieb Turca*. Žilina: ŽU v Žiline - SvF - KPSaU, 2008, ISBN 978-80-965547-9-7

[3] VINAŘ, J., KUFNER, V.: *Historické krovy – konstrukce a statika*, Grada, Praha 2004,

Projekt „Rozvoj příhraniční spolupráce vysokých škol v oblasti historické architektury“

ITMS 22410320032

ISBN 80- 7169-575-0

[4] KORENKOVÁ, R.: *Analýza podstrešných priestorov historických krovov*. Zborník z konferencie 36. Mezinárodní vědecká konference kateder a ústavů pozemního stavitelství Brno 2012. VUT Brno,p. 49-52, ISBN 978-80-214-4536-9.

[5] Korenková, R.: *Remediation modification of historic roof trusses in region Liptov* [Sanačné úpravy historických krovov v regióne Liptov]. In: Theoretical foundation of civil engineering : XX Polish - Russian - Slovak seminar : Warszawa - Wrocław, 05.09.-10.09.2011 : proceedings. - Žilina: University of Žilina, 2011. - ISBN 978-80-970248-6-4. - S. 395-400.

[6] Korenková, R. – Krušinský, P.: *The analysis of moisture regime of the under-roof space in historical truss.* In: Theoretical foundation of civil engineering: XXI Russian - Slovak - Polish Seminar : Moscow - Arkhangelsk, 3.07-6.07.2012. - Warszawa: Politechnika Warszawska,