

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

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THE ANALYSIS OF METHODS USED IN RENOVATION OF HISTORICAL ROOF FRAMES

ANALÝZA POUŽÍVANÝCH SANAČNÝCH METÓD PRI OPRAVÁCH HISTORICKÝCH KROVOV

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About the article

It is a teamwork, done in cooperation with experts from the field of conservation, and it is mainly focused on typology, construction, and the current technical and constructional condition of investigated trusses. So far about 460 historical trusses have been documented. This paper is an analysis of remediation methods used in historical trusses in the Slovakia. Methods are analysed in terms of construction and in view of the requirements of historic preservation.

1. Introduction

The preservation of historical buildings in Slovakia is essentially comparable to the preservation in other western countries (not only in Europe). Unlike most of these countries, Slovakia had, in the past and present too, much smaller financial base to implement quality renewals. Historically valuable timber structures are unique by design, originality, age, appearance, adjustments in the maintenance, or fixing. As a result of missing upkeep, requirements for their repairs and restoration are being increasing, e.g. sacral buildings, Gothic trusses, etc.. [1, 2, 3].

2. General demands for renovation of a timber truss as a cultural heritage

Designs for major renovations and repairs of timber structures with historical value are to meet, in addition to specific requirements, demands for the preservation of their originality and features. One of elementar needs is to retain the maximal portion of original timber, and to keep the authenticity of a construction. This can be achieved mostly by:

- making the close building technical inspection of a construction, and the detailed diagnosis of damage,
- prompt and permanent removal of moisture sources, and other factors of damage,
- careful sterilization of a timber construction, including non-wooden materials,
- chemical preservation of timber and other materials (using fungicides, insecticides...),
- preferring conservative and restorative strengthening of timber to its replacement,
- not using timber that is stripped of the bark insufficiently, or not at all. It must be sound, stored for a minimum time that is required for drying; not from the long-lasting wood storing in the forest, or quarried.

The interventions that would change its original character may not be made because of the historical value of building. This is supervised by conservationists together with the designer of a reconstruction. The following requirements are to be taken into consideration:

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- using the same wood species as the original one when inserting new wood into a construction - prostheses of members, their replacement, sealing, etc.,
- adapting the way of treatment, as well as dimensions of a new wooden part, to original timber - cutting, hewing (do not use for cut wood [4]), due to the elimination of dimensional differences of elements - a natural appearance,
- employing traditional techniques and procedures when repairing damaged wood (to prefer carpenter's methods to polymer-concrete when using prostheses),
- using wooden pegs with bone glue when fixing conventional carpenter's joints [3],
- bolted joints have to meet, besides obvious technical requirements (the fulfilment of specified minimum distances of bolts, washer types), aesthetical demands too (joint locations and bolt spacing),
- applying protective coatings in the colour of original timber, or paints with no added pigments (a different method should be worked with to control the realisation); it is also possible to use adjustments with or without a patina,
- using steel elements in a truss construction, if inevitable - they should be fitted with a protective dark-colour coating (grey, brown, black); historic wrought iron parts need to be rid of rust, or be coated with graphite,
- if mending is required, it is better to take temporary measures than wrong permanent ones, or some inappropriate solutions (e.g. to choose a provisional static support of a construction in case of not ensuring its proper repair or reconstruction at the time),
- the necessity of preserving original constructional arrangements (i.e. not to change the typology of an original roof truss, a roof shape, a roof or dormer window size, their types, numbers etc.).

3. Methods of renovation

Three fundamental methods of renovation are distinguished in practise, as well as in the field of an investigation:

1. the reinforcement of damaged parts,
2. the strengthening of weakened constructional wholes,
3. the replacement of damaged components.

More restoration procedures of reinforcing timber truss constructions are being verified in a research. When working with all these techniques for the renewal of historical roof frames, it is needful to meet the general requirements that are mentioned in Chap.2. Various ways of reinforcing timber parts are known [5]:

I. Section enlargement of an element

A. Fishing - right to reinforce damaged parts, and those that have not sufficient load capacity as for the present, or the future situation. Fishplates made of heavy wood, wood substances, steel, and other materials are put into effect e.g. in repairing beam or rafter

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heads. This is the most applied method of reinforcing, but from the view of a preservationist, it is not proper about the number of auxiliary means for connections.

B. Lengthening with polymer concrete - a specific technique for toughening beams using synthetic polymer with addition of filler. It is used mainly abroad, there is no available information about its utilization in the reconstruction of historical roof frames in Slovakia.

C. Anchoring, i.e. inserting sound part of a member into a steel console - applied in particular situations, e.g. strengthening beam heads that are markedly damaged. Anchoring can be made in a traditional manner, or with special stainless monolithic consoles. It is rarely employed in our country.



Fig. 1. Left - double-sided fishing in the church truss in Okoličné.

Right - an example of anchoring tie beams using steel consoles in the Blatná's castle (the Czech Republic).

Obr. 1 Vľavo obojstranné príložky v krove nad kostolom v Okoličnom, vpravo príklad kotvenia väzných trávov do ocelových konzol, hrad Blatná (ČR)

II. The application of carbon lamellas, or rugs based on carbon fibres - they are placed primarily into the parts of rafters, beams, or ties that are exposed to pressure or tension. This way of reparation is not used in common practice related to the renewal of historical trusses.

III. The replacement of damaged timber in a member with sound one, or other material with keeping its original dimensions:

A. Using prostheses - a broken part is replaced, or completed with a new one (prosthesis). This is accomplished either by classic, or beta method. Carpenter's techniques are required to be preferred in historically valuable buildings. It is the most used way of repairing. In terms of the conservation, it is tolerable until connective parts are related, and newly inserted wood is of the same species and treatment.

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B. Sealing - a local addition, or an exchange of broken timber by sealing. It is utilised to recover the wholeness of timber members, or re-establish the resistance to compression using wooden, putty, foam sealants. Regarding historical trusses, it is applied as a restorative procedure only sometimes.

C. Preserving - a technique used for impregnation of damaged timber with hardener - epoxide resins, polyacrylate, shellac etc. Its application during the renovation of historical roof frames is limited on account of its higher price.



Fig. 2. Left - the repair of a tie beam together with rafter heels and struts. Photo shows new parts, dressed to fit for dimensions of original ones, in the St. Jacob's Church in Horní Slavkov (the Czech Republic). Right - the repair of tie beam heads with prostheses, an exchange of wall plates in the church truss in Okoličné.

Obr. 2 Vľavo Oprava väzného trámu, spolu s päťami krokiev a podkrokvových vzpier. Nové prvky sú hobľované, tvarovo prispôsobené rozmerom pôvodných prvkov. Horní Slavkov – Kostol sv. Jakuba staršieho (ČR). Vpravo Okoličné, oprava zhlavia vzných trámov protézami, výmena pomúrnic.

IV. The permanent change of a member solution - takes an advantage of additional components made of steel, wood, or other materials (e.g. creating a new carrier system from a single beam using steel draw rod). This solution is sporadically employed in practice. In case of putting new elements, and different materials, it is recommended to follow conservationist's instructions, thus meet general requirements mentioned in Chapter 2.

There are also other, indirect ways of reinforcing members, or increasing fastness and toughness of constructional wholes. They are as follows:

V. Supporting - used when implementing temporary as well as long-term repairs of horizontal, and some diagonal members. It is a frequent, very often provisional solution

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lasting for a long time. The stable solution is required to be made as soon as possible, according to valid principles.

VI. Bracing - regarding trusses, this is, along with toughening unbound parts of a spacial construction, the most employed technique. Its application is common, it have to be realized in accordance with structural engineer's instructions, and conservationist's requirements as well.



Fig. 3. Left - supporting, Kysucké Nové Mesto. Right - bracing, Liesek.
Obr. 3 Vľavo Kysucké Nové Mesto, podopretie. Vpravo Liesek, stuženie



Fig. 4. Left - the steel construction used for construction of an object and unloading of a ceiling in the manor house in Moravský Krumlov. Right - bidirectional bracing of a truss using steel tie bars, Kvačany.

Obr. 4 Vľavo kaštieľ - Moravský Krumlov – vložená oceľová konštrukcia na stiahnutie objektu a odľahčenie stropu. Vpravo stiahnutie krovu oceľovou pásovinou v oboch smeroch. Kvačany

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Fig. 5. Left - the removal of a surface layer from the timber member damaged by ligniperdous insects (degradation of a carpenter's mark) in the St. Martin's Cathedral in Bratislava.

Right - the restoration using fishplates finished with dark-green protective coating in the wooden, so-called Peace Church, dated from the middle of the 17th century in Jawor, Silesia (Photo by L. Suchý).

Obr. 5 Vľavo zosekanie povrchovej vrstvy dreveného prvku poškodenej drevokazným hmyzom (znehodnotenie tesárskej značky) – katedrála sv. Martina v Bratislave. Vpravo Sliezko, Jawor (drevený tzv. mierový kostol) z polovice 17. storočia sanačná obnova príložkami „zavřená“ farebným tmavozeleným ochranným náterom – foto LŠ.

VII. Unloading - used mostly in repairs of ceiling joists, and tie beams. It is seldom implemented in renovating historical roof frames.

VIII. Other methods - e.g. inserting of some members, constriction of constructional wholes, or the transfer of preload onto a construction. It is often applied due to the problematic transfer of horizontal load in historical trusses.

IX. The treatment of the damaged surface of a timber element resulting in lessening the section without breaking a minimal bearing section - it is consider to be unsuitable by conservationists, because both traceological prints and a historical value can be degraded when removing a surface layer [6].

X. Chemical staining of timber members, i.e. their treatment with chemical agents - insecticides, fungicides. Applied, if there is a need of using this technique in specific cases, but it should be consulted with dendrologists and conservationists on account of its side effects and consequences which are often neglected (e.g. wood pulping).

XI. Other procedures of a truss renovation that are not counted among the ways of renewing, but they solve an exchange of members, possibly the entire construction, so the imitation. The exchange of members, or roof parts (e.g. a neck gutter, a hipped end etc.) is

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commonly realized in practice. It is a proper method provided the rules hereinbefore (see Chapter 2.) are kept.

4. Conclusion

Most renovations of historical roof frames are done only as a roofing exchange, when a builder realizes them without a technical documentation. There is no concept, detailed analysis, damage specification, and state estimation. The following circumstances may affect the result of a historical truss reconstruction:

- owner's investments (finances),
- the project of a reconstruction, or a renewal ,
- conservationist's requirements,
- craftsmanship of a building company.

The most striking repair is usually the extension, or the replacement of a damaged part using new wood. The question is, whether there is a need to pay attention to covering joints of repairs, or to try applying the most modest repair, as for the historical truss constructions that are off limits to the public. When choosing the proper reparation method, it is firstly important to allow for the reliability of joints, as well as to ensure the right conditions for making a repair. Then comes an aesthetic effect, and taking account of the costs. Renovations of historically valuable trusses should be implemented in such a way that they would not be noticeable, and the roof frames would not lose their aesthetic value, unique decor, features, and originality. The often trouble that emerges in truss renewals is to tell what kind of reparation can be consider traditional, or permissible regarding conservationists' demands, and what kind cannot [7]. Restorative modifications themselves are to be made on the basis of a technical documentation, where the use of particular methods is exactly prescribed. It calls for co-operation of a designer, a structural engineer, an expert on wood (or other experts), and finally a conservationist.

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