

STRENGTHENING OF TIMBER STRUCTURES BY CARBON COMPOSITES

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Abstract

Rehabilitation of load-bearing timber structures with buildings of historic preservation protection raise a number of problematic issues. One of the problems is the need for analysis of timber framed structures made of solid wood for large spans over irregular ground plan with large loads.

These input conditions and dimensions of cut profiles making it necessary to increase the resistance profile, eliminating deflection and elimination of load-bearing elements dimensions. This case was solved in the rehabilitation of the roof space of the former stables in historically protected ruin Vitkuv Hradek. A massive wooden structure with spatial beam amplification technology built of carbon composite blades into the body of the beam was chosen.

Key words: *historical buildings, renovations, wood construction, carbon composites*

1. INTRODUCTION

Ruins of the castle Vitkuv Hradek is on the top of the hill above the village of St. Thomas at an altitude of 1029.40m. The ruin is the object of heritage protection and is used as a tourist attraction with a view to Lipno region. In the western part of the ruins of the original entrance to the castle there are the remains of the former stables. The main task for the designer was to design sitting place with protection against the rain. The existing space is defined by the original stone masonry. The floor is clay gravel. A serious condition of the workers of the Heritage Institute has been non-interference in the original stone walls of the castle, to minimize interference in the underlying soil, green roof design and use only materials and structures adequate to the historic environment.

The selection of construction significantly influenced mainly climatic conditions: altitude of 1029.40 meters above sea level, exposed position of the Bohemian Forest ridge, geographic location of Bohemian Forest open in the direction to the dam Lipno and to Bohemian Forest on the side of Austria, location of a strong wind and snow precipitation. The ruin is permanently under snow cover from about mid-November to late April; snow reaches a height of 1.500 to 2.000mm.

1.1 Supporting construction

A wooden structure of massive timbers separately built into a chosen space. The only supporting element of other material is the supporting circular pillar walled by quarried stone, which enables centric supporting of joists and currently serves as the smoke extraction from the open fireplace. Ceiling structure was solid with the kulaks with green roof coverage.

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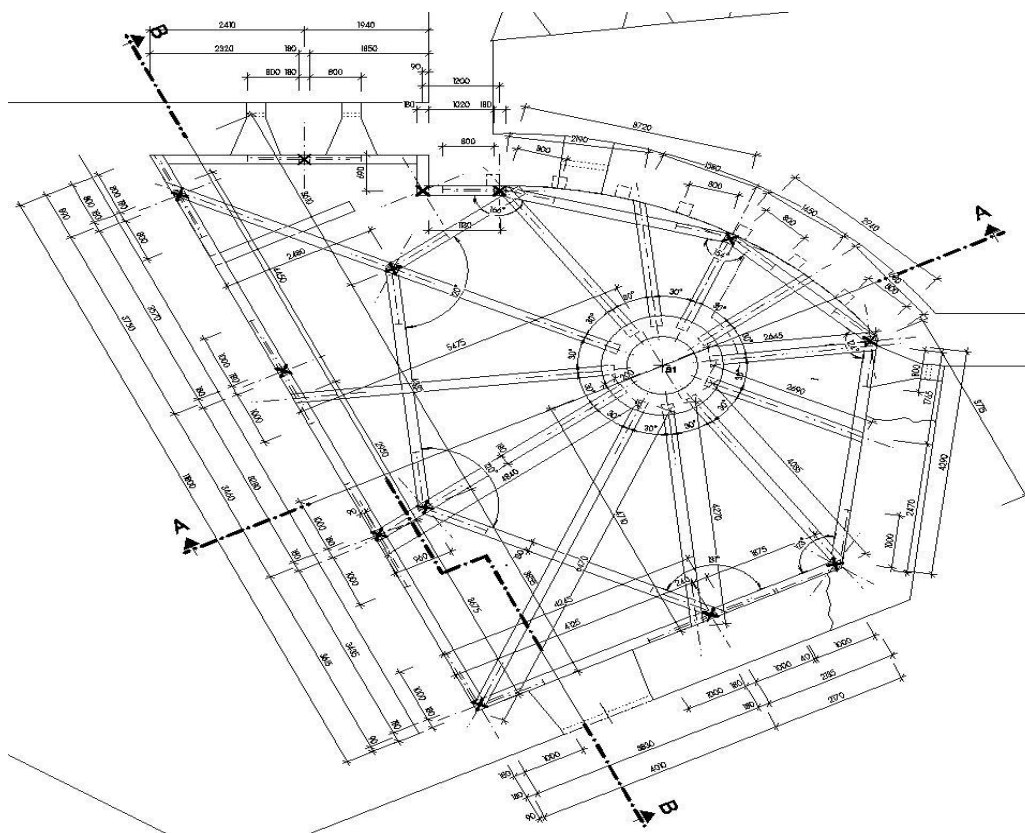


Fig. 1 Construction

1.2 Static values

A serious problem to address was the need to design wood structures in the massif. The total computational load of rafters and purlins amounted 22.9 k N m^{-1} . The rafters and purlins reached the critical length of 6,000mm, with a combination of rafters and purlins in a form of a grid, the length ranged from 3.000 to 5.000mm. The initial calculation led to very robust profiles – rafters 180/280 mm and purlins 260/420 mm. A variant of the shortening of span by clamps did not produce any significant change in the profile. Other considerations led to the solution to the rafters with supports to the static diagram of continuous beam. Even this option, which would enforce the compression of supporting columns in interior, did not lead to significant improvement.

1.3 Carbon composite reinforcement technology:

To calculate and simulate the evaluation of the limit construction height of columns, for the vertical clearance in so-called interior the limit profile 180/280 mm was chosen as the maximum possible for all horizontal beams - rafters and purlins. Beams, where an excessive load limit profile failed, were designed reinforced by composed carbon fibre blades.



Fig. 2 View of the construction in the interior

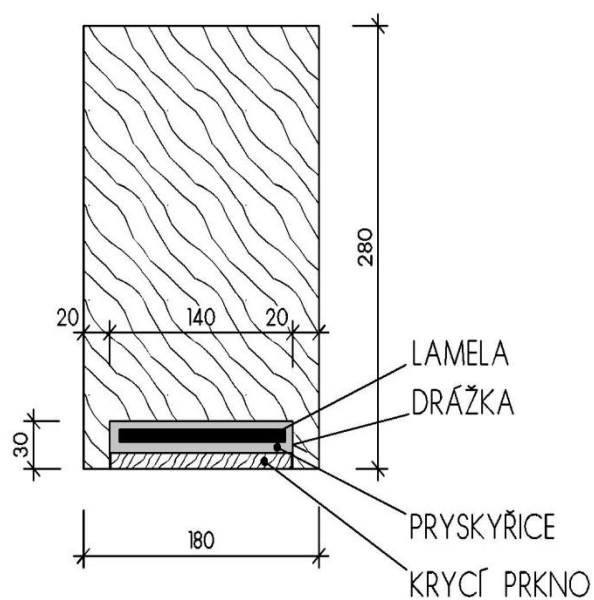
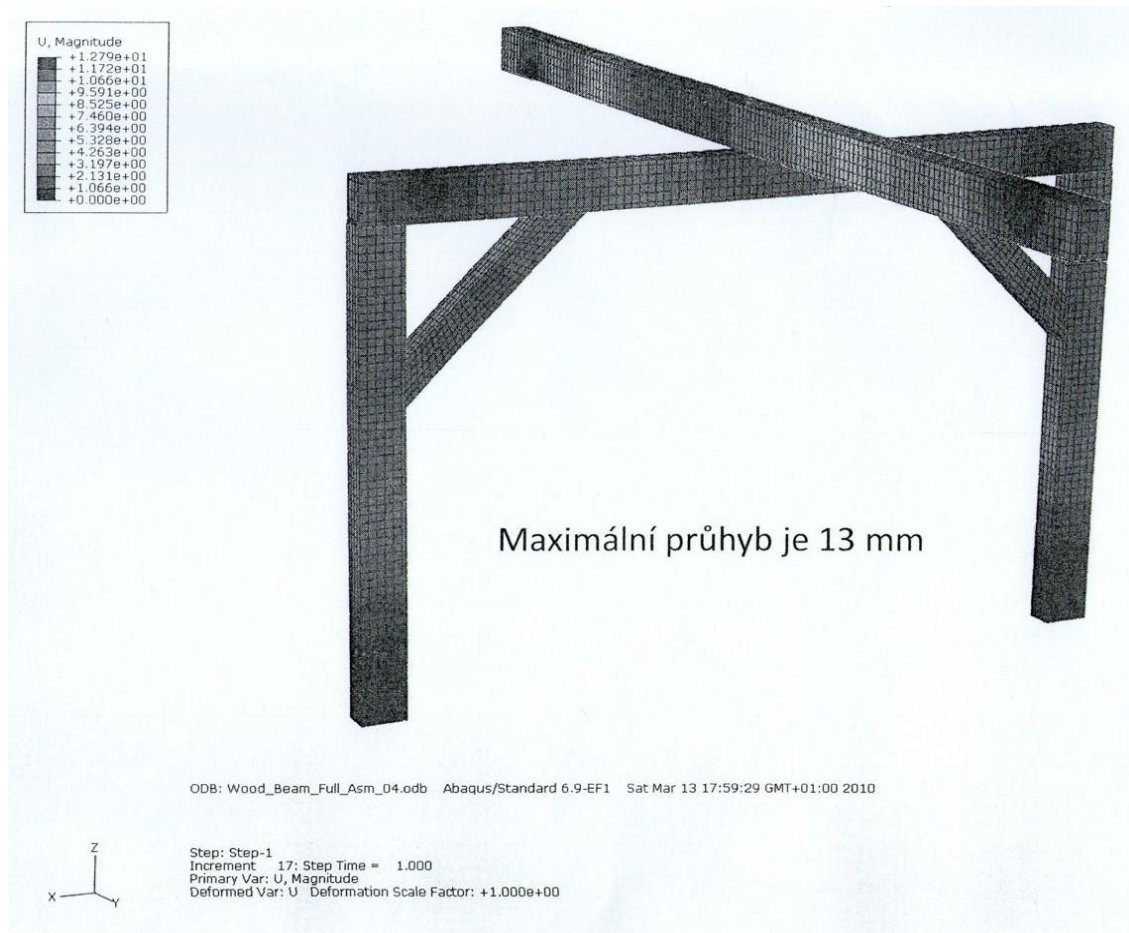
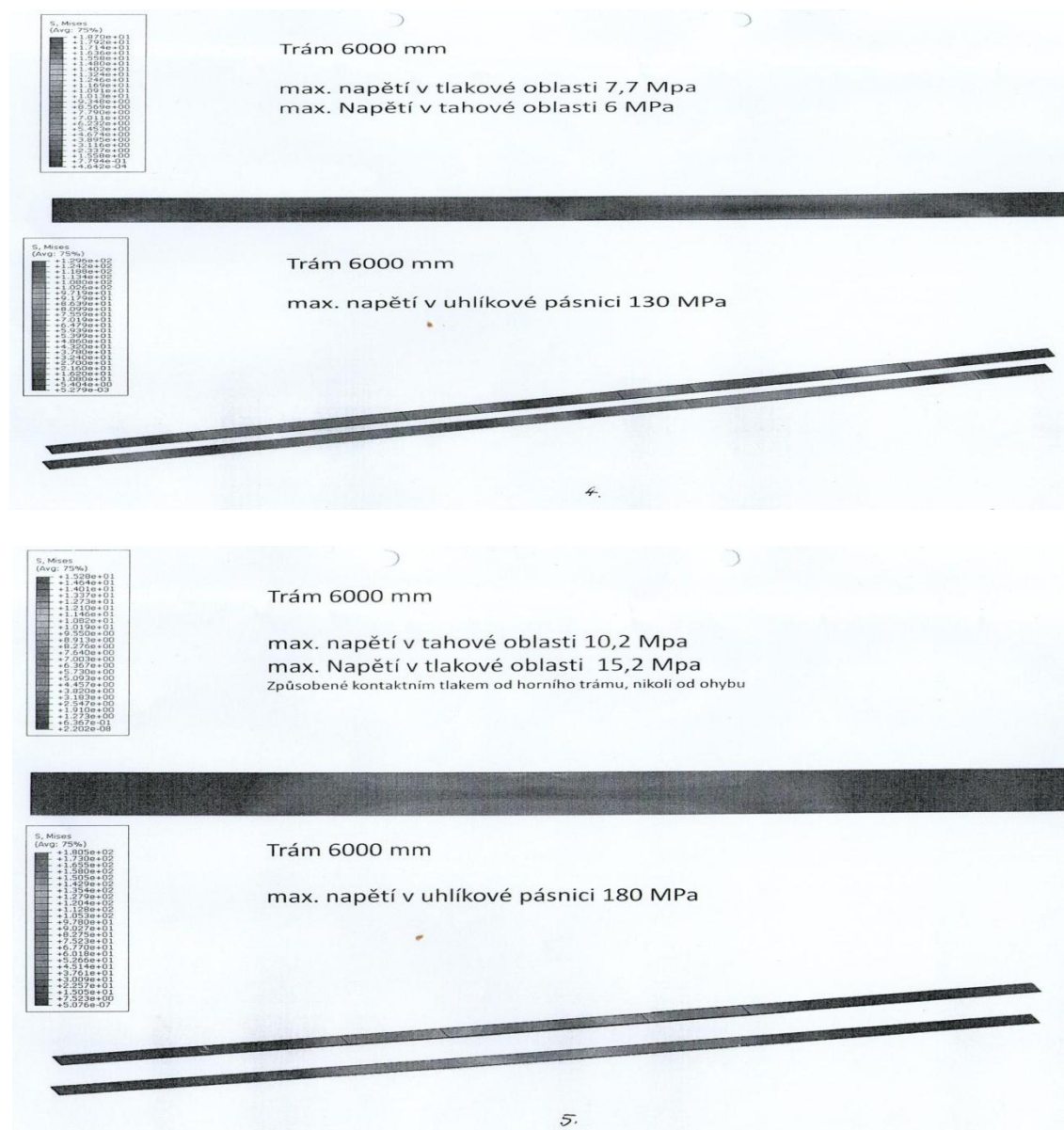


Fig. 3 The scheme of gluing strips

Reinforcing plates were designed for each individual reinforcing element. Slats are glued into grooves in the beam size 140/30mm. After the length of the amplified profile blades do not have the same cross-sectional area. They are moulded into the vault. After gluing the slat the groove will be covered with board being affixed to the resin. Graining of the glued board will be adapted by selecting the wood by the beam so that gluing was unified with the original drawing of the beam.





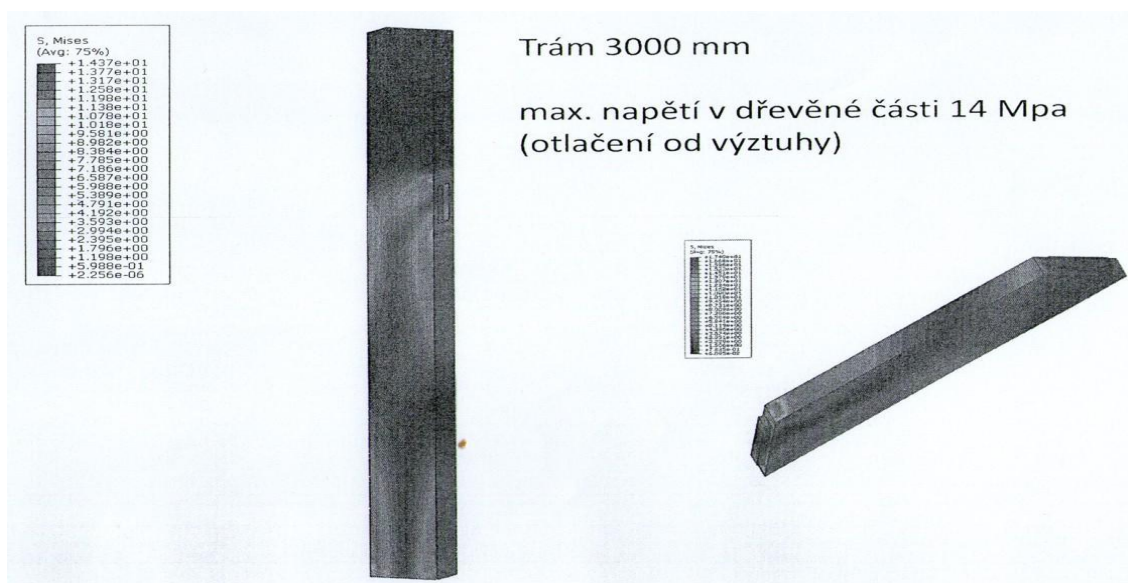
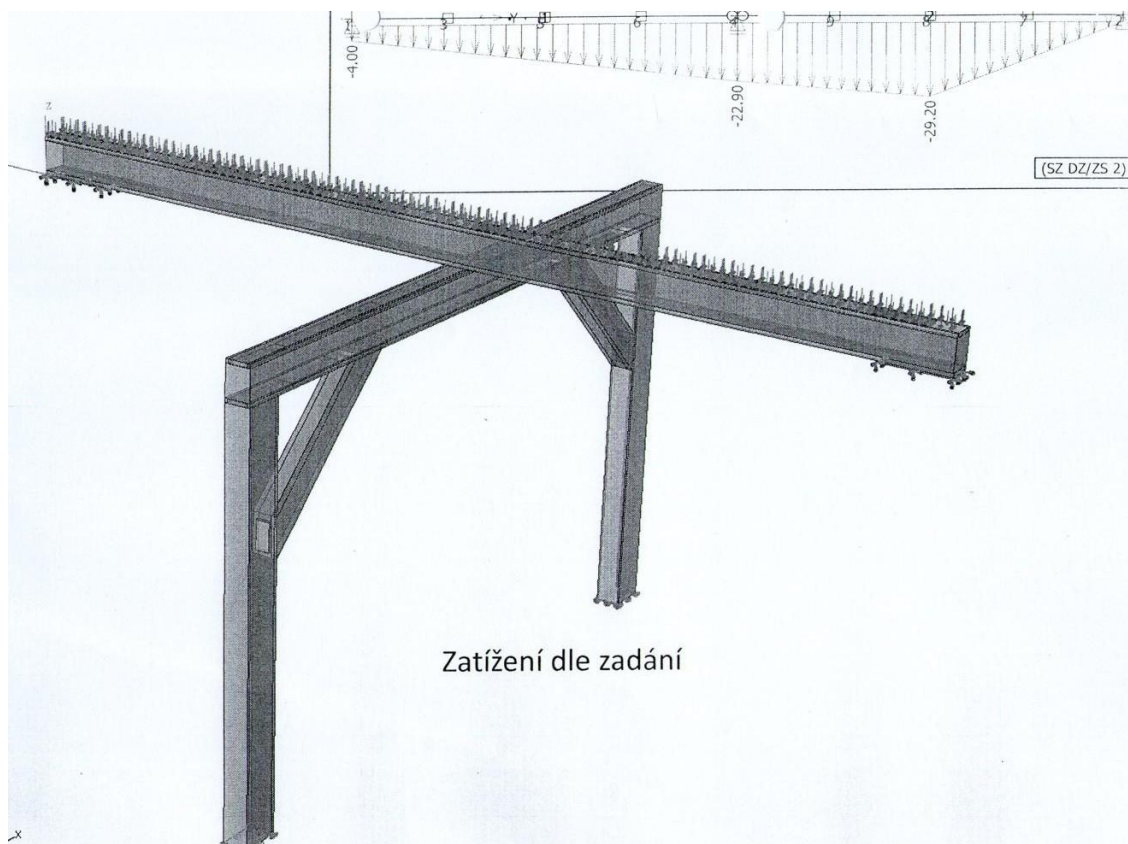


Fig. 4 Sequence of modelling

1.4 Technological conditions for strengthening the implementation

The basic conditions for a perfect connection and function of the function of the reinforcement of the beams by blades so as to achieve mutual interaction are:

- a) Fully cure of the matrix and adhesive resin
- b) Prohibition of mechanical damage to slats built into the beam

Criterion a) enforces to perform reinforcing beams in professional business premises, dealing with the manufacture of composites with experience in their design. Individual profiles are therefore available for building in the exact lengths for installation without modification as so-called prefabricated. Criterion b) enforces the special procedure. When you need to cut the reinforced profiles can be cut by special blade and only by trained personnel of the supplier of reinforced beams. Using standard discs may result in injury or death by static electricity. Joining reinforced beams with tapes must be carried out double pin outside interference in the amplification plates.

2. CONCLUSION

Strengthening of timber structures by composite materials based on fibres in resin matrix can help to the solution of reduction of the wooden profile at high loads, amplifying the original and historical wooden structures or solution of atypical and complex wooden systems. It is a new technology which may shift the application of wooden structures in the position of the material capable of load transfer of higher values with the elimination of deflection

REFERENCES

[1] construction project, prepared VYKOS CZ s.r.o. Ceske Budejovice team: Ing. Alena Hynkova, CSc., Ing. Petr Hynek, Ing. Frantisek Profant, February 2010.

The contribution in the collection is authors.