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The timber truss: The studying of the behaviour of the spatial framework joint☆

Jana Rumlová [a,*], **Roman Fojtík** [b]

[a] *Department of Building Structures, VSB — Technical Univerzity of Ostrava, Faculty of Civil Engineering, Ludvika Podeste 1875, Ostrava-Poruba 708 33, Czech Republic*
[b] *VSB — Technical Univerzity of Ostrava, Faculty of Civil Engineering, Ludvika Podeste 1875, Ostrava-Poruba 708 33, Czech Republic*

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Summary Using of timber in civil engineering is increasing at the moment. Main timber elements are used for main supporting structures, typically for buildings, roofs, footbridges or towers. This work studies unique timber trusses as a supporting roof structure of spatial timber building. Timber trusses are used as roof supporting construction for objects with open inside space, especially halls or office buildings. This paper resolved critical joint in roof construction which is created by four timber trusses. The FEM model monitored strain changes in critical places of resolved joint.

Introduction

The aim of this paper is description of heavy timber framework of administrative building and analysis of strain and fixity changes of unique spatial timber truss. This spatial truss is designed as framework for roof of atypical administrative building and it is consisted from four trusses in different axial directions. The truss in this work is design by larch wood from certain areas of Poland and Ukraine. This type of wood was used for its very good strength characteristics and for another really positive feature, its high resistance to weathering.

The critical point of the structure is the crossing of two trusses. This joint is realized without steel element, so it is realized by rods and notches. The beam and board FEM model were created to get exact strain and deformation results, which were compared.

Description of the structure

The proposed object is formed of four units, each of which has a plan shape of a regular octagon with a side length of 3.7 m; individual cells have different heights (Fig. 1). This paper discusses only first one. This part of building has two floors and the total height is about 8.5 m. Based on the

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* Corresponding author.
E-mail address: jana.rumlova.st@vsb.cz (J. Rumlová).

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Figure 1 Set of a heavy skeleton made of four Portakabins.

Figure 2 Implementation of the strength test on wooden samples.

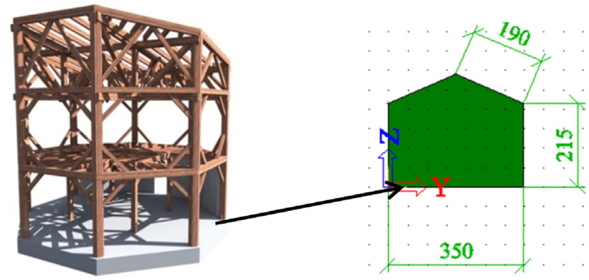

Figure 3 Supporting structure of the object and ground plan of pillars.

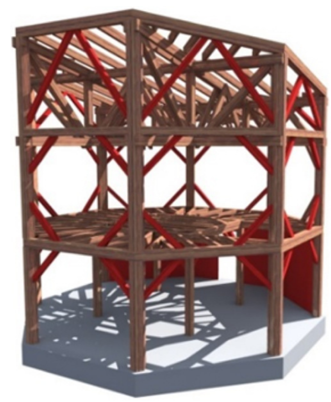

Figure 4 Designated stiffening elements.

assumption of the largest burden, this part has become the prototype for other parts of the entire building. The aim of the project was to design a building using the minimum of steel fasteners.

The supporting structure of the building is designed as a heavy skeleton with joints which do not use steel elements. As a building material was chosen massive larch wood of large profiles, whose origins are in different parts of Europe, particularly in Ukraine and Poland. Based on the mechanical destruction tests, the timber was placed in the C30 strength class (Fig. 2) (Lokaj et al., 2010; Lokaj and Marek, 2009). Thanks to these strength tests it was possible to classify the wood and use it effectively in the structure.

Most of the construction is solved in articulated joints. The joints were designed as pin ones, using beech pegs of the D40 strength class or traditional craft joints. The construction had to be designed so that the wooden joints could transmit the resulting internal forces. The bearing capacity of the wooden dowels was based on tests conducted on the joints of historical buildings (Agel and Lokaj, 2014).

Because the rigidity of the timber joints is lower than steel joints, one of the most important thing, was to designed hardening system of the building.

Main hardening systems of the building are the overall bracing system (Fig. 3) of the object, the supporting structure of the ceiling and the roof support system (Fig. 4). With all these design measures, there was a significant increase in the stiffness of the whole structure. The biggest influence on spatial stiffness then has a spatial truss structure. The ceiling level stiffness is ensured by a coupled wood-concrete ceiling which follows the reinforced concrete walls in the level of the first floor. Spatial stiffness is largely supported by straps placed both at ceiling level and at floor level. The straps are designed only for pressure tension.

Truss — bearing structure of the roof

To ensure an open area without internal columns on the second floor, a roof using space truss was chosen. This design can be divided into two main directions (Fig. 3). In one direction are used two identical counter trusses with the upper belts slope of 12°. Pitched trusses have a structural height of 2900 mm at the highest point. Perpendicularly to these beams are placed two straight trusses of the construction heights of 1600 mm and 2300 mm. Because of the limited design lengths, the secondary elements in central fields are replaced and attached to the outer field using pin connections. The strips of the outer fields are formed by two sections so as to facilitate the installation of anchors to the support columns of the structure (Fig. 5).

Suggestion for crossing

The most critical and also structurally the most interesting design detail in the structure is the crossing point of lower and upper belts trusses (Fig. 6). In this joint there is a crossing of elements in three directions. To achieve the same level crossing of the beam axes, these beams were given notches halfway through the profile.

Thanks to the intersection the node does no longer act as a hinge joint, but there are negative bending moments which can be compared to the case of restraints. Besides these bending moments there are also additional moments