

REHABILITATION OF A TIMBER TRUSS FROM THE ROOF OF TURDA THEATRE HALL

Nicoleta COBÎRZAN¹

Abstract: Damages or some local failure of timber trusses used in case of existing buildings are related in almost all the situations to weathering or biological attacks caused from insects and fungi and rarely to aging phenomenon or amplified loads. Strengthening or substitution of some parts of the truss (especially the beam supports) are necessary interventions used to ensure the safety of the structure or to increase its level of performance. In this respect, the paper present the strengthening solution used in the case of a timber truss, for a building located in Turda city. The strengthening solution was consisting in a metal structure fitted to the truss support designed in order to transmit their loads to the lateral load bearing masonry walls.

Key words: strengthening, damages, truss, plaster, humidity.

1. Introduction

Beneficiaries of old buildings are interested to keep on using the buildings as they are, though they would require during lifetime capital repairs and interventions in order to meet the performance criteria. Capital repairs demand, imposed in most cases, rehabilitations or strengthening interventions which are complex works because every existing building has its own specific features and behaviours.

The entire damages found in a structural element or some parts of a construction can affect substantially not only its operation safety but sometimes its structure.

The incapacity of old constructions to meet the structural performance criteria, often followed by local failures of component members in the structure, puts the safety and stability of these buildings

in a very great danger. Investigations show that the causes leading to the incapacity of existing buildings to satisfy the minimum performance level, are many and varied, but in almost all the cases the origin of the degradation process lies in water presence.

In the case of constructions where roof trusses are made of timber, humidity represents a very harmful factor, as wooden materials are water sensitive; moisture generating and increasing the damage phenomenon which can be sometimes followed by some local failure.

The structural rehabilitation issue in the situation of such constructions is solved only in principle in today's studies and research. For this reason, every single construction represents a case study in itself where structural intervention measures are varying from one element to another one and from one building to another one.

¹ Technical University of Cluj Napoca, Cluj Napoca, Romania.

Scientific concerns in the field, conferences with issue dedicated to timber roof framing and trusses, increased in number and extent during the last years being more and more focused upon new research methods dealing with the assessment of structural strengthening of framings, the methods and techniques of rehabilitation or applying advanced technologies in a proper manner for this field [1-5].

In this context the paper present the damage causes, and rehabilitation solution applied in case of a damaged timber truss belonging to a masonry building.

2. Materials and Methods

2.1. Description of the Construction

The roof timber truss under investigation is one of the trusses belonging to the timber framing of a masonry building (Figure 1) situated in the city of Turda.

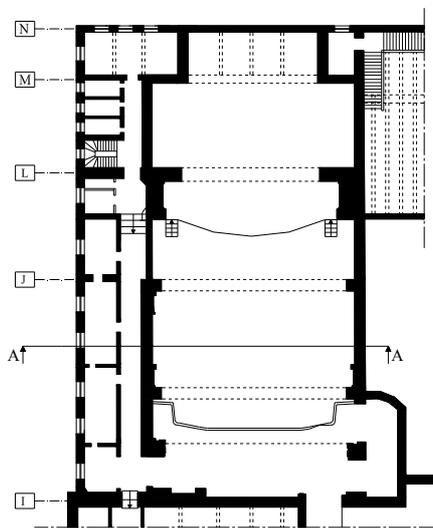


Fig. 1. First floor plan

Building having a high regime of ground floor+attic (Figure 2), was erected at the beginning of 20th century, on an existing basement of a building belonging to the 19th century.

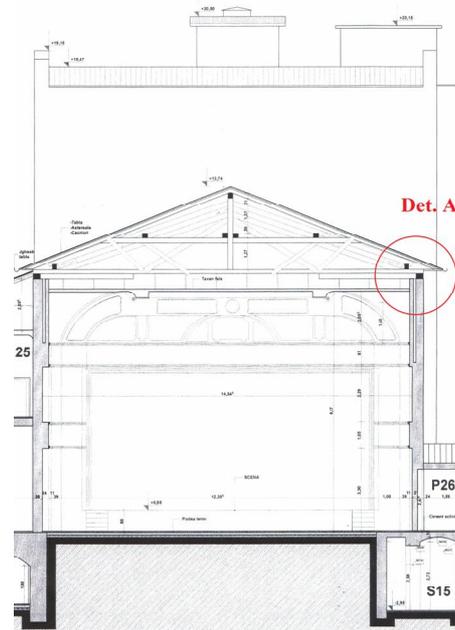


Fig. 2. Building cross section

The vertical structural system of the building is made from loadbearing walls of brick masonry with lime mortar.

The over the basement floor has the form of a thin membrane of plasters, cast over a mesh of reinforcing steel of diameter $\varnothing 10$ mm at the between-the-axes distance of about 40 cm. The plaster is suspended to the roof frame with wire tie-rods (Figure 3a, b).

Structural system of attic is consisting in principal frame, which support on all lateral load bearing masonry walls belonging to the theatre hall room.

The timber trusses are made of vertical and diagonal bars connected with metallic fixings. Where stresses are high, the sections are reinforced with metal strips (Figure 3b).

In order to take over the loads transmitted from attic roof were provided purlins between roof trusses in order to sustain rafters. Wind bracing fixed on the inferior part of the truss flange (Figure 3b) were provided to assure bracing in longitudinal direction.



a)



b)

Fig. 3. *Suspended tie- rods*

The trussed beam end bars are connected by housed joints, added by supporting subbeams that take over the loading. They are fastened to the trussed beam inferior flange by means of wooden wedges fixed with metallic ties.

The compression and shear stresses in the joint are undertaken by both, the joint elements and metallic ties, being transmitted to bearings.

Foundations are made of brick and stone masonry works.

2.2. Structural Damage and its Causes

The observations in situ showed that the structural damage stops at the level of the attic floor and are not due to earthquakes, foundation settlements or similar causes,

but are mainly determined by the moisture originating in rainfall water and to a lesser extent to the aging of the timber. One end of truss no. 2 from J axis (see Figure 1) got rotten and failed locally, the vertical displacement of the truss support after failure being about 10-12 cm (Figure 4).



a)



b)

Fig. 4. *Truss failure*

It was also found that part of the existing steel elements are displaced, deformed and corroded. Truss no. 2 (from J-axis - Figure 1) had a support that failed and was strengthened probably soon after inauguration.

The vertical displacement of the truss and other members moved together with the former, affected the stress state in the suspended tie rods of the ceiling leading to ceiling cracks.

The advanced state of degradation of the truss support put in danger of collapse

actual attic floor and the entire construction area. In this respect is required to be taken a rapid intervention measures to counteract this phenomenon [6].

2.3. Intervention Measures

To rehabilitate the truss (the affected beam support area), the study took into consideration the idea of consolidating it's area in the displaced position, as the movement to the initial position would encompass the collapse of the floor and its ceiling decorations.

The following general principles were analysed:

- realise a consolidation system that could be transported in situ through a network of tie-rods suspending the ceiling of the hall, made by the workers, and assembled in situ without welding, to prevent fire;
- removing moisture due to water infiltrations, the main cause of structural damage that affected the timber material;
- increasing the number of steel anchors from trusses no. 1 (L-axis) and no. 2 (J-axis), removing rust and painting them;
- after strengthening the truss support, all tie-rods shall be checked to be active.

Strengthening solution was established considering the methodologies imposed by P100-92 [7], NP 005-2003 [8] and NP 018-2003 [9].

3. Result and Discussion

For the strengthening of the truss flange, a steel structure fitted to the lower end of the truss was used, to transmit the load from the truss to the bearing masonry walls.

The metallic structure is made from two U16 bars, fixed to the flange (Figure 5); these bars transmit gravitational loads from the truss to the structural masonry wall. The load transmission is made through a metal bearing (Figure 6).

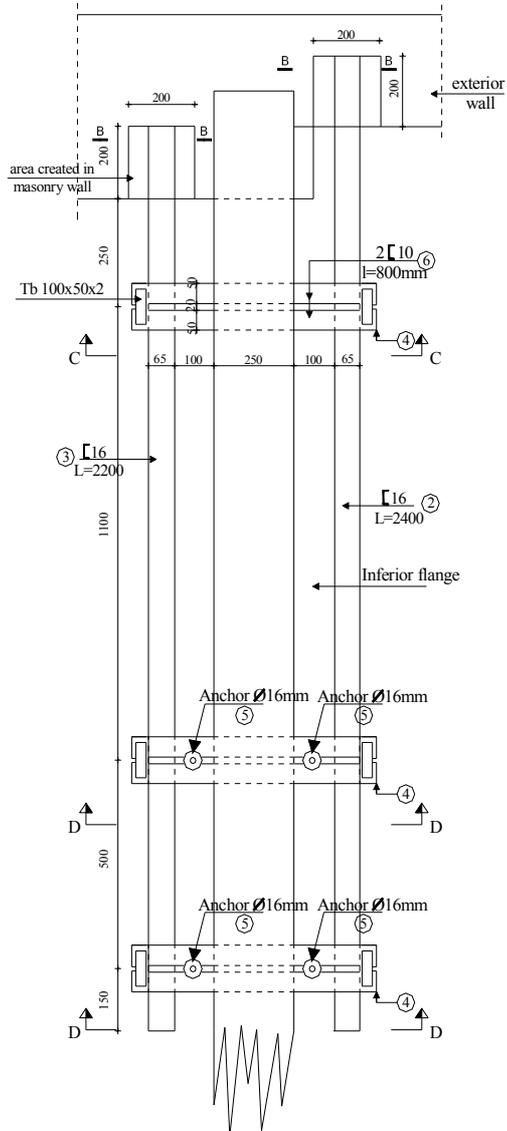


Fig. 5. *The strengthening structure*

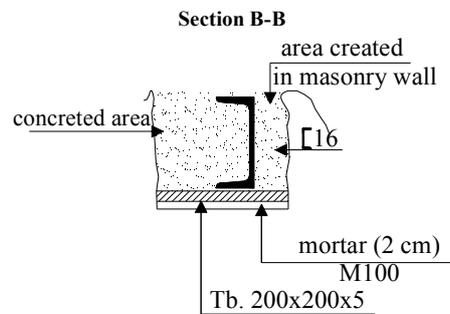


Fig. 6. *Metal beam*

Details of the strengthening system of truss are presented in Figure 7.

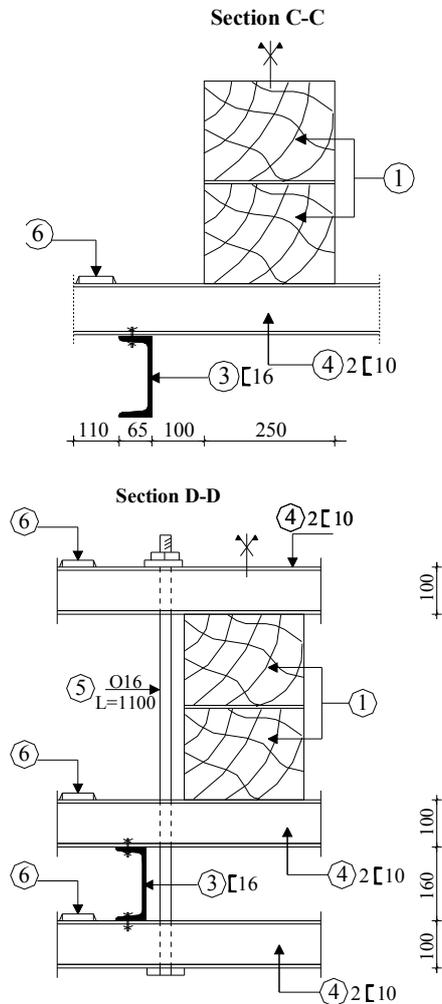


Fig. 7. *Adopted solution for strengthening*

The assembling screws allow an improved contact between the truss flange and the strengthening system, at the end of the work. Finally, was concreted the bar ends supported on the masonry walls.

Strengthened support of truss after intervention is presented in Figure 8.

Suspended tie-rods were all of them verified after the truss strengthening was finished in order to satisfy the structural exigency and to be efficient in taking over the loads transmitted by the plaster floor.



a)



b)



c)

Fig. 8. *Truss after consolidation*

In order to avoid further damages all the sources of humidity was removed.

The behaviour in time of the strengthened truss support and all the intervention were under observations for five years than execution works has been finished.

The observation shows that not even the smallest indications of improper building behaviour were detected, leading to the conclusion that the design and implementation of the solutions were correct and adequately applied.

4. Conclusions

Rehabilitation of existing buildings or of some damaged elements assumes to find some new solution which can be more complex than in case of new buildings.

When the rehabilitation solutions are chosen it should be analysed not only the possibility to realise a correct transmission of loads or to satisfy the minimum performance level, but also the possibility to put it in practice from technological point of view.

In this analysed case study the chosen strengthening solution was very much influenced by the possibility to put in practice in a very short time without affecting functionality of the building, and to assure the safety of the workers during execution stage.

The strengthening intervention effect on the suspended plaster floor has been also considered.

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