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Research Article

The Collapse of Wooden Roofs of Public Buildings in Macedonia Caused by Winds

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Abstract

Wooden roofs that collapsed as a result of a shock effect of the wind in eight public buildings in Macedonia caused great damage and threatened the lives and safety of the citizens. This incited us to carry out research on social responsibility for the quality of construction and reconstruction of roofs in general. The studies that were performed to determine the reasons for the suffering of the roofs had been directed in several directions, especially on the legal regulations concerning the construction, quality of construction, material used, the control and the constructed roofs themselves. This paper presents the results of studies that have shown that they do not comply with the existing legislation on roof construction structures made of wood. We have also identified the shortcomings, inconsistencies, and the use of building materials, as well as the inadequate technical control and responsibility for the consequences of social and economic damage. At the end, there are some recommendations and measures to be taken to improve the current situation.

Keywords: *The social responsibility, quality of construction, wooden roofs.*

1. Introduction

Construction buildings of low and high-rise buildings should be protected against weather influences, especially precipitation such as rain, city and snow. In Macedonia, most of the buildings have tilting roofs, while one smaller number has flat roofs. Buildings that have flat roofs are protected by insulation that over time, due to high temperature differences and other reasons, relaxes and leaks and humidifies the building itself. In addition to damaging hydro-insulation, the final reinforced concrete slab loses its original properties. The construction of public and private buildings with flat roofs has been a trend in recent decades, but they have proved to be impractical because of these abundances. In recent years, due to the increasing demand for residential space, upgrades have been built on existing buildings, most often as mansards, but in most cases, two new floors were built and upgraded (Figure 1). This trend of building upgrades on objects leads to a change in the stability of the objects themselves and directly affects the stability of roofs that rise to a new height, the building itself becomes dominant, requires new parameters of calculation and dimensioning. Upgrades as well as reconstruction of roofs were performed on public buildings. Due to the worsening and changes made to the facilities, in recent years there has been the construction of new roofs or the reconstruction of existing ones. In this regard, roofs on public buildings have been reconstructed, such as municipal buildings, hospital facilities, schools, kindergartens, as well as facilities of other public purpose.

(Source: Taken by the author)

Fig. 1 Changing the height of the existing building by upgrading two new floors

In recent years, there have been several disasters in the territory of Macedonia in public buildings, where roof structures were destroyed because of windy weather. Roof structures were built in three hospitals: in Ohrid, Gostivar and Tetovo, as well as in several

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schools: in elementary schools in Trapcin-Dol near Kicevo, in Ohrid, in the village of Debarce and in the village Bogovinje near Tetovo, as well as at the gymnasium in Tetovo. When a roof fell from a hospital building in Tetovo, one person was killed and serious injuries were caused to several people. Considerable material damage was done. The roof construction of the hospital in Tetovo was previously reconstructed twice; however, it collapsed under the influence of the wind (Figure 2). In January 2012, the roof of the school in the village of Debarce near Tetovo collapsed.

Fig. 2 The roof of the hospital in Tetovo

Fig. 3 School in Debarac-Tetovo

During the inspection and documentation of the factual situation, many defects were found in all reconstructions, primarily in the construction and installation of wooden structures themselves, but also in the process of tender, supervision and technical reception. The anomalies that led to the demolition of roofs are mostly subjective. In determining the reasons that led to the demolition of roofs, it was established that in all phases of construction, the legislation on design, the auditing, the quality of materials, the quality of supervision, the quality of the design and the technical reception were not followed per se.

2. Material and methods

In order to determine the causes that led to the demolition of roofs, research was conducted in several directions:

- Requirements for construction legislation;
- Design requirements;
- Quality of the material used;
- Performance quality;
- Performance control and technical acceptance.

2.1 Legislation

In Macedonia, there is no special law on technical regulations for timber structures, so this matter is generally regulated by the construction laws (Official Newspaper of RM No. 130 of 28.10.2009 and No. 39 of 2006).

The first law regulates construction issues, the basic requirements that need to be fulfilled by the built object, the necessary project documentation for obtaining the building permit, the rights and obligations of the participants in the construction, the way of using and maintaining buildings, and other issues important for the construction.

The second law regulates the conditions for placing construction products on the market, the certification procedures in accordance with technical specifications, the implementation of special procedures for the recognition of conformity, as well as other issues of relevance to the construction product.

2.2 Design requirements

The project task related to the design and dimensioning of wooden roof constructions, mainly requires these elements:

-Quoted projection of the base of the building with the appearance of the roof and all elements of the system;
-Specified spacing between horns (≈60-100cm);
-Distance between the roof links (≈300-500cm);
-Altitude to which the object is being built;
-Wind zone (depending on wind speed, there are 1st, 2nd and 3rd zone);
-The height of the object and the degree of protection;
-Snow load;
-The weight of your own design;
-Type of cover,
-The weight of the inner construction (insulation, etc.);
-Possible worker load (P = 1.0 kN);
-The quality of the class of timber (usually class II);
-Carpentry connections, coupling agents and anchoring method;
-Additional elements depending on the structure of the roof structure itself.

In the case of demolished roofs, project documentation was not available as well as data on supervision and technical acceptance, which prevented the execution of the audit and the identification of possible causes of error.

2.3 Quality of materials

For all the above-mentioned roof constructions, a lot of solid wood from fir (Abies alba), spruce (Picea excelsa) and pine (Pinus sp) was used as the primary material. Legislation as the design principles foresees that the material that is incorporated into the structures must meet certain requirements; in particular, it should be within the limits of the permitted and standardized. In

the case of roof constructions, in the course of costing and dimensioning, materials of Class II are usually envisaged.

Fig 4. Non-standard timber

Fig 5. Enforcing the wreath of the roof with armature

The material used for roof structures was, above all, not in accordance with standards, and had many defects such as: bumps larger than 1/3 of the cross-section and crossing the whole cross-section of the beam; Rot and color of wood; Insect damage (Figure 4); Bugs in construction, unmanaged finishes; Irregularity and sharpening of fibers; Untended core and bark of wood as well as many other defects of wood. In almost all elements of the construction, several errors have been detected on the supporting elements, such as beams, columns and on planks below the sheets.

2.4 Performance quality

The construction of roof structures as well as the assembly of the elements on all roofs had numerous shortcomings, especially when it comes to craftwork of carpentry and carpentry that did not meet the construction standards.

Anchoring of the roof structure and connection to the reinforced concrete structure was carried out by bonding with thin reinforcement or cracked pins and concrete (Figures 5 and 7), where the connection was loose, which enabled the movement of the roof structure in the wind, and then demolition. In Figures 5 and 7, there is an unqualified design after the completion of the installation of roof structures, as no surpluses and waste of materials such as woodcuts, pieces of metal sheet, wire, silicone bottles, nails and others have been removed.

All carpentry works were performed using a primitive tool, the requirements for the geometry of the carpentry connections were not respected; only nails were used as connecting means in insufficient quantities.

After the demolition of all the roofs mentioned above, a large amount of waste material could be found on the basis of the same, with a large sanitary disorder left by the contractors who carried out the construction work.

Fig.6 Coarse bonding without geometry

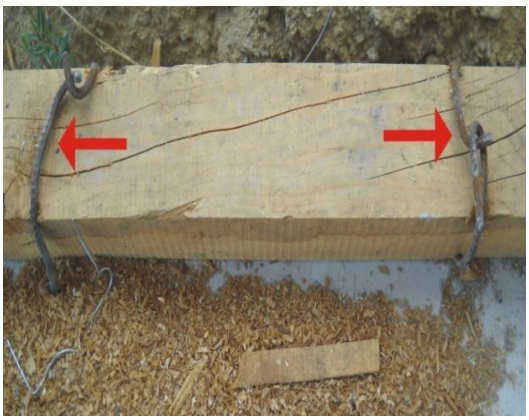

Fig. 7 Inadequate armor anchoring

2.5 Performance control and technical acceptance

From the presented factors that were crucial for demolition of roofs, it can be established that there was no control at all stages of construction, especially in the case of: receiving materials, quality of construction, use of carpenter's connections, coupling, roofing anchoring for the base as well as inadequate use of coupling

devices. Technical reception in all roofs was performed by incompetent and unprofessional commissions, and they did not have an insight into all stages of construction, as they could not see the unit roof of the roof structure during control, since it was closed from all sides.

Conclusions and recommendations

Social responsibility, as well as the danger from the demolition of eight roof constructions, and the resulting pecuniary damage, make it necessary to take decisive measures in the future in order to eliminate the flaws that arise when building roofs. We can also conclude on the real causes.

Recommendations for further action in terms of permanently removing the causes of such accidents would be:

1) Introduce order and observe the statutory regulations for the construction of wooden roof constructions. The construction law should incorporate special technical standards for timber structures in accordance with the regulations of the European Union.
2) The Commission for Technical Inspection should be competing. Construction control it should be permanent, at all stages of construction.
3) Pay particular attention to anchoring the base of the roof structure for armor-concrete supports, stop with the current practice of wire and armature bonding, which proved inadequate. The basics of roofs must be fixed with special anchors that must be attested and meet the standards.
4) Wooden materials used for building roofs should be pre-arranged examined, in particular her health condition as well as class quality.
5) Conduct control of other roof structures that collapsed, as in the future, or there would be disasters and threats to people and material goods.
6) Leave the construction and reconstruction of wooden roofs to the professional organizations, competent contractors and specialized institutions.
7) Raise the level of quality of wooden roof construction by introducing a higher one the degree of processing (woodworking) and wood protection, as well as removal defects of the wood before assembly in the roof structure.
8) Wooden construction, after reconstruction or adaptation of the building whose is an integral part, have technical characteristics that will enable satisfactory mechanical resistance and structural stability.
9) Permanently, at given time intervals, should be carried out periodically control on all the roofs that were built as well as the roofs that collapsed, and appropriate corrective measures would be taken in order not to create new disasters.

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