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Fire resistance of roofs with loadbearing wooden beams and fire protective claddings made of magnesium oxide boards

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Abstract: The paper presents verification of fire resistance of roofs with loadbearing wooden beams with fire protective claddings made of magnesium oxide boards. Checking of fire resistance is limited to practical testing. Preparation of the test specimen is also presented.
Keyword: *fire resistance, wooden beams*

1. INTRODUCTION

The general European Standard that describes the design procedures for wooden structures in normal temperature is standard PN-EN 1995-1-1 [2], while in fire – standard PN-EN 1995-1-2 [3].

The highest fire resistance class required for roofs, in accordance with the currently applicable Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their locations (Journal of Laws No 75, item 690) [1] is class RE 30, however, according to the standard [4] based on which the fire resistance classifications are issued, it is also possible to achieve fire resistance classes as high as RE 240 or REI 240.

How to verify the fire resistance class of roofs where wooden beams are the loadbearing members, the core is made of combustible materials, and the claddings are made of magnesium oxide boards? Unfortunately, we cannot verify such a system using computational methods. Therefore, a fire resistance test must be carried out as specified in standard PN-EN 1365-2 [5].

2. FIRE RESISTANCE TEST - REQUIREMENTS

The main issue to be addressed when performing verification of fire resistance using test methods is the preparation of a test specimen. When the actual size cannot be accommodated in the furnace, the test specimen should measure at least 3 x 4 m [5].

The number of tests to be performed depends on the support and fixing of the specimen, and the specified conditions of heating and loading. It also depends on the inclination and required range of validity of the test results. For example, for the roofs with inclination angle of $\leq 10^{o}$, the test results are extended into the range from 0 to 25°. The full scope of application is given in the standard [5].

Roofs are tested with the assumption of simple support (simply supported member), extending in one direction that enables free longitudinal movement and deflection. The surface of the concrete or steel bearings shall be smooth and flat. The width of the bearings shall be the minimum representative of that used in practice and in any case not more than 200 mm. [5].

Loads are taken into consideration in the structure design process. The following types of loads are mainly considered in the fire resistance tests of roof structures:

- Snow load,
- Loads from structures suspended under the roof, e.g. ventilation systems.

Standard PN-EN 1991-1-3 [7] specifies 5 snow zones in Poland. The load applied to the structure is assumed as 20% of the load calculated according to the above standard. Reduction of the load results from a reduction coefficient of 0.2 for accidental situations, which in this case are the fire conditions. [9]. When considering the suspended load, its characteristic value is taken into account. The assumed value and distribution of the load shall ensure that the maximum bending moment and shearing forces produced in the test specimen are representative or higher than the actually expected. The test load shall be distributed evenly by a system of spot loads. It is the responsibility of the test ordering entity to decide whether the structure is to be tested as loaded. An example test specimen is shown in Fig. 1 and 2.

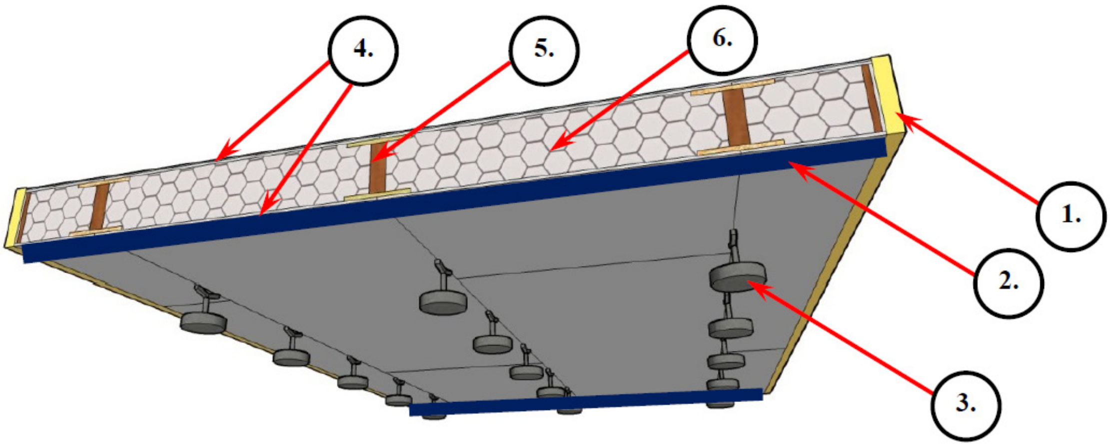

Fig. 1 Example test specimen containing wooden loadbearing beams and MgO board cladding (tested roof viewed from the bottom); where: 1 – free edge (protected with rock mineral wool), 2 – the edge on which the tested member is fixed/supported, 3 – suspended load, 4 – MgO board roof cladding (roof top and bottom), 5 – wooden loadbearing beams (along the member to be tested), 6 – roof core, e.g. PIR, EPS.

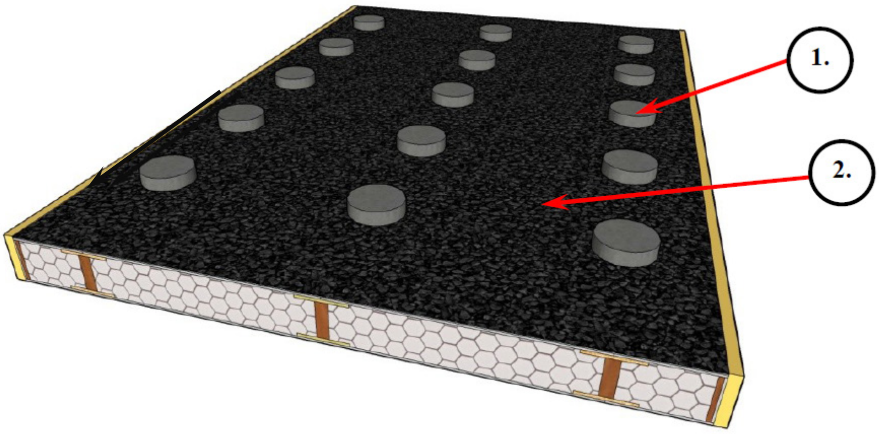

Fig. 2 Example test specimen containing wooden load bearing beams and MgO board cladding (tested roof viewed from the top); where: 1 – load (e.g. steel weights), 2 – roof finish layer, e.g. roofing sheets, PVC membrane or other.

Roofs are tested for the fire applied from below and heating conditions according to the standard temperature –time curve.
Fire resistance tests are carried out in heating conditions according to the standard temperature-time curve, when heating from the bottom side. The temperature–time curve is shown in Diagram 1.
Pressure in the test furnace is 20 Pa at 10 cm from the bottom roof surface. The test conditions shall correspond to the requirements specified in standard PN-EN 1363-1 [6].
Thermocouples for average and maximum temperature are distributed over the roof surface in order to verify the fire insulation capacity (parameter I).

3. FIRE RESISTANCE TEST - RESULTS

The roof with layers as seen from the top:

- bitumen roofing membranes,
- Magnesium oxide boards (MgO),
- EPS core / double-T wooden-beams – beams with OSB flanges,
- Magnesium oxide boards (MgO),

with the loadbearing members tensioned to 90% (in normal conditions) is capable of reaching the fire resistance class of at least RE 30 or even REI 30. The bottom cladding layer of 11 mm in thickness is capable of protecting the loadbearing wooden beams for a period of at least 20 minutes.

Diagram 1. Heating curve

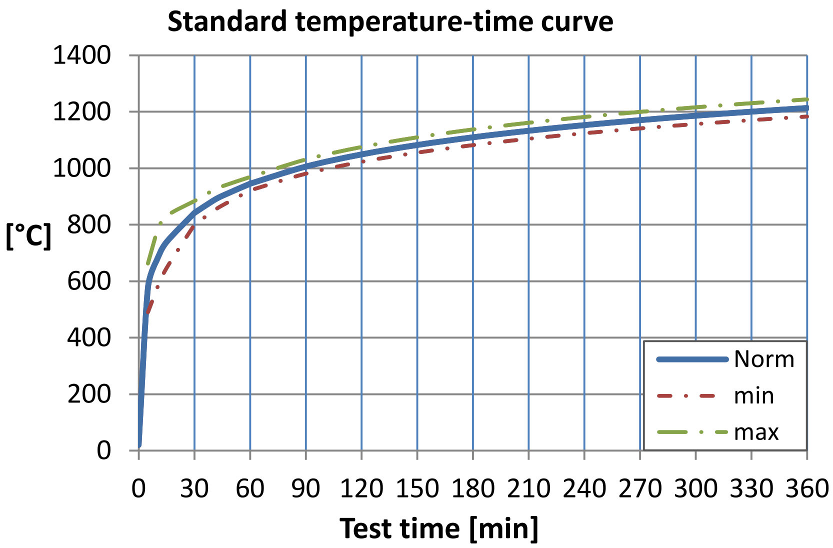

Fig. 3 Roof after finished test (top load removed and bitumen roofing membranes revealed)

Fig. 4 Roof after finished test, where: 1 – wooden loadbearing beams, 2 – suspended weight.
After the test (heating acc. to standard curve – time), the weights were removed from the roof (for safety reasons), and the bitumen roofing membranes were revealed. The bottom layer of the MgO boards were fell into furnace, the upper boards were fractured, locally holes were visible as shown in Fig. 3. During the following minutes (after the test) the bitumen roofing membranes were completely removed – the top boards also were fell into the furnace. Despite the complete damage of all roof layers, the revealed wooden members charring could still be observed – the suspended weights were fixed to the loadbearing beams and the beams themselves did not lose their loadbearing capacity. The actions described are shown in Fig. 4.

4. SUMMARY

The obtained results indicate that when an increased number of the MgO board cladding layers or their larger thickness is used, the fire resistance class of REI 45 or higher is achievable. It all depends on the spacing and lateral cross-section of the wooden loadbearing beams, their span, utilization factor, and the applied roofing layers.

Wooden beams (in roof assemblies) protected with magnesium board perform very well in fire conditions. The char layer around the fire exposed wooden beams creates insulation that protects the member for a time sufficient to maintain its loadbearing properties.

The characteristics charring of wooden beam as well as the computational methods of calculation of the beam loadbearing capacity can be found in the Reference Book [8] and in works [10], [11] and [12].

5. REFERENCE

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Streszczenie: *Nośność ogniowa stropów drewnianych z elementami nośnymi w postaci belek drewnianych w okładzinach z płyt magnezowych.* Opracowanie opisuje sposób weryfikacji odporności ogniowej dachów z nośnym szkieletem drewnianym, w których ogniochronne okładziny stanowią płyty magnezowe. Sprawdzenie odporności ogniowej sprowadza się do weryfikacji w sposób badawczy. Opisano jak należy przygotować element próbny do badań.