



Short report for the research project

Fire behaviour of large scale wooden roof structures

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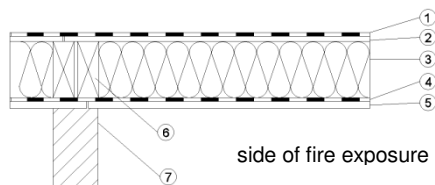
(IGF-Vorhaben 17340 N)

The responsibility for the content of this report lies with the authors.

Introduction

According to the German guideline for industrial buildings, like storage and production facilities and German standards, such as DIN 18234-2, the use of timber and wood based products is limited for the non-loadbearing envelope structure like walls and roof elements. In addition for the construction of a wide span timber structure often a special permission by authorities is needed.

To achieve code compliance structural loadbearing elements have to be designed for a certain fire resistance, depending of building size and further active fire protection methods. This is also possible with structural timber elements. However the use of prefabricated timber frame wall and roof elements is currently not allowed, unless passing a specific fire test, if compartment size is exceeding 2,000m² for walls and 2,500m² for the roof structures respectively. These elements have to show a limited contribution to flame spread at surface and inside the elements, no further glowing combustion after fire exposure and a specific fire resistance under natural fire conditions in accordance with the German test standard DIN 18234-1.



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|-------------------------------|---|
| 1 roof covering | 4 air tightness membrane / vapour barrier |
| 2 wood based panel | 5 wood based panel/ gypsum plaster board |
| 3 cavity insulation | 6 timber frame element |
| 7 supporting timber structure | |

Figure 1: example of timber frame element for large area roof system

Within the scope of the German research project the behaviour and performance of timber frame elements for large scale roof systems have been examined in the case of fire. In this process the effect of flame spread at exposed lining and inside the elements, the protection capacity of lining under parametric fire exposure as well as measures to avoid smouldering fires inside the elements were analysed. The scope of the investigations is to reach sufficient level of fire safety for the plane elements, junctions, penetration areas and the entire structure.

Study of parameters

The fire behaviour of a construction is significant affected by the specific boundary conditions such as geometry and the type of occupancy. Finally these conditions results in different fire load densities and ventilation conditions. The effect of boundary conditions and the distance between the roof and the fire causes different fire scenarios and temperatures for the exposed structure.

Assuming an effective fire service intervention the German standard DIN 18234 examines only the time of fire growth. In this fire stage sufficient oxygen for combustion is available and the fire is designated as fuel controlled.

However the maximum of the temperature on the exposed lining depends on the distance between the roof and the fire load. A diagram for the critical fire area and heat release rate as a function of the distance between the roof element and the fire was developed on the

basis of plume theory. By using this diagram critical fire loads, used in DIN 18234, and non-hazardous fire loads related to different distances between the roof and the fire were identified.

Furthermore the influence of the exposed lining material, the effect of roof inclination, the compartment size and the concept of fire safety system must be considered in examinations for asses flame spread and the fire exposure level.

In a first part of the project small scale fire tests of insulated timber frame roof elements lined with fire retardant and non-combustible materials respectively have been conducted under natural fire exposure, based on DIN 18234-1. The exposure level is used depicted in Figure 2.

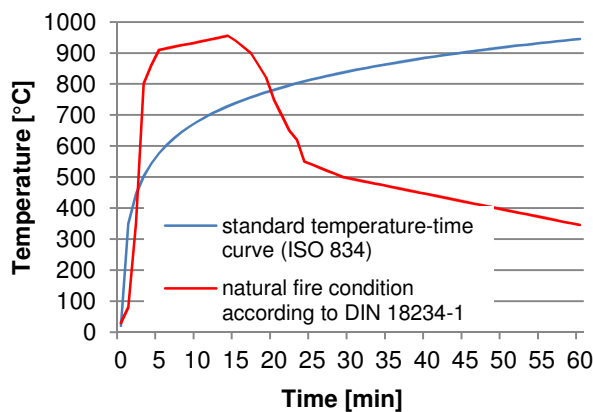


Figure 2: Comparison of ISO 834 fire exposure and measurements taken from DIN 18234-1 fire test

In these investigations protection capacity of the linings (gypsum fiber boards) and wood based panels were analysed. Further on the influence of mineral wool insulation and cellulose insulation on temperature formation, falling off time of linings and the risk of smoldering fires have been assessed.

Based on these results large scale fire tests (roof area 2 m x 8 m) and fire tests to improve the penetrations of service installation and dome lights have been conducted.

Results

The small scale fire tests brought new fundamental knowledge in respect to the behaviour of materials and components of the timber frame elements under natural fire exposure.

Furthermore the thermal softening, the crack formation and a potential falling off of the lining and other components were determined. The protective capacity of each layer, the effect of flame spread at exposed lining and inside the elements and the risk of uncontrolled smouldering fire inside the element after the fire exposure were also investigated.

A study of parameters shows the protection time of the assessed cladding materials under parametric fire exposure. As criteria to determine the protection capacity of the lining the critical ignition temperature of 300°C for wood members was used. For elements insulated with cellulose the protection capacity of the lining was determined by using a critical temperature of 200°C .

The large scale fire test showed the effect of a new designed jointing detail between two elements to avoid glowing combustion and uncontrolled smouldering fires for timber elements.

By using specific lining materials in combination with cavity insulation and under consideration of the developed jointing detail a large number of designs are applicable. These are summarised in a design catalogue for fire safe wooden roof elements.

Thus the desire of clients, architects and carpenters for practical application to renewable primary products comes true. This contributes to a wider use of timber and wood based products as well as of biogenic insulation material and the benefit of image.