ABSTRACT: Recent developments in structural design and timber engineering favor the increased use of the renewable resource wood as an alternative, high-performance construction material to meet rising quality demands regarding functionality, durability and fire safety. In several research projects of the Department of Structural Design and Timber Engineering (ITI) at the Vienna University of Technology (VUT) the combination of timber products with other conventional building materials and components was explored with the purpose to fulfill the many fire safety standard requirements as well as the most stringent fire norms in the building sector [1, 2, 3, 4]. The reported research results indicate a potentially fire-retarding thermodynamic effect in wood-based composites, which is analyzed in detail based on empirical findings and fire safety calculations.

KEYWORDS: Fire safety, fire resistance, fire protection, fire safety standard, fire risk assessment methods

1 INTRODUCTION

The building market has always been the most important mass market for timber products. Growing awareness of and sensibility towards the ecological impact of buildings has led to more environmentally responsive design solutions favoring the use of renewable resources such as wood.

New engineered timber products, component technologies and improved construction techniques progressively allow wood to compete with such still dominating construction materials as steel, concrete or masonry. Equipped with a number of favorable mechanical properties (low mass combined with high strength for compression and tension parallel to the grain), wood can be regarded as an excellent material, especially for efficient lightweight structures. In the past few years, an increasing number of wood-based buildings have been constructed in Central and Western Europe.

The building codes are in constant revision, actually nearly all European countries allow at least four-story buildings in timber as regular solutions and pilot projects have been built up to ten-stories. Consequently, one of the major challenges of advancing timber construction is currently to innovate in the fundamental approaches to fire safety and develop new strategies that are both sophisticated and simple in application.

2 INVESTIGATIONS

In several research projects of the ITI at the VUT the combination of timber products with other conventional building materials and components (Figure 1) was explored with the purpose to fulfill the many fire safety standard requirements as well as the most stringent fire norms in the building sector [1, 2, 3, 4].

Figure 1: Wood-based composite specimens made of steel (1), polymer concrete (2) and timber (3) [2]
2.1 OBJECTIVE OF INVESTIGATIONS

The objective of the research projects was to develop innovative wood-based composites as structural building components (e.g. beams, columns, floors or walls) with distinctly improved fire performance characteristics. Hereby the aim was to investigate and exploit beneficial thermal effects, which arise when timber is combined with other conventional building materials and components, under the extreme conditions of a fire load, while keeping or, ideally, improving the structural efficiency of the building components under regularly assumed mechanical loads.

2.2 SCIENTIFIC AND TECHNOLOGICAL RELEVANT RESULTS

The use of wood-based composite elements was to be supported by scientifically robust background data. The following stages were proposed to achieve relevant results:

- Development and optimization of wood-based structural building components (Figure 2),
- Design of structural components, analysis of the experimental results to develop design concepts,
- Evaluation of the thermal behavior,
- Evaluation of fire resistance by tests and fire risk assessment methods as well as fire safety design tools,
- Optimization of the manufacturing methods,
- Case studies.

Under restricted geometrical circumstances, an optimal material configuration should lead to both a mechanical performance gain and a fire-retarding effect, observable as a significant reduction of the component’s effective burning rate – an effect to be investigated in detail both theoretically and empirically.

Composite component design criteria were determined not only based on thermal behavior, but also under the consideration of optimal mechanical performance.

![Figure 2: Wood-based elements – Timber-steel-polymer concrete composite section of I-Beams [2]](image)

Furthermore, consequences for buildings containing wood-based elements were analyzed by fire risk assessment methods and fire safety design tools based on the various scenarios and selected case studies [3]. The results of studies show that buildings containing wood-based elements can achieve the same levels of safety as buildings made of non-combustible materials, such as steel or concrete.

3 CONCLUSIONS

The reported research results indicate a potentially fire-retarding thermodynamic effect in wood-based composites, which is analyzed in detail based on empirical findings.

The use of timber as a building material is strongly restricted by building regulations and standards due to its combustibility. However, the intensity of a fire in a building depends on various factors, e.g. ventilation conditions. Based on the results of research projects, buildings containing wood-based elements can achieve the same levels of safety as buildings made of non-combustible materials, such as steel or concrete.

This shall form the basis for new fire protection strategies, which shall ultimately be drawn up in design guidelines to facilitate implementation in structural design practice.

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