



Fire safety in timber buildings

Technical guideline for Europe

The very first European-wide guideline on the fire-safe use of wood in buildings

Main results from the WoodWisdom-Net Research project
FireInTimber – Fire resistance of Innovative Timber structures



Part of the answer to the climate challenge

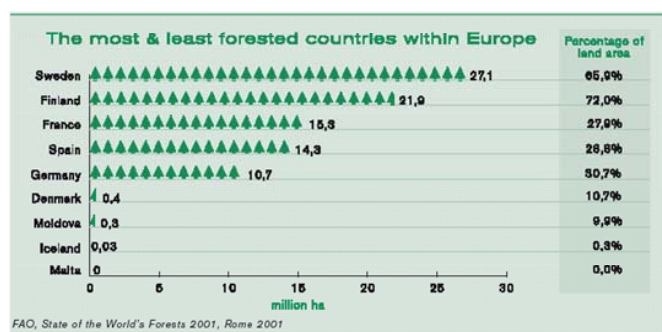
During the past hundred years, the average temperature on earth has risen by 0.7°C. The UN's climate panel has established that mankind's emissions of carbon dioxide and other greenhouse gases are the main cause. Combustion of fossil fuels has brought about a dramatic rise in the level of carbon dioxide in the atmosphere [IPCC – UN Intergovernmental Panel on Climate Change – Assessment Report, 2000]. Governments throughout Europe and world aim to achieve up to 60 % reduction in CO₂ emissions by 2050. One of the key areas for improvement, not only contributing considerably to CO₂ emission levels, but also to our general quality of life, will be the structures in which we live and work. There is better awareness of the issues related to the sustainable design and construction of buildings, which has led to an increased interest in the use of timber.

Forests play a key role in mitigating climate change as they absorb carbon dioxide from the atmosphere and store the carbon in trees and in the ground. Research shows that cultivating forests and utilizing their resources benefits the environment. The combination of active silviculture, using tree tops and branches to produce electricity and thermal energy and manufacturing of timber products can bring about significant reductions in emissions of carbon dioxide [Swedish University of Agricultural Sciences, 2008].

Increased use of timber in construction is one means of using renewable raw materials and energy from forests that constitutes a key aspect to the climate strategy. Wood and paper are climate-friendly alternatives, provided forestry activities are sustainable. More than 80 % of Europe's forests are managed sustainably, adhering to established and well-policed management schemes and guidelines. Two main schemes are established in Europe, namely PEFC and FSC. Both schemes ensure a sustainable healthy yield of wood, while maintaining biological diversity and replacing harvested stocks [CEI-Bois, Tackle Climate Change, 2006].

Wood products from sustainably managed forests

- act as a carbon sink throughout their life,
- have low energy consumption and one of the lowest CO₂ emissions of any commonly used building material,
- are renewable and
- encourage further forest expansion, increasing the carbon sink effect and reducing the CO₂ in the atmosphere.



Reference: CEI Bois "Europe's forests"

"Forestry practices can make a significant contribution by reducing greenhouse gas emissions through increasing the amount of carbon removed from the atmosphere by the national forest estate, by burning wood for fuel, and by using wood as a substitute for energy-intensive materials such as concrete and steel."

Securing the Future – UK government strategy for sustainable development

Timber construction

Globally, forests are an immense resource, accounting for about 30 % of the Earth's total land base. Europe has more than 1,000 million ha of forest spread over 44 countries, equivalent to 1.42 ha (more than two football pitches) per person.

The wood-based sector is one of the main contributors to the European social, economical and environmental set strategies. With an annual production value in EU-25 of some EUR 550-600 billion, the forest-based industries account for about 8 % of the total value added in the manufacturing industry in the EU. Additionally, there are some 16 million private forest owners in Europe owning more than 60 % of the forestland. The sector and related industries provide between 3 and 4 million jobs in industry in the EU, to a large extent in rural areas and in SMEs, constituting one of the EU's most important and dynamic industrial sectors by representing some 10 % of the EU manufacturing industries. In many regions, this bio-based economy often represents the main source of livelihood. [European Forest Based Sector, 2005]. It has been shown that the increased use of timber can help promote and implement sustainability in construction, thereby helping society to mitigate climate change.

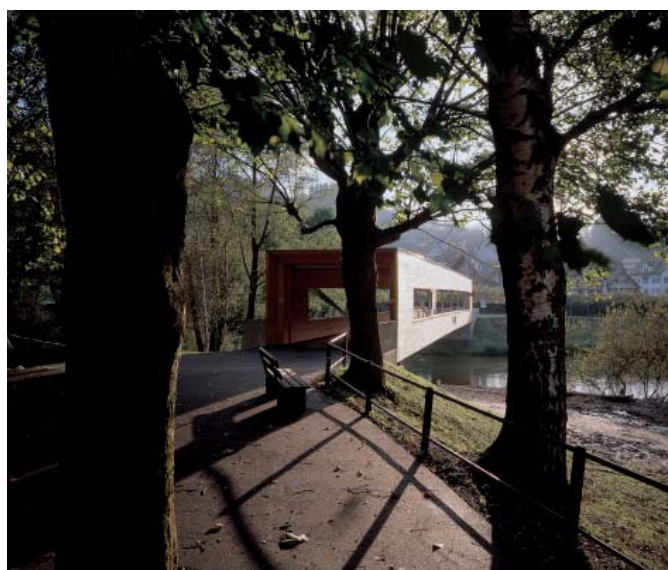
Recognizing the importance of wood, a naturally renewable building material is vital for meeting the challenges of climate change and ensuring a sustainable future.

Timber has been a favoured construction material from the beginning of civilization because of its abundance, high stiffness and strength-to-weight ratios and the relative simplicity with which it can be adapted to use. These days, timber products have experienced a renaissance as their environmental credentials and an industry striving for continuously lower energy and less pollution appeal to consumers in a variety of sectors, from furniture to construction. The highest forest management standards ensure that there is a potential for a continuous and sustainable supply and use of timber as a building material in the future. It is therefore not surprising that timber structures are becoming an important element in sustainable and economic development, and have attracted worldwide attention in recent years.

New construction methods and new design tools have made timber framed houses an efficient construction method, offering good quality at affordable prices. Construction sites mainly employing timber products are recognised for their quiet and dry conditions, and the completed buildings offer user-friendly, healthy, natural living environments.



Multifamily house, former corn storage, Eslöv, Sweden.



Foot- and bicycling bridge Gaissau, Vorarlberg, Austria.

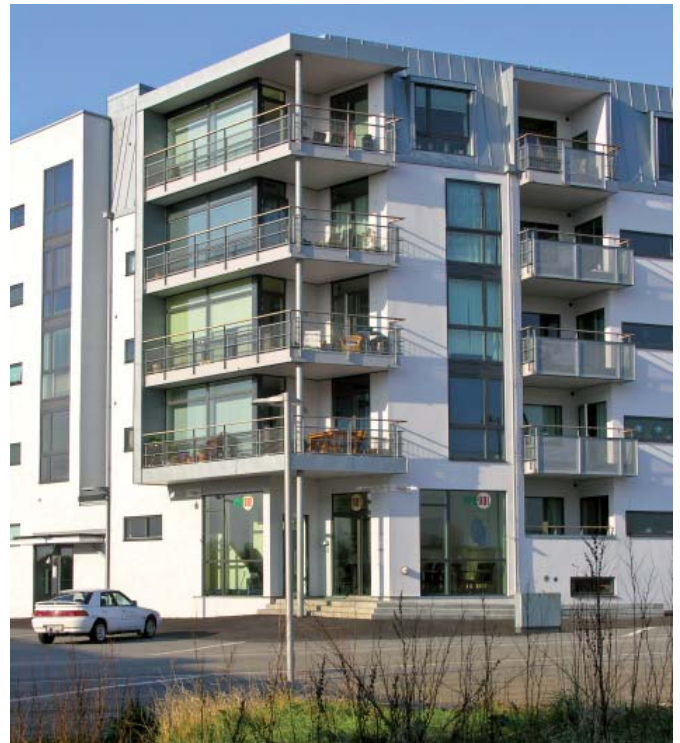
Fire safety

The combustibility of timber is one of the main reasons that too many building regulations and standards strongly restrict the use of timber as a building material. Fire safety is an important contribution to feeling safe, and an important criterion for the choice of materials for buildings. The main precondition for increased use of timber for buildings is adequate fire safety.

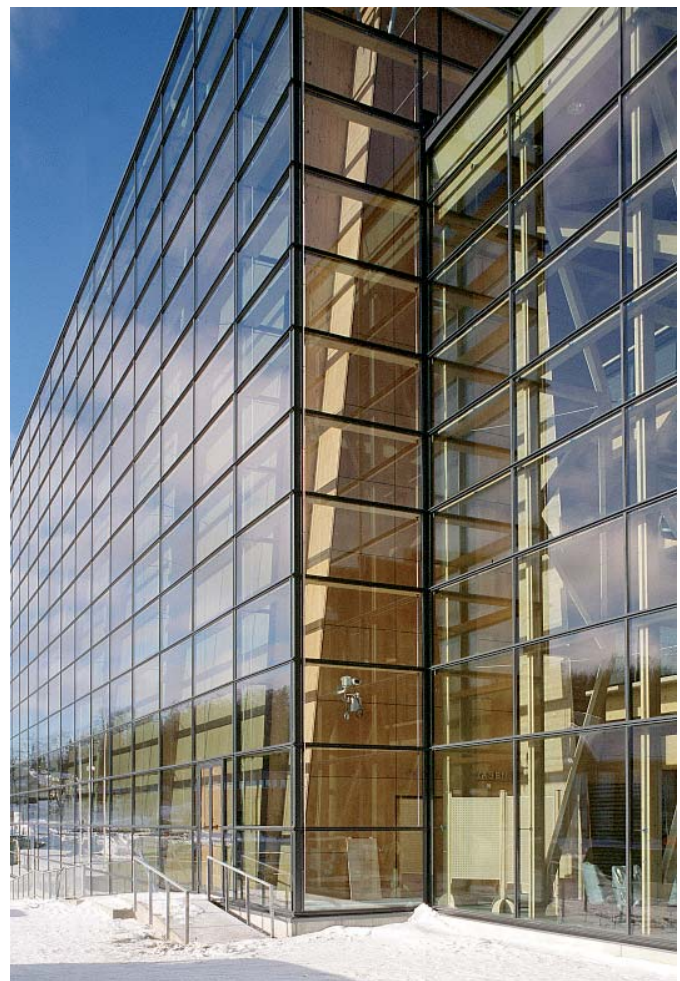
World-wide, several research projects on the fire behaviour of timber structures have been conducted over about the past two decades, aimed at providing basic data and information on the safe use of timber. Novel fire design concepts and models have been developed, based on extensive testing. The current improved knowledge in the area of fire design of timber structures, combined with technical measures, especially sprinkler and smoke detection systems, and well-equipped fire services, allow safe use of timber in a wide field of application. As a result, many countries have started to revise fire regulations, thus permitting greater use of timber.

Fire test and classification methods have recently been harmonised in Europe, but regulatory requirements applicable to building types and end users remain on national bases. Although these European standards exist on the *technical* level, fire safety is governed by national legislation, and is thus on the *political* level. National fire regulations will therefore remain, but the new European harmonisation of standards will hopefully also speed up the reform of regulations.

Major differences between European countries have been identified, both in terms of the number of storeys permitted in timber structures, and of the types and/or amounts of visible wood surfaces in interior and exterior applications. Several countries have no specific regulations, or do not limit the number of storeys in timber buildings. However, eight storeys are often used as a practical and economic limit for the use of timber structures. This limit may be higher for facades, linings and floorings, since these applications may also be used in, for example, concrete structures.



Multifamily house Rydebäck, Helsingborg, Sweden.



Concert and conference centre Sibelius hall, Lahti, Finland.



Multifamily houses, Inner harbour, Sundsvall, Sweden.

The FireInTimber project

The WoodWisdom-Net research project FireInTimber was conducted during 2007–2010 in close cooperation with 14 partners in nine countries.

The key objective for the project was to provide new possibilities for wood products in construction through proper fire design. The use of wood products is to be supported and stimulated by comprehensive and scientifically robust background data, which is presented in user-friendly and adapted tools for engineers and other stakeholders. The programme and its outcome are to facilitate and lead to simplified and quicker approval processes for wood products in buildings. This will increase the general public's confidence and positive perception of and about wood products.

The vision is to ensure that the wider use of wood in buildings will be associated with improved fire safety. The project also built a knowledge base by promoting core competence and multidisciplinary research. The transfer of new knowledge will be enhanced by networking between research and industry.

Main results

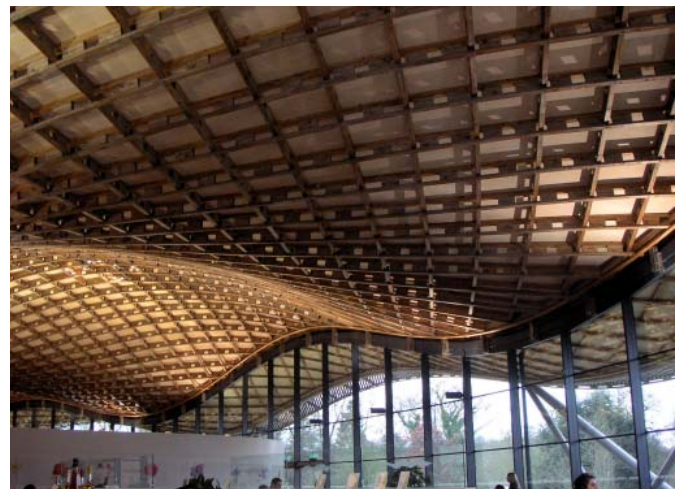
The FireInTimber project has resulted in new knowledge, especially for modelling of the load-bearing capacity of new types of timber structures. The project has resulted in about fifty scientific papers, reports and presentations at scientific and technical conferences. The main result for a greater audience is the technical guideline **Fire safety in timber buildings**. It is the very first Europe-wide guideline on the fire safe use of wood in buildings.

The design guide presents information for architects, engineers, educators, authorities and building industries on the fire safe use of timber structures and wood products in buildings. It aims at providing the highest scientific knowledge with regard to fire safety at the European level. The guidance covers the use of design codes (such as Eurocode 5), European standards, practical guidance and examples for fire safe design and principles of performance based design.

The design guide is focusing on structural fire protection by providing latest detailed guidance on load-bearing and separating functions of timber structures under standard fire exposure. New design methods are presented. They will be used as input for the next revision of Eurocode 5, but can already be used by designers. The guideline includes information on reaction to fire performance of wood products according to the new European standards. The importance of proper detailing in building design and on execution and control at building sites is stressed by practical solutions. Active measures of fire protection are presented as important means in fulfilling fire safety objectives.



Multifamily house Ölbündt, Dornbirn, Vorarlberg, Austria.



Savill Gardens in Windsor Park, UK.



Multifamily house, Zug, Schweiz.

The Technical guideline for Europe

Short summary of guideline chapters

Chapter 1; **Timber buildings**, provides a short introduction to the established uses of timber buildings and the renaissance of timber structures in recent years as a result of the drive towards more sustainable construction solutions.

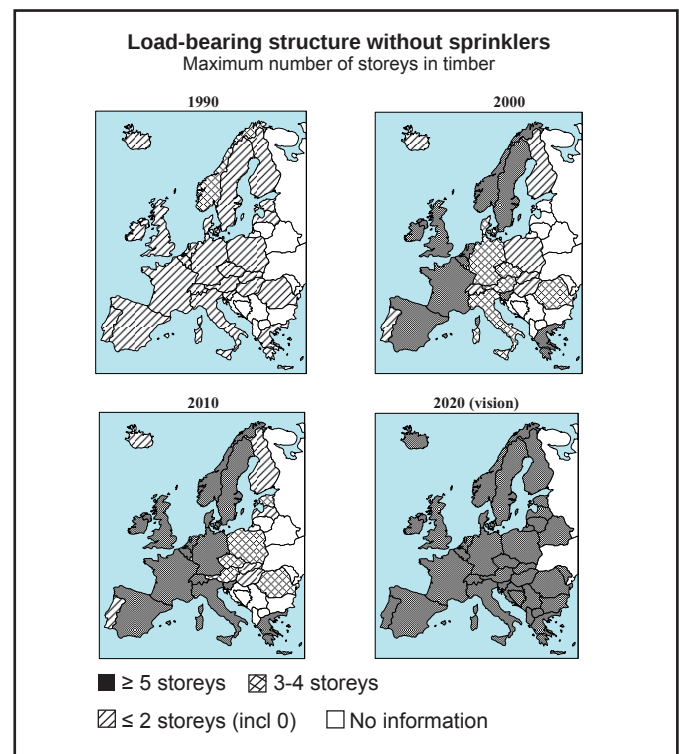
Chapter 2; **Fire safety in buildings**, gives an overview of the basic concepts of fire safety in buildings. It presents information on fire behaviour, fire loads, fire scenarios and fire safety objectives. Means of fulfilling the fire safety objectives are described for use in all buildings and as a basis for the design solutions in these guidelines.

Chapter 3; **European requirements**, presents an overview of the new European requirements for fire safety in buildings based on the Construction Products Directive (CPD) and its essential requirements. These requirements are mandatory for all European countries. They include the classification systems for reaction to fire of building products, fire resistance of structural elements, external fire performance of roofs, fire protection ability of claddings and structural Eurocodes. Descriptions of how these requirements are applied to wood products and timber structures are given in the following chapters.

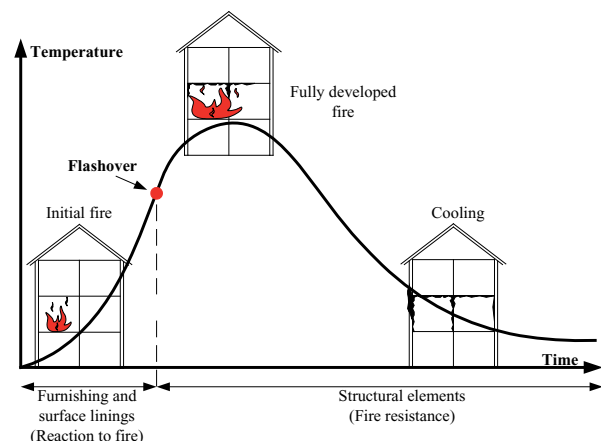
Chapter 4; **Wood products as linings, floorings, claddings and façades**, presents the reaction-to-fire performance of wood products according to the new European classification system. A wide range of products is included: wood-based panels, structural timber, glued laminated timber (gluelam), solid wood panelling and wood flooring. A new system for the durability of the reaction-to-fire performance of wood products is explained and put into context, as well as the recently published K-class system for coverings with fire protection ability.

In addition to reaction-to-fire performance, some countries have additional requirements for façade claddings for which no European harmonised solution currently exists. Best practice and state-of the art information on fire scenarios for façades are presented.

Chapter 5; **Separating structures**, presents the basic requirements, calculation methods based on component additive design and the Eurocode 5 design method. It also presents an improved design method from recent research as potential input for future revisions of Eurocode 5 and practical examples on how to use the method.



Restrictions to use of timber structures in higher buildings, set by national prescriptive regulations, have been eased in Europe over the last decades. A further increase in permitted use is expected.



Design for both the initial and the fully developed fire in buildings is included in the guideline.

Chapter 6; **Load-bearing timber structures**, introduces the design methods for verification of the structural stability of timber structures in the event of fire, applying the classification for Criterion R for fire resistance (load-bearing function). Reference is made to Eurocode 5 with respect to charring and strength and stiffness parameters. Alternative design models are presented, as well as new design methods for timber structures currently outside the present scope of Eurocode 5.

Chapter 7; **Timber connections**, provides an overview of the basic requirements for timber connections. The calculation methods in Eurocode 5 are complemented with state-of-the-art design methods, the result of recent research. Both timber-to-timber and steel-to-timber connections are included. The models are described and worked examples presented.

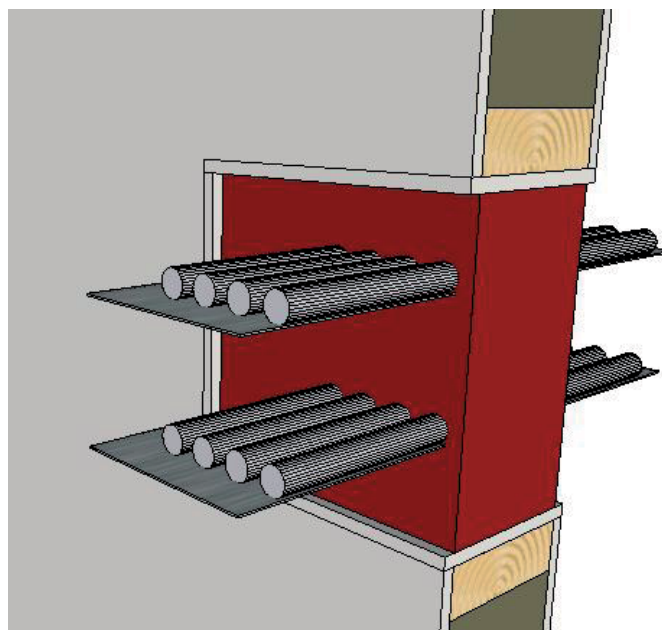
Chapter 8; **Fire stops, service installations and detailing in timber structures**, deals with the need for adequate detailing in the building structure to prevent fire spread within the building elements to other parts of the building. Special attention is paid to basic principles, fire stops, element joints and building services installations. Several practical examples of detailing in timber structures are included.

Chapter 9; **Novel products and their implementation**, is aimed primarily at product developers. It describes guidelines for introducing novel structural materials and products. The basic performance requirements and potential solutions for insulating materials, encasing claddings and board materials, thin thermal barriers and fire-retardant wood products are included. The innovation process from idea to approved product ready for the market is outlined.

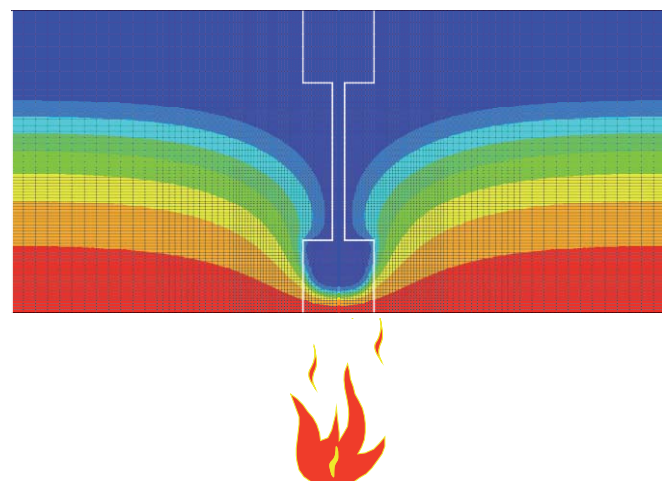
Chapter 10; **Active fire protection**, describes how such protection is used to achieve a more flexible fire safety design of buildings and an acceptable level of fire safety in large and/or complex buildings. The chapter introduces common active fire protection systems, including fire detection and alarm systems, fire suppression and smoke control systems. Sprinkler installation provides special benefits for increased use of wood in buildings, particularly where surfaces are to remain visible.

Chapter 11; **Performance-based design**, describes the basic principles of performance-based design, requirements and verification. Fire risk assessment principles are described in terms of objectives, fire safety engineering design, design fires, calculation/simulation methods and statistics. A case study of a probabilistic approach is also included.

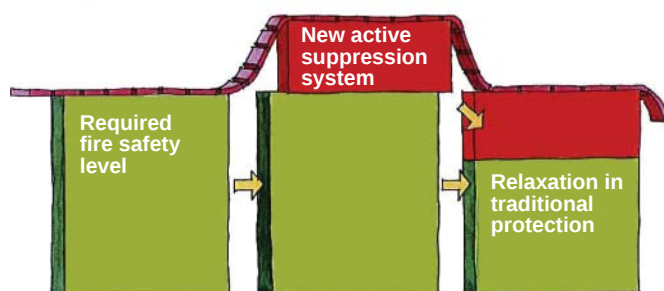
Chapter 12; **Quality of construction workmanship and inspection**, describes the need for execution and control of workmanship to ensure that the planned fire safety precautions are built in. It also emphasises the need for fire safety at building sites, when not all fire safety measures are yet in place.



Proper detailing in timber structures is necessary to ensure that the fire resistance of structures is maintained. Fire stops are needed for joints, penetrations and installations.



New fire design models have been developed for new innovative timber structures and verified by testing. The new models will be included in next version of Eurocode 5.



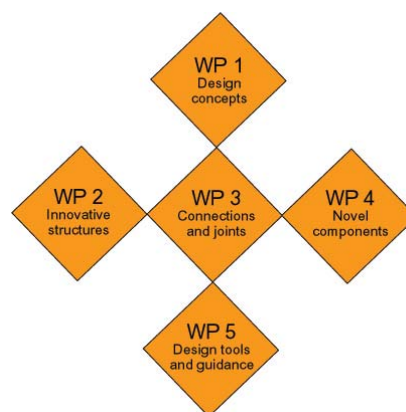
Principle for fire safety design by sprinklers: Increased fire safety by installation of sprinklers may lead to relaxations in the passive fire means, and still fulfil the same or higher safety level.

FireInTimber

The guideline Fire Safety in Timber buildings has been developed within the European research project FireInTimber (Fire Resistance of Innovative Timber structures). Leading experts and researchers from nine European countries are participating and guarantee its quality and relevance.

The project has been sponsored by national funding organisations within the WoodWisdom-Net Research Programme and by European wood industry represented by the Building With Wood process of Roadmap 2010 within CEI Bois.

In addition, work packages 1-4 have resulted in about fifty scientific papers, reports and presentations published by the research partners.



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