Short report for the research project

Detail catalogue for multistory timber buildings

Research Institution:

Technische Universität München
Lehrstuhl für Holzbau und Baukonstruktion
Univ.-Prof. Dr.-Ing. Stefan Winter

Project management:

Dipl.-Ing. Michael Merk
Dipl.-Ing. Norman Werther

Project Team:

Dipl.-Ing. Martin Gräfe
Dr.-Ing. Claudia Fülle
Dipl.-Phys. Dietmar Sprinz
Dipl.-Ing. (BA) Nadine Leopold
Dipl.-Ing. Matthias Busch
Dipl.-Ing. (FH) Markus Brunn

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Deichmanns Aue 31-37
52179 Bonn

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1 Objective of the research project

Since the German building regulation code “Musterbauordnung 2002” and accordingly the guideline to fire-resistant timber structures (*Muster-Richtlinie über brandschutztechnische Anforderungen an hochfeuerhemmende Bauteile in Holzbauweise – M-HFHHolzR*) was introduced in 2004, it has become possible to build multy-storey-timber structures within the “Gebäudeklasse 4” (up to 13 m height of upper floor level) without special permissions of the construction supervision agencies.

A fire protecting cladding of the load-bearing timber structures is required regularly with the objective to prevent the timber from charring within the 60-Minute timespan of protection. Regarding fire safety, these buildings behave identically as mineral-based structures within the time of protection.

After some years of experience in constructing multistorey timber buildings in Germany it has become apparent, that the constructive rules defined by the M-HFHHolzR are partly impractical, and therefore sometimes lead to legal problems. This research project engages at this point by developing improved and more practical constructive rules and details to ensure a higher level of planning certainty and clarity in detailing multistory timber buildings.

To maintain the required quality and grade of fire protection, the elements must be produced with factory- and third-party production-control monitoring. The timber elements are prefabricated and installed on site as a ready-to use building product.

Constructing high-rise timber buildings requires a very high grade of precise and comprehensive planning. It is necessary to consider various aspects like fire safety, building acoustics, statics, building physics and assembly processes all at the same time. It is often not possible or reasonable to adjust constructions on site, so all elements have to be completely ready-to-use.

The formal, technical and legal requirements are pretty strict and more complex for high-rise timber buildings than for other building materials and methods. Moreover, many planners so far do have little experiences in this relatively new building method.

The grade of complexity is partially a restraint to the competitiveness and broader market share of timber structures, which nevertheless yield undoubtedly many technical, ecological and architectural advantages.

Therefore the purpose of the project has been the creation of a catalogue with thoroughly designed details and structures, such as walls and floors, for timber structures. All constructive details and components are designed to satisfy all requirements mentioned above.

All necessary technical information is being provided, and recommendations are being made, for instance to parameters like thermal insulation and other important technical aspects.

Anticipated as an outcome of the project are a substantially simplified planning process and an improved planning certainty, which should lead to a broader market share of multi-storey timber buildings.

2 Realisation of the research project

2.1 Literature research and legal boundary conditions

The first step of the project was to research and analyze the national and international literature regarding fire safety in high-rise timber buildings. The German legal, technical and normative boundary conditions concerning fire safety, soundproofing, thermal protection and timber protection were specified and compiled in a comprehensive overview.
Particularly in Austria and Switzerland, extensive and detailed information and constructive planning rules for multistory timber buildings are available. Most of them are not directly applicable for buildings in Germany as legal requirements are different. Required by the German building law is the encapsulation criterion "$K_2$60" additional to the REI60 fire resistance class, whereas the fire classification in the most other countries is confined to REI60 respectively REI90 without encapsulation criterion.
Experiences and recommendations of other countries have been used as informative basis and transferred as far as possible to the German requirements.

2.2 Fire tests

Four fire tests on solid timber and timber framed wall- and ceiling elements were planned and conducted. The test specimens consisted each of one ceiling and one or two wall elements, in which customary building service installations such as electrical wiring and pipework had been installed. Apart from that the construction was assembled accurately following the rules of commonly used general appraisal certificates for REI60/$K_2$60 constructions.

The design of the test specimens was based on the following questions:

- How can electrical installations be installed by maintaining the protective goals of fire safety? What is the maximum size of openings in the encapsulation cladding? What is the minimum distance between openings and timber elements?
- What are possible solutions for electrical installations integrated in solid timber elements?
- Do electric insulation materials ignite earlier than timber and therefore potentially infringe the encapsulation criterion? What is the behavior of insulation materials with "improved fire performance"?

- What types of pipework may be installed and what are the constructive rules?
- How can wall/ceiling joints in the protective cladding be designed to satisfy requirements of fire safety, soundproofing, mounting ability and economy?
- How may corners in the protective cladding (such as on windows, doors, fire bulkheads) be improved compared to the M-HFHHolzR?

All test specimens were equipped internally with thermocouples to register temperatures of the timber at critical points over the timespan of fire exposure. The fire tests were conducted in a combined wall/ceiling furnace with 60 minutes of exposure to the standard time-temperature curve following ISO 834. Subsequent to the fire tests the specimens were dismounted and visually examined and the temperature charts were analyzed.
The tests resulted in either confirmation, alteration or exclusion of the preliminary designed constructions. Based on the test results, suitable constructions for the detail catalogue could be developed, and constructive recommendations concerning the integration of building services could be made.

2.3 Rating of the soundproofing properties

The aim of the project was to create a catalogue of technical and legal impeccable constructions and constructive details for REI60/$K_2$60 timber building elements. For this purpose the soundproofing quality of each element type had to be rated, and a specific sound reduction index had to be provided to the user of the catalogue. In the design of constructive details soundproofing rules had to be considered.
For the catalogue, sound reduction indexes have basically been taken out of existing literature and testing experiences. For some constructions this approach was not sufficient, in those cases sound damping measurements have been conducted.

2.4 Building physics

An important part of the project was the examination of the building physic properties (moisture protection, heat protection) of the wall and ceiling elements and constructive details. For all external wall elements the thermal insulation quality was calculated, as well as thermal bridge losses for constructive details. All planar elements and constructive details were designed to be free of condensation water and therefore maintain the highest standard of timber protection according to DIN 68800. All details are designed by minimization of thermal bridge losses.

3 Derived recommendations

3.1 Recommendations for the integration of building service installations

Based on the fire tests, the preliminary conducted literature research and considering technical and legal boundaries recommendations for the integration of building service installations in REI60/$K_2$60 timber building elements have been developed. Detailed recommendations can be made particularly concerning the following points:

- The necessary distances between openings in the encapsulation cladding and internal timber elements.
- The maximum size of openings in the encapsulation cladding.
- The distance between openings in the encapsulation cladding.
- The type and size of pipework mounted internally in timber elements.
- The type of electrical installations to be mounted in timber elements.
- Solutions for electrical wiring mounted in solid timber elements.

The recommendations are published in terms of constructive rules and related drawings. Detailed information based on fire tests and literature research is provided concerning the integration of fire bulkheads in timber ceiling elements.

3.2 Recommendations for further details

Additionally, constructive recommendations to the following details have been developed:

- Wall/ceiling joints connecting visible solid timber ceilings to cladded timber walls
- Corner joints in the encapsulation cladding at scuncheons or other types of corners
- Solutions mounting windows and doors.

All details have been designed with the principle of maintaining the protective goals of the M-HFHHolzR and the general protective goals of fire safety defined by the German building regulation code. Practical workability and partial technical properties could be improved at the same time.

3.3 Element and detail catalogue

Core of the research project report is the element and detail catalogue containing legal and technical impeccable and trouble-free usable timber elements and related constructive details in the fire safety classification REI60/$K_2$60. The elements and details have been select-

ed by the authors as practical and feasible for the most common applications. Other solutions and constructions of timber elements may be appropriate and preferred in some cases. Such constructions may be designed corresponding to the recommendations given in the present research report, e. g. concerning corners in cladding layers or electrical installations. All solid timber elements may be made of CLT, stacked board ceiling slabs or similar construction types. When using solid timber elements it has to be guaranteed that there are no gaps and slots between timber parts in order to prevent fire or smoke spread.

The element catalogue contains 16 types of walls and ceilings in respective datasheets providing all necessary technical and legal information. Based on these element types, 37 constructive details have been designed and plotted in detail-datasheets. The target of the detail-catalogue was to provide a comprehensive overview of the possibilities of connect different timber elements, and at the same time maintaining all technical and legal requirements as good as possible. Special detail solutions which may be necessary depending on each specific building can be designed following the described principles.