Fire safety Engineering

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What are the key barriers for timber constructions?
Key barriers for timber constructions

- Regulations/laws
- Education
- Experience
- Durability
- Costs
- It burns!
- And few more…
Key barriers for timber constructions

Why is the fire behaviour of timber a key barrier?

... timber burns.
... I do not want to live in a building that might burn.

Yes, it burns! I agree. But let me explain why this is a great behaviour:
Timber behaviour in fire – some basics

<table>
<thead>
<tr>
<th>Fire behaviour</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pyrolysis</td>
<td><strong>Pyrolysis:</strong> Thermal degradation of wood producing combustible gases and accompanied by a loss in mass</td>
</tr>
<tr>
<td>Charring rate</td>
<td>Timber burns, but totally predictable</td>
</tr>
<tr>
<td>Char layer</td>
<td>And many more…</td>
</tr>
</tbody>
</table>
Timber behaviour in fire – some basics

Fire behaviour

- Pyrolysis
- Charring rate
- Char layer
- And many more…

Description

Charring rate:
Ratio between charring depth $d_{\text{char}}$ and fire time $t$ (in mm/min)

$$\beta = \frac{d_{\text{char}}}{t} = \frac{50 \text{ mm}}{71 \text{ min}} = 0.7 \text{ mm/min}$$

Charring rate is constant!

Fire time $t = 71$ min

Char layer
Timber behaviour in fire – some basics

**Fire behaviour**
- Pyrolysis
- Charring rate
- Char layer
- And many more…

**Description**

**Char layer** protects the residual cross-section from high temperatures

The inside of the cross-section is “cold“ and load-bearing

<table>
<thead>
<tr>
<th>Temp. [°C]</th>
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<tbody>
<tr>
<td>850</td>
</tr>
<tr>
<td>700</td>
</tr>
<tr>
<td>580</td>
</tr>
<tr>
<td>400</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>20</td>
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</tbody>
</table>
Intumescent coating systems on steel members

Mode of action: intumescent systems expand at a temperature of about 200°C by a factor of 30 to 60 and form a compact insulating layer.
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Modern manmade intumescent materials applied to steel structural elements are in essence an attempt to replicate what timber does naturally.”

From paper “Overview of design issues for tall timber buildings”, I. Smith, A. Frangi, Structural Engineering International SEI 2/2008
Steel girders cannot take any loads anymore.

Timber beam still has a residual load-bearing capacity.

Fig. 20-4. After fire scene. Shows a wood beam supporting twisted steel I-beams. (Forest Products Laboratory)
Timber behaviour in fire – Fire resistance

Basic strategies

- Use of massive cross-sections
- Increase of cross-sections by charring depth
- Protection of the timber elements with non-combustible materials
Key barriers for timber constructions

- Regulations/laws
- Education
- Experience
- Durability
- Costs

It burns!
And few fmore…
Key barriers for timber constructions

Why is the fire behaviour of timber a key barrier?

... we are not allowed
... we are not able
... we do not have the knowledge

Yes, but regulations and education as well as assistance from experts are the key!
Key barriers for timber constructions

Why is the fire behaviour of timber a key barrier?

So, what is the situation in your country? Can you help me?

Yes, with pleasure. Cooperation and best practice experience is important.
Fire safety regulations in Switzerland

New fire safety regulations in Switzerland since 1\textsuperscript{st} of January 2015

Timber as a construction material can be used in all categories of buildings (low-rise, medium-rise and high-rise buildings).

Building categories with respect to height

- **Low buildings**
  - Up to 11 m total height
  - Usual 1 – 3 stories

- **Medium-rise**
  - Up to 30 m total height
  - Usual 4 - 8 stories

- **Tall buildings**
  - More than 30 m total height
  - Usual 9 and more stories
Fire safety regulations in Switzerland

New fire safety regulations in Switzerland since 1\textsuperscript{st} of January 2015

1. Timber as a construction material can be \textit{used in all categories of buildings} (low-rise, medium-rise and high-rise buildings).

2. With regard to requirements of fire resistance, there is \textit{no difference} between combustible structural elements and non-combustible structural elements.

3. Structural elements in wood needs to be designed for a fire resistance of \textit{60 minutes}.
Fire safety regulations in Switzerland

A fire resistance of 60 minutes only?

We have good experience with 60 minutes combined with good engineers and a good fire brigade
Fire safety regulations in Switzerland

A fire resistance of 60 minutes only?

And: We help the engineers to design a building with standards, handbooks etc.
Fire safety regulations in Switzerland

Lignum Documentation

- Important tool in planning, execution and implementation for architects, engineers, fire authorities and contractors.
- Is recognised by the fire authority as state of the art.
Fire safety regulations in Switzerland

How to design a building

- Use of products or components given in the Swiss Fire Safety Register
- Use of **standardized components** (according to Lignum documentation)
- Verification by calculation using recognized calculation methods (according to Lignum documentation)
Fire safety regulations in Switzerland

Principals of the regulations

- Revision every 10 years
- Same format as previous fire regulations
- Implementation of state of the art
- Economic optimization
Fire safety regulations in Switzerland

I understand that you have great documents. Anything else of importance?

A big YES!
A good quality management system is essential!
Fire safety regulations in Switzerland

Quality management system:

- Fire safety plan with all fire safety measures
- **Careful** planning and detailing
- Professionally implementation of fire safety measures during the construction
- Periodic controls and maintenance
- The intensity of maintenance and controls must be set depending of the type of structures and the type and importance of the building
Fire safety regulations in Switzerland

Wow, but this is very expensive! Do you have this for all types of buildings?

Of course, this depends on the type of building, the materials, the location, etc.
Fire safety regulations in Switzerland

And what type of timber buildings do you build in Switzerland?

Let me show you some examples.
Zürich, 7 storeys (Switzerland)

Steinhausen, 6 storeys (Switzerland)

Lugano, 6 storeys (Switzerland)

Baar, 5 storeys (Switzerland)
Trends for timber structures in Switzerland

More and more buildings in the city
Trends for timber structures in Switzerland

More and more hardwood (?)
Trends for timber structures in Switzerland

More and more digital fabricated (?)
Trends for timber structures in Switzerland

More and more exposed to weather
Trends for timber structures in Switzerland

How tall is the tallest timber building? What is the market share of timber?

The tallest timber building will be a 10 storey building. It is currently under construction.
Trends for timber structures in Switzerland

…and the market share:

Load-bearing structures

Development of market share of timber (new buildings)

- Residential
- Multi-family
- Non-residential

Non-residential
Multi-family
Multi-family
Identified requirements to reduce barriers:

Requirements with regard to fire safety engineering:

- Good education of engineers
- Good documents for engineers (standardized products, handbooks)
- Help each other and learn from fire experts
- Establish an effective quality management system for fire safety
- Reasonable and adequate regulations /laws (fire safety, design loads) considering the building environment (education, documents, knowledge, experience) in each country
- Identify risks and be careful. One fire in a timber building might have an enormous negative impact!
- Do not overestimate your abilities. With increasing complexity of a building more experienced (fire) engineers should be involved
- Clarify that a burning material like timber has a predictable, foreseen fire behavior

General requirements:

- Consider a timber solution for your building in a very early state of planning!
- Reduce costs, use standardized products (do not reinvent the wheel every time!)
Conclusions

- Sustainability is not a trend, it is a necessity
- Timber construction = sustainable construction
- To burn timber for heating is a pity
- Bring together people and ideas to gain the greatest benefit of timber as building material
- We are in the era of timber

Building materials

Top of the tree

The case for wooden skyscrapers is not barking

Sep 10th 2016 | From the print edition

The five-storey pagoda of the Temple of the Flourishing Law in the Nara prefecture of Japan is one of the world’s oldest wooden buildings. It has withstood wind, rain, fire and earthquakes for 1,400 years. Analysis of the rings in the central pillar supporting the 32-metre structure suggests the wood that it is made from was felled in 594, and construction is thought to have taken place soon after.

In an age of steel and concrete, the pagoda is a reminder of wood’s long history as a construction material. New techniques mean that wood can now be used for much taller buildings. A handful are already going up in cities around the world. The 14-storey Treet block of flats in Bergen, Norway, is currently the tallest. But Brock Commons, an 18-storey wooden dormitory at the University of British Columbia in Canada, is due to be completed in 2017. That is when construction is expected to begin on the 21-storey Haut building in Amsterdam. Arup, a firm of engineering consultants working on the project, says it will be built using sustainable European pine. Some architects have even started designing wooden skyscrapers, like the proposed Trapeze (“the tree top” illustrated above), a 40-floor residential tower on the drawing-board in Stockholm.

Timber!

Wood has many attractions as a construction material, apart from its aesthetic qualities. A wooden building is about a quarter of the weight of an equivalent reinforced-concrete structure, which means foundations can be smaller. Timber is a sustainable material and a natural “sink”