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Fire safety in wooden buildings – the most important questions identified by the Swedish fire safety community

By: Caroline Bernelius Cronsioe, BRIAB, Sweden; Robert McNamee, RISE, Sweden

The Swedish SFPE chapter has assembled the questions that the Swedish fire safety community have concerning wooden buildings in general and the design, construction, and maintenance of wooden buildings in particular. The summary contains 43 questions from professionals working at fire safety consultant firms, insurance companies, municipalities (fire brigade and city planning office), county boards, universities and companie s that sell fire safety products.

The Swedish SFPE chapter have approximately 350 members. Everyone with an interest in fire related questions are welcome to join. Therefore, we have a variety of professions, related to fire safety, represented in the local chapter. The Swedish chapter (Chapter 47) was founded in 1996 and have since then played an important role in promoting good fire safety engineering and influencing the development of sound industry practice and the Swedish legislations in the fire safety area.

For quite some time now there has been a discussion among the members of the Swedish SFPE Chapter regarding the difficulties to achieve an acceptable level of fire safety in wooden buildings. Some of the frequently asked questions concerns the combustibility of wood and its sensitivity where a small error can result in large consequences. Other important topics that are discussed are how the level of fire safety should be maintained as a building grow older, is altered, the wood ages. There is a great need for development in this area of engineering and a need for support concerning how the fire safety should be designed. A first step towards this development is the problem identification that is stated below.

Why does Sweden build buildings with wood?

Sweden have used wood as a building material for a long time, mostly because Sweden is covered with forests. Today the use of wood is also motivated by the fact that it is a sustainable building material. The construction and property sector were, in 2019, responsible for 21 % of the carbon dioxide emissions in Sweden [1]. If the construction and property sector lowered its carbon dioxide emissions, it would have a great impact on the total amount of emissions. Therefore, wood as a building material, is very attractive.

The Swedish building code is material neutral (function based)

Sweden have had many great city fires in the past and over the years requirements has been added to the building code to reduce the consequences of a fire in a wooden building. In 1994 Sweden went

from a building code with deemed-to-satisfy solutions to a function-based building code, with the consequence that the fire safety code became neutral concerning the building material, i.e. the function of the material or structure were defined, not the choice of material. A consequence of this change in the building code were that it once again was allowed to build high rise buildings in wood. Even though it has been possible to build high rise buildings in wood since 1994 it is first in recent years that high rise buildings and other complex buildings has been built in wood.

The fact that the fire safety code, concerning building materials, is neutral means that the same requirements are to be fulfilled regardless if the construction is made of steel, wood or concrete. In recent years the knowledge of different fire properties concerning wood as a building material has increased in Sweden [2] but there are still several questions that are unanswered or just partly answered.

Problem identification

Wood is a combustible material and to build complex buildings, that may include combustible façades and internal exposed surface layers in wood, is a challenge from a fire safety perspective. Since we don't have a history of building complex buildings in wood the uncertainties are considerable. These uncertainties create doubts about how the building code should be interpreted to achieve an acceptable fire safety level. The fire safety community needs to work together to find common solutions and reduce the uncertainties. This is also important from the perspective that the motivation to use wood can be reduced if we get fires in wooden buildings with large consequences. We need to build wood buildings based on sound engineering principles anchored in science to reduce this risk of using wood.

The interest in fire safety concerning wooden buildings is increasing since there is a political and common wish to build more buildings with wood. But since there also are unanswered questions and uncertainties the Swedish SFPE chapter stated that there is a need for development in this area. Step one in this process was to ask the fire safety community in Sweden what the uncertainties and unanswered questions are. The response was great and came from professionals working at fire safety consultant firms, insurance companies, municipalities (fire brigade and city planning office), county boards, universities and companies that sell fire safety products.

The 43 questions

The questions below are a summary of an extensive material that the members of the Swedish SFPE chapter and others within the fire safety community sent us. The summary shows that there are many and complex questions that we need to solve concerning wooden buildings. In the summary the questions are divided in categories that follows the different stages of a buildings life, from design to management. The summary is published in a Swedish report *Sammanställning av frågeställningar kring trähus och trähusbyggande från föreningen för brandteknisk ingenjörsvetenskaps medlemmar* [3]. The following section is a translation of the questions identified. We hope that this snapshot of the questions discussed in the Swedish fire safety community can inspire similar discussion in other countries that in the long run leads to the use of sound fire safety engineering based on science. And we also hope that the European community can work together to answer the questions.

Design phase

Fire load

- *How do we ensure that a fire in a structure made out of wood will self-extinguish?*
- *Does internal surfaces made of wood in a significant way effect the fire dynamics in a room or a fire compartment?*
- *How do we protect a structure made by cross laminated timber if we don't want it to participate in a fire?*
- *When should we include unprotected wood in the fire load?*
- *The strategy for the fire brigade depends on the size of the fire and its potential size. How can the fire brigade know, when they arrive at the fire scene, that a building has the potential of a great fire due to a lot of unprotected wood?*

Structures exposed to fire

- *How do we handle the risk of collapse as a consequence of the contribution of the structure to the fire and the fact that the fire won't go out until all the combustible material is out?*
- *How shall we manage the fact that a building suddenly can collapse due to continued heat penetration after the flaming phase?*
- *What are the pros and cons with Eurocode 5 EN 1995-1-2? Are there other methods that can be use instead?*
- *At what temperature, in the core, does wood lose its load-bearing capacity and how is this handled in fire safety engineering design?*
- *Which pre-accepted solutions in the Swedish building code can be replaced with the installation of sprinklers when the load-bearing structure is made out of wood? (The Swedish building code generally accept that a few of the pre-accepted solutions can be replaced with the installation of sprinklers).*
- *Is it possible to use fire retardant paint to give a wood structure a given R-class? Is it appropriate to use EN 13381-7:2019[4]? What is required for the combination of a wood structure and a fire-retardant system to be approved and preserve its load-bearing capacity over time?*

Delamination

- *At what conditions can a second (and third, forth…) fully developed fire evolve due to delamination?*
- *At what situations should CLT with heat resistant glue be used to avoid delamination?*
- *How shall a load bearing structure be designed if delamination is considered?*
- *Are different recommendations needed if a building element made of wood is mounted vertical or horizontal? If the building element is loadbearing or not or has some other purpose like fire separation?*

Internal surfaces

- *How much exposed wood is acceptable in a fire compartment or in a room (in Sweden it is generally accepted with 20% (except in escape routes))? What fire protection is needed if there is 20, 40 or 100 % exposed wood? Are there other factors to consider that are more important than the percentage?*
- *Which measurements can be used to allow more exposed wood indoors?*
- *Can painted (or similar products) wood be enough to fulfil the fire code, like B-s1,d0? If yes what are the requirements that these systems need to fulfil?*

- *What should be included in a design if we want combustible internal surfaces in an escape route?*
- *What is a surface of an enclosure and what is an additional surface cover? (Relevant question from the Swedish regulation perspective)*

Modules and cavities

- *How shall we design and maintain the fire protection in cavities in a building with a wooden structure?*

Sprinklers and analytical design

- *At what circumstances can sprinklers (conventional or fog) enable the use of exposed wood?*
- *Under what circumstances shall sprinklers be required to allow the loadbearing structure to be combustible?*
- *Do we have to install sprinklers to prevent fire spread to the façade, to cavities etc?*
- *Can all of the pre-accepted solutions that you can replace with sprinklers be used in a wooden building? (The Swedish building code generally accept one or two of the pre-accepted solutions can be replaced with the installation of sprinklers).*
- *Which requirements shall the sprinkler system fulfil concerning area of protection, hazard class, type of sprinkler system and redundancy, when the sprinkler is used to create robustness in wooden buildings? Should there be different requirements due to which parts are exposed (façade, internal surfaces, load bearing structures, etc.) or which parts that are made of wood?*

Construction phase

Fire safety during the construction phase

- *Which parts need to be repeatedly controlled during the construction phase to (i) reduce the risk of fire during the construction phase and (ii) to reduce the risk of extensive damage in the finished building? (The control should include construction, production and organizational risks).*
- *What measures are required during the construction phase to minimize the risk of a fire in the exposed structure?*

Required controls

- *How can we create necessary routines for control, during all stages of the constructions phase, to ensure that deficiencies do not lead to disproportionate consequences (or to avoid them)?*
- *Which controls, during the construction phase, are most important for a wooden building?*

Management phase

Rescue operation

- *How shall a rescue operation in a wooden building handle specific challenges? (For example if the fire brigade have access or not to all of the facades around a building, the fire event triggers an extensive rescue operation, fires in cavities).*
- *What information should be included in the pre-defined action plan for the fire brigade?*
- *What should be included in the design of a wooden building to take account of the fire brigades rescue operation and security?*

- *How is a rescue operation affected if flashovers keep reoccurring and if the flash overs also affect the load bearing capacity?*

Endurance

- *How do we ensure that the properties of fire retardant treated wood are kept during the lifetime of the structure when exposed to moisture and UV light?*
  Is it appropriate to use EN 16755[5] knowing that the test method does not compare to real aging?
- *How should management and maintenance be ensured? As an example, in residential buildings owed by the residents?*
- *Is it at all possible to retain and maintain the properties of a wooden panel that has been impregnated?*
- *Who's responsibility to ensure that the fire protection has a specific endurance?*

Insurance

- *Do we need requirements additional to those in the building code to be able to insure a wooden building?*

<u>Other</u>

Fire testing/applicability

- *Large surfaces of exposed wood can generate extensive pyrolyzing areas that contribute with extra energy to a fire. If the fire is under-ventilated the excess energy will create big flames outside an opening like a window. How does this affect the thermal exposure of a façade?*
- *How can we spread the information that the generic reaction to fire classification of wood, D-s2,d2 is only valid for unmodified unpainted wood?*
- *Which standardized test and calculation methods are available for wood in Sweden?*
- *Isolation and sealings are mainly tested in walls made of gypsum or concrete. How can we know that a sealing within a wall made of CLT will fulfil the requirements in the building code?*

Next step

The Swedish SFPE chapter cannot answer all these questions without external help, especially since we as an organization do not have the time or resources. The activities in the chapter are voluntary and some of the questions require extensive research efforts. The whole fire safety community, not just within Sweden, have to work together to reach the goal to build safe wooden buildings based on sound engineering principles anchored in science.

The Swedish SFPE chapter has initiated a RoundRobin-study to investigate how fire safety consultants in Sweden design fire safe wooden buildings. Two different buildings, including different wooden components, were to be designed by the consultants. The designs sent back to the working group are then anonymized and the engineering methods and models used in practice are identified as well as possible deviation in safety level between the participants. The study is conducted in

January and February of 2023 and a report, with the results, will preliminary be published in May. Depending on the results the Swedish SFPE chapter will start one or more workgroups to write guidelines concerning the design phase.

Parallel with the RoundRobin-study the Swedish chapter has started two workgroups that will write guidelines. The two workgroups are working with question related to delamination and safety during the construction phase including controls that are required due to the sensitivity for errors in wood structures.

If you want more information regarding the activities in this area you are welcome to contact us. Together we can promote the use of sound engineering principles!

References

[1] A webpage at the national board of housing building and planing (the Swedish regulators): *www.boverket.se/sv/byggande/hallbart-byggande-och-forvaltning/miljoindikatorer---aktuell-status/vaxthusgaser/* received 2022-05-27.

[2] Pettersson C., *Fire Safety in Timber Buildings – A review of existing knowledge* Brandforsk 2020:10 (Brandforsk is a Swedish fire research sponsor)

[3] BIV Rapport 2022:1 *Sammanställning av frågeställningar kring trähus och trähusbygg-ande från föreningen för Brandteknisk IngenjörsVetenskaps medlemmar*, https://sfpe-biv.se/news/sammanstallning-av-fragestallningar-kring-trahus/

[4] EN 13381-7:2019 *Test methods for determining the contribution to the fire resistance of structural members – Part 7: Applied protection to timber members*, Brussels, 2019

[5] EN 16755:2017/AC:2018 *Durability of reaction to fire performance – Classes of fireretardant treated wood products in interior and exterior end use applications,* Brussels, 2017