REPORT

FCLT PROJECT | FINISHES

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Industrial finishing, painting structures in place

Speaking of finishes in general, it involves stains, paints or sealers that protect, colour or enhance the natural beauty of wood structural panels.

Exterior finishes are used primarily in order to protect siding and maintain its appearance. They minimize the weathering action that cause the surface of unfinished wood to roughen and erode. There is a wide range of finishes available that provide different degrees of protection, which is why the type, quality, quantity and application must be considered in order to achieve the desired performance. If wood panels are to be painted or stained, all exterior panel edges should be sealed. Recommended exterior finishes include semi-transparent stain, solid-colour stain and acrylic latex paint. (APA 2012)

Interior finishes require minimal amount of preparation. Sanded and textured grades only require touch-sanding. Recommended interior finishes are oil base paint, latex paint, stain and sealer. (APA 2012)

In general, most of solid timber constructions come fully finished. Solid timber on its own has the advantage that it is suitable to be exposed as an interior surface. This option has several benefits – it can lower the costs needed on other common finishing materials, such as gypsum boards, paints, etc. Another benefit is the ability to provide the designer/architect with an option to use the interior wood surface in an innovative way. (Smith, Griffin, Rice. 2015.)

Surface treatment and finishing depend on the use of the slab. Visible surfaces can be sanded and finished to order. The slabs can be used as loadbearing and stiffening structures, and in both wall and floor construction. In interior spaces, the slabs can be finished or, building regulations permitting, be left visible depending on the atmosphere being sought. The light but stiff slabs can be worked to precise dimensions to form different shaped construction elements. In elevations, windows and doors can be located with considerable freedom, even corner windows can be used, because the slab-like structure acts, when necessary, as a cantilever. Free forms can be used, as well. In external walls, the slabs are insulated in the normal way. The insulation is located outside the slabs. In intermediate floors, the slabs can be used either as they are, or in conjunction with a system of wooden beams and/or a composite construction with poured concrete. In a composite construction, the wood acts as fire protection, while poured concrete and plaster act as sound insulation. The composite structure does the loadbearing. Composite construction can also be replaced with a floating floor, with the slabs stiffening the beams. In buildings where the requirements set for sound insulation are not great, CLT slabs may be used on their own. CLT slabs are very popular in Central Europe, where people are used to massive construction. In Finland too, the popularity of CLT is growing fast. CLT is particularly suited to, for example, frame construction of spatial elements. In frame construction, the competitiveness of CLT increases with the number of storeys. As yet, there is no harmonised European product standard for CLT, so that the slabs can be given the European CE mark in accordance with receiving technical approval. The technical properties and structural dimensioning of CLT slabs are dependent on the manufacturer. Architects are able to design buildings with CLT construction in a general way, but they must take into account the manufacturer's values and calculation methods in the dimensioning of the construction. (Puu 3/15, 69)

Planning is an important part of the process, not only from the construction point of view, but also from the actual finishing point of view. The design is crucial, because the mechanical and electrical systems are located before fabrication. Knowing where and how will affect the finishes that are going to be used. There are different types and grades of solid timber panels, some of them come with certain sealers or finishes from the producer of such panels. It is critical to understand how the panels will be exposed. (Smith et al. 2015.)

As for CLT, as a building systems, it is quite adaptable and it performs well in long spans in floors, walls and roofs. It also has the potential for a high degree of exterior and interior finishes

preinstalled off-site. Another advantage of CLT is that it can be used jointly with basically any other building material, such as light wood frame, heavy timber, even steel or concrete. (CLT Handbook – US Edition. 2013.)

After pressing of CLT, standard CLT elements are trimmed on the edges. The elements' surfaces after pressing are handled in different ways, usually without further processing like sanding or planing. As previously mentioned, it is critical to understand how the particular elements will be used. Depending on the use, it is possible to apply additional non load-bearing layers, for example oriented strand board, acoustic panels or gypsum plaster boards. These layers are primarily connected by surface bonding. (Brandner 2014).

For both exterior and interior finishes, it is however required to adhere to fire protection regulations (explained further in this chapter).

It is however not possible to apply any type of finishes. The buildings must adhere to particular fire and acoustic standards. These standards vary only slightly, depending on the country. Occupancy classification and the use of the building in question is a key factor that determines what fire protection measures need to be applied and what acoustic standards have to be followed. This might include limitations to building geometry, means of egress, fire protection and interior finishes. The regulation of size of structures is based on the hazards associated with the occupancy and the characteristics of construction materials used. (Tyree, Stone. 2015.)

That being said, wood and wood-based products are nowadays widely used in interior walls, ceilings and floor surfaces in basically all types of buildings. The attractive qualities of wood surfaces are mainly appearance, acoustical qualities and interior design versatility. In general terms, wood materials can be used as interior finish within almost all occupancies, however, the finish materials must adhere to rules and regulations, and must comply with minimum finish performances based on their location within the building. The main classification here are flame spread index numbers. These values are determined in a standard fire test which evaluates the surface burning characteristics of a material. The maximum flame spread indices vary according to the building occupancy, location of the material in the building and the presence of sprinklers. It is only logical that nonsprinklered buildings require lower flame-spread materials than sprinklered buildings. The flame spread indices are usually available from the manufacturers. (Tyree, Stone. 2015)

Finishes and coatings are recommended when dealing with timber, in order to enhance the appearance and the durability of the timber.

The interior surfaces may be coated with a wide range of products like paints, stains or oils as the timber is normally seasoned and free of surface impurities which interfere with the coating process.

As for exterior surfaces, they are exposed to a wide range of elements, such as ultraviolet light, heat, cold, water and airborne contaminates not only before, but also during the coating, which causes difficulties for the painter. The main purpose of the exterior coating is to provide protective coating against weathering. Another aim of the exterior coating is to provide an appealing finish to the structure.

Each timber has particular characteristics that could affect the application of certain products, so it is important to know about the timber that is being coated and make reference to the manufacturers'product literature in order to receive specific recommendations.

Speaking again about timber specifically, the CLT panels may offer aesthetic benefits if left exposed on the interior side to show the solid wood finish. As already mentioned, fire safety and acoustic requirements must be followed. In some building types and some jurisdictions, it may be required to cover exposed wood surfaces with gypsum drywall or other non-combustible finish to meet the fire safety requirements. (CLT Handbook 2011)

The Finnish Puu magazine also gives a great insight about external finishes. It mentions the fact that in order to guarantee durability, it is essential that the external cladding boards, the fixing method and finish used are chosen and executed correctly. The latest industrial paints will give an interval of 15 years between painting and repainting. After painting, the building will be like new, which will increase its value. The same types of finishing materials are normally used for the interiors of wooden buildings as for other buildings. Thus wear and tear is the same for both. Cleaning and maintenance are carried out according to the instructions of each individual manufacturer. (Puu 3/15, 40)

About addressing the Flame Spread Rating interior finish requirements, the most common method to do that is the installation of gypsum board. For situations where there is no fire-resistance requirements, the gypsum board will need to be fire-rated as either Type X or Type C. (CLT Handbook 2011). Type X fire rated gypsum drywall is 15.9mm thick. Its minimum fire rating is 1 hour, which is a typical requirement for many building codes. Type C fire rated gypsum drywall is sometimes called improved Type X. It is similar to Type X, but it contains more glass fiber reinforcement and other ingredients in the gypsum core that makes its fire resistive properties superior to Type X. (CertainTeed). The interior finish requirements for low Fire Spread Ratings can also be addressed by decorative hardwood plywood panels, particleboard or medium-density fireboard panel products that have been treated with fire-retardant chemicals to achieve higher FSR. (CLT Handbook 2011)

The finishing also depends on the type of building the timber is used in. For example, in high buildings, the smoke that is generated from a fire by a surface that is burning is an additional concern. The occupants of such buildings must be protected from the effects of smoke until they have left the building or the fire has been extinguished. This is because the evacuation of a high building takes a lot of time. Therefore, in high buildings, the smoke emission characteristics of wall, ceiling and floor surfaces are regulated. In comparison to lower buildings, additional regulations are placed on flame spread ratings and smoke developed classification of interior finish materials. Again, everything depends on whether or not the building is sprinklered or not. In sprinklered buildings, under some jurisdictions, the interior surfaces of the building would be permitted to be lined with significant combustible fuel loading within the building. This would be similar to the use of exposed Mass Timber as a final finish treatment within the interior of the building and would also be fully protected with automatic sprinklers to effectively limit surface burning characteristics in the interior compartments. (Green and Karsh, 2012)

One of the advantages of CLT is that charring can be used as a strategy for fire protection. Charring is specific for mass timber and it means that during fire, the surface of the wood chars and forms a kind of a protective layer, enhancing the fire performance of mass timber. While it is assumed at this time that dropped ceilings and wall finishes will be used in locations to provide fire protection and acoustic treatment and the concealment of services, there is a possibility to build spaces into the panel assemblies in order to provide chases for services. In the cases where charring is used as a strategy for fire protection, all member sizes would need to be checked and adjusted to meet the post-fire load case. Green and Karsh have conducted a preliminary analysis that has shown that the charring design approach impacts the sizing of the structural member in most cases only minimally. (Green and Karsh, 2012)

More about the flame-spread rating and other surface burning requirements – according to the code that is to be applicable to interior finish materials, such materials that form part of the interior surface of a floor, wall, partition or ceiling are included. Specifically it concerns such elements as: interior claddings, surfacing of fabric, paint, veneer and similar; also doors, windows, trim; lighting elements such as light diffusers/lenses; carpet material that overlays a floor. Typically, wood materials in a non-combustible building may represent an increase in the fuel load and fire hazard within an interior compartment of a building. However, owing to the large dimension, solid wood nature of Mass Timber construction, the surface burning characteristics of the solid wood panels and similar Mass Timber systems will be substantially different: these solid materials are more resistant to ignition and will not sustain surface flaming as easily due to the difficulty in generating sufficient vapours at the surface to sustain flammable mixtures of combustible gases. For these reasons, the surface burning characteristics

of Mass Timber elements is expected to be significantly better than standard finishes of limited thickness. (Green and Karsh, 2012)

There is, however, a different approach to ensure the adequate fire performance of Mass Timber assemblies. This is called 'encapsulation' approach. This approach utilizes an encapsulation system which is similar to standard construction techniques used to construct fire-rated floor, roof and wall assemblies, not only in combustible building types, but also non-combustible ones. In this approach, the solid wood members are protected with 2 layers of fire-rated gypsum board within each compartment and generally throughout the building. This approach usually includes the installation of 2-layers of Type X rated gypsum board directly to the exposed surfaces of the Mass Timber materials, using positive fastening devices (like screws) of sufficient depth to resist deterioration and pull-out during fire exposure. This assembly is expected to achieve 2-hour fire-resistance ratings. In this case, the finished gypsum board surfaces providing protection of the Mass Timber structural elements of the building may also perform as the interior room finishes. In this case, the building owners must be warned about altering or damaging the ceiling/wall finishes. (Green & Karsh, 2012)

Timber systems in sprinklered buildings are usually proposed to be used in an exposed condition, because the surface burning characteristics of the wood members could be augmented through fire-retardant treatments or other chemical applications. Fire testing programs have demonstrated that in sprinkler controlled fire scenarios, temperatures will be effectively controlled by the sprinkler discharge with the result of minimal damage or charring of the wood panel materials. What is more, since the exposed wood surfaces will form part of a solid Mass Timber panel system (as opposed to a thin interior finish or lining material that these code requirements are intended to regulate), the wood surfaces will not be as readily ignitable and will not sustain surface combustion in the same manner as thin/low mass interior finish materials. (Green & Karsh, 2012)

About fire separation and panel joints where wood panels are used as a finished surface or in the charring fire protection method, it is crucial that joints are sealed properly to prevent fire from breaching the assembly at a faster rate than anticipated during a fire. (Green & Karsh, 2012)

Results of the full-scale fire tests show that CLT panels have the potential to provide excellent fire resistance often comparable to typical heavy construction assemblies of non-combustible construction. Due to the inherent nature of thick timber members to slowly char at a predictable rate, CLT panels can maintain significant structural capacity for an extended duration of time when exposed to fire. (CLT handbook – US edition)

The APA also gives examples of CLT Appearance Classifications. This is supposed to be used for reference only. The requirements are based on the appearance at the time of manufacturing and the actual CLT pane appearance requirements are recommended to be agreed upon between the buyer and the seller.

The first type is the Architectural Appearance Classification. This appearance classification is normally suitable for applications where appearance is an important, but not overriding consideration. Specific characteristics of this classification are as follows:

- In exposed surfaces, all knot holes and voids measuring over 19mm thick are filled with a wood-tone filler or clear wood inserts selected for similarity with the grain and colour of the adjacent wood.
- The face layers exposed to view are free of loose knots and open know holes are filled.
- Knot holes do not exceed 19mm when measured in the direction of the lamination length with the exception that a void may be longer than 19mm if its area is not greater than 323 mm^2.

- Voids greater than 1.6mm wide created by the edge joints appearing on the face layers exposed to view are filled.
- Exposed surfaces are surfaced smooth with no misses permitted.

The second type is the Industrial Appearance Classification. This appearance classification is normally suitable for use in concealed applications where appearance is not of primary concern. Specific characteristics of this grade are as follows:

- Voids appearing on the edges of laminations need not be filled.
- Loose knots and knot holes appearing on the face layers exposed to view are not filled.
- Members are surfaced on face layers only and the appearance requirements apply only to these layers.
- Occasional misses, low laminations or wane (limited to the lumber grade) are permitted on the surface layers and are not limited in length.

(APA 2011)

Fire protective paints on internal surfaces

Wood products may be treated with fire retardants in order to enhance their fire performance by delaying time to ignition, reducing heat release rate and lowering flame spread ratings. These fire retardant treatments may also reduce the smoke developed classification. It is important to understand that while these treatments enhance the flame spread performance of wood and wood-based products, these treatments do not make them non-combustible materials.

There are two types of fire retardant treatments:

- Surface coatings
- Pressure-impregnated chemicals

Furthermore, there are two objectives for treating wood products with fire retardant chemicals. One is used in cases where fire retardant-treated wood may be used instead of non-combustible construction. The other objective is to meet requirements related to fire performance. (CLT Handbook 2011)

There is one thing to keep in mind, and that is the interaction between fire-retardant treatment chemicals and the mechanical properties and performance of the adhesives. The wood industry, at the time when CLT Handbook was published (2011) did not recommend the use of fire retardant treatments of glulam, for instance. (CLT Handbook 2011)

If the CLT components will be fire-retardant treated by pressure-impregnated chemicals, the effects on mechanical properties will need to be addressed in the design. In this case, reference-specified strength values, including connection strength values, for lumber and CLT pressure-treated with fire retardant chemicals, should be obtained from the manufacturer providing the treatment. (CLT Handbook 2011)

As for interior finish fire protective paints specifically, fire retardant surface treatments may be also used to address interior finish requirements that are more restrictive than the flame ratings for untreated wood. Surface treatments, including clear intumescent coatings, allow designers to use unprotected CLT (that means without gypsum board or other cladding), while achieving the more restrictive finish rating requirements.

The authors of CLT Handbooks, FPInnovations have also conducted full-scale fire resistance tests in an attempt to evaluate the effect on surface treatments (e.g., Intumescent coatings) on fire resistance. The full-scale fire-resistance tests have been conducted on 3-ply (105-mm) CLT wall assemblies. Surprisingly, the treated CLT assembly failed earlier than the untreated CLT wall assembly. The difference was not that significant, but one explanation for such a variance may be that by the time the inturnescent coating had degraded and no longer provided its thermal insulation, the furnace temperature (i.e., heat flux emitted to the CLT surface) was significantly greater. At that point, the uncharred wood ignited and burned faster than usual (at a rate much higher than 0.65 mm/min.), thereby reducing the effective cross-section more quickly. The CLT Handbook suggests that further research is required to properly evaluate the effect of surface coatings on charring rate (i.e., fire resistance) on timber assemblies. (CLT Handbook 2011)

These tests were, however, conducted in 2011, and there might have been further advancement in the field. Schmidt, Griffin and Rice mention in their publication from 2015 that currently, there are fire performance tests that indicate CLT is capable of being completely exposed and having adequate fire resistance ratings to meet the requirements. Additional fire protection could be as simple as adding an additional layer to each side of the layers required for structural integrity. This could provide an additional hour of fire protection and could give another option for an interior finish. (Smith, Griffin, Rice 2015)

So it is possible to expose CLT, but additional sacrificial lamination may be required to accommodate required fire resistance rating. Most of the exposed CLT will have different finish ratings, according to the location of the timber in the buildings. (WoodWorks 2012)

In general, the results of the full-scale fire tests show that CLT panels have the potential to provide excellent fire resistance often comparable to typical heavy construction assemblies of non-combustible construction. Due to the inherent nature of thick members to slowly char at a predictable rate, CLT panels can maintain significant structural capacity for an extended duration of time when exposed to fire. (CLT Handbook – US edition 2013)

As for commercial examples of fire retardants and fire retardant wood stains, woodproducts.fi shows a description of such products, both for interior and exterior use. The treatment can be done industrially (by spray, vacuum or pressure treatment) or at site by spraying or brushing. Designer have the freedom to choose from thousands of translucent shades from most major paint manufacturers. Transparent treatment is also available. This treatment leaves woods natural colour and texture fully visible. (WoodProducts.fi)

The Finnish Company CrossLam Kuhmo Oy in their presentation also discuss that the wood can be left visible. They mention that CLT is easy to treat with stains or paints. The surface can be planed or sanded and even special effects like grooves and other shapes can be added to the surface. These treatments include acoustic insulation, improved fire resistance, surface profiles and figuring, colouring and cutting and sanding. (CLT, Cross Laminated Timber from Finland)

Acoustic paints

There is no specific research or publication referring to the use of acoustic paints and CLT in particular. That suggests that the use of acoustic paints must adhere to general rules and regulations when it comes to fire protective treatments and fire performance. There is also nothing to suggest that acoustic paints cannot be used, as long as all the rules and regulations are being followed and it is ensured that there are no undesired interactions between the CLT adhesives and other possible surface treatments/finishes, meaning that the acoustic paint does not cause undesired chemical reactions and that it does not cause damage to mechanical performance of CLT adhesives.

References

Articles:

Brandner R., 2014. *Production and Technology of Cross Laminated Timber (CLT): A state-of-the-art Report.* Accessed 16.2.2016. Available at: https://www.researchgate.net/publication/261884030

Publications:

APA – The Engineered Wood Association. 2011. *Standard for Performance-Rated Cross-Laminated Timber*.

APA – The Engineered Wood Association. 2012. *Engineered Wood Handbook and Grade Glossary.*

FPInnovations, 2011. *CLT Handbook*.

FPInnovations, 2013. *CLT Handbook – US edition.*

E-references:

Green M., Karsh J. February 22, 2012. *THE CASE FOR Tall Wood BUILDINGS: How Mass Timber Offers a Safe, Economical, and Environmentally Friendly Alternative for Tall Building Structures.* Accessed 18.2.2016. Available at: http://www.woodworks.org/wp-content/uploads/CWC-Tall-Walls2.pdf

Woodproducts.fi. Accessed 18.2.2016. Available at: http://www.woodproducts.fi/multiprotect-flame-retardant-wood-stain

Smith R., Griffin G., Rice T. August 2015. *Solid timber construction: process, practice, performance.* Accessed 18.2.2016. Available at: http://www.rethinkwood.com/sites/default/files/Solid_Timber_Construction_Report_August_2015.pdf

Stone J., Tyree D. 2015. *Designing for Fire Protection: Expanding the possibilities of wood design.* Accessed 18.2.2016. Available at: http://www.rethinkwood.com/sites/default/files/Designing-For-Fire-Protection-CEU-Aug-2015.pdf

CertainTeed. 2016. *CertainTeed Learning Center: Drywall and Performance Wallboards*. Accessed 20.2.2016. Available at: http://www.certainteed.com/learning-center/gypsum/?qid=124

Presentations:

WoodWorks. 2012. *The Case for Cross Laminated Timber: Part 2 – Opportunities and Challenges for a New Class of Timber Product.* Accessed 20.2.2016. Available at: http://www.woodworks.org/wp-content/uploads/The-Case-for-CLT-Part-21.pdf

Oy CrossLam Kuhmo. *CLT, Cross Laminated Timber from Finland.* Accessed 18.2.2016. Available at: http://www.metla.fi/tapahtumat/2015/barentsff/Virta.pdf

Magazines:

PUU Magazine. 3/2015. Suomalaista puuarkkitehteuuria ja-rakentamista (Finnish Wood Architecture and Construction). Accessed 18.2.2016. Available at: http://www.woodproducts.fi/sites/default/files/Puu_3_15_low.pdf