General finger joint for CLT

Technical data

Date: 07.07.2014

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Disclaimer

The present document shall give an idea about the possibilities with general finger joints in CLT panels along with recommended load bearing capacities. These capacities are based on technical expertise and research reports – see references. The proposed values need to be checked and verified by the engineer who is in charge of the lifting operations.
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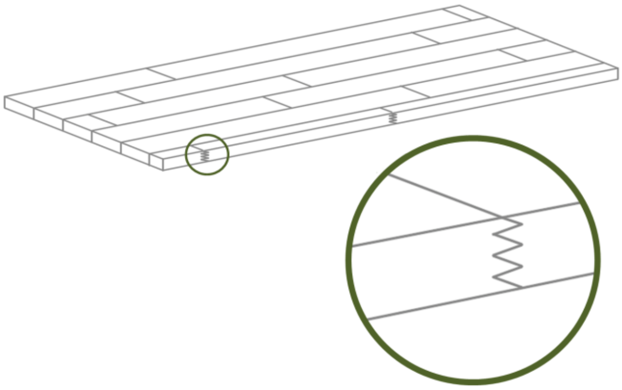
General finger joint for CLT

1. General

1.1. What is a general finger joint (GFJ)?

A finger joint allows to extend the length of a timber batten or lamella with only a minor increase in strength at the finger joint location. In the production of CLT, finger joints are necessary to create a lamination of the required length, in order to create a CLT master panel. So far finger joints have been only applied to the individual Lamination strings. These finger joints do not cause an effective decrease in the strength of the entire CLT element, because the joint locations are spread out over the entire panel, so they are not concentrated in one spot where they would create a weak spot.
A general finger joint (GFJ) – also called large finger joint - is a finger joint that is not only limited to the one lamella or one lamination layer, but it actually reaches over the entire thickness of a CLT panel.



Finger joint on lamination scale in a single layer board

General finger joint = finger joint over the entire thickness of a panel

1.2. Benefits of a GFJ

- Larger panel sizes are possible
  (Master panel size of 3,95 m x 16,00 m)
- Higher clear story heights, beyond 2,95 m are possible.
- Increased degree of prefabrication shortening the construction time at the site

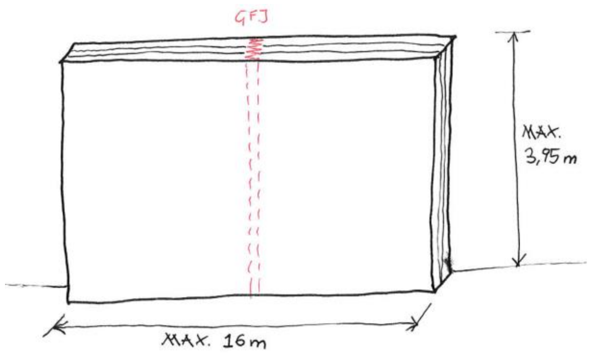
2. Boundary conditions

GFJs cannot be placed randomly within a master panel. There are certain limits to the use of a GFJ. The limits are related to the production and to the load bearing mechanism.

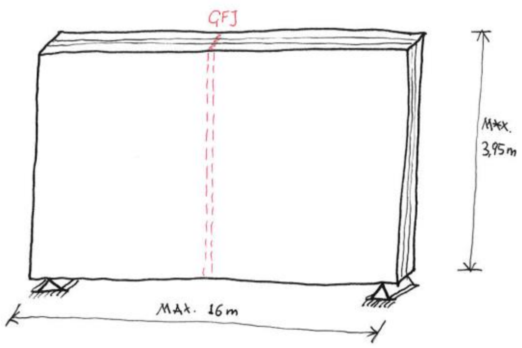
2.1. GFJs are ideally limited to wall elements (in plane load bearing)

CLT panels that receives a GFJ shall receive most of the loading in plane of the element. This is typical for:

- Walls
- Headers (CLT-beams)
- Deep beams

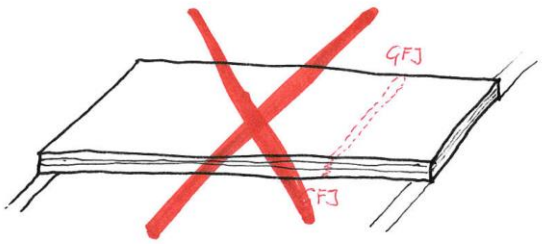


GFJ in a wall



GFJ in a deep beam

The use in a panel that receives the majority of loading perpendicular to the plane is not recommended. So a GFJ should not be placed in a floor panel. If a GFJ is really necessary, it shall be placed in zones with low internal forces.



Ideally no finger joints in panels with loading perpendicular to the plane

2.2. Maximum GFJ length and width

- Any GFJ cannot be longer than 4,00 m
- Any GFJ cannot be wider than 220 mm

2.3. Final or master panel size

The final panel size of any panel, assembled using GFJ cannot be larger than 3,95 m x 16,00 m. Due to the maximum size of regular CLT panels which are the raw material for CLT panels with GFJ, GFJs are required at a maximum spacing of 2,95 m, due to the maximum width of 2,95 m of a regular CLT panel.

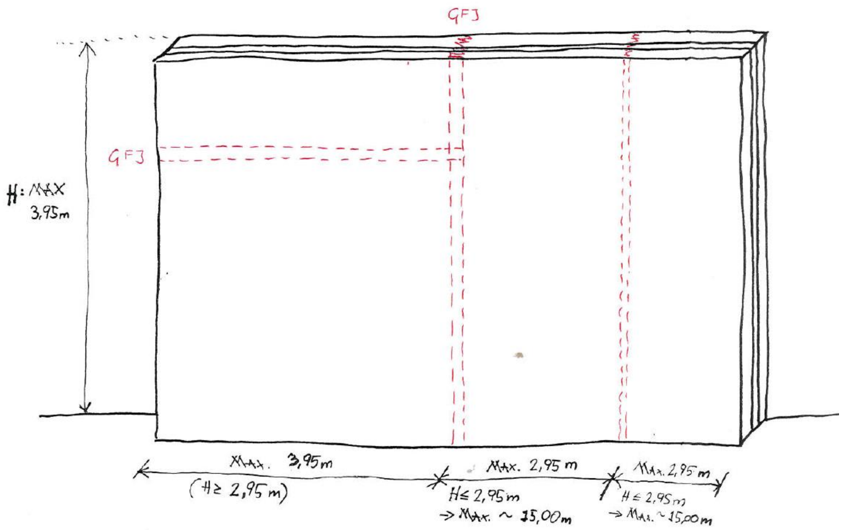
2.4. Recommendation: no GFJ in places with high internal forces

Ideally GFJ shall be placed in locations, where bending moments (in plane and out of plane) are low. Generally GFJ can be placed at any location where it is technically possible, but the internal stress distribution needs to be verified within a structural analysis, applying the characteristic strength values for CLT sections with GFJs.

3. Possibilities provided by GFJ

Regarding the boundary conditions, the following possibilities are offered by GFJs:

- If a final panels height exceeds 2,95 m (max. width of a regular CLT panel), the maximum GFJ spacing in horizontal direction is limited to 3,95 m.
- If a final panels height is less than 2,95 m (max. width of a regular CLT panel), the maximum GFJ spacing in horizontal direction only limited to the maximum over all panel length of 16,00 m. Reasonably this would result in a maximum possible length of roughly 15,00, otherwise there would be no need for a GFJ.



Possibilities provided by GFJ

The required openings will be cut in the new master panel (max. 3,95 x 16,00 m) by CNC portal processing equipment, after the GFJ assembly.

4. Characteristic strength values

According to the expertise by Professor Blaß, dated 02.05.2014, the following characteristic strength values apply (assuming a minimum timber strength class of C24 or T14):

<table>
<tr><td colspan="2">A reduction in:
▪ shear strength,
▪ rolling shear strength,
▪ tensile strength perpendicular to the grain,
▪ compressive strength perpendicular to the grain or
▪ stiffness
is not required.</td></tr>
<tr><td>Characteristic bending strength
(in plane or out of plane):</td><td>$f_{m,GFJ,k} = \frac{5}{6} \cdot k_l \cdot f_{m,14080,k}$

$k_l = min \begin{cases} 1 + 0{,}025 \cdot n \\ 1{,}10 \end{cases}$

<table><tr><td colspan="2">n</td></tr><tr><td>CLT slab, loading out of plane</td><td>CLT wall, header or beam, loading in plane</td></tr><tr><td>number of lamellas next to another in one lamination layer</td><td>number of lamination layers with grain orientation in principal span direction</td></tr></table></td></tr>
<tr><td>Characteristic tensile strength:</td><td>$f_{t,0,GFJ,k} = \frac{5}{6} \cdot f_{t,0,14080,k}$</td></tr>
<tr><td>Characteristic compressive strength:</td><td>$f_{c,0,GFJ,k} = \frac{5}{6} \cdot f_{c,0,14080,k}$</td></tr>
</table>

Example for C24:

<table>
<tr><td>Characteristic bending strength
(in plane or out of plane):</td><td>

$$f_{m,GFJ,k} = \frac{5}{6} \cdot k_l \cdot f_{m,14080,k} = \frac{5}{6} \cdot 1{,}075 \cdot 24 = 21{,}5\ N/mm^2$$

$$k_l = min\begin{cases}1 + 0{,}025 \cdot n \\ 1{,}10\end{cases} = min\begin{cases}1 + 0{,}025 \cdot 3 \\ 1{,}10\end{cases} = 1{,}075$$

Assume n=3

<table>
<tr><td colspan="2">n</td></tr>
<tr><td>CLT slab, loading out of plane</td><td>CLT wall, header or beam, loading in plane</td></tr>
<tr><td>number of lamellas next to another in one lamination layer</td><td>number of lamination lay-ers with grain orientation in principal span direction</td></tr>
</table>
</td></tr>
<tr><td>Characteristic tensile strength:</td><td>$f_{t,0,GFJ,k} = \frac{5}{6} \cdot f_{t,0,14080,k} = \frac{5}{6} \cdot 19{,}20 = 16{,}00\ N/mm^2$</td></tr>
<tr><td>Characteristic compressive strength:</td><td>$f_{c,0,GFJ,k} = \frac{5}{6} \cdot f_{c,0,14080,k} = \frac{5}{6} \cdot 24{,}00 = 20{,}00\ N/mm^2$</td></tr>
</table>

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Ybbs a.d. Donau, 07.07.2014