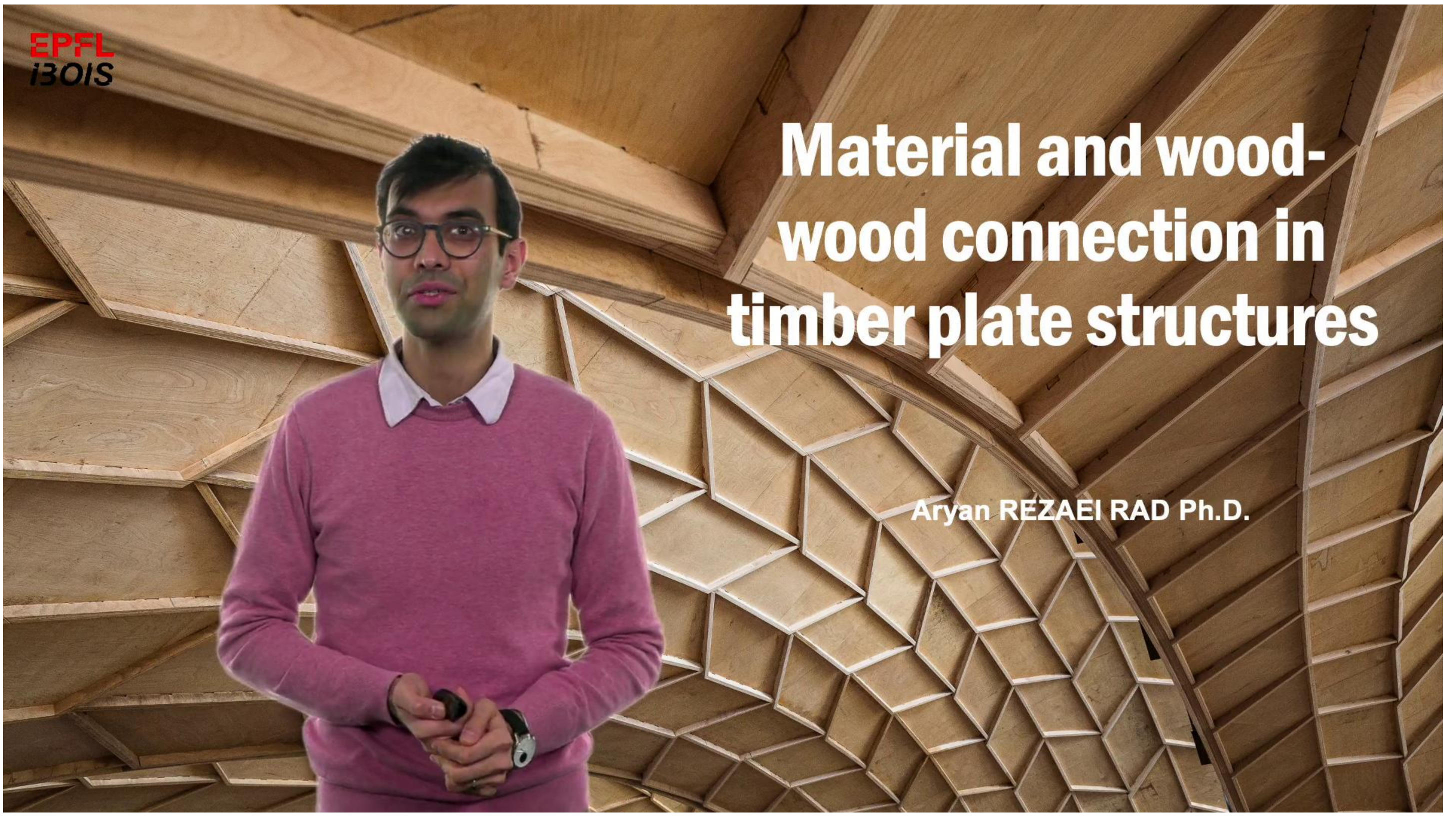
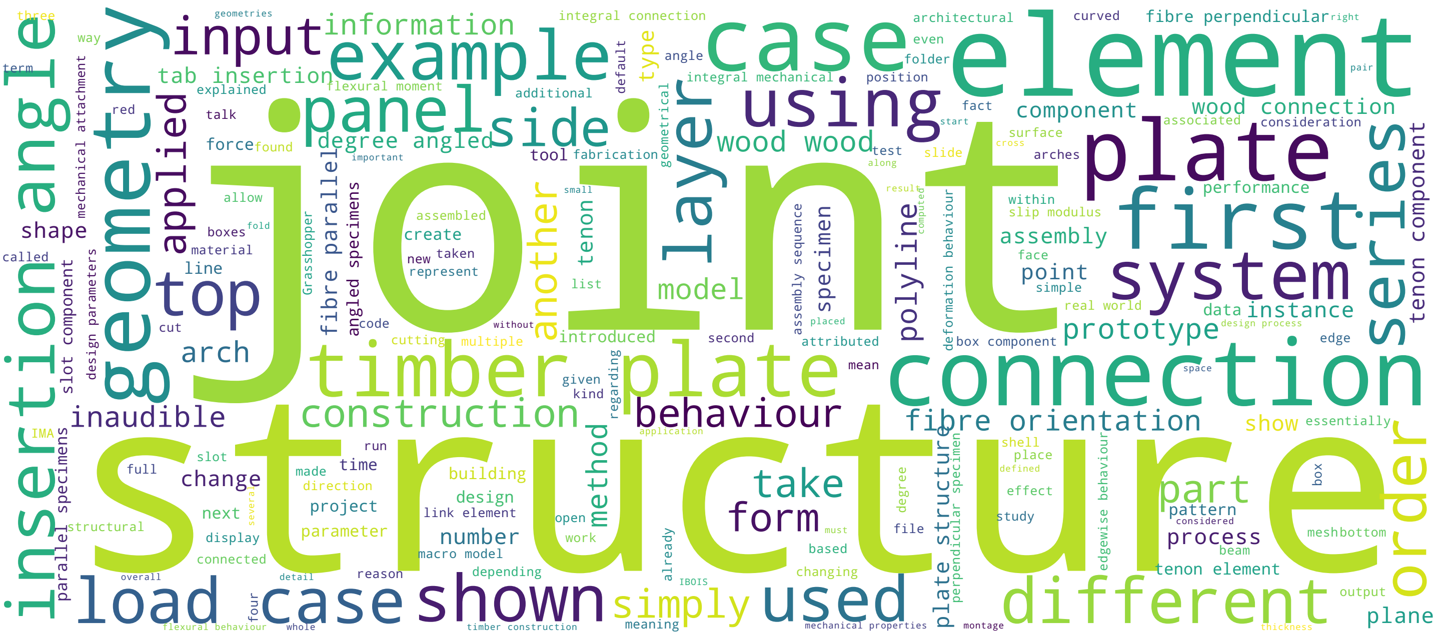
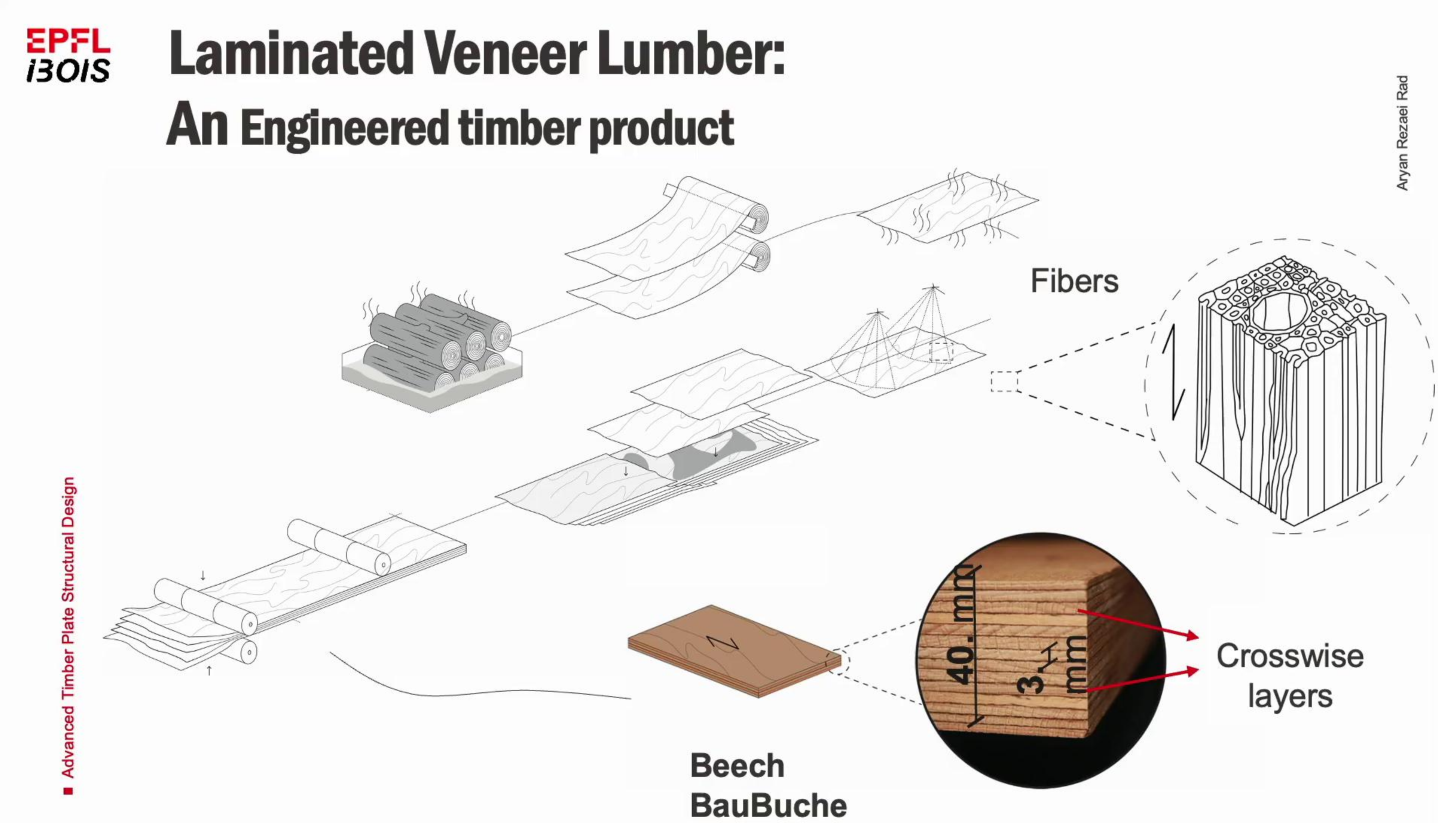




Search MOOC

Video

EPFL



Let's talk about the material and connection scale first. The industrial production of wood panels initiated in the early 20th century. Revolutionized timber construction by introducing engineered timber products. Laminated Veneer Lumber or LVL, which is one of the most recent timber products, is categorised as composite product, where multiple thin layers of veneer are glued together to form a homogenised material with orthotropic properties. Each layer has a ribbon like shape with a uniform thickness that is peeled from a log under a constant pressure. The cellular structure of a wood for each layer is such that the fibre or vessels are oriented along one direction. In LVL panels, most of the layers are oriented parallel to the long edge of the panel, while some layers are oriented perpendicular to the long edge. Beech Elsevier or in German, BauBuche, which is a hardwood timber material produced by Pollmeier, is considered as the construction material in our current session today to give a overview about the structural performance of IMAs. The LVL boards have 40-millimetre thickness and they include 13 layers of 3-millimetre thick veneers where two layers are crosswise oriented, as you can see in this slide. Crosswise layers are accordingly shown.

Notes

Summary

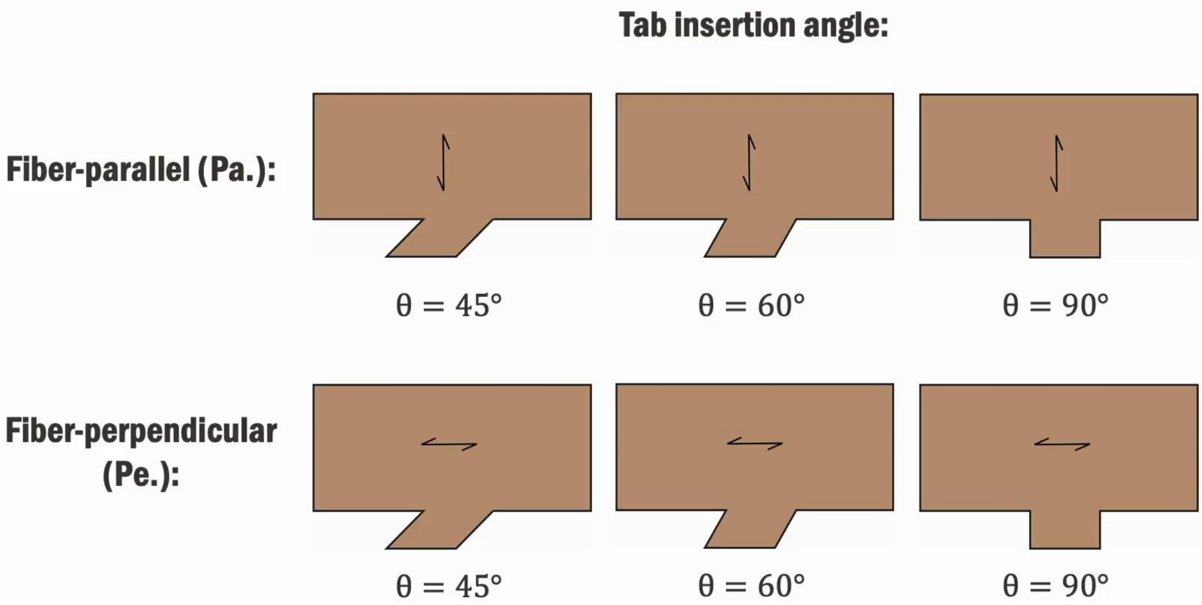
0m 04s

EPFL i3OIS

Design parameters

Aryan Rezaei Rad

Advanced Timber Plate Structural Design



Using BauBuche Beech Elsevier and digital fabrication technology that I explained before, the connection skill for the integral joints is introduced. Two design parameters are generally considered in our experimental cases, fibre orientation and tab insertion angle. Also, two categories of the fibre orientation are adopted. In the first category, the cross-section of the tenon component consists of two crosswise and 11 longitudinal fibre layers. This category is recognised as fibre parallel specimens because most of the specimens are oriented parallel to the load direction. Now, the fibres in the second category are oriented 90 degrees with respect to those in the first category. This is recognised as fibre-perpendicular specimens. Also, there are three tab insertion angle that we should talk about 45-degree angled specimens, 60-degree angled specimens and finally, 90-degree angled specimens.

Notes

Summary

1m 50s

EPFL IBOIS

Design parameters

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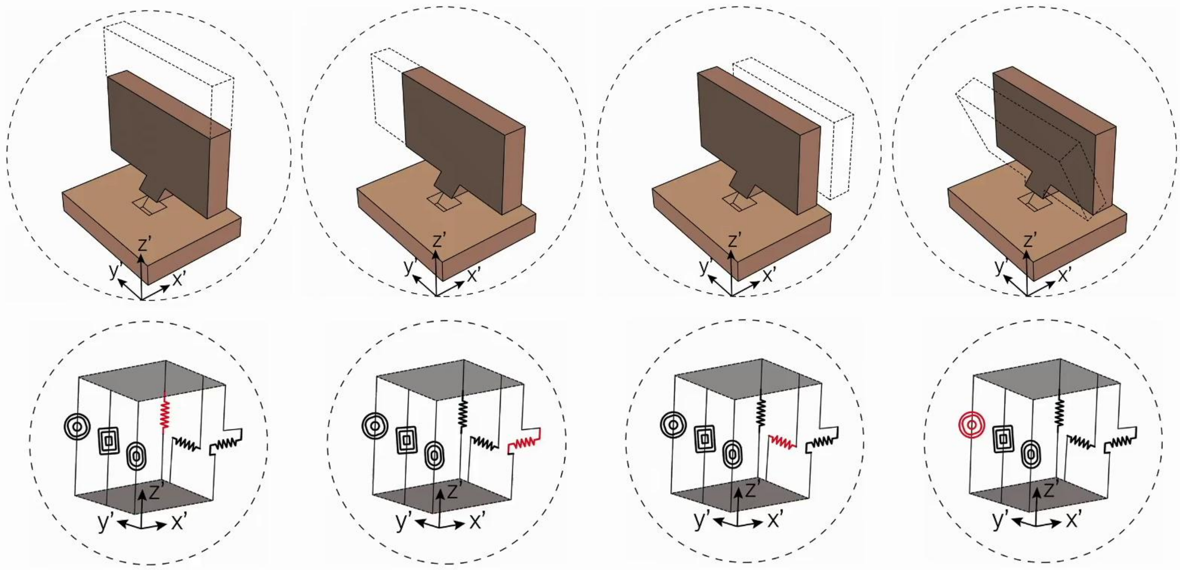
Tensile | Edgewise | Flatwise | Flexure



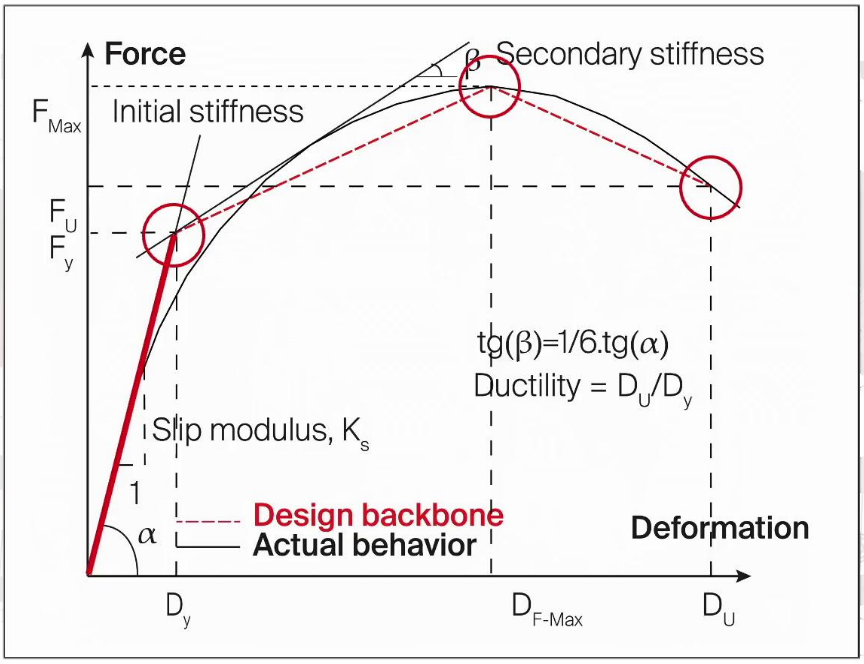
After the fabrication of the connection, their behaviour under different mechanisms and load cases should be understood. In our case, the behaviour of the joints or integral mechanical attachments is studied under four load cases. The first one is a tensile load that you see here. The second load case is the edgewise load. The next one is the flatwise load and finally flexural moment. The kinematic degrees of freedom associated with the real geometry is idealised using the link element. That link element is basically summarises the mechanical properties of the connection between the slot and tenon component. This link element consists of different springs, which capture the tensile behaviour, edgewise behaviour, and flatwise force deformation behaviour. They're all shown in red in three different directions and of course, flexural moment rotation behaviour of the connections, which is also shown in a red rotational spring hearing.

Notes

Summary

3m 09s

Design parameters



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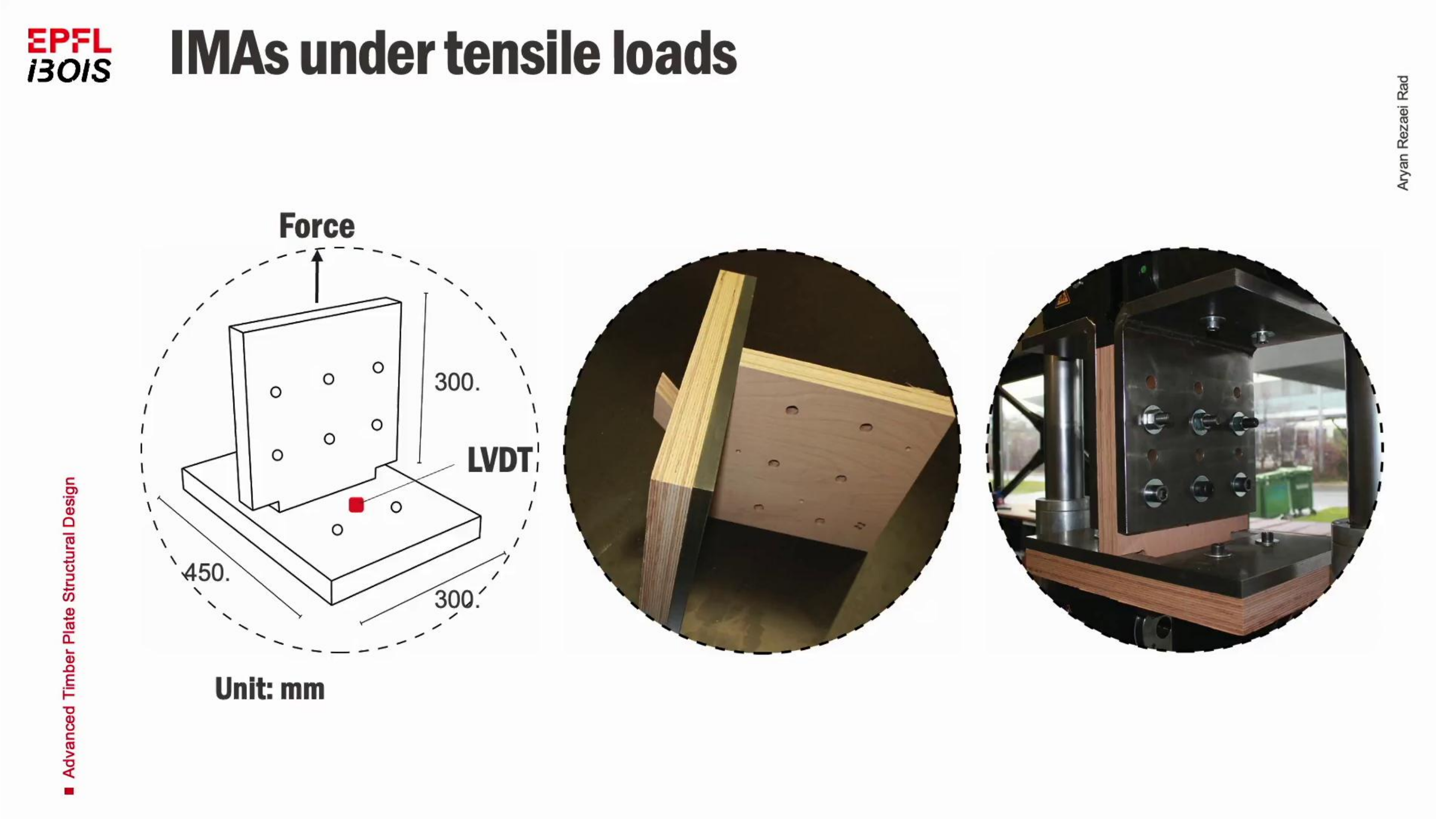
Afterwards, the force deformation behaviour of our integral mechanical attachments or in our cases, through tenon joints is characterised using... For example, in our case we use, European Standard EN 26 891. The associated design parameters include the maximum capacity state shown in red in this slide, yield state, ultimate state, design slip modulus, and finally, the ductility of the connection. Okay, now we are going to study each of these load cases separately from experimental campaign point of view and talk about the associated mechanical properties, giving you the design recommendations, etc.

Notes

Summary

4m 29s

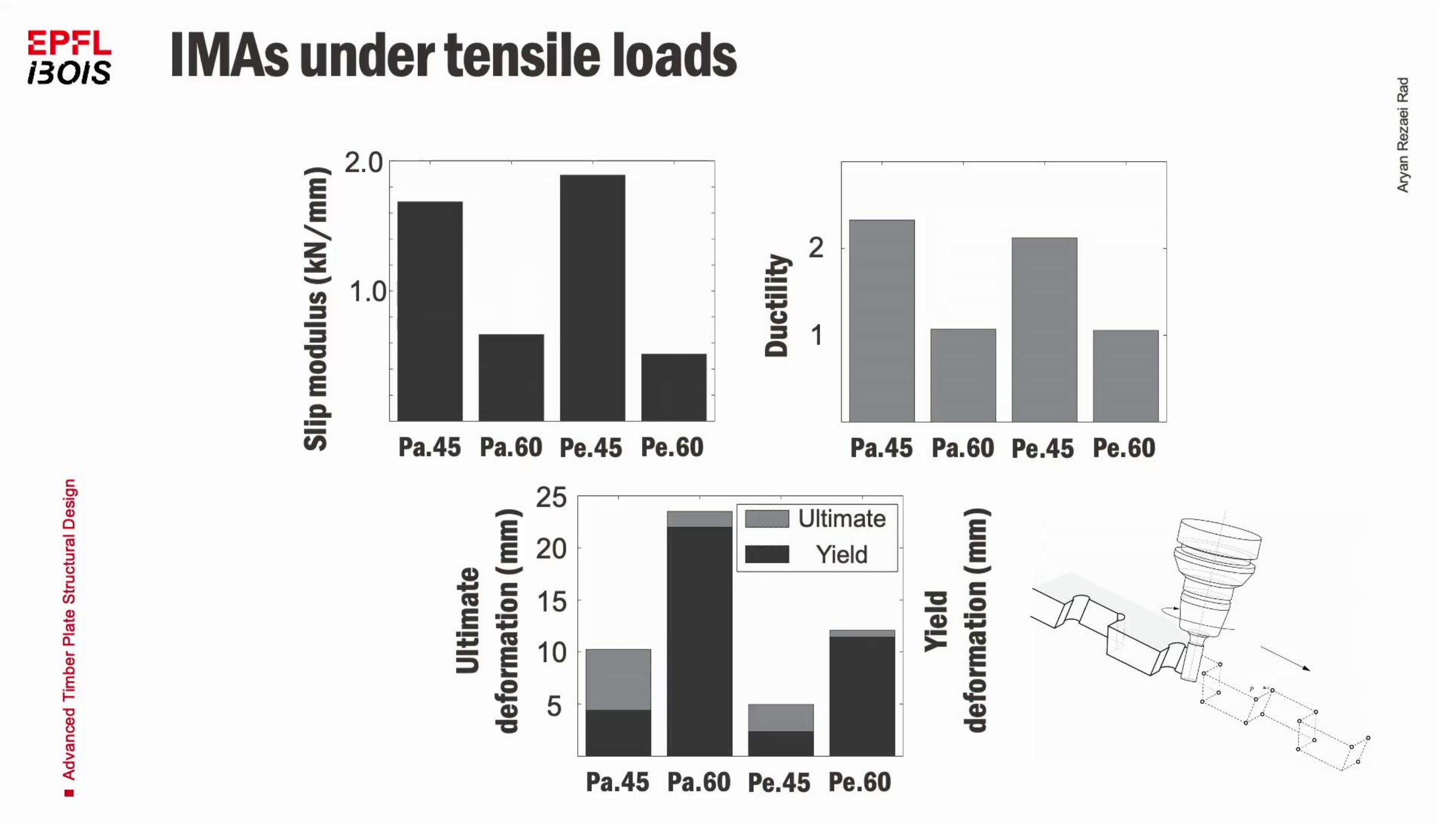


Regarding the behaviour of the integral connections under tensile behaviour, here is an experimental set-up that can be used to understand the associated load-deformation behaviour. The tenon element is fixed and the tensile load is applied to the slot component. The tenon and the slot and the overall experimental test also shown in this slide in real world and also schematically.

Notes

Summary

5m 24s



Studies indicate that with the minimum amount of a slip, the 45-degree angled specimens provide a more secure interlocking mechanism compared to the 60-degree angled of the specimens in both fibre orientations. Also, changing the tab insertion angle from 45 degree to 60 degrees, decreases the ductility and slip modules in both fibre orientations. This is attributed to the effect of nut sizes in the performance of the joints. Furthermore, the specimens reach their ultimate deformation soon after yielding occurs. This shows that the joints cannot demonstrate post yield non-linear behaviour and ductile behaviour. This is one of the very important design parameters and considerations that should be taken into account during the design process.

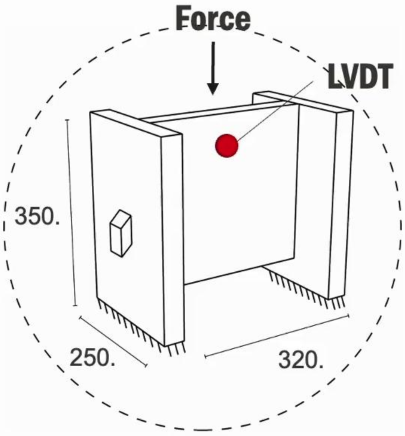
Notes

Summary

5m 51s

IMAs under edgewise loads

Aryan Rezaei Rad



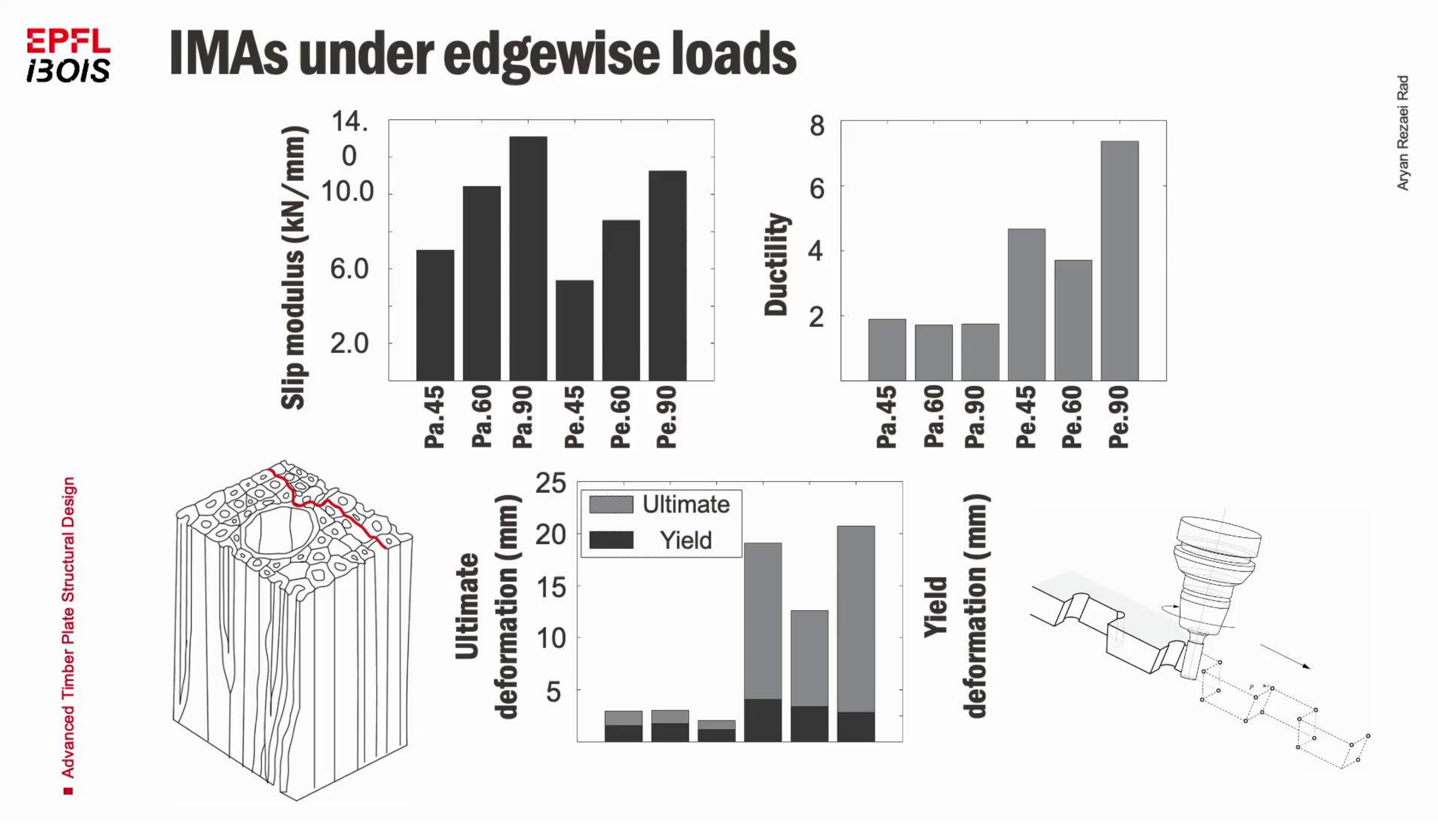
Unit: mm

Okay, regarding the edgewise behaviour of the integral connections, for connections under edgewise behaviour, a symmetric configuration is adopted, that means that the slot components are placed on top of a rigid concrete base, as you see here in, and the force is applied to the tenon component. Again, the tenon component and the slots are schematically shown in a real-world experimental specimen, is demonstrated on the right hand side of the screen.

Notes

Summary

6m 52s



It is found that the slip modulus increases with the tap insertion angle for both fibre orientations. This is attributed to the effect of fabrication tool in providing bigger notches around the 45-degree angle tenon element, which decreases the capacity. Also, it is found that the performance of the fibre-parallel specimens is independent of the tab insertion angle. In this case, the interfiber layer resistance, which are also shown in red, governs the behaviour. This in particular results in a very brutal behaviour and a sudden rupture and should be taken into consideration during the design phase of these connections.

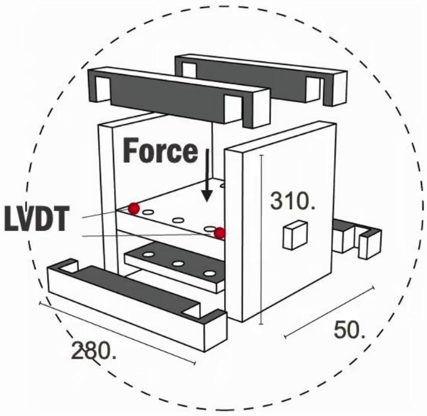
Notes

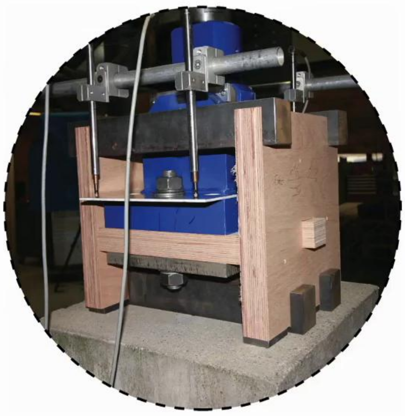
Summary

7m 26s

IMAs under flatwise loads

Aryan Rezaei Rad





Unit: mm

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Regarding the flatwise behaviour of the integral connection, again, a symmetric configuration is adopted similar to the previous load cases that I explained. The slot components are placed on top of a rigid concrete base and the force is applied to the tenon component. Similar to the previous case, you can see the schematic illustration and also a real-world design specimen.

Notes

Summary

8m 17s

IMAs under flatwise loads

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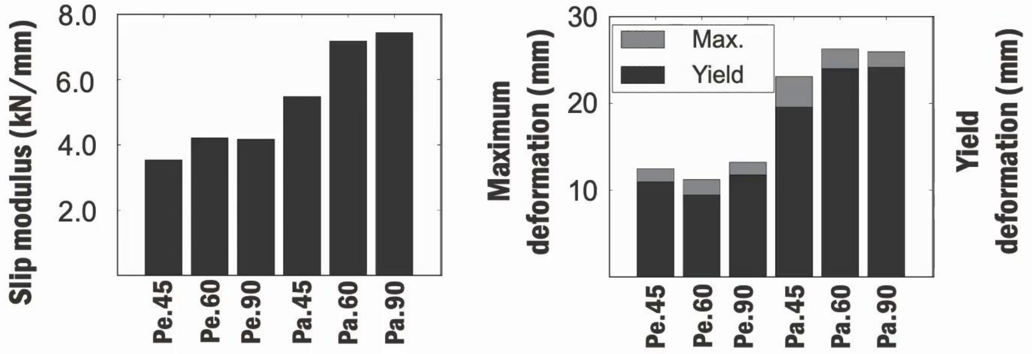


Flexural resistance

Embedment resistance

Shear resistance

For the fibre-perpendicular specimen, the yield and maximum deformations and the slip modulus are not affected by the tab insertion angle, as you see here in this chart. This is due to the role of interfiber layer resistance in governing the behaviour. However, for the fibre-parallel specimens, higher restraint was observed when compared to the fibre-perpendicular specimens. The reason is attributed to the fact that multiple resisting mechanisms exist in this type of elements or specimens, namely flexural behaviour or flexural resistance, shear resistance or sheer behaviour of the tenon elements, and the embedments compressive resistance of a tenon elements can be named as the most influential parameters.

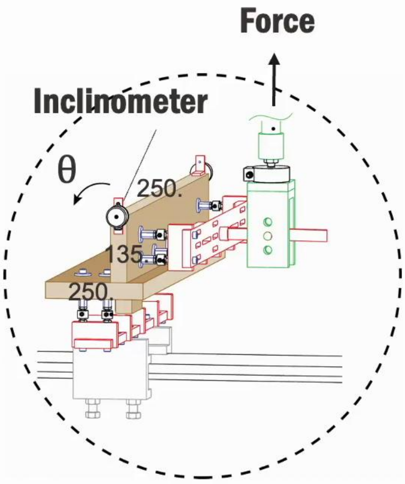
Notes

Summary

8m 47s

IMAs under bending moments

Aryan Rezaei Rad



Unit: mm

- The original test setup was initially design by Roche 2017

Advanced Timber Plate Structural Design

Finally, regarding the flexural behaviour of the integral connections, two pairs of tangent compression load cells are attached to each of the tenon and the slot components. The specimen is mounted on a rigid support and the lever arm between the specimen and the hydraulic jack is then introduced to apply flexural moments to the joint.

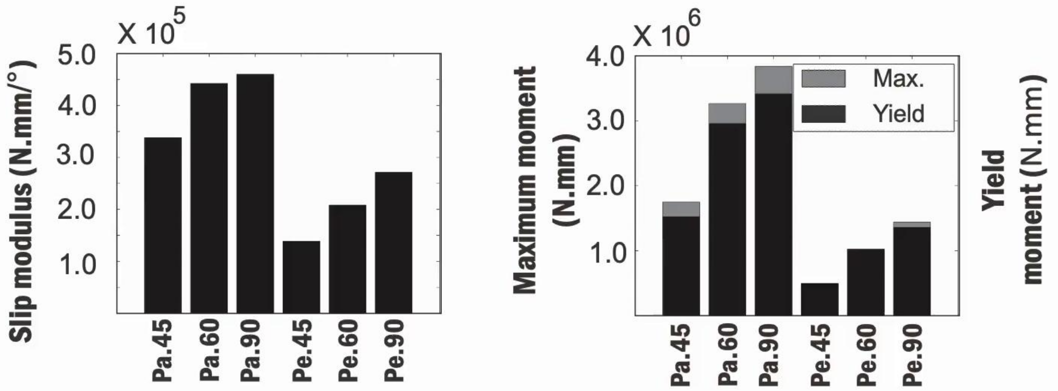
Notes

Summary

9m 47s

IMAs under bending moments

Aryan Rezaei Rad



Reason of increase: Tenons with the insertion angle of 90° create a symmetric geometry.

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The design recommendation for the integral mechanical attachment connections under this load case is that changing the insertion angle from 45 degrees to 90 degrees, increases the joint stiffness and the capacity in both fibre orientation, fibre-perpendicular or fibre-parallel specimens. The reason is that the tenons with the insertion angle of 90 degrees create a symmetric geometry. Therefore, minimal torsional moments are applied to such specimens.

Notes

Summary

10m 16s