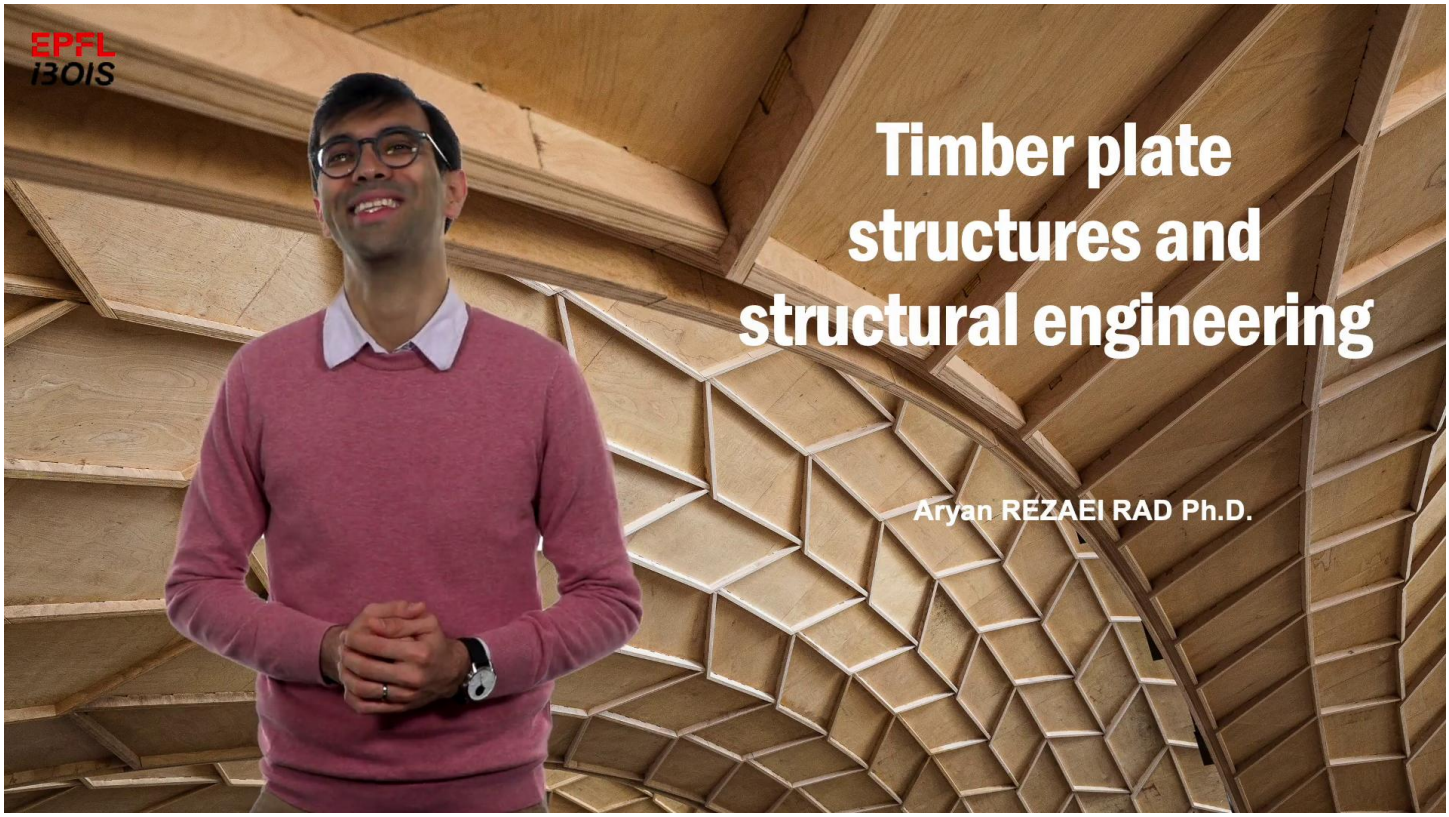
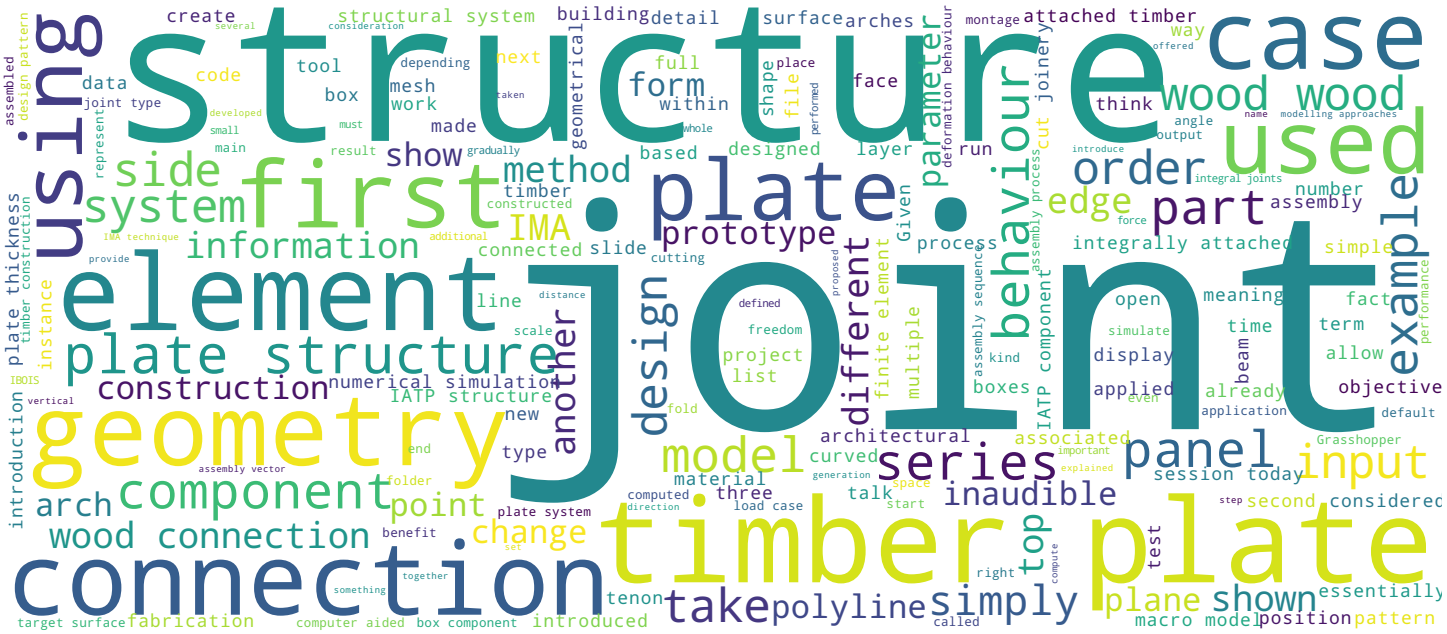


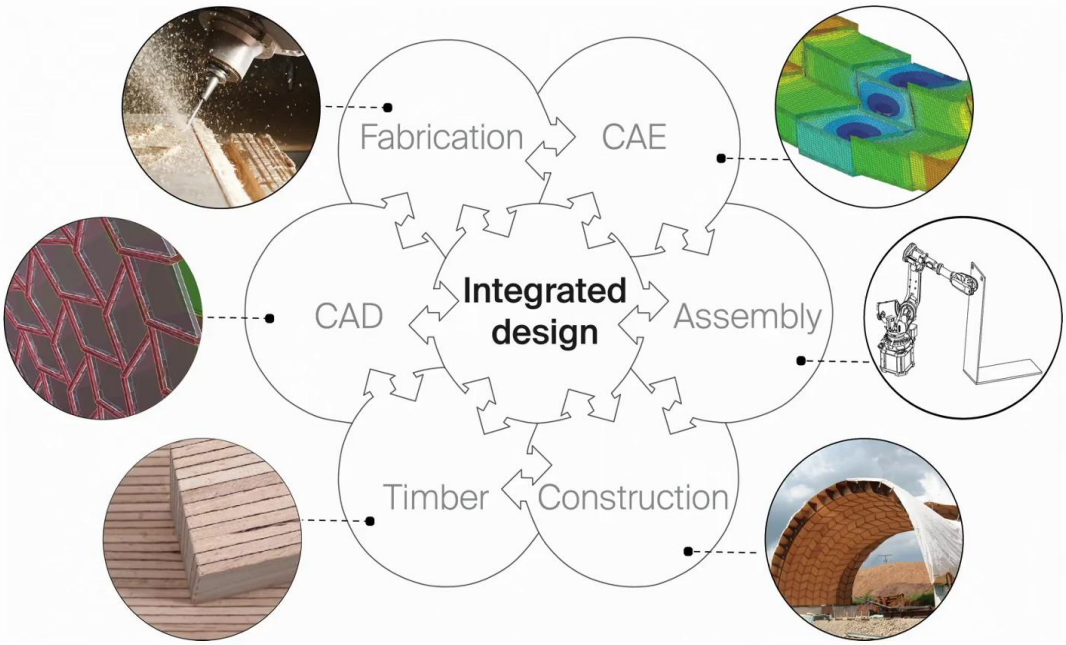


Search MOOC

Video

EPFL

Aryan Rezaei Rad

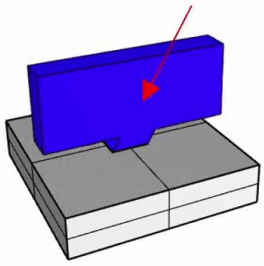


Hello and welcome. My name is Aryan Rezaei Rad. In this session, I will be introducing a structural design methodology for special timber structures with Plato shell action. First, I will give a brief introduction to timber plate systems with integral joints and available calculation methods. With that introduction, I will then talk about the objectives of this session in detail. Next, we will go through the details. Our class session today has been motivated by recent advancements in computer-aided design and interactive modelling tools. Also, digital fabrication and robotic assembly has been considered as one of the main and important parameters in this domain. In fact, this advancement gave rise to algorithmic programming and parametric geometry processing which enabled the generation of complex geometries. Furthermore, numerical simulation techniques which have been widely embedded in the computer-aided engineering has been considered as an additional domain in this area. Additionally, engineering timber products such as laminated vineyard lumber panels have offered a reliable construction material. These advancements have offered an interdisciplinary design framework for timber plate structures. The aim is to minimise this use of material and benefit from the geometry.

Notes

Summary

0m 04s



Advanced Timber Plate Structural Design

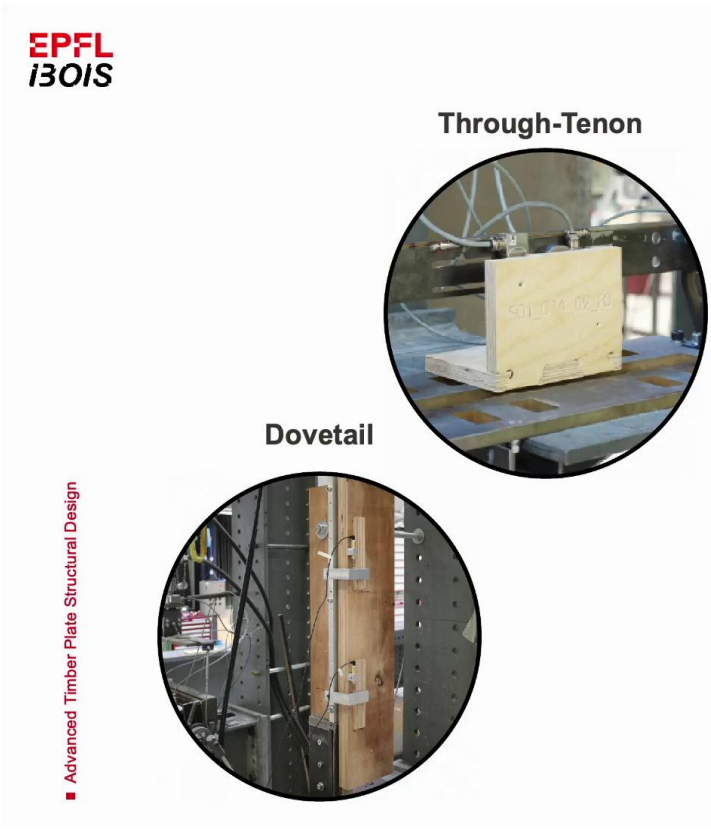
Integral Mechanical Attachment (IMA)

The wood-wood connections, which are also referred to as integral mechanical attachment or IMA, are recognised for being the oldest known method of joinery in timber construction. The defining feature of IMAs is that the connection between timber elements is established solely through the geometry without additional connectors such as nails, screws, dowels, adhesive, and welding. Therefore, the connections rely on direct force transfer between timber components. In our class session today, two tenon IMAs are studied. According to their geometry, the mechanical degrees of freedom are reduced to a single translational vector, which is the same as the assembly direction. In other words, there is only one translational vector in a 3D space to disassemble or assemble adjacent elements.

Notes

Summary

1m 39s



Mechanical Characterization

- The initial stiffness affected by variability in fabrication.
- IMAs as an alternative to the conventional joinery methods.
- Brittle connection failure under shear loads.
- High in-plane strength.

Understanding the mechanical characteristics of integral joints has been the subject of courses, research, and professional products in recent years. Especially, the force deformation behaviour of such connections have been experimentally investigated. Overall, the studies show that the initial stiffness of the connection is affected by variability in the fabrication process. Different configurations with variations in the joint type, tab insertion angle, tab length, fabrication imperfection, number of tabs have been the major effects on the behaviour of the connections. More importantly, it was determined that the IMAs can be designed to meet the regulations put forth in the timber standards, although they demonstrate brittle connection failure under the loads.

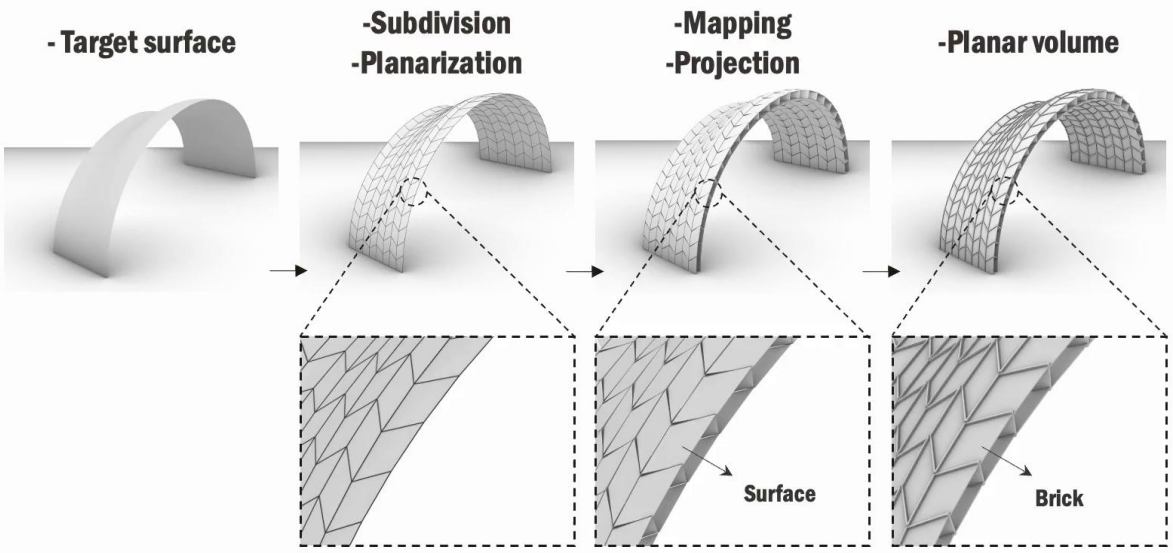
Notes

Summary

2m 42s

Integrally-Attached Timber Plate (IATP) structures

Aryan Rezaei Rad



The IMA technique can be used to design timber plate structures which are generally referred to as integrally-attached timber plate or IATP structures. The target surface of an IATP structure is established by utilising parametric geometry processing tools within a CAD platform. Then this target surface, as you see here in this slide, is then discrete sized into planner segments or design patterns. By the way, why planner segments? You can think about. The design pattern is then mapped into predefined offset layers. Next, the plate thickness and the location of IMAs around the plates are designed.

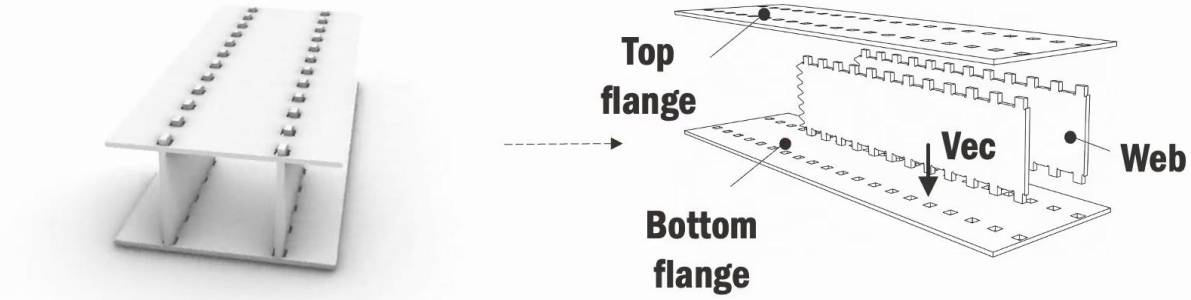
Notes

Summary

3m 41s

Assembly Process

Aryan Rezaei Rad

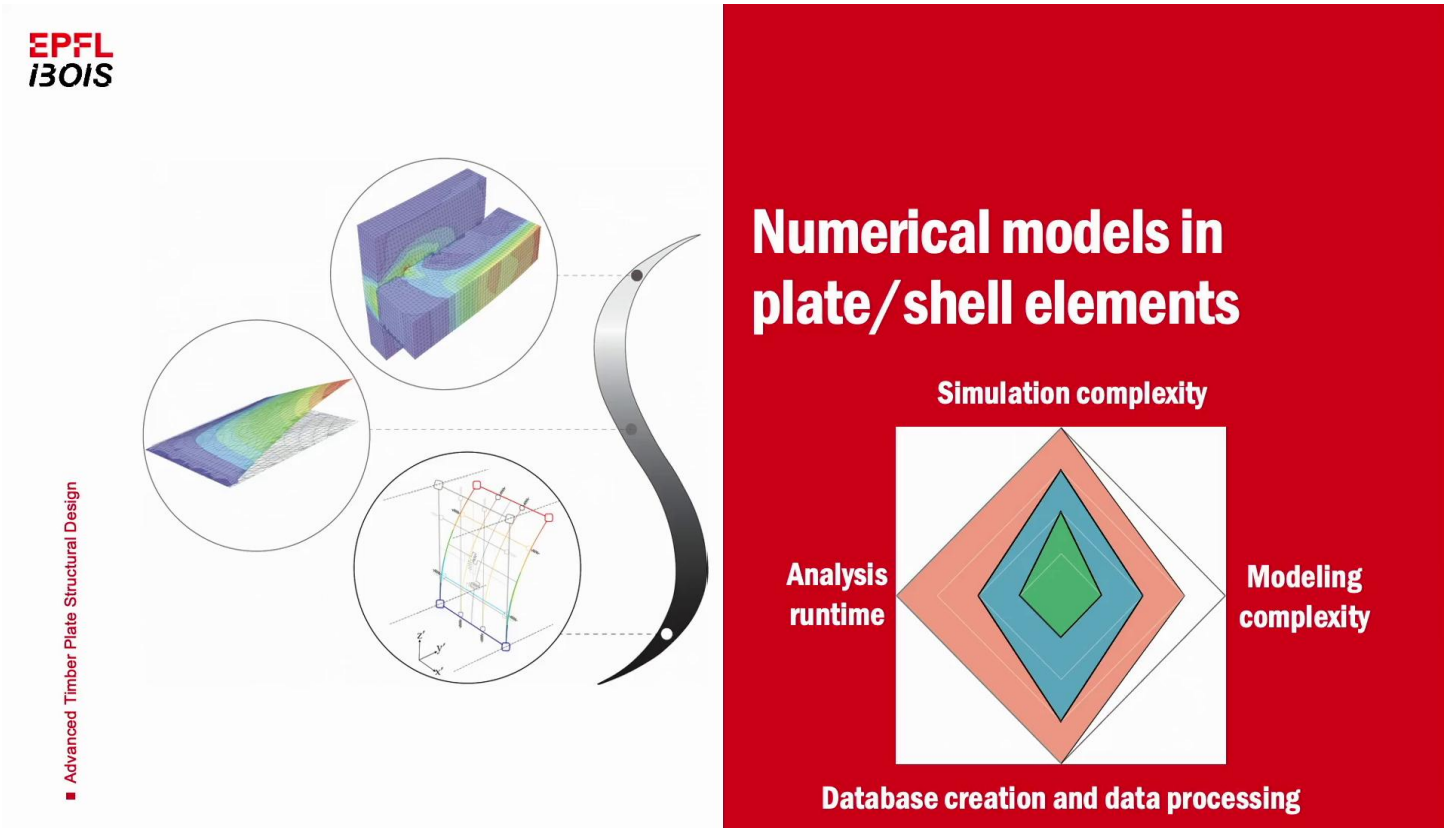


Now to better understand the structural behaviour of such systems, the assembly process is briefly reviewed here. Given the geometry of the IATB structure that you see, multiple tabs along the edge of the plate and multiple slots along its mate is provided. For this structure, the system consists of top, bottom, cross longitudinal, and cross transverse plates. The cross plates are first connected to each other like this. Next, the top and bottom plates are connected to those plates that I show, and accordingly, the entire structural system is constructed through the assembly of several four-sided boxes. The IMA technique is also used to basically construct planner structures and shape standard systems such as beam elements that you see herein. The system includes top and bottom flanges and web elements, and they are denoted in this slide. These elements are connected along a single assembly vector, as I've already explained before; this single assembly vector denoted as vec in this slide here.

Notes

Summary

4m 31s



Now that we have an overview of the structural system, we can study possible numerical simulation and mechanical modelling approaches for design and analysis of integrally-attached timber plate structures. Overall, design and analysis process of such structures with plate or shell action, typically, lie along a spectrum of complexity. Finite element, continuum models with 3D brick elements can be viewed as one end of that spectrum. These models are detailed or refined. They are complex and require a high level of sophistication. However, they provide the benefit of enabling an evaluation of the state of stress-strain across the plate thickness. In less complex models, the plate thickness is neglected, and the continuum shell elements can be used to simulate the behaviour of plate and capture the stress-strain state across the plate surface. In more simplified models, only beams and springs are utilised to simulate the structural response. The primary goal of such models, which are generally referred to as macro models, is to reduce the computational expense while maintaining the accuracy of the simulation.

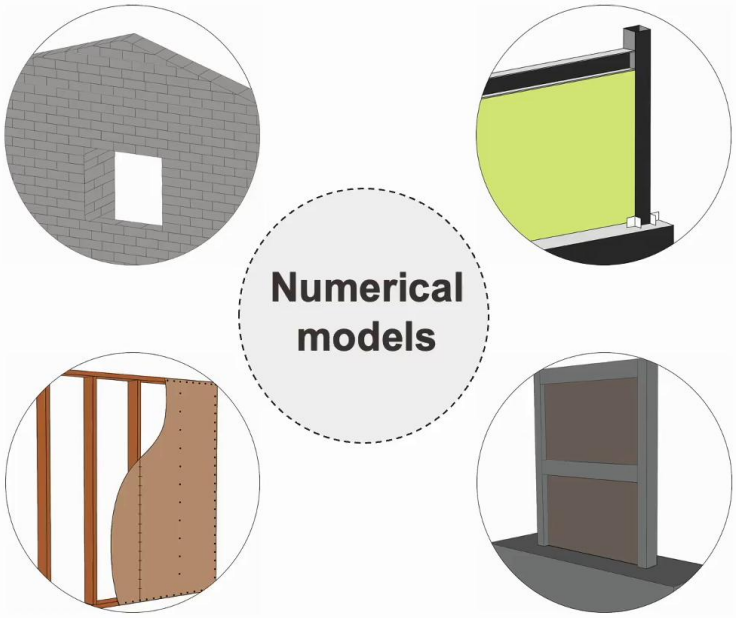
Notes

Summary

5m 57s

Numerical Models

Aryan Rezaei Rad



Mechanical models, and consequently numerical simulations, have been widely developed for different structural systems and types such as for example, masonry structures, steel shear plate systems used in steel frame structures, reinforced concrete shear walls, and of course, standard timber shear walls or timber plate structures.

Notes

Summary

7m 24s

Now I think after this introduction to special timber plates and available modelling techniques, we can talk about the objectives of our session today.

Notes

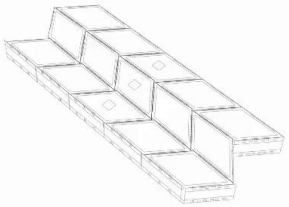
Summary

7m 52s

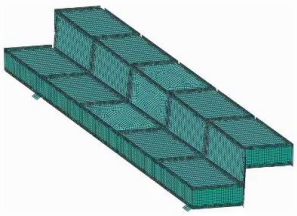
EPFL IBOIS

Why?!

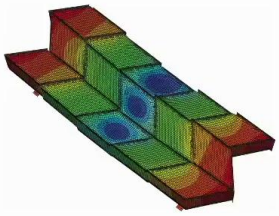
- The behavior of IMAs under different load cases needs to be understood:
  - **Wood-wood interlocking mechanism.**
  - **Global structural analysis.**
- Structural analysis of IATP structures requires idealization (simplification) in the modeling process:
  - **To reduce the computational time.**
  - **To be suitable for industry application.**



CAD model



Simplified geometry



CAE model

Aryan Rezaei Rad

Advanced Timber Plate Structural Design

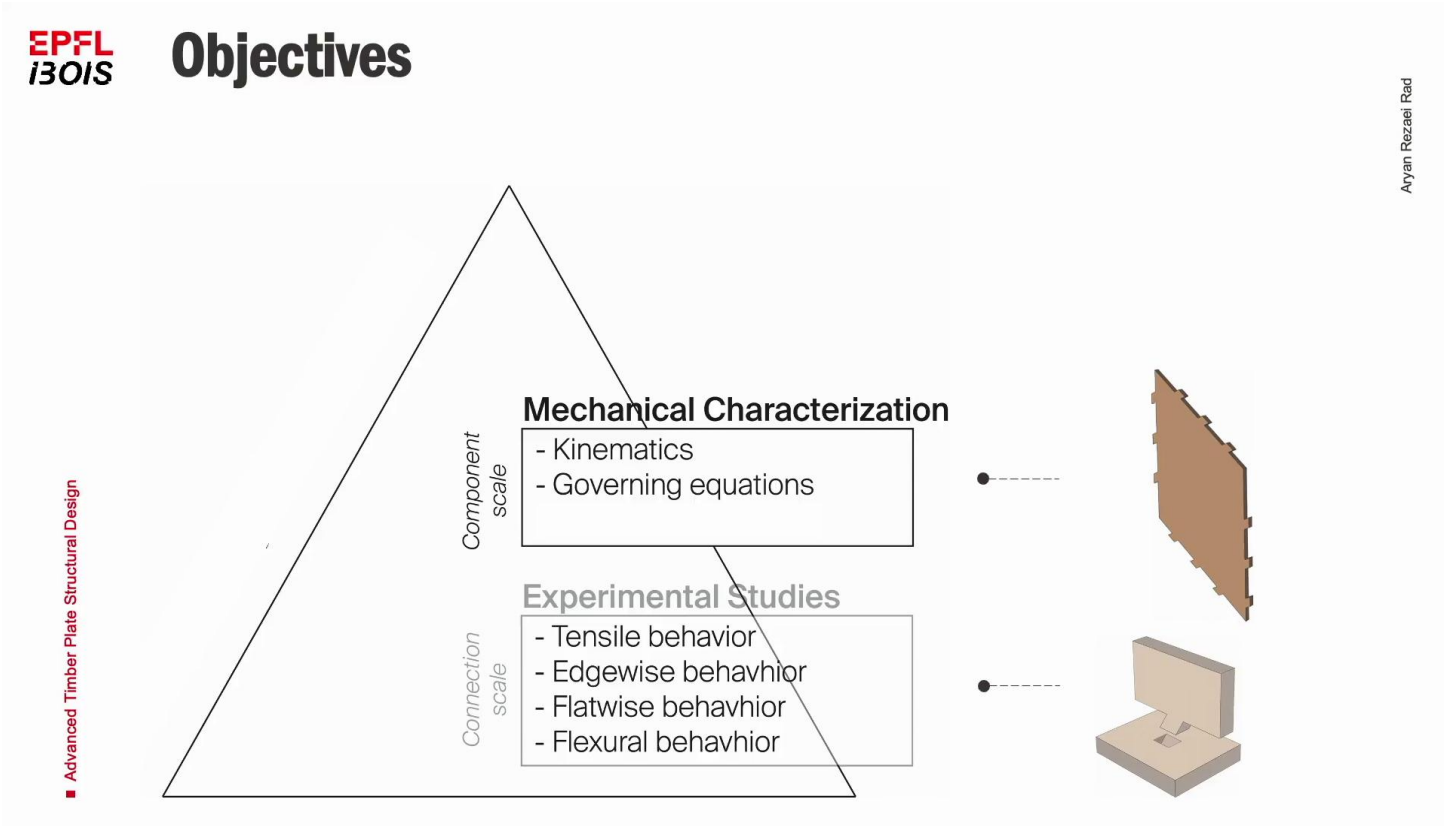
Given that IMAs are the only connection mechanism in integrally-attached timber plate structures, their behaviour, under different load cases, will be introduced and widely investigated, and mainly through experimental studies. This is also necessary to understand the behaviour of the global structural system. Furthermore, to have a better understanding of numerical simulation in timber plates, the mechanical behaviour of IATP components will be introduced.

Notes

Summary

8m 02s

Objectives



Given this objective that I explained here and according to that, our session today will be executed in two main phases. The first phase will be the connection scale, where the behaviour of the IMAs or joints under tensile, edgewise and flatwise loads and flexural moments is introduced and the associated load-deformation behaviour is shown and used in the next phase of our courses. The next one is the component scale, where the kinematic degrees of freedom of IATP components is studied. This part will be used to develop different modelling approaches that I'm going to talk about in the next slide.

Notes

Summary

8m 41s