

Master's Thesis Presentations 2021

Sustainable Structural Engineering, Master Program

Time

Date: June 2, 2021
Room: Zoom (the link is distributed separately)
Time: 8:00-15:00

Schedule

Check-in

8:15 - 8:50 Sebastian Svensson Meulmann & Egzon Latifi
8:55 - 9:30 Ahmad Al-Najjar
9:35 - 10:10 Jenny Abrahamsson & Filip La Fleur

Break

10:40 - 11:15 Viktor Petersson & Andreas Svanberg
11:20 - 11:55 Jakob Myhrberg & Johan Gustafsson

Break

13:00 - 13:35 Benjamin Bondsman
13:40 - 14:15 Musaab Mahjoub
14:20 - 14:55 Ren Honghao

Procedure

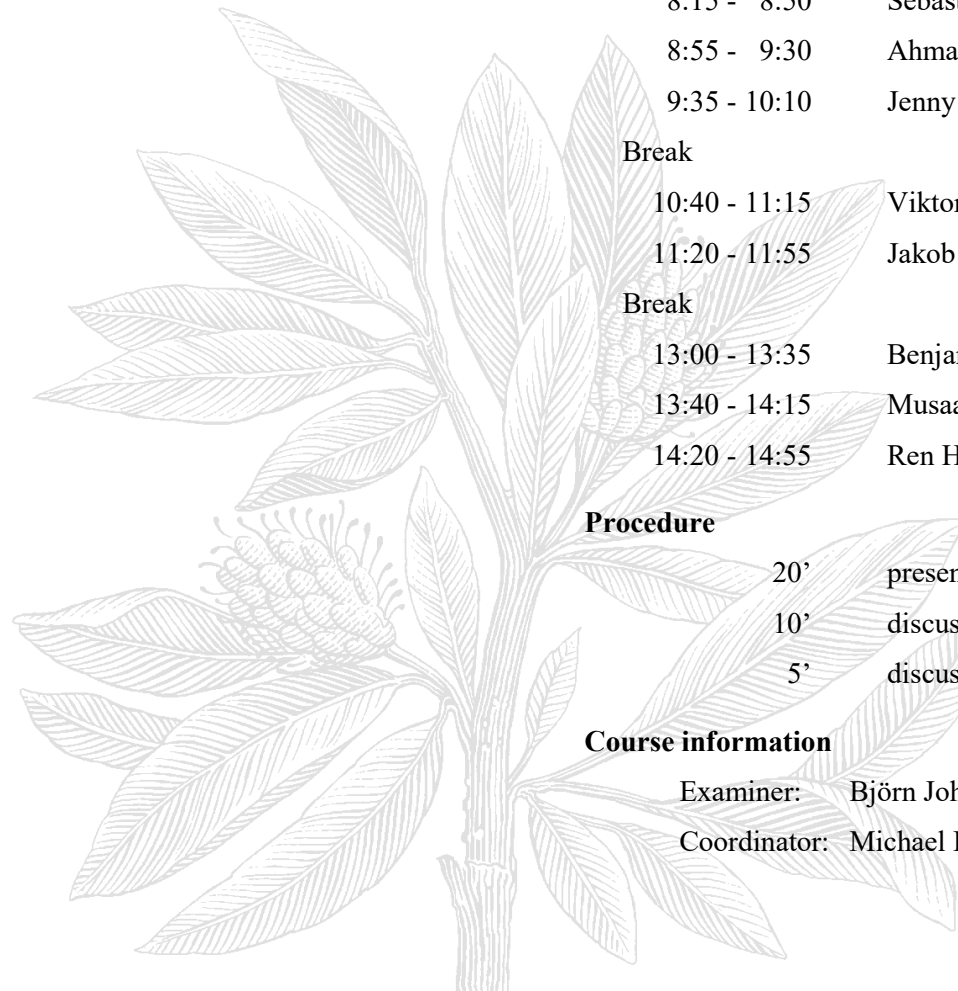
20' presentation
10' discussion with the opponent group
5' discussion with the audience

Course information

Examiner: Björn Johannesson
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Sebastian Svensson Meulmann & Egzon Latifi

Modelling and testing of CLT panels for evaluation of stiffness

The use of timber in building structures is steadily increasing. Cross-laminated timber (CLT) is an engineered wood product made of an uneven number of layers of lamellas glued at an angle of 90 degrees to each other. This gives CLT high stiffness and strength to bending in all directions, and capability of taking load both in-plane and out-of-plane. Due to the large size of CLT elements, they allow for quick assembly of strong structures. Due to both economic and environmental reasons it is important for producers of CLT to optimize the use of the wood material by using the timber with higher stiffness and strength where it is most needed. This thesis is about evaluating the bending and shear stiffness of CLT elements, when used as plates, depending on the quality of wood used in the different layers. Four-point bending tests are carried out on elements of different compositions and a parametrized finite element model is created. Thus, the model is validated on the basis of experimental tests to evaluate the influence of different quality of different layers. The measured dynamic MoE proved to have good potential to be used as the longitudinal bending stiffness in an FE-model, with a deviation from the experimental tests of about 3%. There is a strong correlation between the bending stiffness and bending strength of the plates. The effective rolling shear modulus in pine was calculated to be around 170 MPa for pine of dimension 40 x 195 mm². Grading the boards into two different classes used for different layers proved to increase the MoE of the plates by 11-17% for 3- and 5-layer CLT.

Supervisor: Anders Olsson

Company participation: Södra

Opponents: Jenny Abrahamsson & Filip La Fleur

Ahmad Al-Najjar

Full life cycle assessment of a cross laminated timber modular building in Sweden

Building industry contributes to massive amounts of harmful greenhouse gases. This trend will continue to rise unless appropriate measures are taken. This master thesis aims to calculate the environmental impact during the whole life time of a prefabricated cross-laminated timber (CLT) modular building. The benefit of some building material beyond the system boundary is also included. Life cycle assessment (LCA) is used as a tool to assess the environmental impacts following the standard SS-EN 15978:2011. Since there is a lack of environmental data about CLT in general and about prefabricated CLT volumetric modules in particular the results from this work will enhance the understanding of the environmental performance of this kind of building system. This work is done with Size Prefab AB, a company that only produces CLT modular multi-storeys buildings.

The studied object is three storeys building located in Nykvarn in Sweden. The total emissions during the building life cycle are at least 377 kg CO₂-eq/m² of the gross floor area (GFA), 0,296 kg PO₄-eq/m² of GFA and kg 1,1 SO₂-eq/m² of GFA for global warming potential (GWP), eutrophication potential (EP) and acidification potential (AP) respectively. The result shows that the share of the AP and EP during the end-of-life stage is only 1% for each, whereas CO₂-eq emission is accounted for 14% during this stage. The material production stage accounted for more than 50% for all environmental indicators.

Through sensitivity analysis it was discovered i.a. that high production intensity in the modules fabrication factory play a significant role in reducing the environmental impacts during the construction stage. This study provides fundamental data similar LCAs in this area.

Supervisor: Ambrose Dodoo

Company participation: Size Prefab AB

Opponents: Viktor Petersson & Andreas Svanberg

The impact of connection stiffness on the global structural behavior in a CLT building

Cross Laminated Timber (CLT) has in recent years become a more important building material. This means that the demand for accurate calculation methods in building standards such as EC 5 has increased. There is limited knowledge about the connections in CLT buildings which is an important part of a CLT structure. This thesis is therefore focused on investigating a wall-floor-wall type connection commonly found in platform type buildings.

An experimental and numerical study on typical wall-floor-wall connections was carried out in this thesis. In the experimental part 60 tests with 8 different configurations were conducted to investigate the influence of different parameters on the connection, moment capacity and rotational stiffness. During the tests the deformation of the specimen under four load levels were investigated. Compression tests were also performed on the specimen to determine the compressive strength and stiffness of the elements. In the numerical part two different models for the connection were created. With these models the influence from the number of stories, span and thickness of the wall on the global behavior of a structure was investigated.

The result from the study shows that there is both moment capacity and rotational stiffness in the wall-floor-wall type connection that can be utilized in the design phase of a structure. This was proven by the experimental as well as by the numerical study. The parameters that influence the behavior of the connection most were the load level applied on the wall and the wall thickness. The model created in the numerical study showed great potential regarding the replication of the connection behavior observed in the experimental study.

Supervisor: Michael Schweigler

Company participation: Södra, Gunnebo

Opponents: Jakob Myhrberg & Johan Gustafsson

Operational modal analysis and finite element modeling of a low-rise timber building

Timber is a building material that is becoming more common and of interest for use in high-rise buildings. One of the reasons is that timber requires less energy input for the manufacturing process of the material compared to non-wood based materials. When designing high-rise timber buildings it is of great significance to understand the dynamic behavior of the structure.

One method to obtain the dynamic properties is to use Operational Modal Analysis, which is based on the structural response from operational use. Finite element (FE) analysis is a tool which can be used for dynamic analysis for large structures. In this study an operation modal analysis (OMA) was conducted on a four-story timber building in Växjö. A finite element model was created of the same building using commercial FE packages. Based on the mode shapes and natural frequencies obtained from the OMA, the FE model was fine-tuned. The purpose of this thesis is to gain knowledge of which parameters that might have a significant role in finite element modelling for a structural dynamic analysis. The aim is to develop a finite element model that accurately simulates the dynamic behavior of the tested building.

It was shown from the result that is possible with an enough detailed FE model to capture the dynamic behaviour of a structure. The parameters that had the largest effect on the result can be pointed to the mass and the stiffness of the structure.

Supervisor: Carl Larsson & Osama Abdeljaber

Opponents: Musaab Mahjoub

Johan Gustafsson & Jakob Myhrberg

Expansion Joints in timber bridges – Mechanical behavior under external loading

To design a bridge, different typologies of construction materials can be used. All materials have in common that deformations occur due to external loading, temperature- and moisture variations. To allow these deformations, Expansion Joints (EJs) are used in the structure. In timber bridges, these joints have turned out to be a complex construction detail, due to problems related to their strength- and moisture capacity. The purpose of this thesis is to overview design codes and to study the mechanical behavior of Nosing EJs in a roadway timber bridge under external loading. The aim is to identify critical actions and provide an alternative design of the studied EJ. The aim is also to create a Finite Element (FE) model and carry out calculations according to the design codes. To achieve this, literature studies, design calculations and FE-simulations were performed. It turned out that there were lack of earlier studies within this field. Therefore, studies which treats EJs in bridges with other material than timber were considered. The results from the simulations indicated that the steel components in EJs are the most exposed parts in the detail. It also turned out that an eventual failure can be lead away from the screws to the parts considered more favorable in the EJ.

Supervisor: Carmen Amaddeo & Thomas K. Bader

Company participation: WSP, Martinssons

Opponents: Egzon Latifi & Sebastian Svensson Meulmann

Benjamin Bondsman

Numerical modeling and experimental investigation of large deformation under static and dynamic loading

Small kinematics assumption in classical engineering has been in the center of consideration in structural analysis for decennaries. In the recent years the interest for sustainable and optimized structures, lightweight structures and new materials has grown rapidly as a consequence of desire to archive economical sustainability. These issues involve non-linear constitutive response of materials and can only be accessed on the basis of geometrically and materially non-linear analysis. Numerical simulations have become a conventional tool in modern engineering and have proven accuracy in computation and are on the verge of superseding time consuming and costly experiments.

Consequently, this work presents a numerical computational framework for modeling of geometrically non-linear large deformation of isotropic and orthotropic materials under static and dynamic loading. The numerical model is applied on isotropic steel in plane strain and orthotropic wood in 3D under static and dynamic loading. In plane strain Total Lagrangian, Updated Lagrangian, Newmark-beta and Energy Conserving Algorithm time integration methods are compared and evaluated. In 3D, a Total Lagrangian static approach and a Total Lagrangian based dynamic approach with Newmark-time-integration method is proposed to numerically predict deformation of wood under static and dynamic loading. The numerical model's accuracy is validated through an experiment where a knot-free pine wood board under large deformation is studied. The results indicate accuracy and capability of the numerical model in predicting static and dynamic behavior of wood under large deformation. Contrastingly, classical engineering solution prove its inaccuracy and incapability of predicting kinematics of the wood board under studied conditions.

Supervisor: Björn Johannesson & Andreas Linderholt

Opponents: Ren Honghao

Musaab Mahjoub

FE modeling of glulam beams with mechanical slotted-in steel plate connections

The mechanical behavior of timber beams with a slotted-in steel plate is studied by creating a simulation model that is able to simulate the global bending and load carrying capacity as well as the nonlinear plastic fasteners forces distribution. Experimental results from Material Testing Institute, University of Stuttgart were compared with simulation results done at Linnaeus University. The modeling of the connection and the beam is done with shell, beam and spacial nonlinear connector elements. Three finite element models were created. The first model was a single-dowel double shear joint to study the feasibility of using the structural elements in modeling of test beams, It was used to simulate failure modes of different joints in Eurocode 5. The second model is a beam/beam model with two connectors for each dowel group used to study the global deflection, and the load carrying capacity of the timber beams. The third model is a beam/shell model with two connectors for each dowel was used to simulate the development of the elastic-plastic shear force distribution in all the dowels. All the models were created using parameterized python scripts, which makes it possible to change different input parameters.

The use of these elements (beam, shell, and connector elements) was found to be effective as they resulted in less computational time compared to three dimensional solid elements.

Supervisor: Sigurdur Ormarsson & Le Kuai

Opponents: Ahmad Al-Najjar

Ren Honghao

Experimental and numerical analysis of orthotropic deformations of wood using Finite Strain Theory (large deformations) and the Finite Element Method (FEM) in 2D

This thesis involves the derivation of a constitutive model under large deformation theory using Updated Lagrange method applied on an orthotropic material. The following aspects are included in this thesis work: introduction, theory, FEM implementation, derivation of constitutive model, calibration, result, discussion, conclusion and the future work. This thesis studies the deformation behavior of wood, which is widely used as a construction material, in an advanced and more detailed way by analyzing the mechanical properties of wood from both, the application in laboratory and theoretical calculation under large deformation theory.

A non-linear elastic constitutive model is proposed, derived and calibrated using a simple inverse analysis procedure. The calibration process was performed to identify 8 constitutive parameters $A1 \square A8$ of the constitutive model by performing inverse analysis against relevant experimental data acquired using the Aramis system. The results in the comparison were extracted from the specimen when it is both in tangential orientation and radial orientation.

The project work will be dedicated to the development of a Finite Element Method (FEM) code implemented in MATLAB scripts which was directly used to study the mechanical properties of the orthotropic wood material when hyper-elastic behavior is assumed.

The results will contain three parts: 1) study of the influence of pith location on the load required to deform the specimen, 2) reaction force comparison of the model results against experimental results, and, 3) comparison of the Green-Lagrangian strain pattern over the specimen between the experimental data and the model's results.

Supervisor: Björn Johannesson & Winston Mmari

Opponents: Benjamin Bondsman

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. On the left side, there is a faint, light gray illustration of a plant. It features several long, pointed leaves with detailed vein patterns. At the top left, there is a cluster of small, round fruits or berries hanging from thin stems. The overall style is simple and elegant, typical of a notebook or journal cover.

