TreProX: Innovations in Training and Exchange of Standards for Wood Processing

MODERN TRÄBYGGNADSTEKNIK

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TREPROX WORKSHOP – SWEDEN - MAY - JUNE 2022

TreProX
Landbúnaðarháskóli Íslands Agricultural University of Iceland
skógræktin ICELANDIC FOREST SERVICE
Trétæknirádgjöf slf. Wood Technology
UNIVERSITY OF COPENHAGEN
Linnæus University
Erasmus+

Wood construction systems –
how to use wood and its different alternatives

Marie Johansson
RISE, Wood building Technology

Modelling and testing of light-frame timber modules

Sigurdur Ormarsson
Lnu, Department of Building Technology

Proven technology

- Oldest **timber bridge** still used for road trafic is from **1737**
- The **largest timber building** is Sävsjö sanatorium built in **1907** with four storeys and almost 100 rooms.
- The largest **single span timber building** is a warehouse in Landsbro built **1946**, 165 m long and **38 m wide.**
- The **oldest timber building is 800 years** and can be found in Eksjö.
- A radio tower of larch from 1936. It is **118 meters high** and located in Poland.

Var i utvecklingsstadiet ligger trähusbyggande?

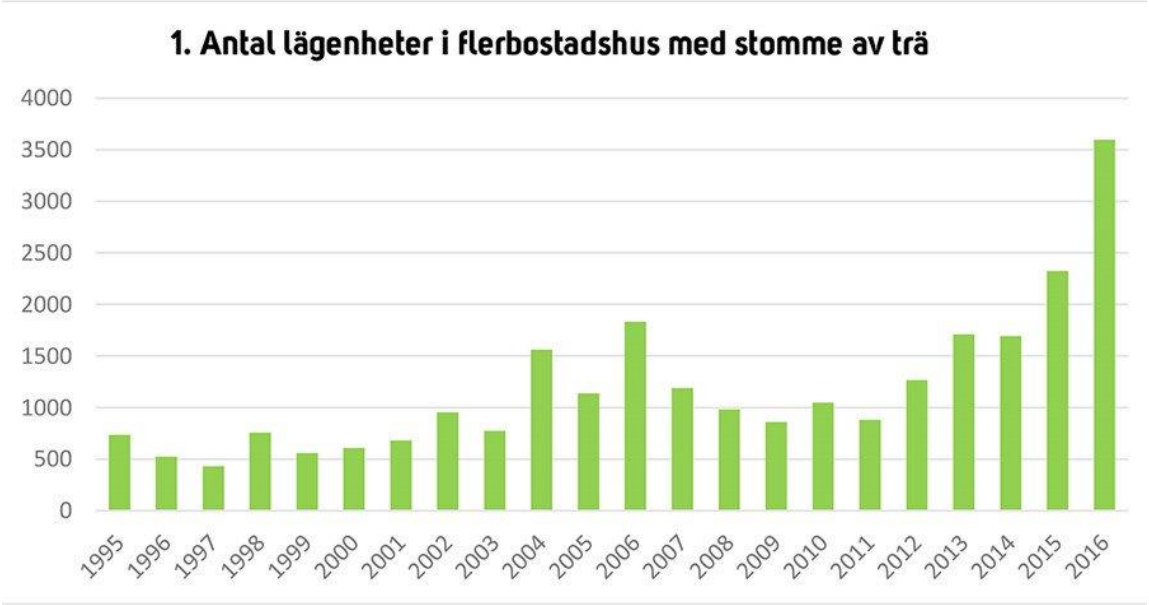
2007

- **Pilot**:
  Flervåningsbyggande i trä
- **Nisch**:
  Studentbostäder
  Volymbyggande
- **Massmarknad**:
  Småhusbyggande
  Hallar
  Idrottsanläggningar

2018

- **Pilot**:
  Flervåningsbyggande i trä >9 våningar
- **Nisch**:
  Påbyggnader
  Kontor
- **Massmarknad**:
  Småhusbyggande
  Flervåningsbyggande i trä
  Hallar
  Idrottsanläggningar

Statistik över antal lägenheter



Källa: SCB och TMF

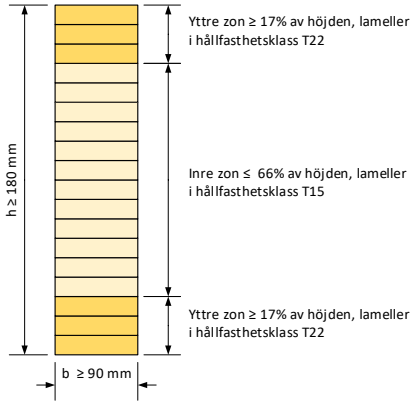
Typer av byggnader

- Småhus
- Flerbostadshus
- Lokaler

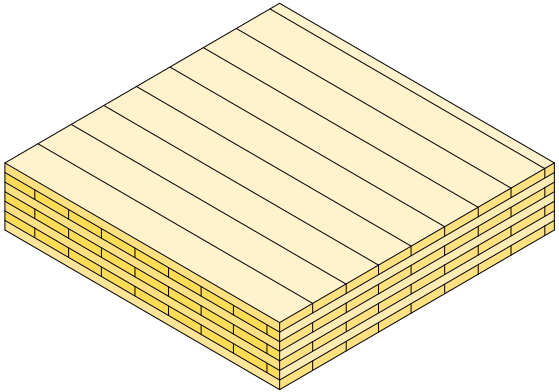

STRAND

Building systems used in Sweden

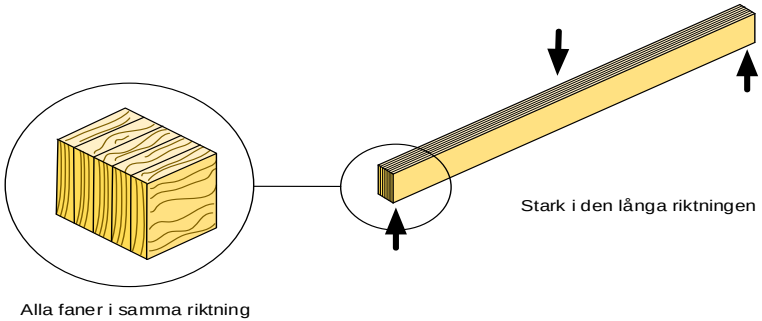
Wood products for construction



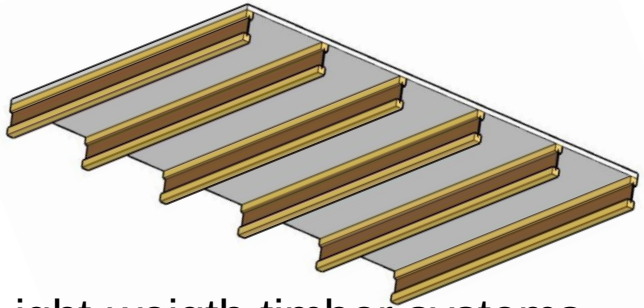
Glulam



Cross-laminated timber



Laminated veneer lumber

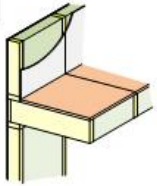


Light-weigth timber systems

Structural systems

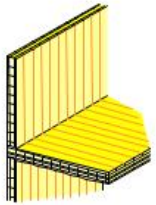
Timber framed multistorey residential buildings

Stud frame



Post and beam

Massive timber



Volumetric elements

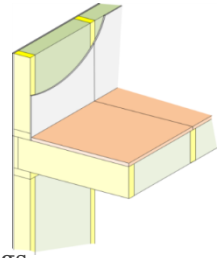
Planar elements

Industrial off-site production. Suppliers with own brand and assembly on site.

Framework and non supporting walls. Assembled and completed by the contractor.

Framework. Assembled and completed by the contractor.

1. Stud frame



- Description:
  - 70-80% of residential timber framed buildings
  - Prefabricated planar (2D) or volume (3D) elements
  - Many examples up to 5 storey
- Possibilities:
  - High prefabrication level yields short on-site construction time
  - Developed by the single family housing industry with long experience of prefabrication.
  - Full responsibility of the building project is taken by the supplier using portfolio concepts
- Limitations:
  - Vertical pressure and stabilization of horizontal loading a challenge over 6 storey.
  - Weather protection needed at building site

Light-frame timber modules

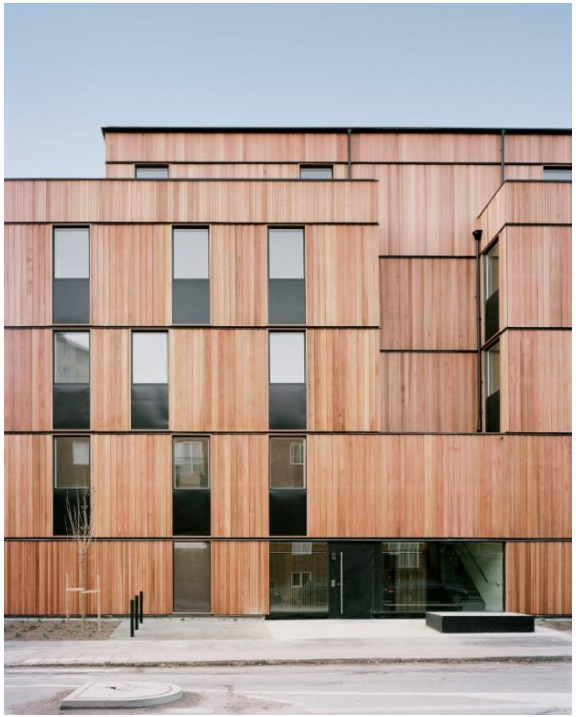
Photo: Lindbäcks bygg

Photo: Moelven byggmodul

Stud frame systems - references

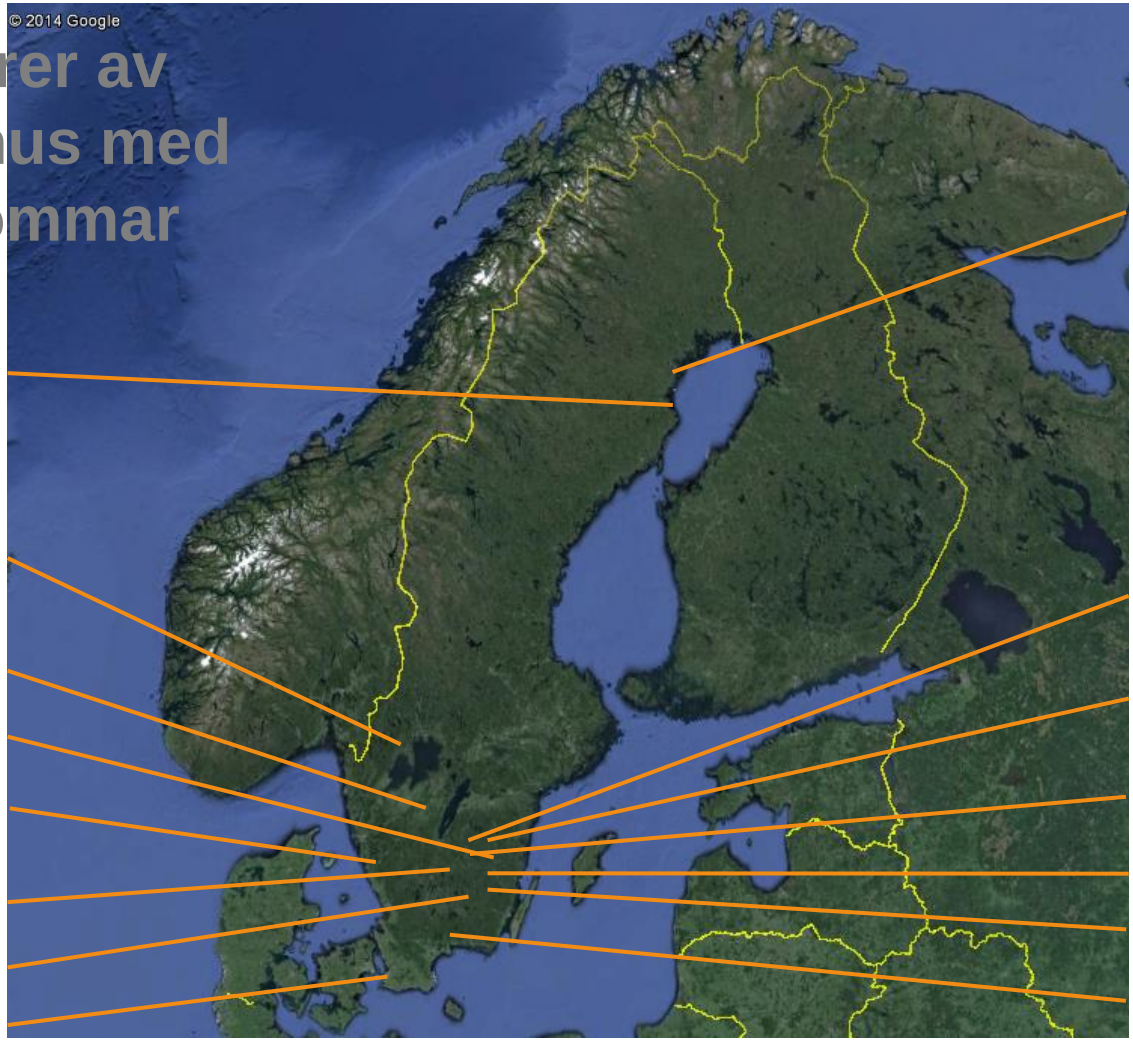
Kv. Månstenen (Kalmar)
© Willa Nordic – 2010
4 storey

Oslo (N)
© Kodumaja – 2011
2 + 5 storey concrete and wood



Skagershuset (Stockholm)
© Moelven – 2013
5 storey

Leverantörer av flerbostadshus med träregelstommar



Derome Plusshus

Moelven Byggmodul

Götene Hus

Anebyhusgruppen

A-hus/Derome

Willa Nordic

Vida Building

BoKlok

Lindbäcks Bygg

Flexator

Hjältevadshus

Eksjöhus

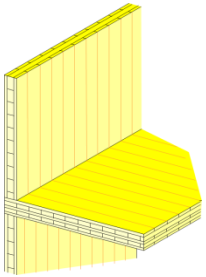
Obos

Trivselhus

Svensk Husp.

2. Massive timber

- Description:
  - CLT walls, floors and roof
  - Up to 12 storey
  - Developed since the year 2000
- Possibilities:
  - Strong
  - Dimensionally stable
  - Planar (2D) elements most common
  - Volumetric (3D) elements still unusual
- Limitations:
  - Difficult to build higher than 12 storey at reasonable cost
  - Adapted weather protection needed at building site



Åsbovägen, Fristad Bygg

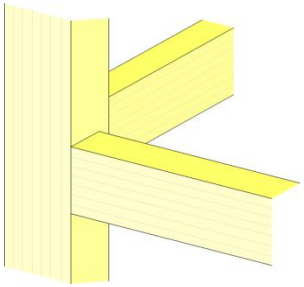
Massive timber systems - references

Åsbovägen, Fristad
© KLH – 2014
6 storey CLT

Vallen, Växjö
Binderholz – 2017
8 storey CLT

Valla Berså, Linköping
Martinsons – 2017
6 storey CLT

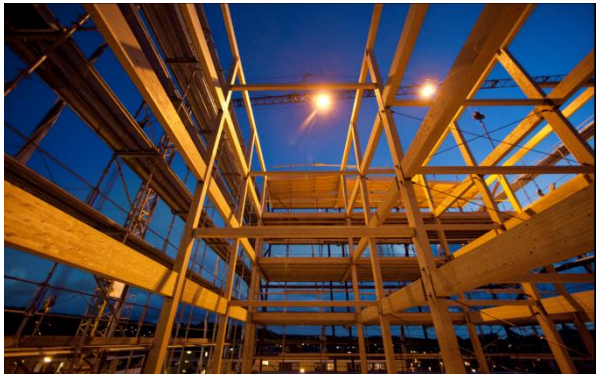
3. Post and beam



- Description:
  - 3D framework with beams, columns and diagonals Up to 18 storey (Mjöstornet in Norway)
- Possibilities:
  - Developed by the glulam suppliers with long experience from large buildings i.e. sports arenas and bridges.
  - Completed with planar (2D) elements or volumetric (3D) elements with different kind of load bearing systems (stud frame, LVL)
- Limitations:
  - Additional components and materials is needed
  - Weather protection needed at building site
  - Few suppliers of complete portfolio concepts

Askimstorg, Moelven Trä8-system

Post and beam systems - references

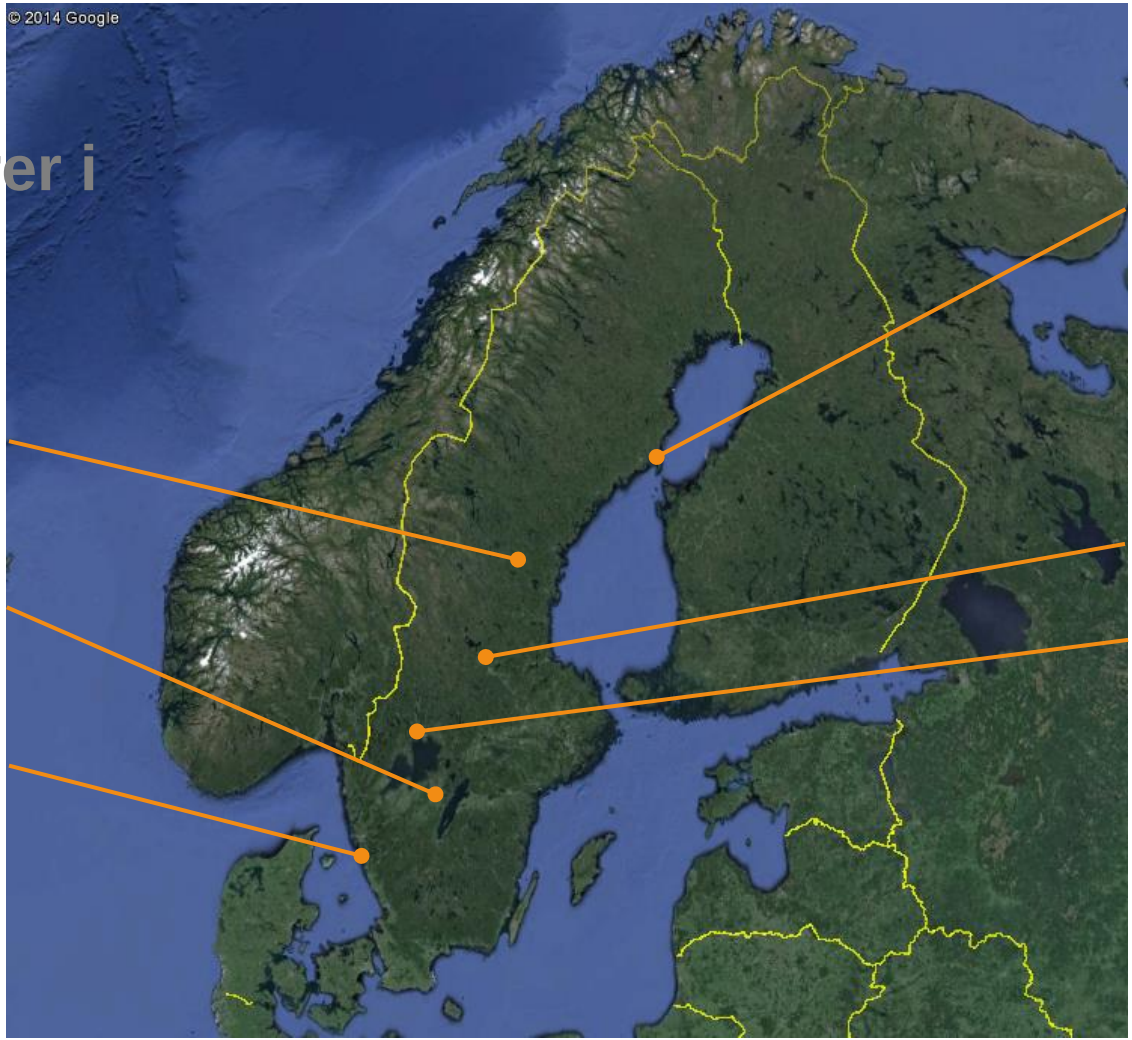


Askimstorg (Göteborg)
© Moelven Töreboda – 2012
6 storey with steel bracing

Treet, Bergen (N)
© Moelven Limtre AS – 2015
14 storey

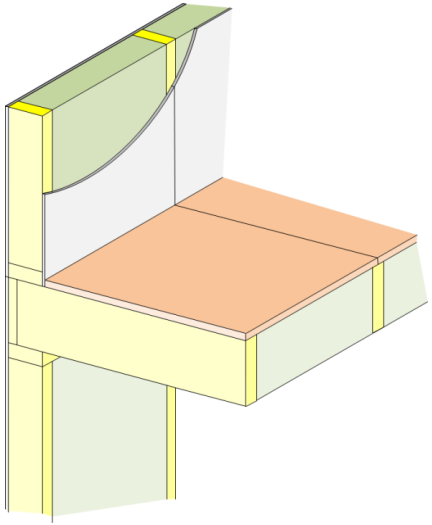
Kv. Vallen (Växjö)
© Moelven Töreboda – 2015
7 storey concrete core

Lim- och KL-träleverantörer i Sverige



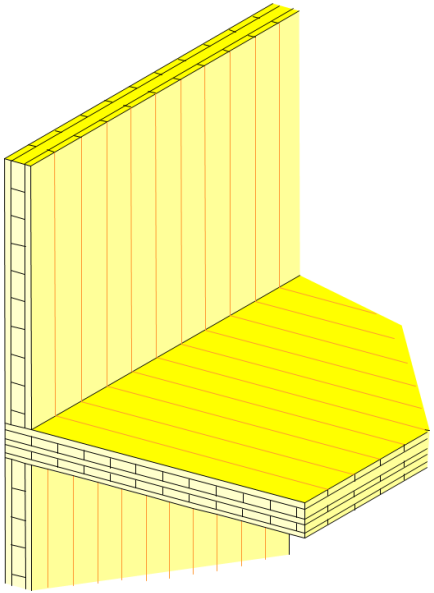
Technical development

Teknikfrågor - Stabilitet



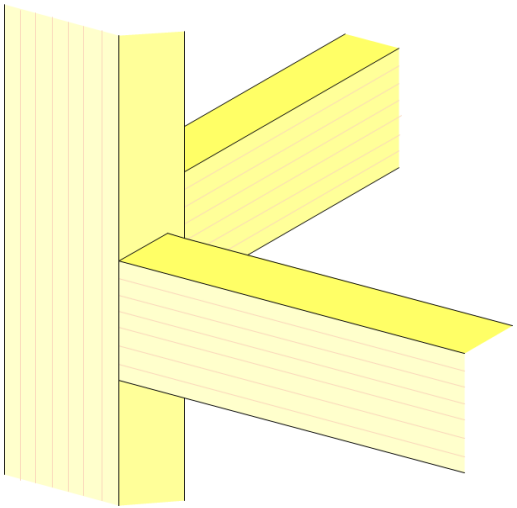
Vertikalt: Reglar

Horisontellt: Skivverkan bjälklag o vägg + förankring



Vertikalt: Massivträskivor

Horisontellt: Skivverkan bjälklag o vägg + förankring

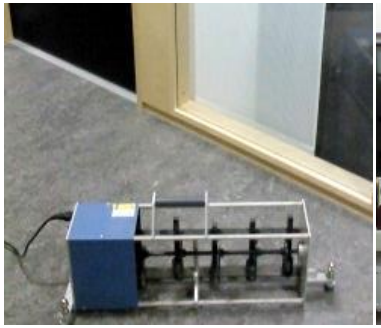


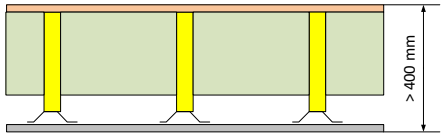
Vertikalt. Limträpelare

Horisontellt: Limträfackverk + hisschakt + förankring

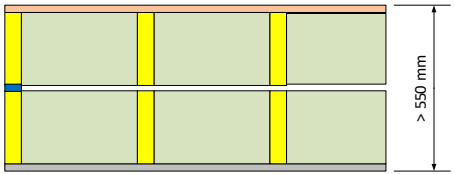
Acoustics and vibrations

- Floor structures –
  - Double structures
  - Increase stiffness and mass
  - Measurements and standards
  - Development of calculation methods and tools

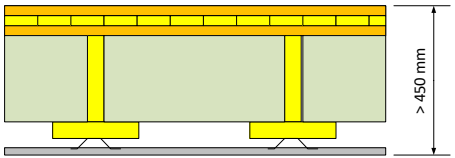




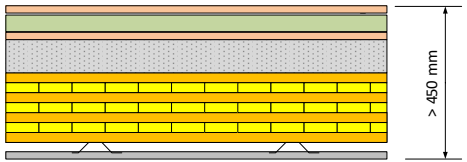
Enkel träregelkonstruktion



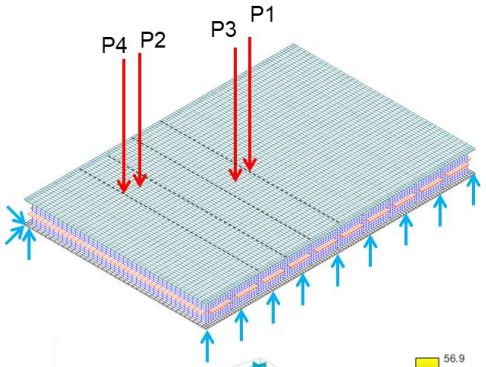
Dubbel träregelkonstruktion,
volymelement

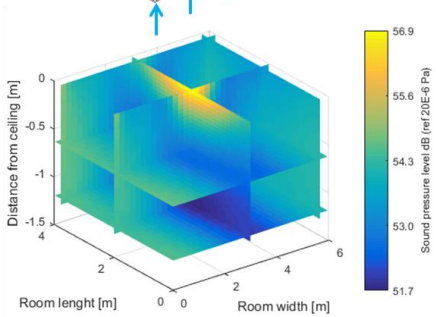


Förstyvade skivor



Skivor med extra massa



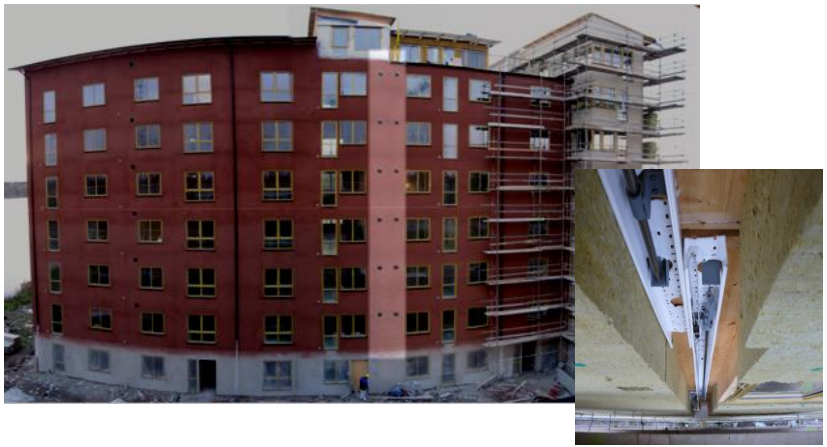


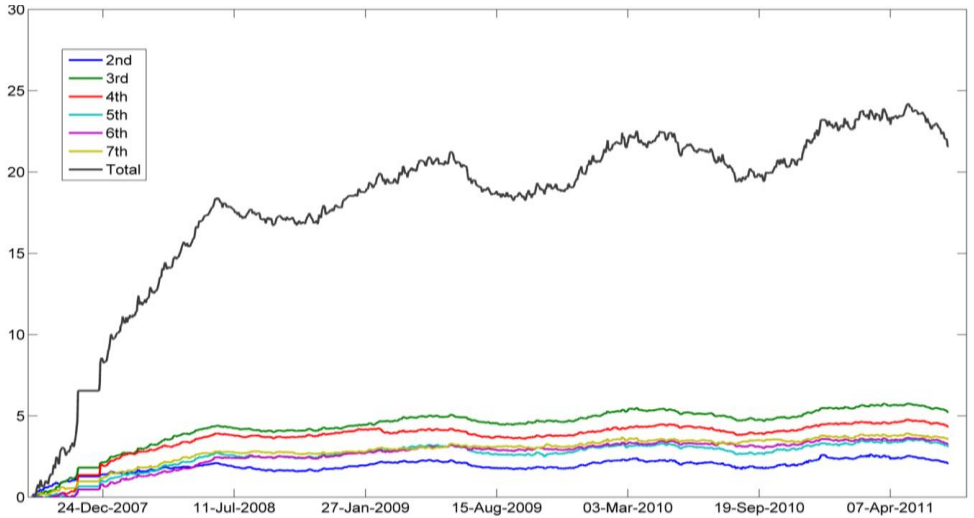
Olsson & Linderholt

Moisture safety

Durability and wood protection

- Construction time (Max 16% when built in)
- Service life
- Moisture related deformations due to shrinkage and swelling of the wood



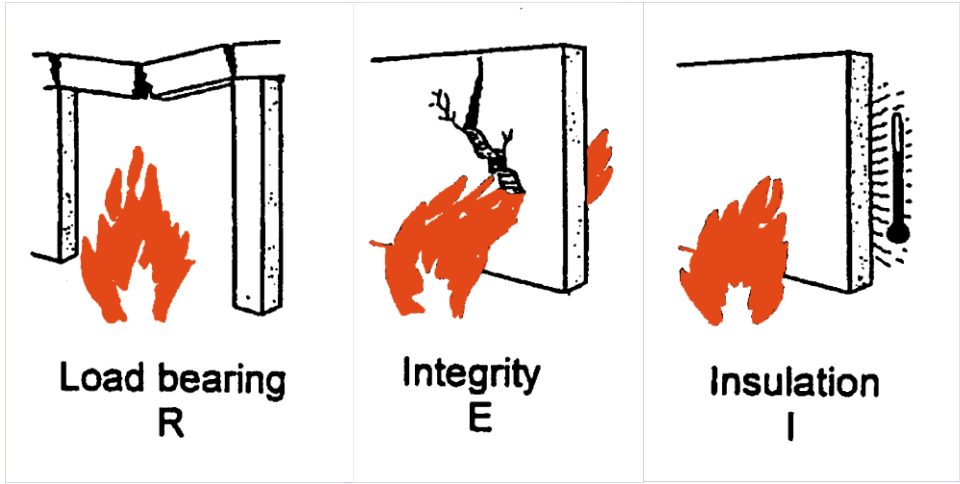


Fire safety

Same requirements as in all buildings

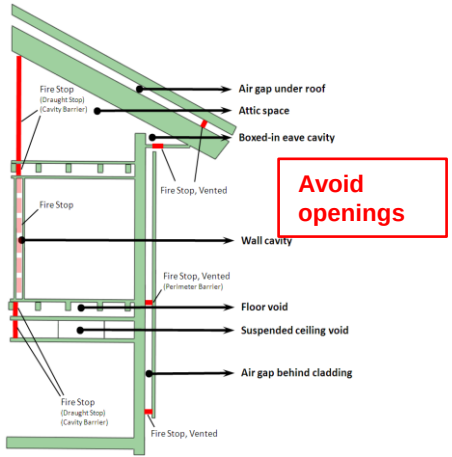
Calculation models/tools

- Resistance
- Integrity
- Insulation



Fire safety design

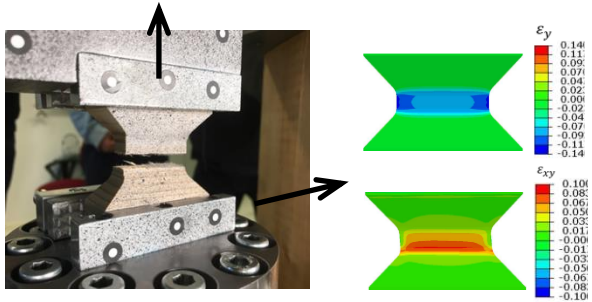
- Determination of the fire load
- Evacuation situation
- Protection against the spread of fire within the building and along the facade
- Possible efforts from the rescue service

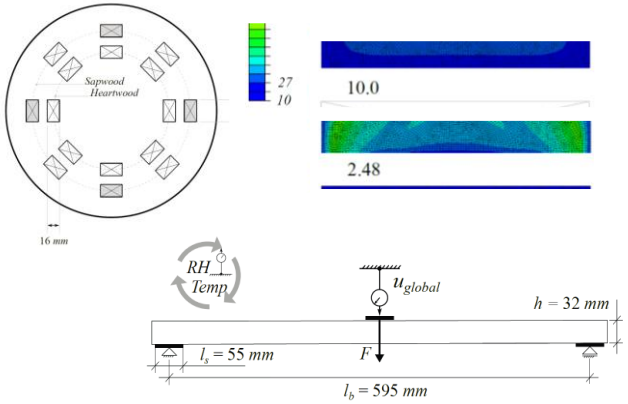


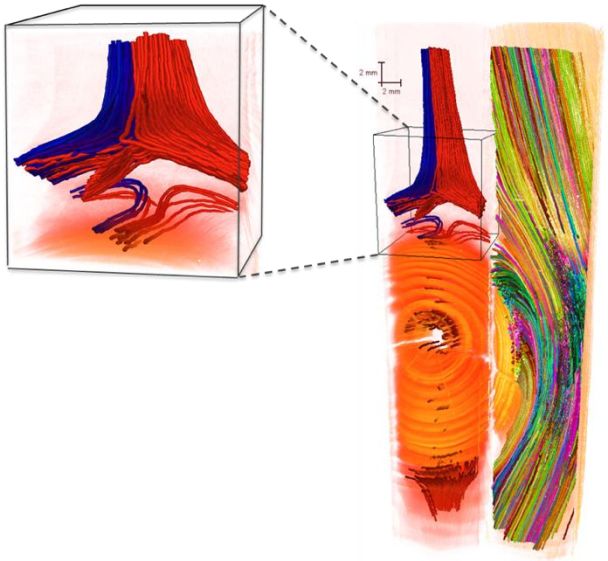
Research in Sustainable Wood Building Technology

Department of Building Technology

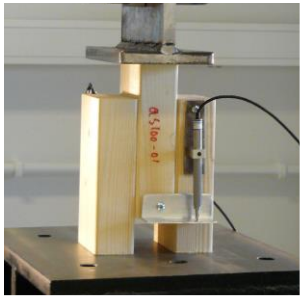
Wood material

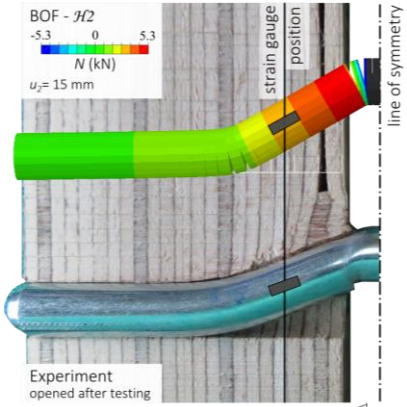


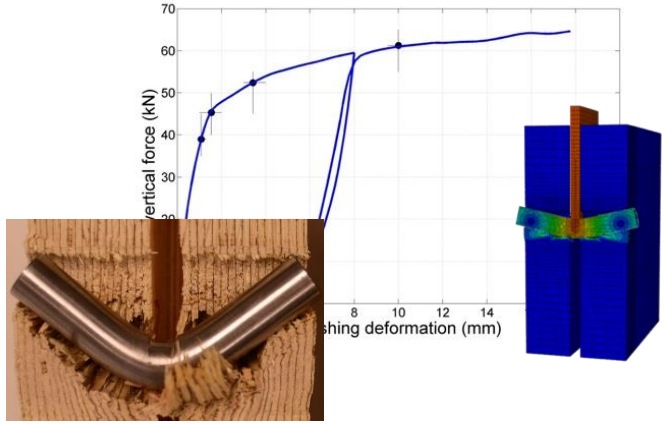


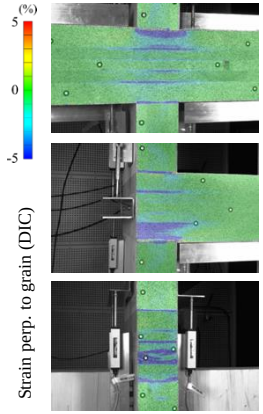


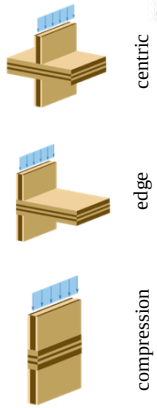
Connections

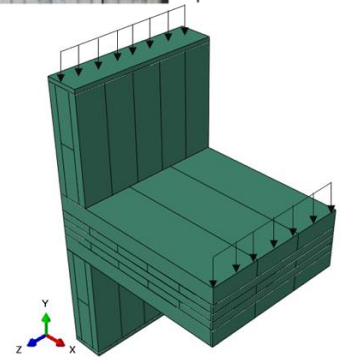


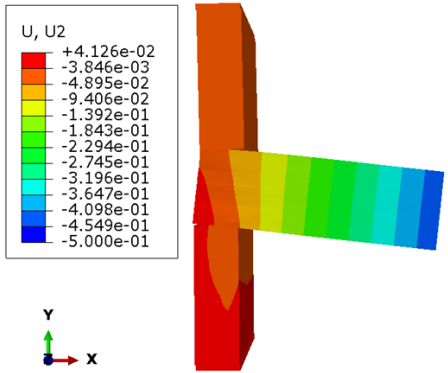




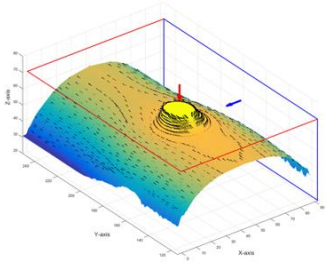


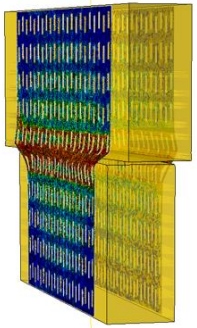


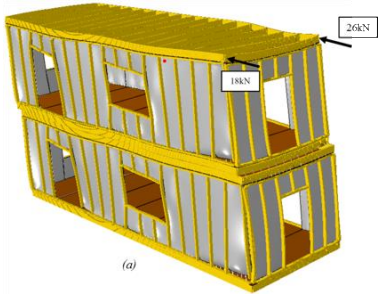


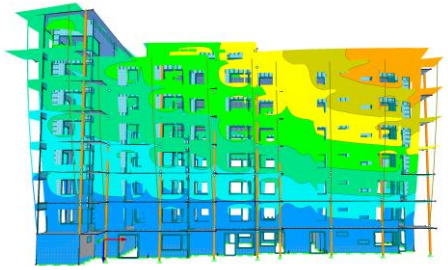


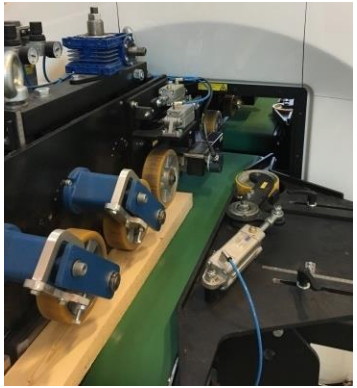
Computational analysis and design of building elements and entire buildings

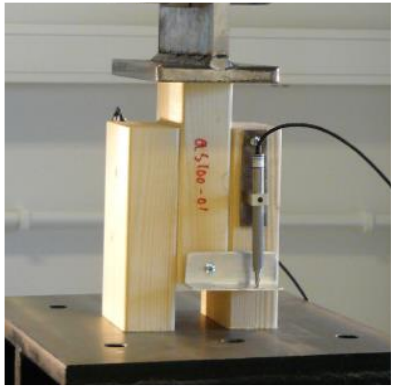


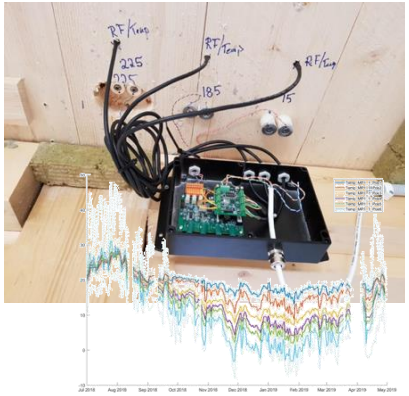






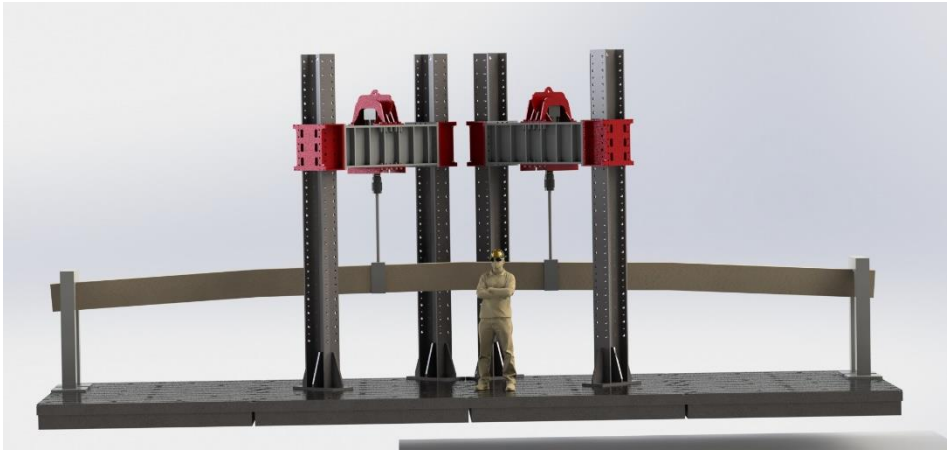


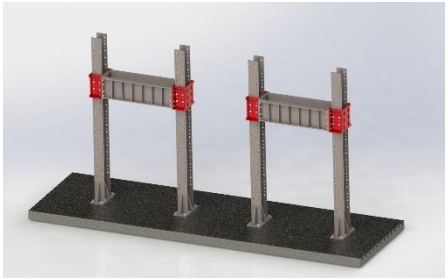


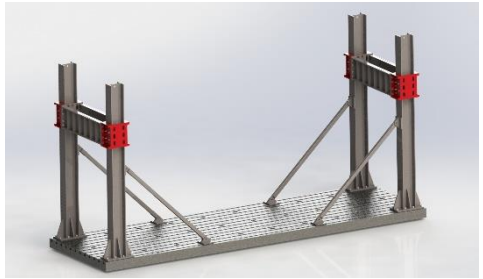


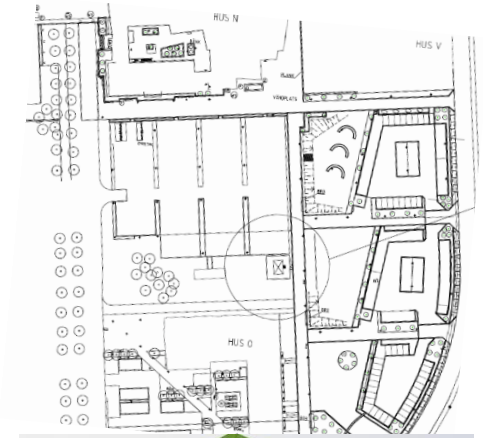
Laboratory / on-site testing / monitoring of structures

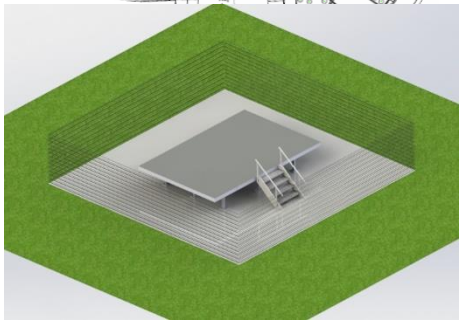
New load frame, outdoor laboratory











Projekt, KK HÖG

Design av innovativa modulbaserade flervåningshus i trä

Avancerad modellering och fullskaleförsök

Projektledare: Sigurdur Ormarsson, Lnu

OBOS MOELVEN Derome VIDA BUILDING

Linnéuniversitetet Kalmar Växjö

KK-stiftelsen

RI. SE Research Institutes of Sweden

Modular based timber buildings

The project deals with light frame mid-rise modular based timber buildings **up to 4-6 storey.**

Research focus:

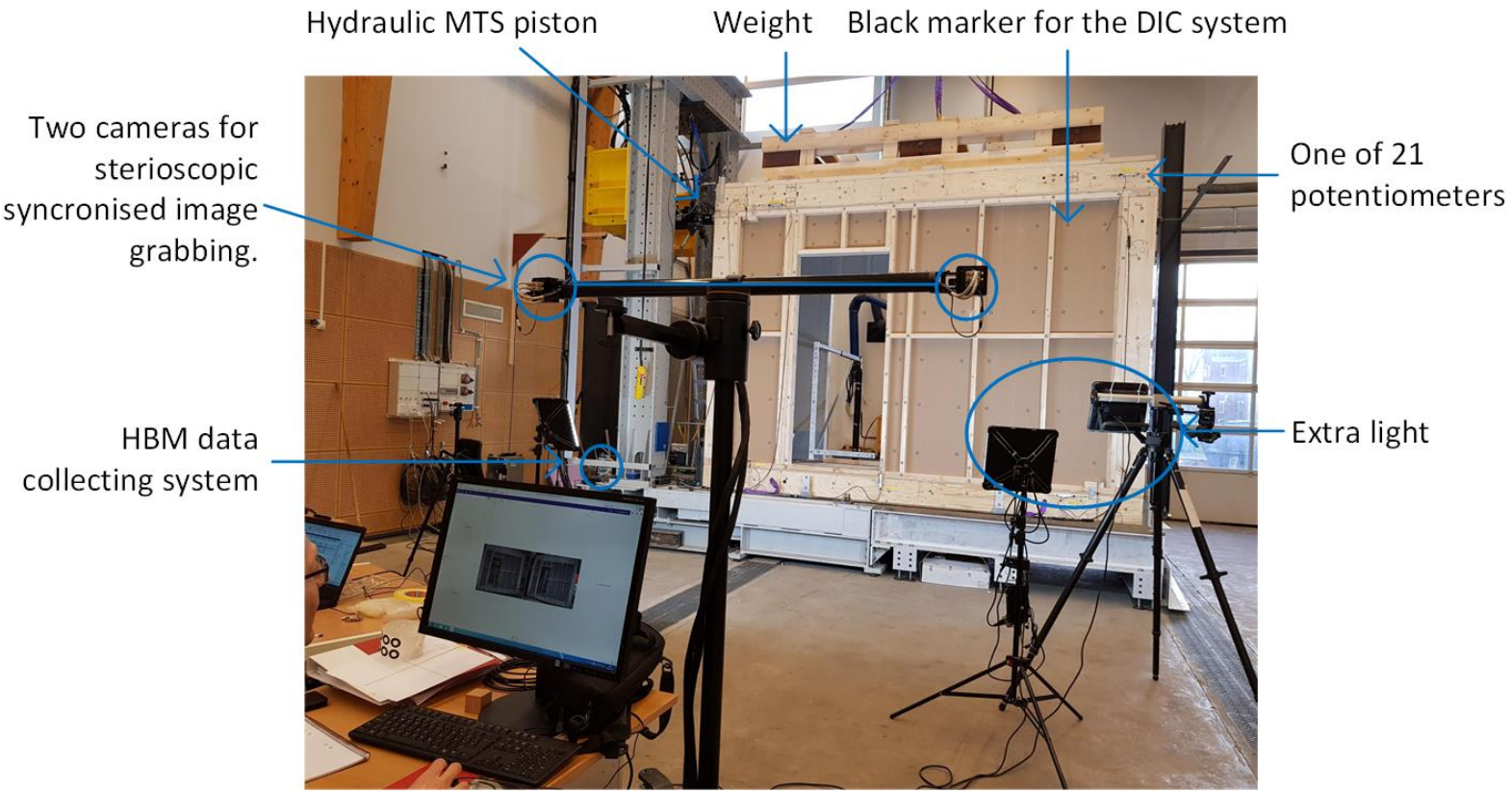
1) **Numerical modelling** of the global structural behaviour of the building
2) **Testing** of (small) **full scale** volume modules

Motivation and aim of the project

- **A number of house manufacturers** are expanding their production to multi-family houses on **several floors (up to 4-6 floors).**
- We would like to understand better the **overall structural behaviour** of this type of building including **mechanical joints** between the volume modules.
- The **aim** is to create an **effective and flexible simulation model** able to simulate **overall (and detailed) structural behavior** of (light frame) modular based **multi-storey** timber buildings.
- The model needs to be fully **parametrized** and experimentally verified at different structural levels.
- The numerical and experimental results from this research project will be used as a base to improve and optimize the **design of modular based timber structures**.

Experimental study (8 test-modules)

Experimental test setup

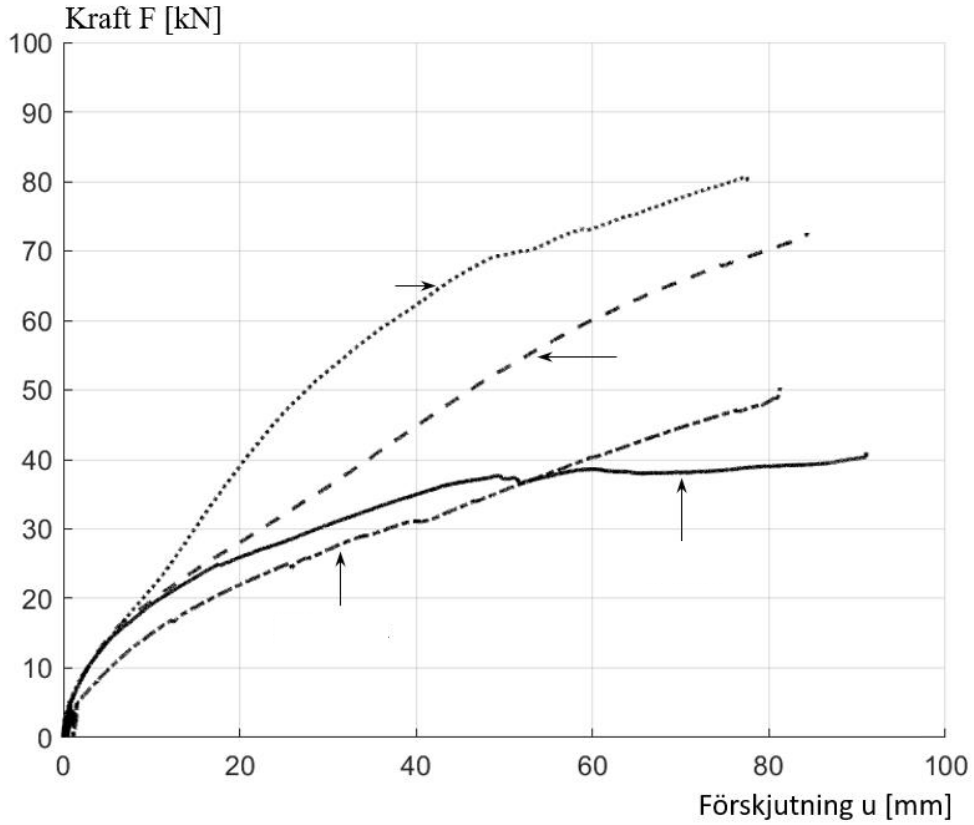


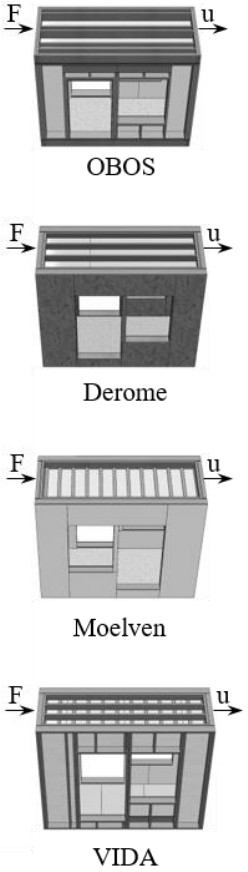
Deformed modules

Module 2

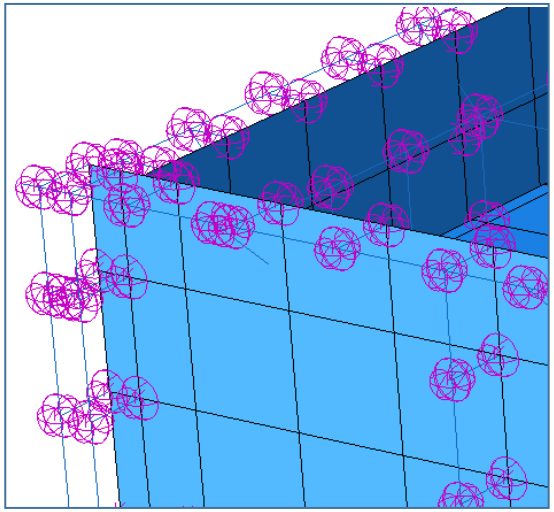
Typical results from the experiments

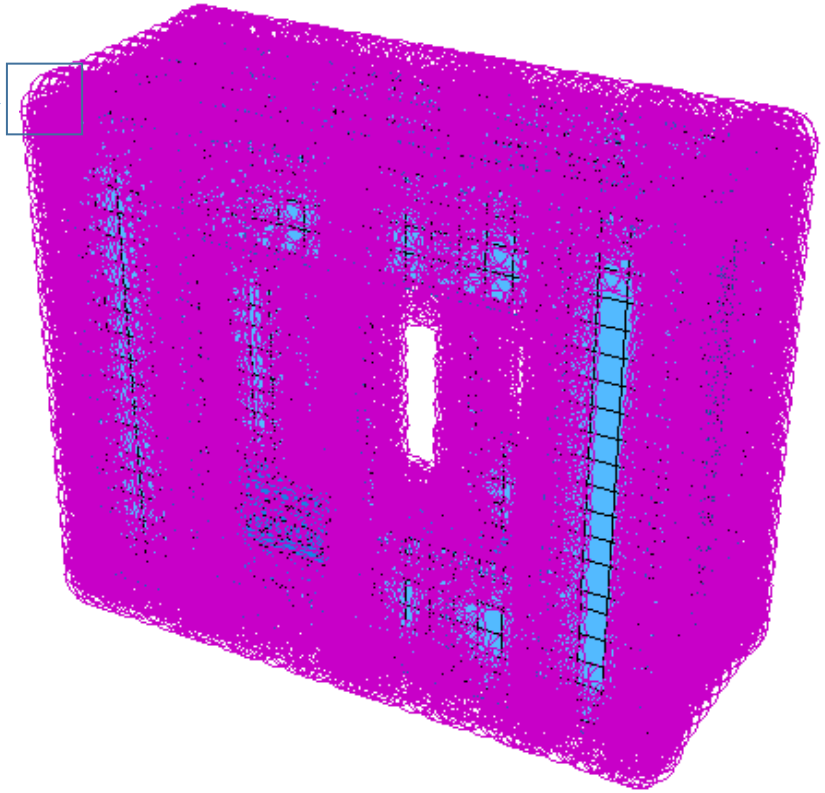
Module 2





Parametrised modelling using structural elements



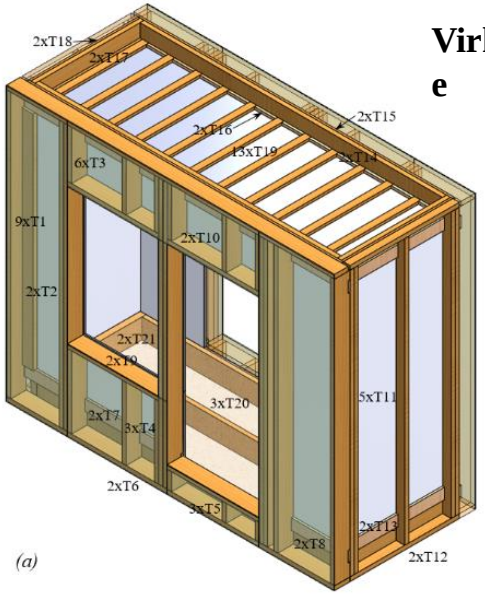


- **Wood members** are modelled with 3D beam elements.
- **Sheathing boards** are modelled with shell elements.
- **Fasteners** are modelled with beam elements which are connected to the frame and sheathing boards with nonlinear connector elements.

Number of connector elements = 12888

Komponentbeskrivning

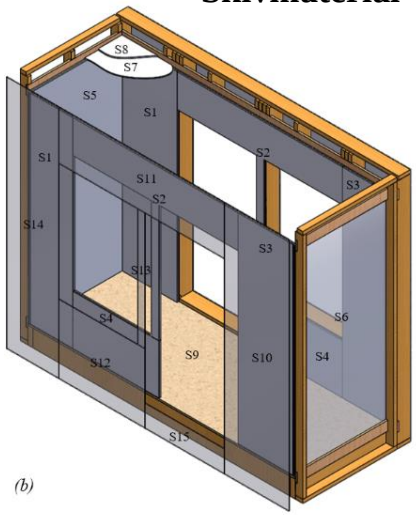
Virke



(a)

Nr	Beskrivning	Beteck.	Bxh (mm)	L (mm)	H-klass	Antal	Anmärkning
1	Reglar (LV)	T1	45 x 170	2915	C 24	9	
2	Spikreglar (LV)	T2	45 x 120	2442	C 24	2	
3	Kortreglar (LV)	T3	45 x 170	535	C 24	6	
4	Kortreglar (LV)	T4	45 x 170	790	C 24	3	
5	Kortreglar (LV)	T5	45 x 170	190	C 24	3	
6	Syll/hamn (LV)	T6	45 x 170	3600	C 24	2	
7	Infälld bräda(LV)	T7	22 x 120	1765	C 24	2	
8	Infälld bräda(LV)	T8	22 x 120	825	C 24	2	
9	Fönsterbalk (LV)	T9	45 x 170	1000	C 24	2	
10	Dörrbalk (LV)	T10	45 x 170	1010	C 24	2	
11	Reglar (KV)	T11	45 x 95	2915	C 24	5	
12	Syll/hamm (KV)	T12	45 x 95	1200	C 24	2	
13	Infälld bräda(KV)	T13	22 x 120	1200	C 24	2	
14	Långbalkar(TB)	T14	45 x 150	3320	C 24	2	
15	Långbrädor(TB)	T15	22 x 45	3454	C 24	2	
16	Långbrädor(TB)	T16	28 x 70	3454	C 24	2	
17	Tvärbalkar(TB)	T17	45 x 150	1200	C 24	2	
18	Tvärbrädor(TB)	T18	22 x 45	1200	C 24	2	
19							
20							
21							

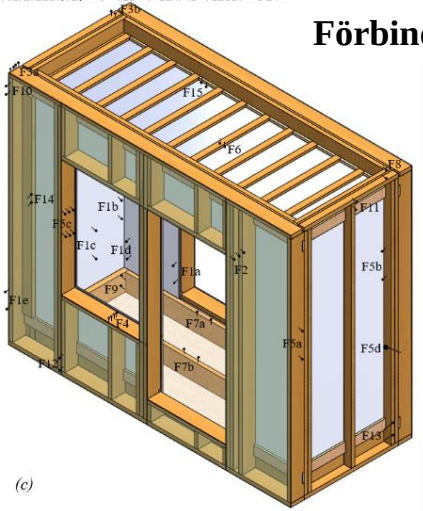
Skivmaterial



(b)

Nr.	Beskrivning	Beteck.	t (mm)	LxH (mm)	Material	Antal	Anmärkning
1	Ytter/Innerlager(LV)	S1	15	697 x 2552	Gips DB	4	
2	Ytter/Innerlager(LV)	S2	15	1010+97+ 1000 x 1500+419	"	4	
3	Ytter/Innerlager(LV)	S3	15	540 x 2550	"	4	
4	Ytter/Innerlager(LV)	S4	15	1097 x 633	"	4	
9	Ytterlager(KV)	S5	15	1200 x 2552	"	2	
10	Innerlager(KV)	S6	15	1200 x 2552	"	2	
11	Ytterlager(TB)	S7	13	1200 x 1200	Gips DN	3	
12	Innerlager(TB)	S8	15	1200 x 1200	Gips DB	3	
13	Enkellager(GB)	S9	22	1200 x 3410	Spånskiva	2	
14	Enkellager(LV)	S10	9	825 x 3000	Ute Gips	2	
15	Enkellager(LV)	S11	9	2107 x 622,5	"	2	
16	Enkellager(LV)	S12	9	1097 x 877,5	"	2	
17	Enkellager(LV)	S13	9	97 x 1500	"	2	
18	Enkellager(LV)	S14	9	97 x 1500	"	2	
19	Enkellager(LV)	S15	9	1010 x 277	"	2	

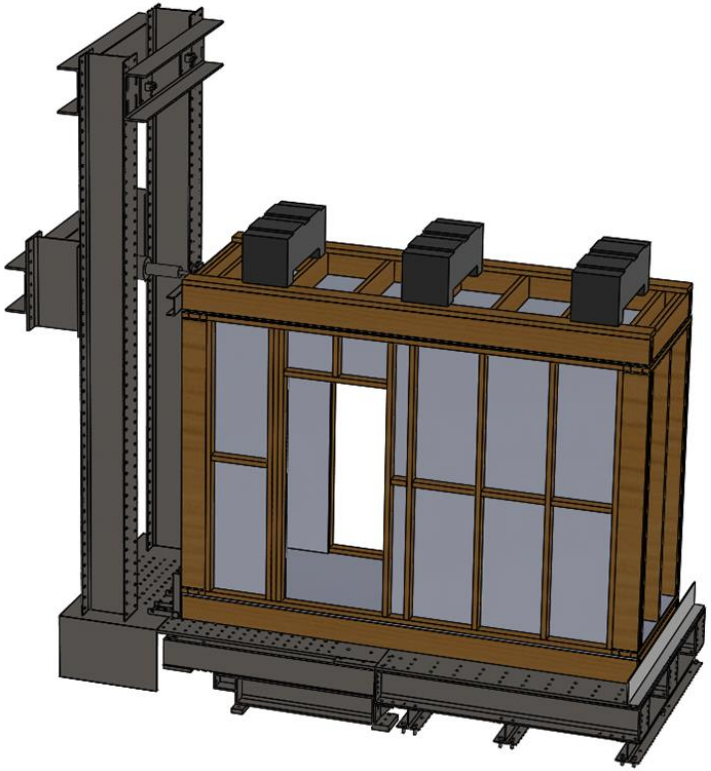
Förbindare

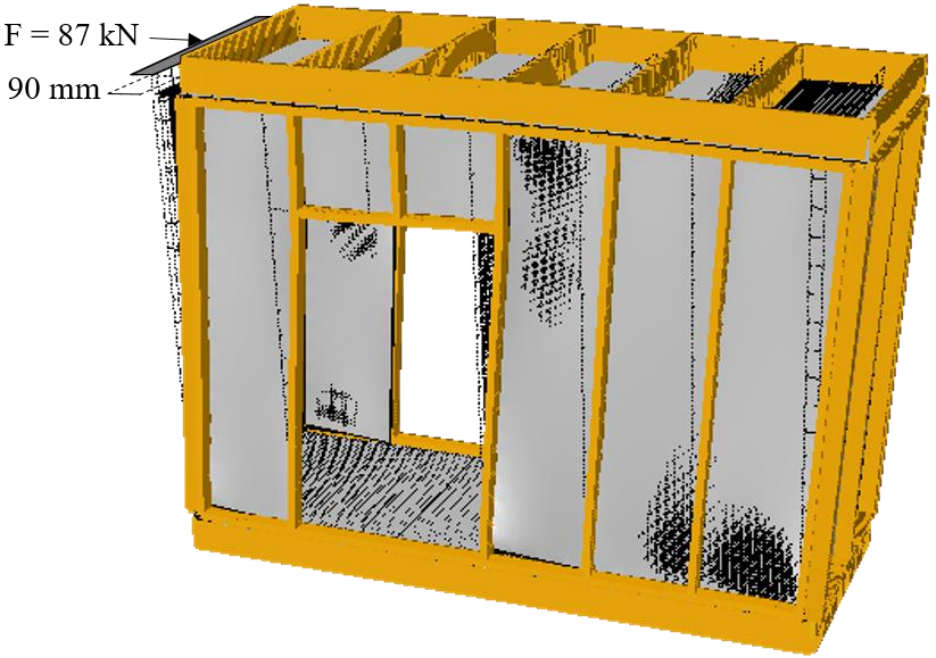


(c)

Nr.	Beskrivning	Beteck.	Typ	Längd (mm)	Diameter (mm)	c/c distans	Antal i rad	Anmärkningar
1	Gips-regel(LV)	F1a	Skruv	55	3,9	200		Kantreglar
2	Gips-regel(KV)	F1b	Skruv	50	3,9	200		Kantreglar
3	Gips-regel(KV)	F1c	Skruv	50	3,9	300		Mittenreglar
4	Gips-regel(LV)	F1d	Skruv	40	3,9	200		Mittenreglar
5	Gips-regel(LV)	F1e	Spik	35	3	200		Ute gips
6	Regel-dörrbalk(LV)	F2	Spik	90	3.1		3	
7	Regel-syll/ham(LV)	F3a	Spik	90	3,1		4	
8	Regel-syll/ham(KV)	F3b	Spik	90	3,1		2	
9	Balk-kortregel(LV)	F4	Spik	90	3,1		4	
10	Regel-regel (LV)	F5a	Spik	90	3,1	300	1	Mellan T11-T2
11	Regel-regel(KV)	F5b	Spik	90	3,1	200	1	
12	Regel-regel (LV)	F5c	Spik	90	3,1	350	3	
13	Regel-regel (HF)	F5d	Skruv	140	6	600	1	Snett skruvat
14	Skivor-tvärbräda(TB)	F6	Skruv	50	3,9	200		
15	Skivor-longbalk(GB)	F7a	Spik	90	3,1	300		
16	Skivor-longbalk(GB)	F7b	Spik	90	3,1	200		
17	Balk-balk (TB)	F8	Spik	90	3.1		2	
18	Balk-balk (GB)	F9	Skruv	160	6,5		2	
19	Reglar-takbalk(LV)	F10	Skruv	220	6		1	
20	Reglar-takbalk(KV)	F11	Skruv	140	6		1	
21	Reglar-golvbalk(LV)	F12	Skruv	220	6		2	Innerreglar
22	Reglar-golvbalk(KV)	F13	Skruv	160	6,5		2	Snett skruvat
23	Regel-spikregel (LV)	F14	Spik	60	2,8		4	
24	Longbräda-balk(TB)	F15	Spik	70	2,5		2	

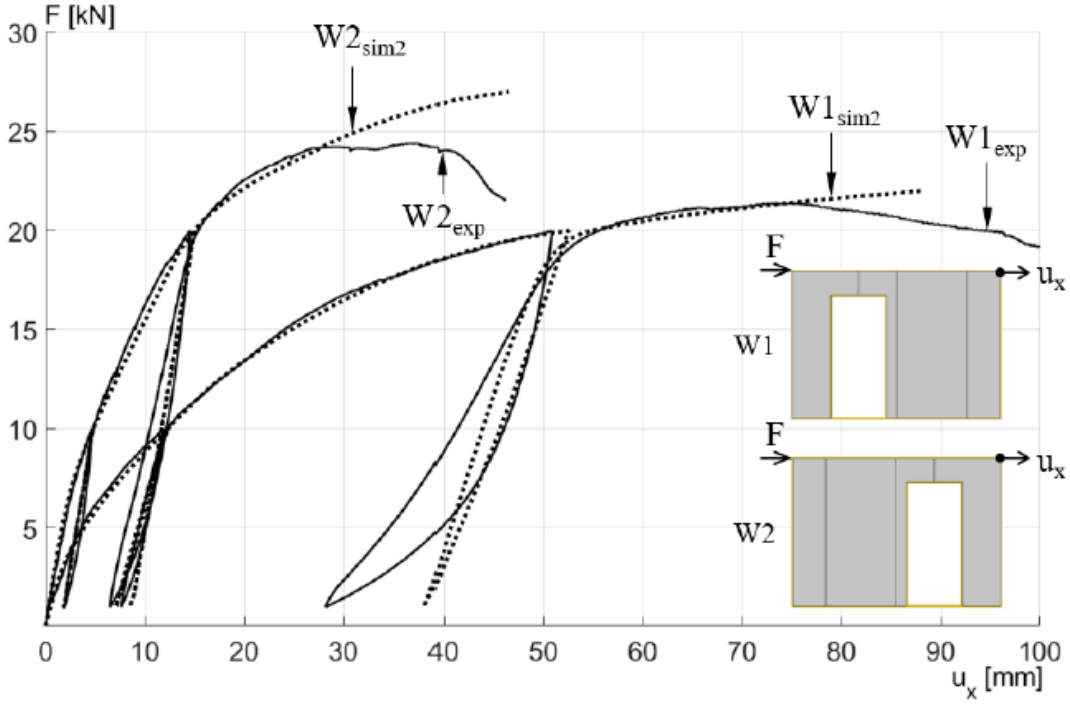
Modelling of the module type 1

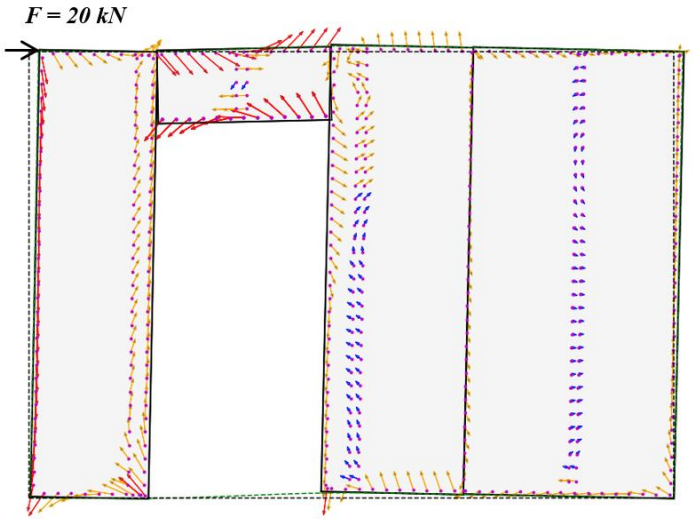


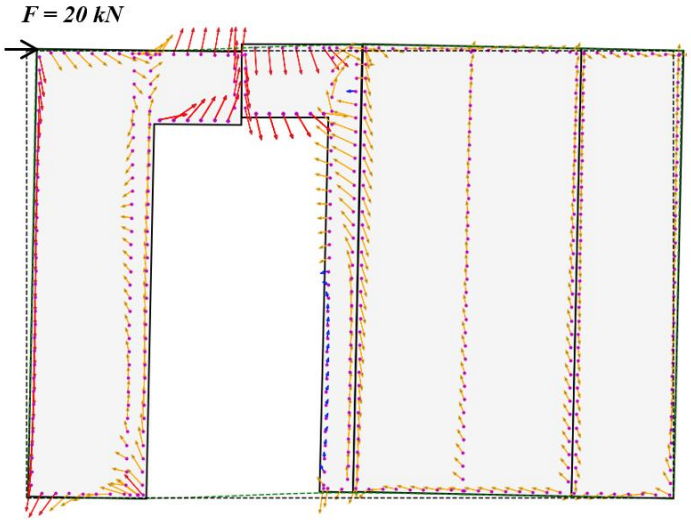


The test results are used for model ve

Model verification



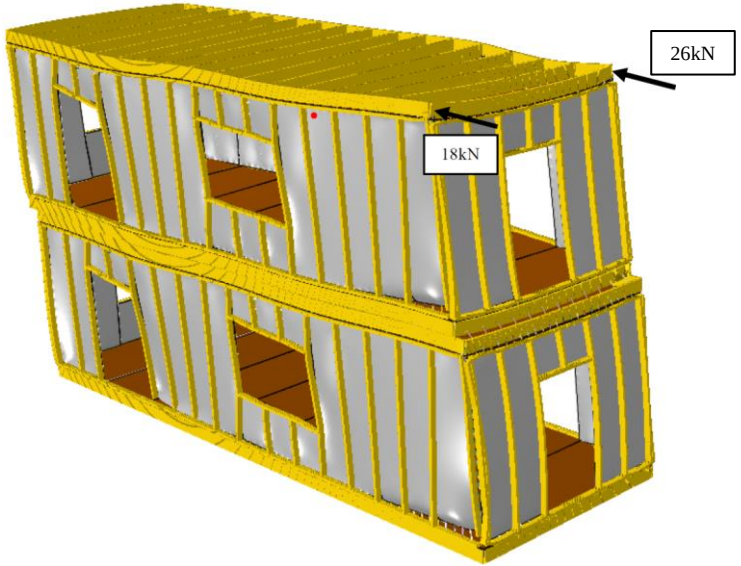




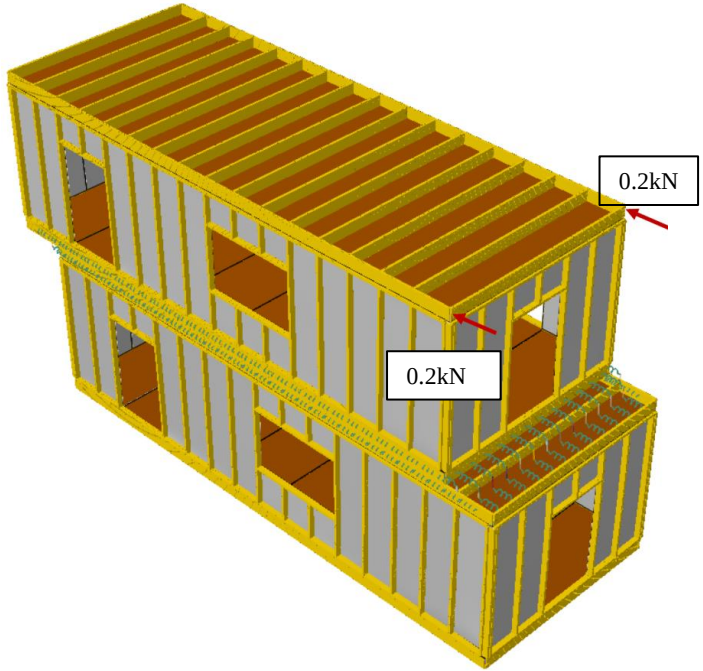
Modelling work by Le Kuai

Modelling of two module structure

- **Influence of openings and friction on the global structural stiffness**

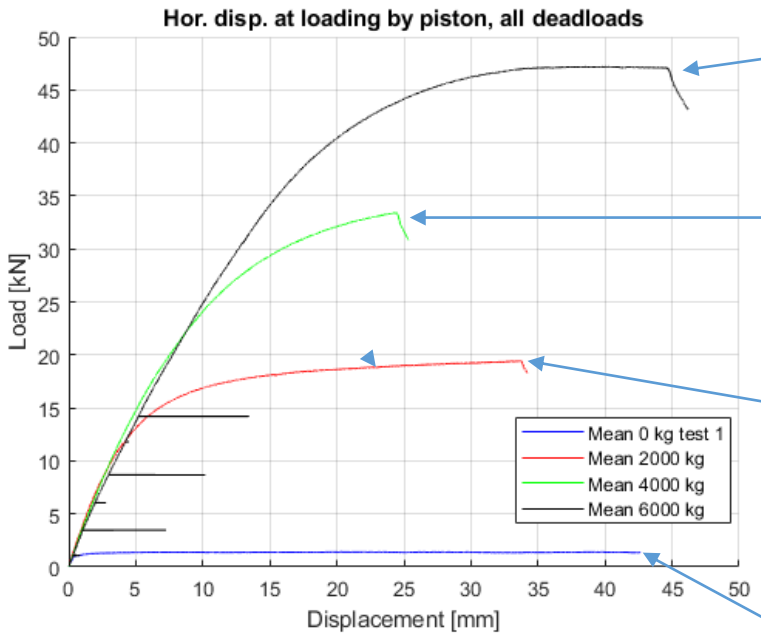


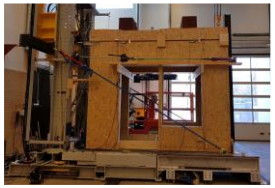
High friction and mechanical joints between the volume modules



Very low friction between the volume modules

Test results on friction joints between modules





Formas projekt

Utveckling av effektiva digitaliserings-hjälpmedel för design och industrialisering av hållbara volymbaserade flervåningshus i trä

Projektledare: Johan Vessby, Karlstads Universitet

OBOS MOELVEN Derome FORMAS

Linnéuniversitetet Kalmar Växjö

KARLSTADS UNIVERSITET

RI. SE Research Institutes of Sweden

Planerade experimentella försök

Principillustration planerade experimentella försök

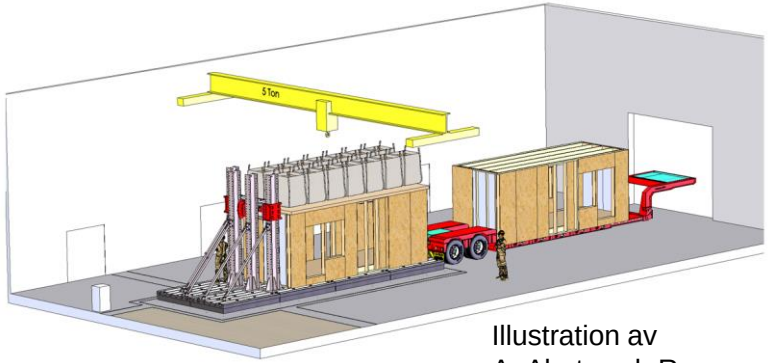
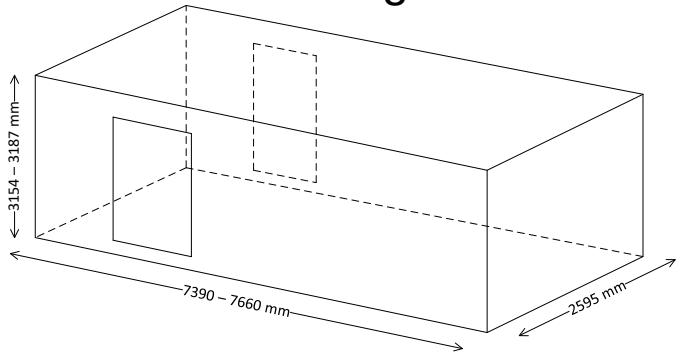


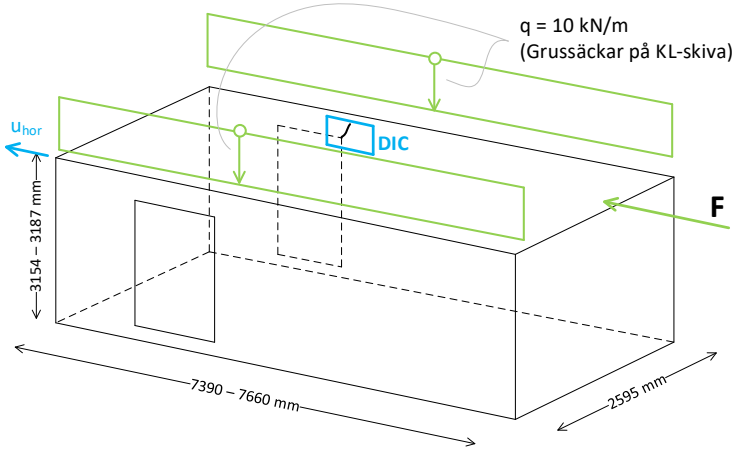
Illustration av
A. Alrutz och R. Maharjan

Fullskaliga experimentella försök planeras under ht -22.
Syfte:

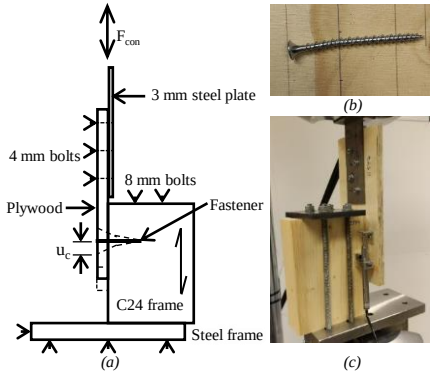
- Vilken styvhet finns i fullstora volymer belastade på liknande sätt som i en verklig flervåningsbyggnad?
- För vilken horisontell last får man sprickor i anslutning till öppningar?
- Eventuellt brottlast på någon volym.

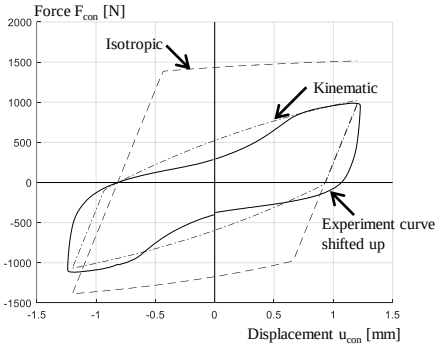
Modulgeometri



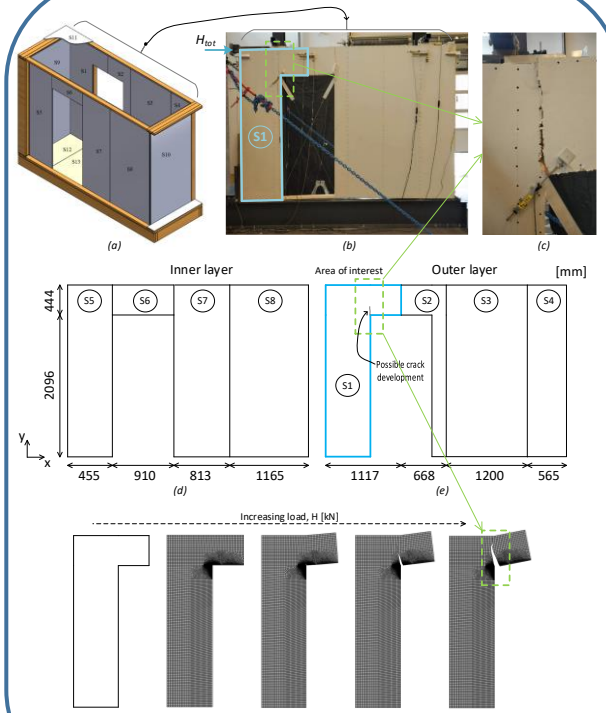


Pågående modelleringsarbete

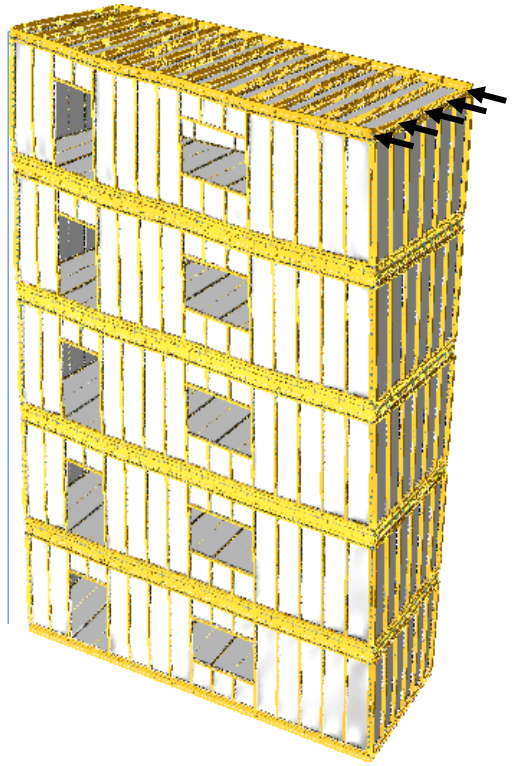




Modeller för cyklisk belastning av



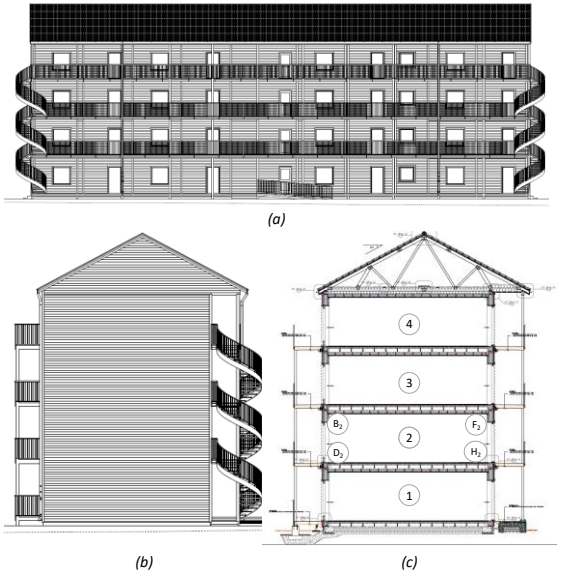
Simulering av sprickbildning i



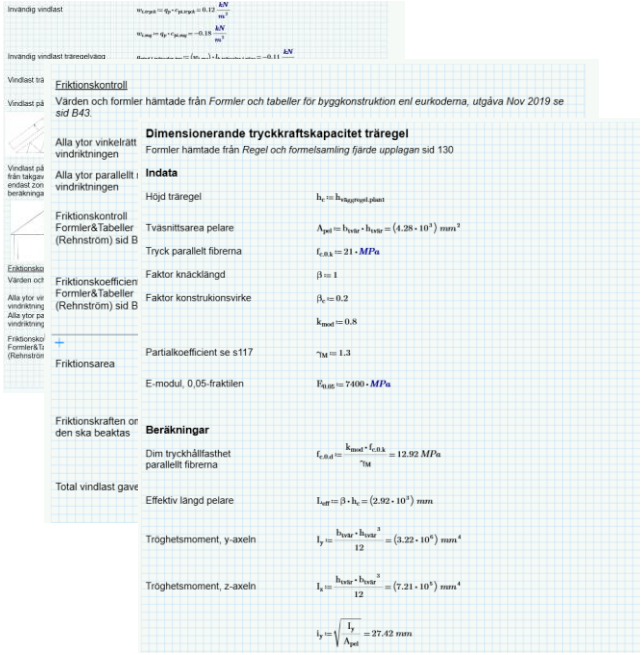
Analys av större delar av

Lastnedräkning och dimensionering enligt EC5 i typhus

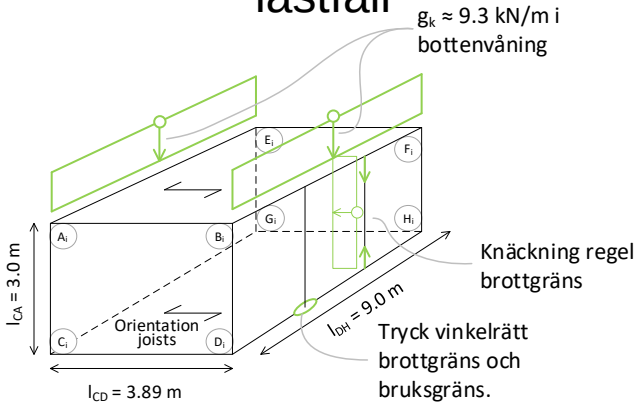
Typhus



Lastnedräkning och dimensionering i Mathcad Prime



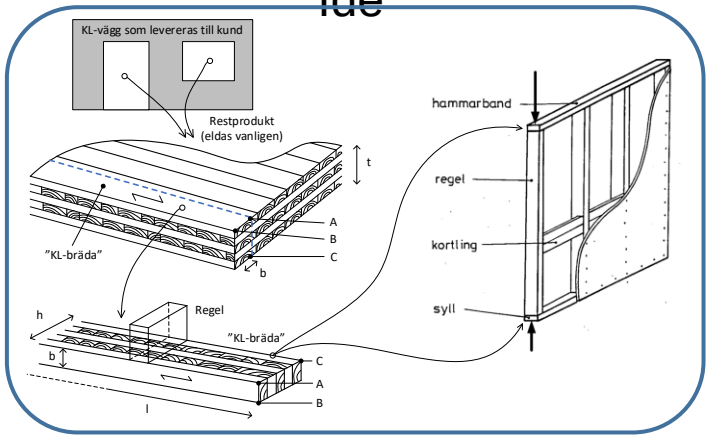
Analys av kritiska lastfall



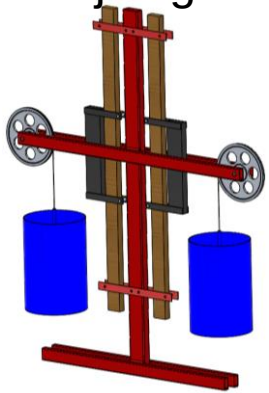
- Tryck vinkelrätt syll i bottenvåning
- Knäckning av regel i bottenvåning
- Global jämvikt
- Vertikala

Lab för långtidsbelastning, ca 40 belastningspositioner

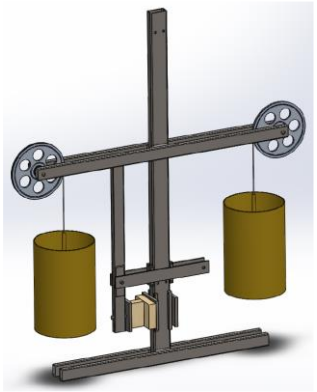
Idé



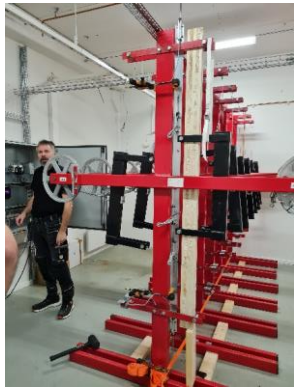
Böjning



Tryck perp.



Långtidslab



December -21,

November -21,