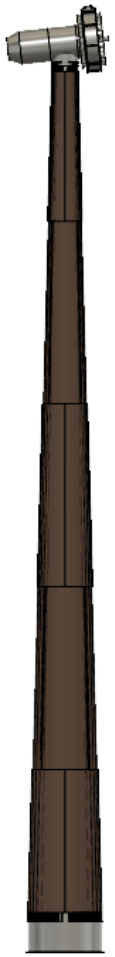
Methods and material for sustainable and cost effective structural supporting systems for wind power plants

Industry partners:
NCC, Modvion, TensionCam, Stena Renewables, Rabbalshede kraft

Academic partners:
Chalmers, RISE



Anders Wickström
RISE Research Institutes of Sweden

Methods and material for sustainable and cost effective structural supporting systems for wind power plants

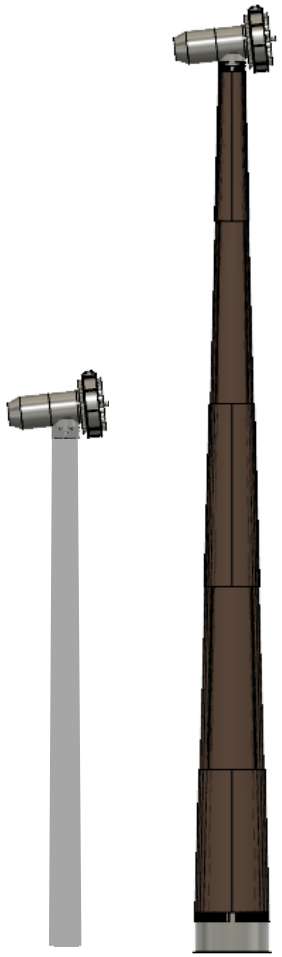
Modular wind turbine towers from laminated wood

for heights of +130 meters.

modvion

Motivation:

1. Easier transportation of tower modules
2. Decreased cost for lower weight and higher height
3. Positive environmental impact



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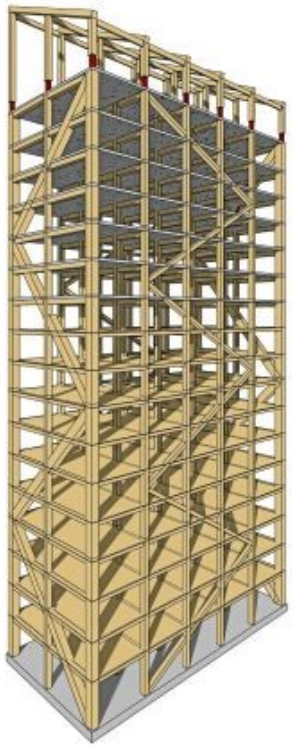
RISE Research Institutes of Sweden

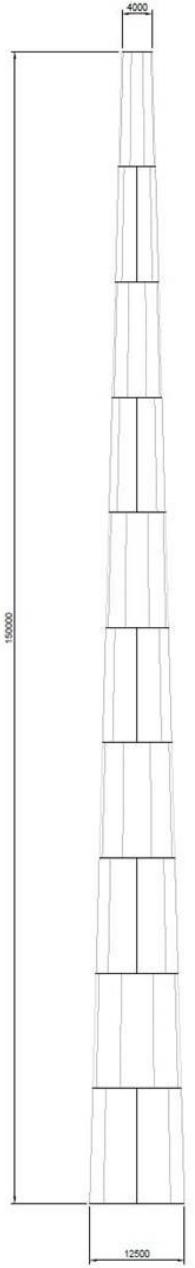
Methods and material for sustainable and cost effective structural supporting systems for wind power plants

modvion

This project will focus on:

- Workshop tests to further investigate and validate fatigue properties of glue joints
- Validate wood tower performance at the new Chalmers pilot research turbine
- New advanced connection to the foundation
- New advanced connection to the tower top yaw bearing





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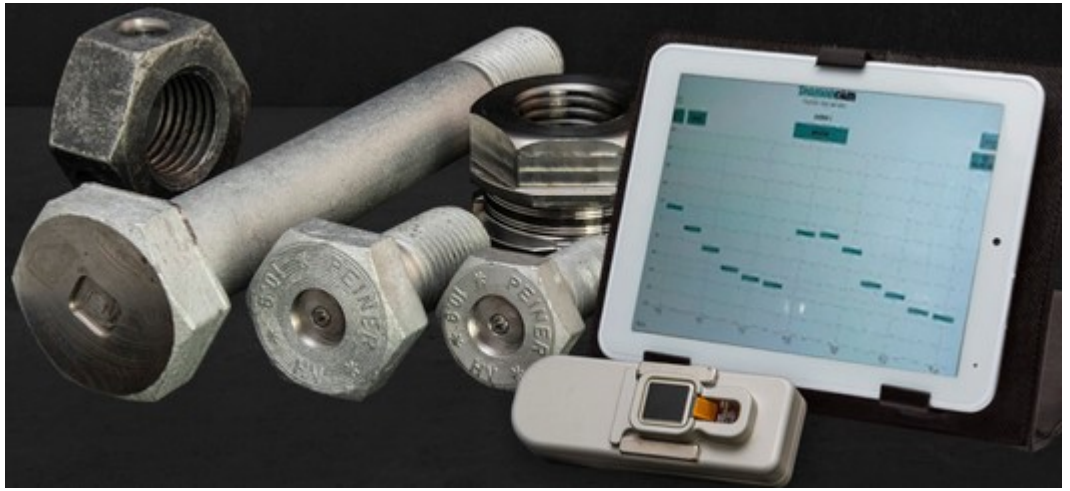
Tensioncam™

Correct bolt pretension is crucial for the structural integrity of steel towers. A new method is proposed, using high resolution measurements of small displacements.

This project will focus on:

- Investigate different bolt head patterns to measure and supervise the bolt pretension
- Validate calculations of bolt head displacements in workshop tests



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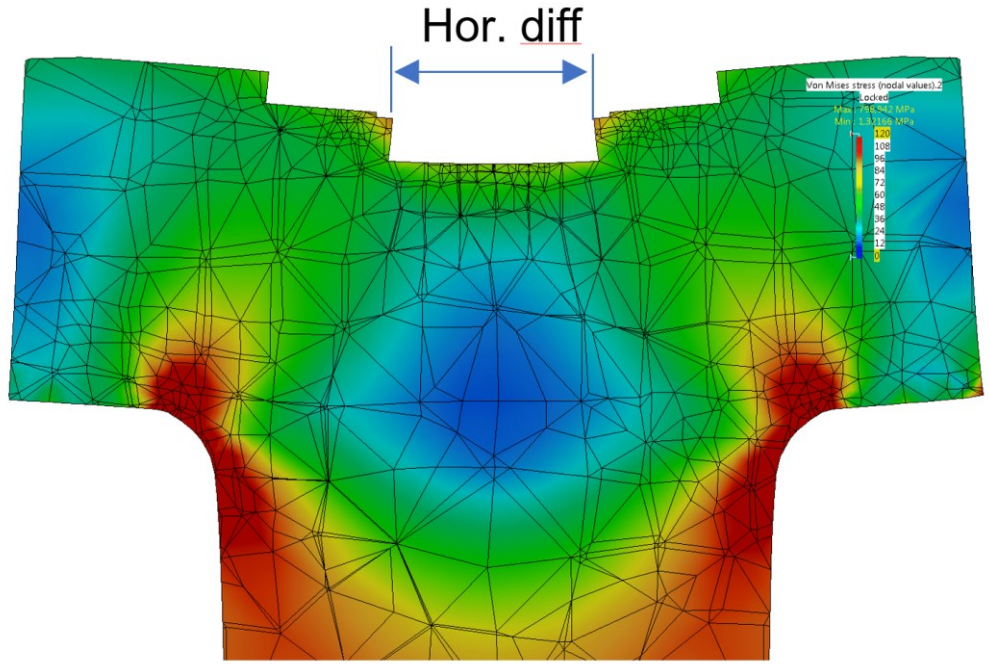

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Questions?

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Backup

The company and the product

Modvion is a Swedish company developing modular wind turbine towers from laminated wood for heights of +130 meters.

Motivation:

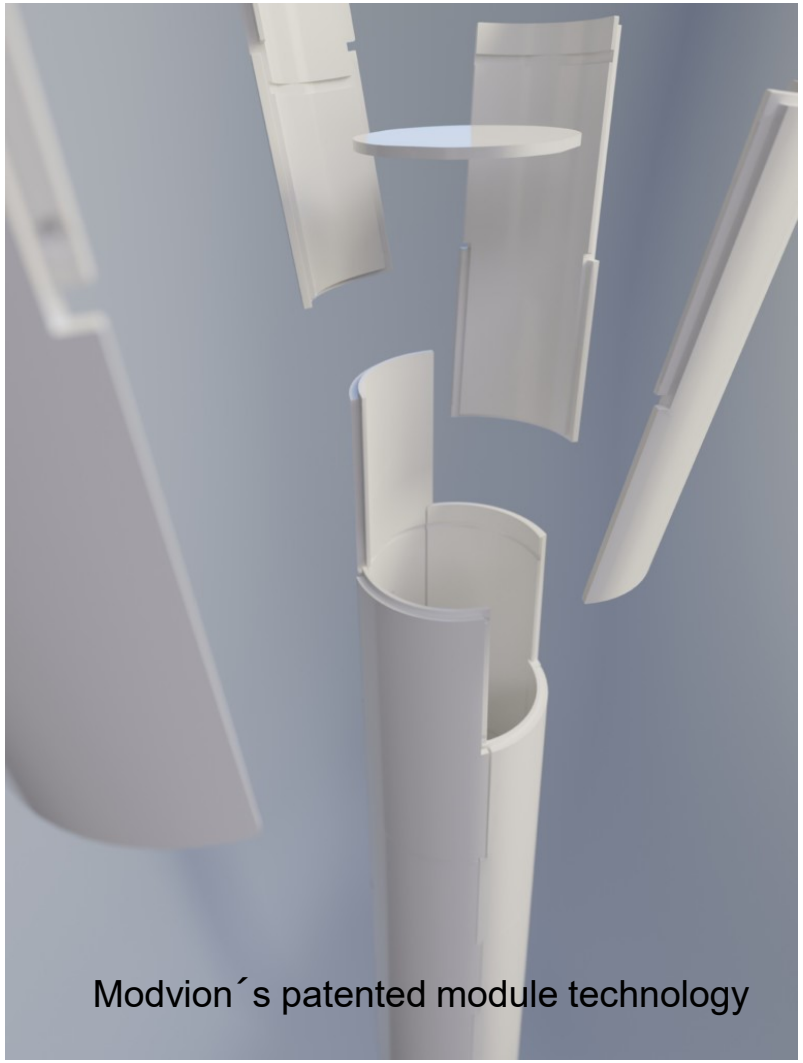
1. Easier transportation of tower modules

   As wind towers rise above 100 meters in height transportation causes considerable problems as 4.3 meters is the limit for transport width in most parts of the USA and the EU.

2. Decreased cost for lower weight and higher height

3. Positive environmental impact

   Emissions of about 2000 tonnes of CO_2 are avoided in tower production only



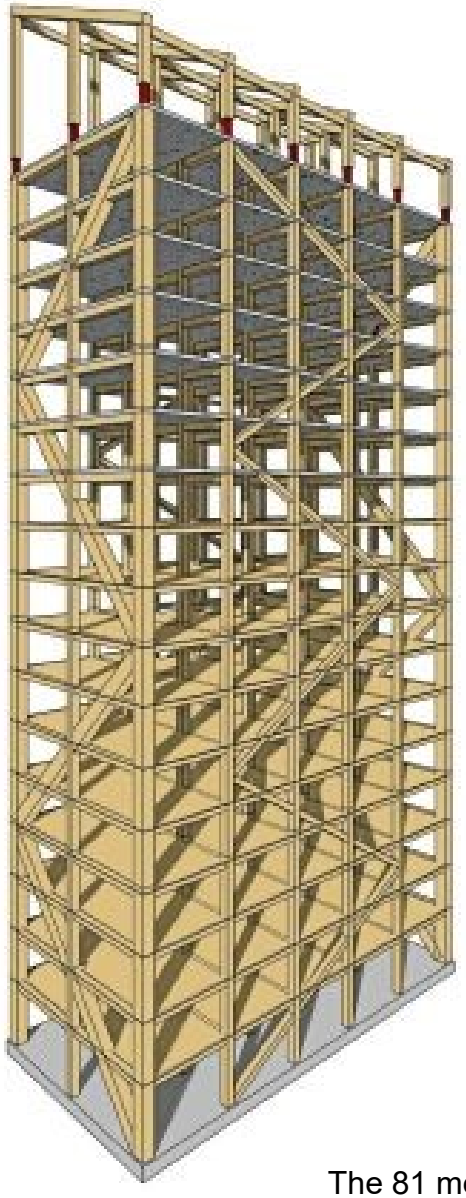
Modvion´s patented module technology

The world's tallest wooden house

The 81 meter high Mjösa tower in Brumunddal, Norway.

Fire impregnated Glue-Laminated Timber

High buildings made from wood is the future



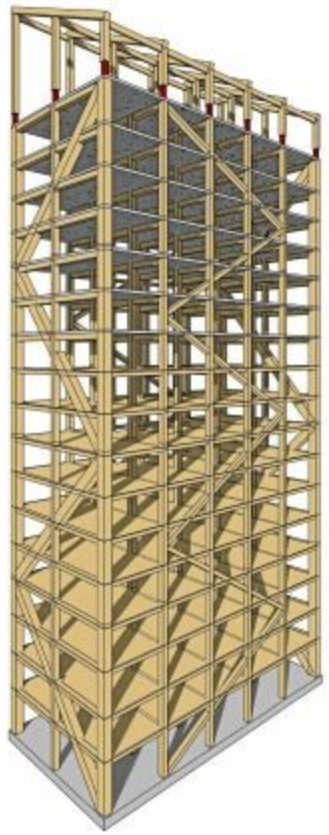
The 81 meter high Mjösa wooden tower

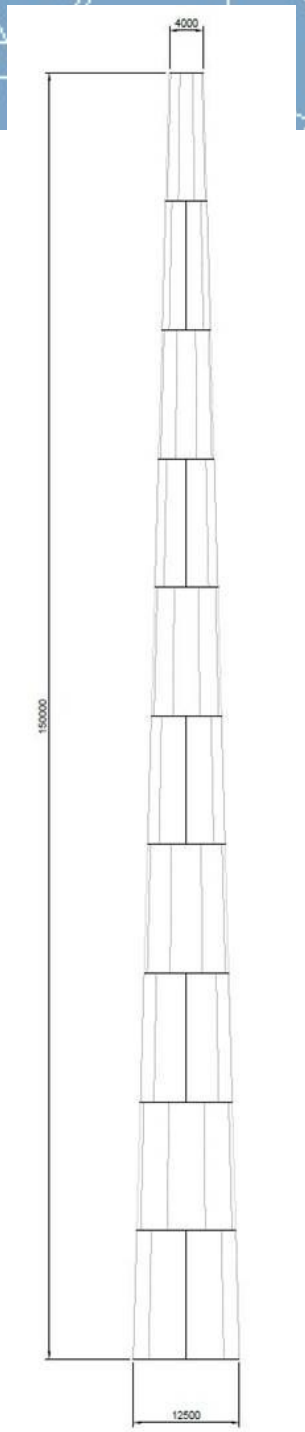
MOELVEN www.moelven.com

The full size 150 m tower

The full size laminated wood tower

next to the Mjösa tower





The tower structure

The tower consists of prefabricated modules. The entire tower is conical shaped.

Shells are laminated from multiple layers of LVL-boards.*1

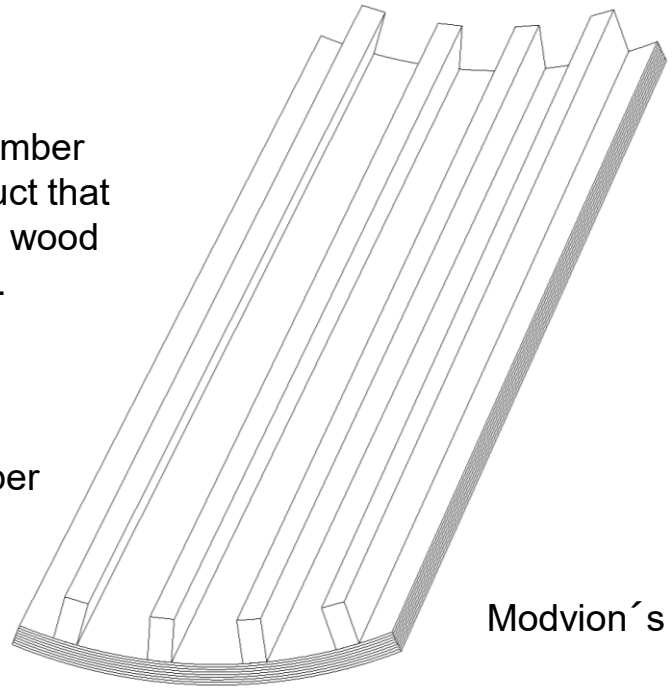
Internal beams are made of GLT.*2

*1

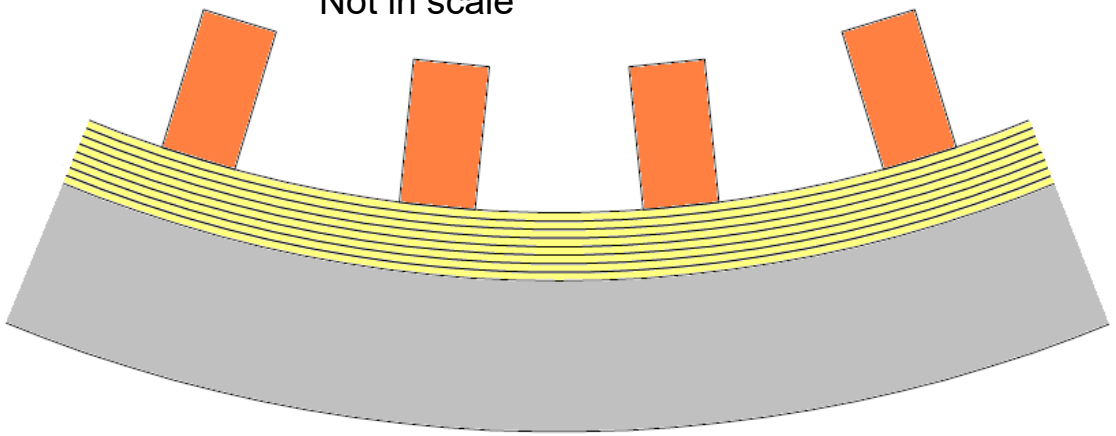
LVL: Laminated Veneer Lumber
An engineered wood product that uses multiple layers of thin wood assembled with adhesives.

*2

GLT: Glue-Laminated Timber



Part of module seen from above.
Not in scale

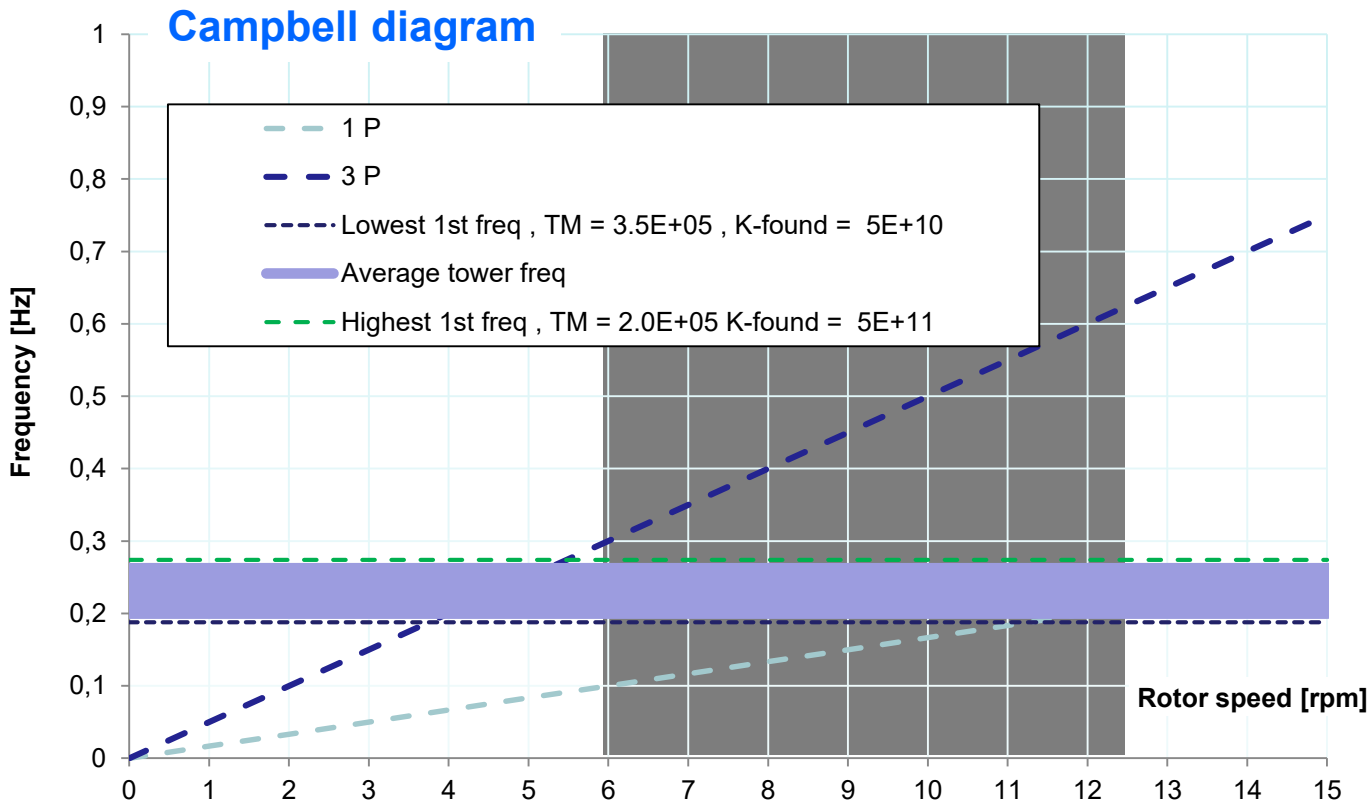


Modvion´s patented module technology

Structural dynamics

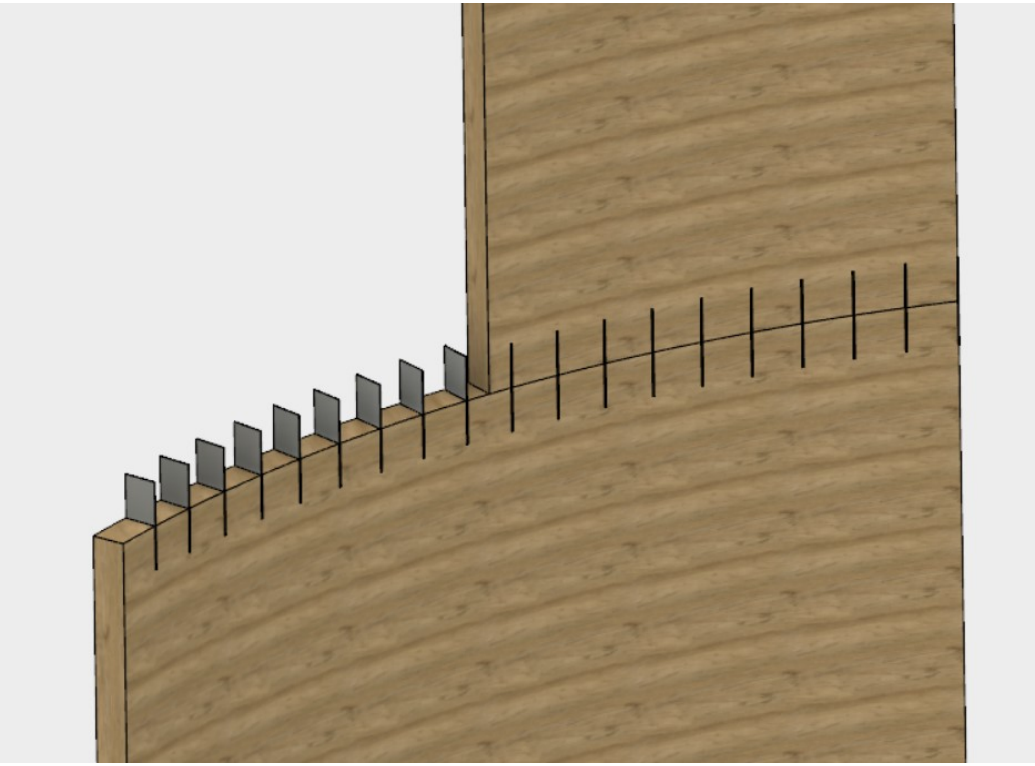
The structural dynamics of a 150 meters laminated wood tower is similar to a 120 meters steel tower .

But wood has better damping properties.



The joint connection

The joint consists of perforated steel plates which are connected to the wooden structure by special glue for the purpose.



Modvion´s patented module technology

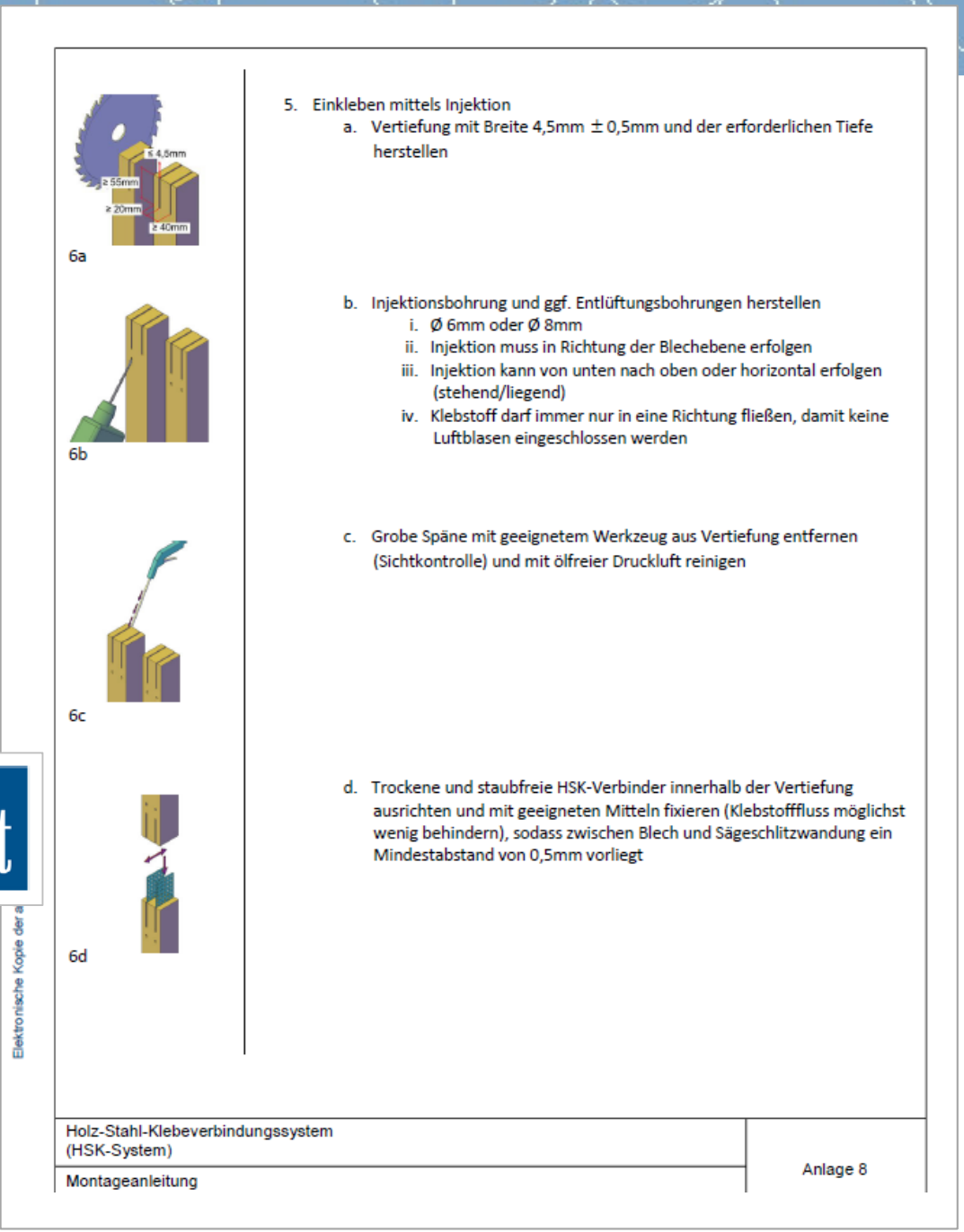
Specification for gluing wooden parts

There is an existing German standard from DIBt and specification for general connections of wood parts.

This has been used and refined in the Modvion tower application.

Deutsches Institut für Bautechnik

DIBt



5. Einkleben mittels Injektion
   a. Vertiefung mit Breite 4,5mm ± 0,5mm und der erforderlichen Tiefe herstellen

6a

6b

   b. Injektionsbohrung und ggf. Entlüftungsbohrungen herstellen
      i. Ø 6mm oder Ø 8mm
      ii. Injektion muss in Richtung der Blechebene erfolgen
      iii. Injektion kann von unten nach oben oder horizontal erfolgen (stehend/liegend)
      iv. Klebstoff darf immer nur in eine Richtung fließen, damit keine Luftblasen eingeschlossen werden

6c

   c. Grobe Späne mit geeignetem Werkzeug aus Vertiefung entfernen (Sichtkontrolle) und mit ölfreier Druckluft reinigen

6d

   d. Trockene und staubfreie HSK-Verbinder innerhalb der Vertiefung ausrichten und mit geeigneten Mitteln fixieren (Klebstoffffluss möglichst wenig behindern), sodass zwischen Blech und Sägeschlitzwandung ein Mindestabstand von 0,5mm vorliegt

Holz-Stahl-Klebeverbindungssystem (HSK-System)

Montageanleitung

Anlage 8

Testing of wood and joint

The current joint design of Modvion's laminated wood tower has been investigated by experimental tests with respect to the structural integrity.

The specimen in the machine which has a capacity of ± 300 kN (compression/tension)

Testing of wood and joint

The current joint design of Modvion's laminated wood tower has been investigated by experimental tests with respect to the structural integrity.

Detail of the reinforced bolted end connection

Testing of wood and joint

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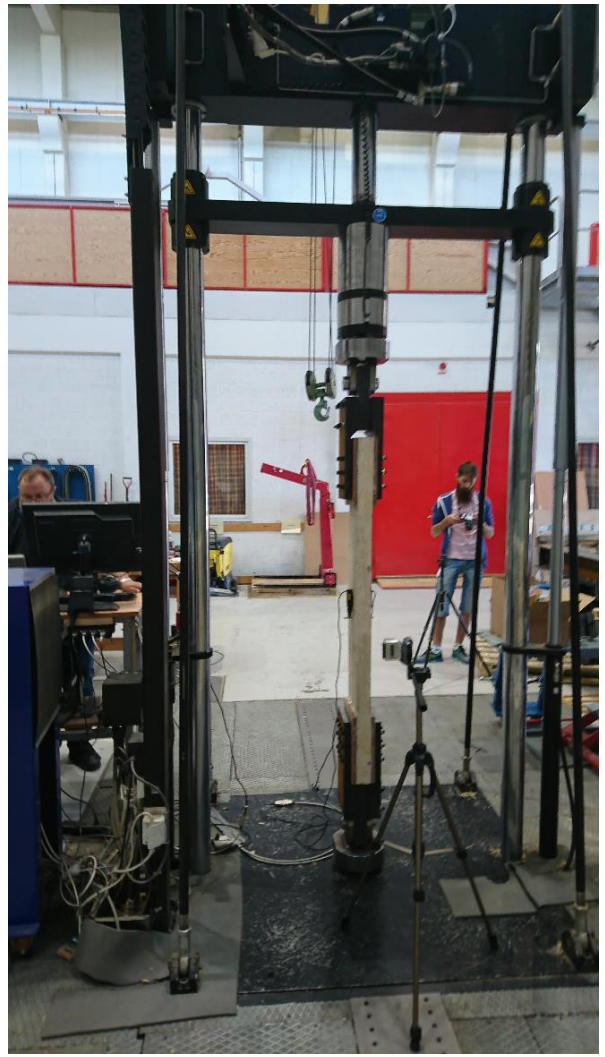
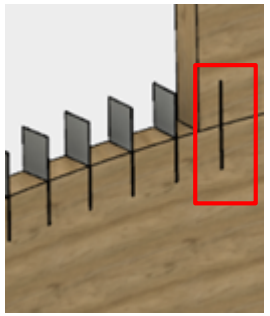


Results from the testing of wood and joints

The steel is designed to be the weaker part of the joint.

It means that failures, in case of both ultimate and fatigue loads, occur in the steel plate itself.

This is validated in the workshop tests.



Picture of the tested samples with cyclic loading
Test sample nr. 7

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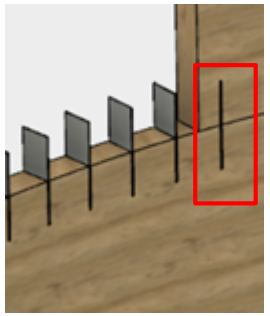
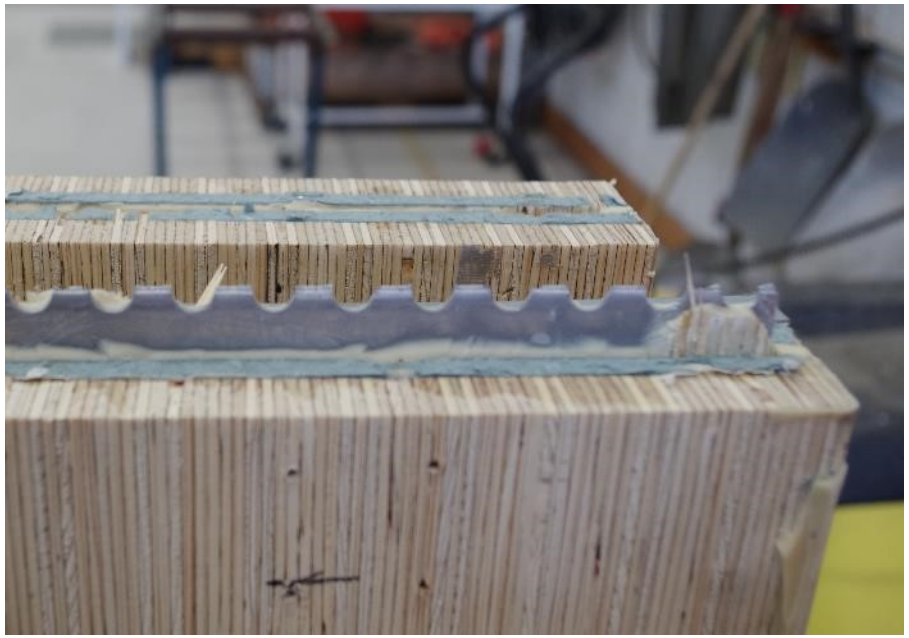


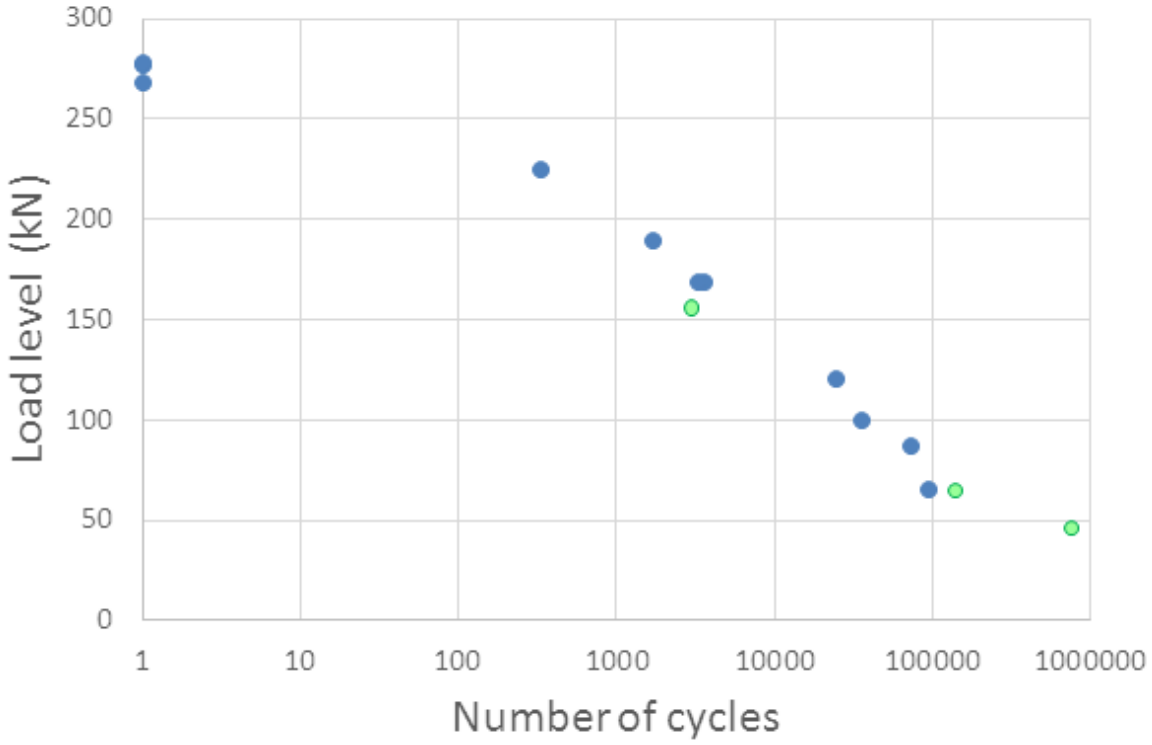


Picture of the tested samples with static load
Test sample nr. 3

Results from the testing of wood and joints

The first group of three samples were tested to failure to establish an estimated failure load.

Another 11 samples, were tested with a sinus shaped cyclic load with a stress ratio between the “upper” load and the “lower” load of R = -1.



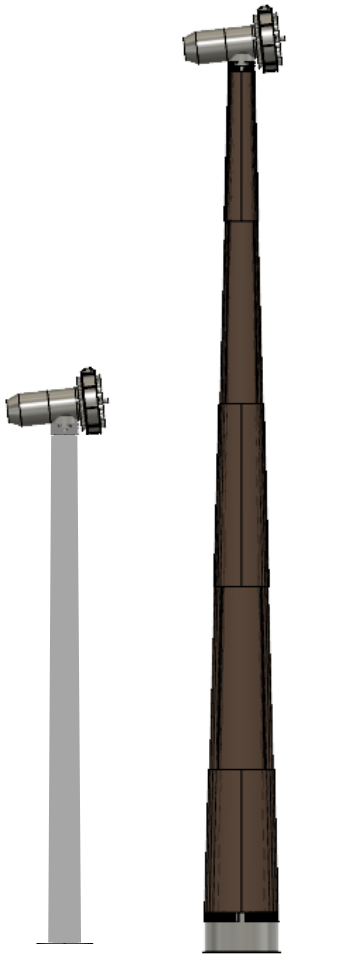
Loads and results for the tested samples Blue dots mark “Failure”, Green dots “Test stopped without failure”

First pilot tower is now in manufacturing

The first pilot tower, 30 m height, will be erected this year,

designed for the Chalmers University test turbine in Gothenburg.

Manufacturing at Moelven in Töreboda



Original steel tower
vs updated wooden tower

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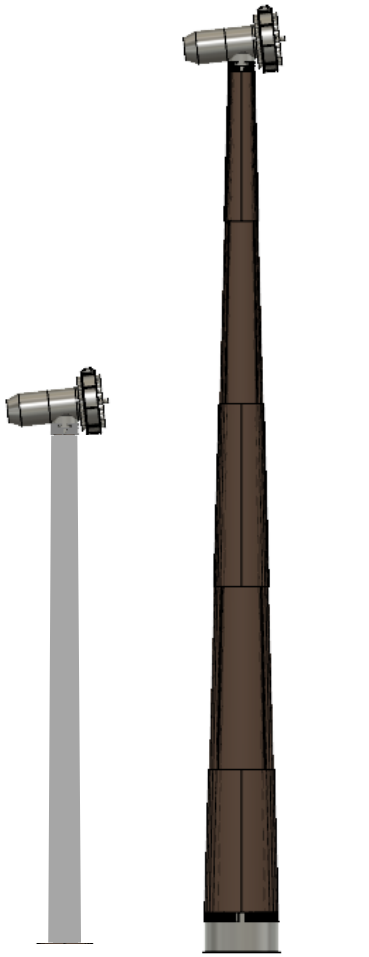

Original steel tower
vs updated wooden tower

First pilot tower is now in manufacturing

Leftover material from the manufacturing

of the first tower.

The mass of this piece is ¼ of a kilo.

The density is about 500 kg/m^3

The density of steel is 16 times higher.