



14 Story TREET project under construction in Norway

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Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

Project group

Bergen- og omegn boligbyggelag (BOB) is a Norwegian housing association. Part of their strategy is to build sustainably in urban areas. In 2010 BOB proclaim that they want to build the world's tallest timber building.

BOB established the following project group to develop the project:

Sweco – engineering

Artec – architecture

Moelven – glulam and CLT structures

Kodumaja – building modules

Where is Bergen?



Location



Toward taller wood buildings. Chicago. Nov 2014

The plot in Bergen



Toward taller wood buildings. Chicago. Nov 2014

Bergen, Norway – 14 story building



“Treet” (The tree) is under construction now.

The first timber elements were installed last month.

Residents can move in autumn of 2015.

Net area of 5830 m².

There is a webcam service in operation

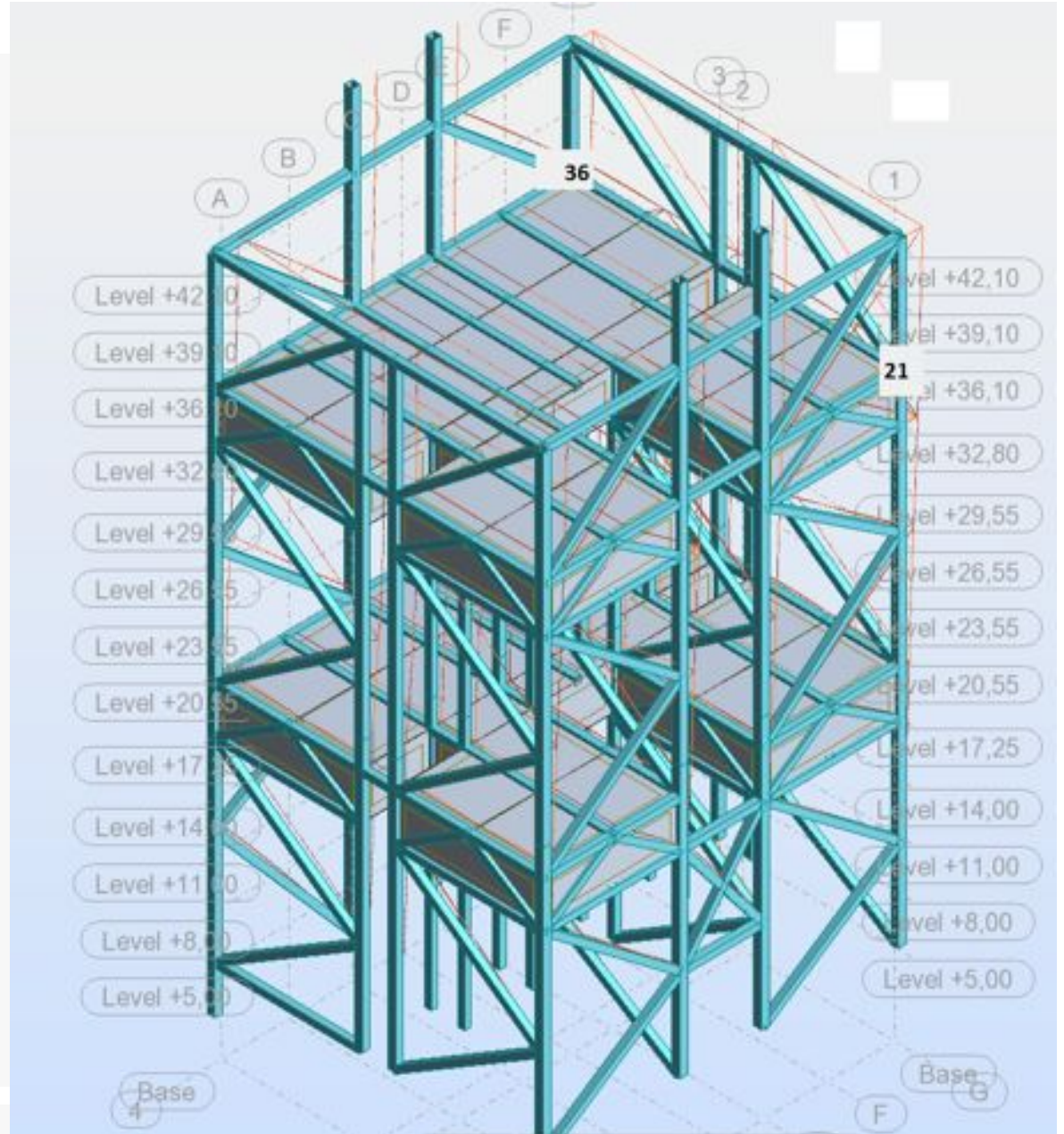
Facts

- Total height 52.8 m (173 ft)
- 550 m³ glulam
- 385 m³ CLT
- The building stands on top of a concrete garage.
- Foundations piled to the bedrock
- Drawn in 3D. BIM. Autodesk Revit.



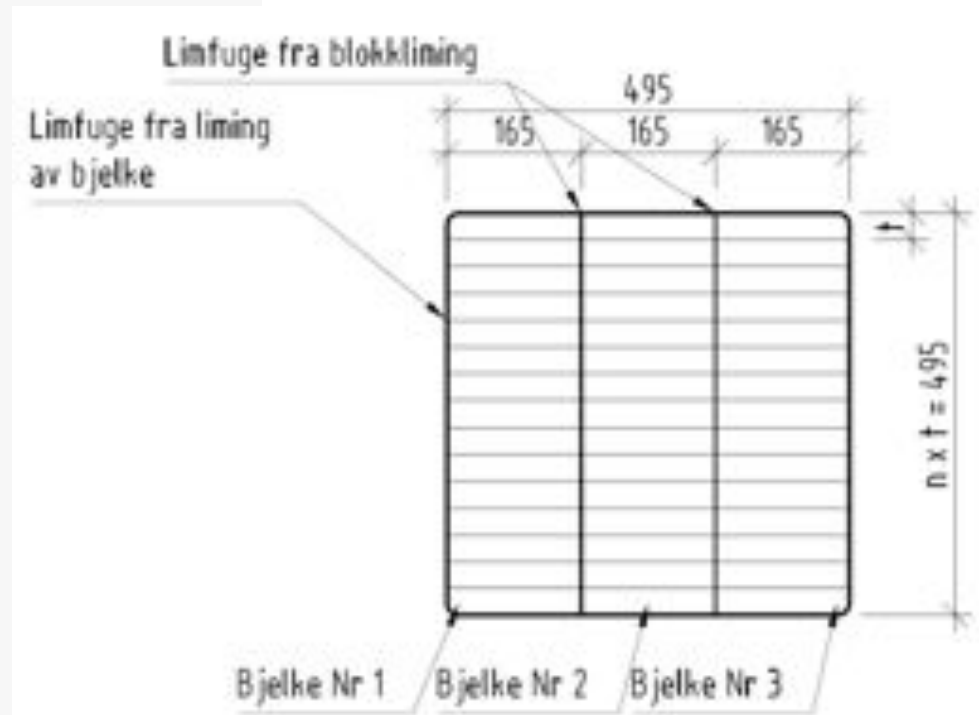
More facts

- Calculated using the software Robot
- Concrete decks serve as extra weight as well as platform for modules
- 71 mm max horizontal deflection (Level 14)
- Prefabricated timber frame based building modules are inserted in the “cabinet rack”



Even more facts

- Large glulam sections are block glued
- Typical column: 405x650 and 495x495 mm
- Typical diagonal 405x405 mm
- Glulam carries all vertical load



... and then some facts

- Wind load from 8 directions was applied for design
- The building is not designed for seismic loads. It's so tall that the wind load prevails, which means that seismic design can be omitted according to Norwegian code
- Highest compression force in a column is
4287 kN = 437 tons

Engineering choices

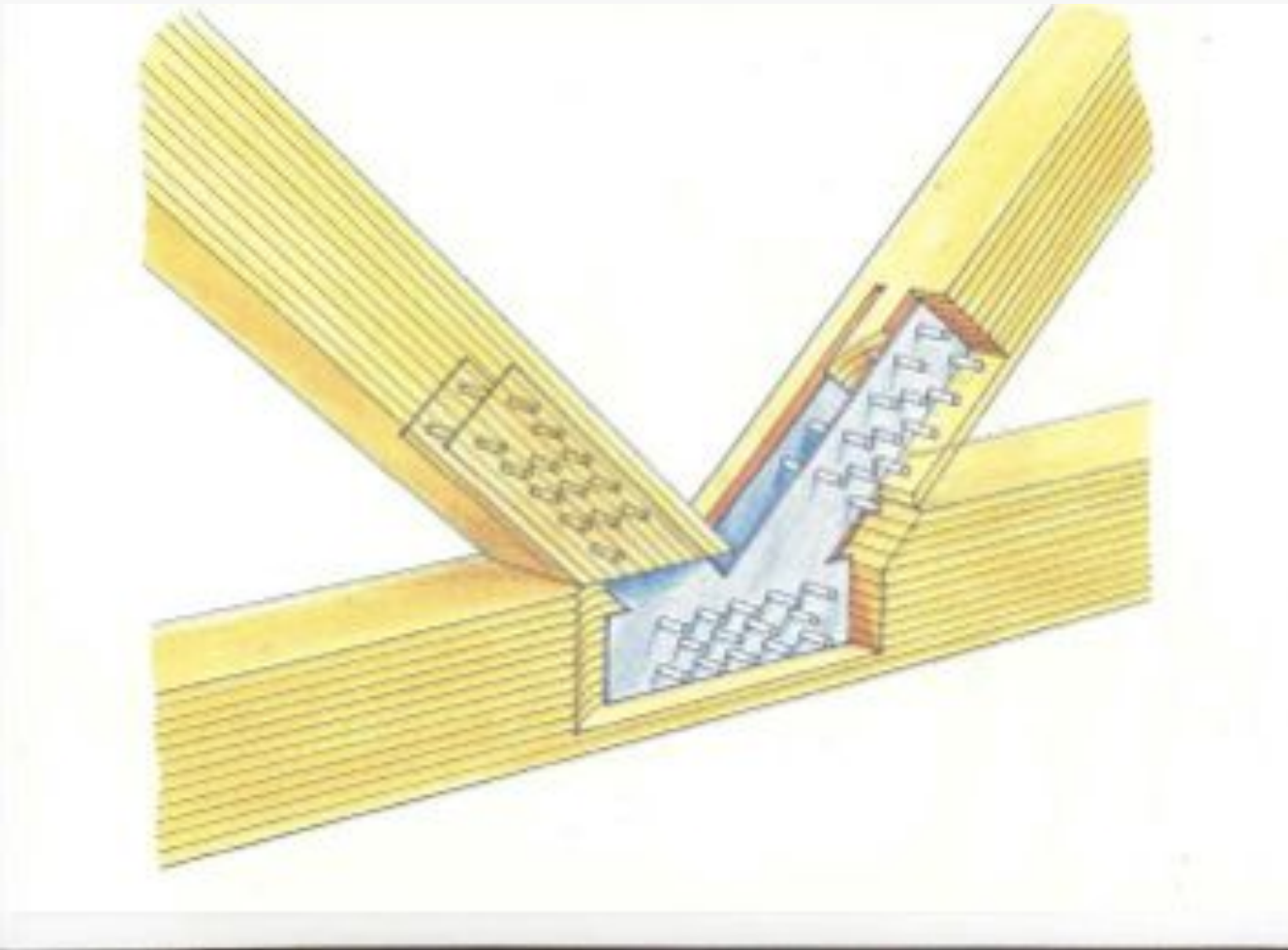
- Sweco used glulam trusses for this 5 story complex in Norway in 2005. This worked well and was chosen as a basis for the high-rise system



Toward taller wood buildings. Chicago. Nov 2014

Engineering choices

- We chose to use proven technology for connections of large timber structures. Slotted-in steel plates and dowels.



Engineering choices

- To limit the need for maintenance a permanent weather protection system was chosen.
- The north and south facades have glass to protect the timber structure
- The east and south facades have metal cladding
- In this way the timber can be regarded as protected

Engineering choices

- The main load bearing is handled by glulam alone. CLT is used in the staircases, elevator shaft (15 stories), some inner walls and balconies, but is not structurally connected to the glulam
- Concrete decks are used on three levels in the building mainly to improve dynamic behavior, but also to serve as platforms for stacking building modules

Engineering choices

- To reduce the work on site and reduce building time, we wanted to prefabricate as much as possible.

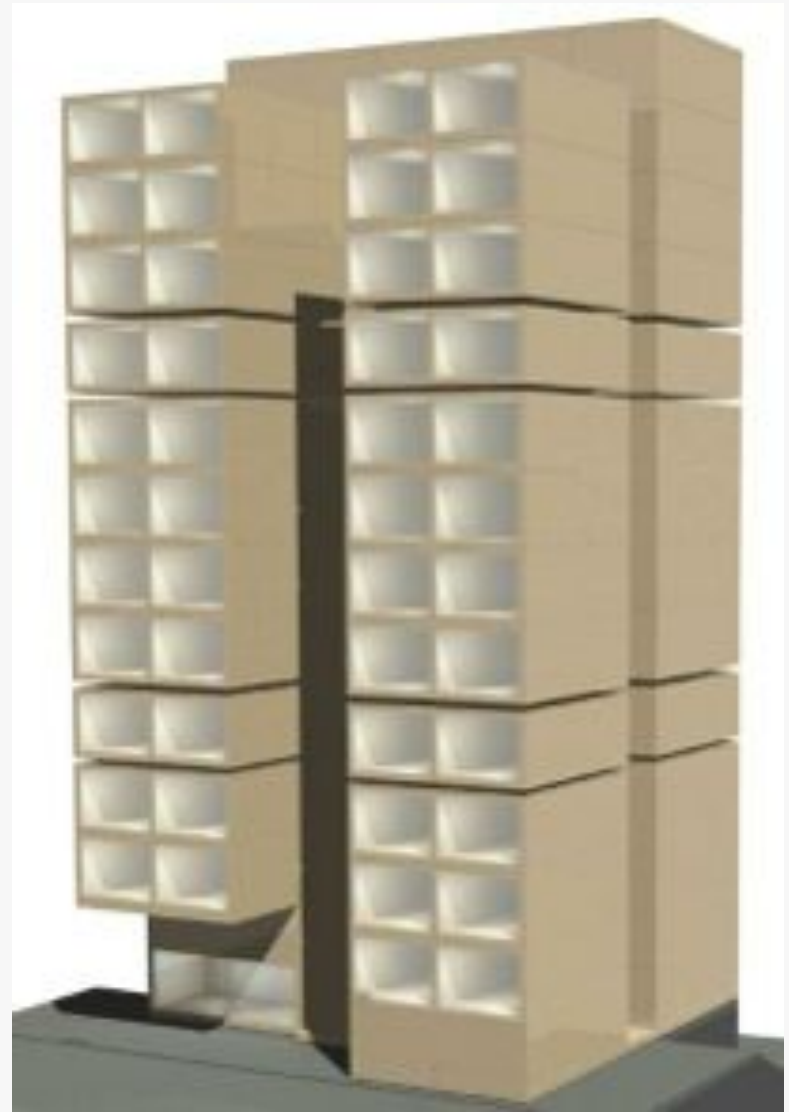


Timber frame
modules

Each module /
apartment
complies with
the passive
house
standard

Building modules

- Modules are stacked up to four levels high
- Single level in the power story
- The stacked modules are only connected in the bottom to the slabs.



Typical plan



Toward taller wood buildings. Chicago: Nov 2014

Structural fire design

- Timber is not a pre-accepted material for highrises in Norway. However, Norwegian regulations open up for alternate materials as long as required documentation is produced
- Fire design is done according to the Eurocode.
- Timber can burn. In this project the glulam is so thick that we allow it to burn for 90 minutes without failing. No extra gypsum is used on the glulam.
- All steel connections are hidden inside the timber. In this way it will not fail within the required fire resistance time
- In addition there are sprinklers, pressurized escape stairs and painted surfaces to improve fire safety

Serviceability

Lack of information on dynamic values. Testing was needed!

Norwegian University of Science and Technology, NTNU, performed the tests.

The building module manufacturer provided modules.

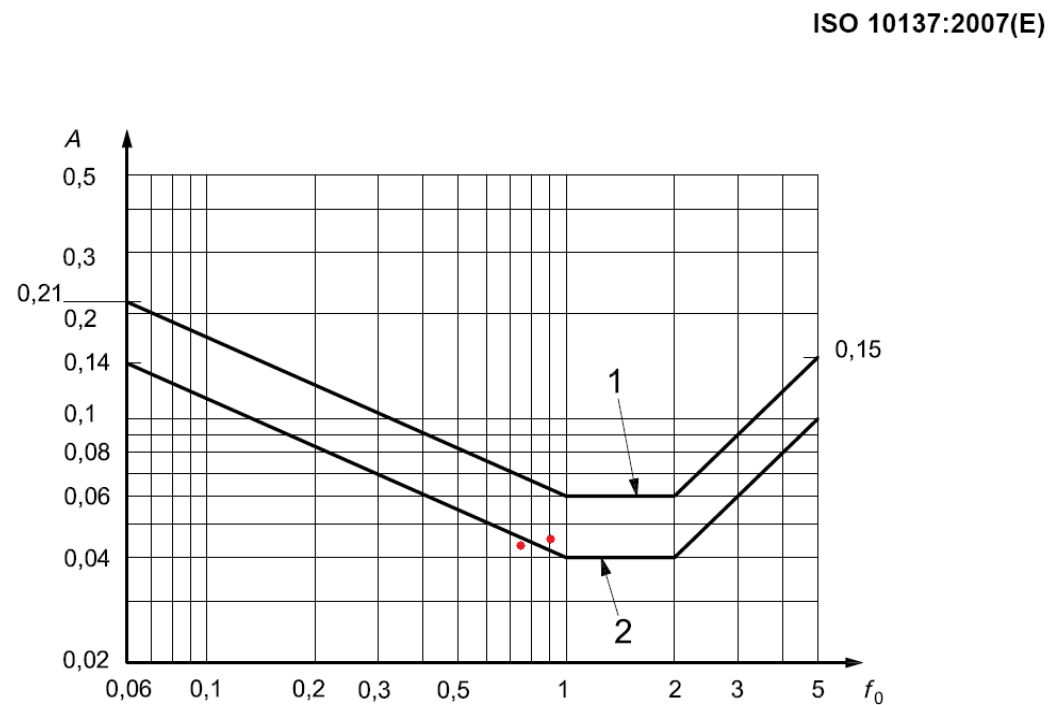
Non destructive testing of similar modules.

Impact hammer and accelerometers.



Results, serviceability

Results plotted into evaluation curves given in ISO 10137:



Key

A peak acceleration, m/s^2
 f_0 first natural frequency in a structural direction of a building and in torsion, Hz

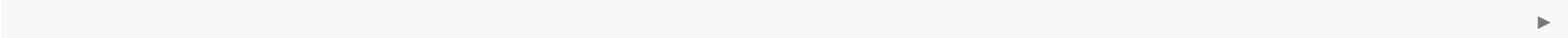
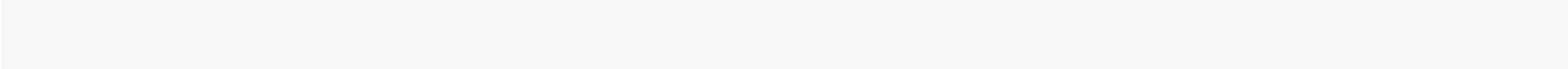
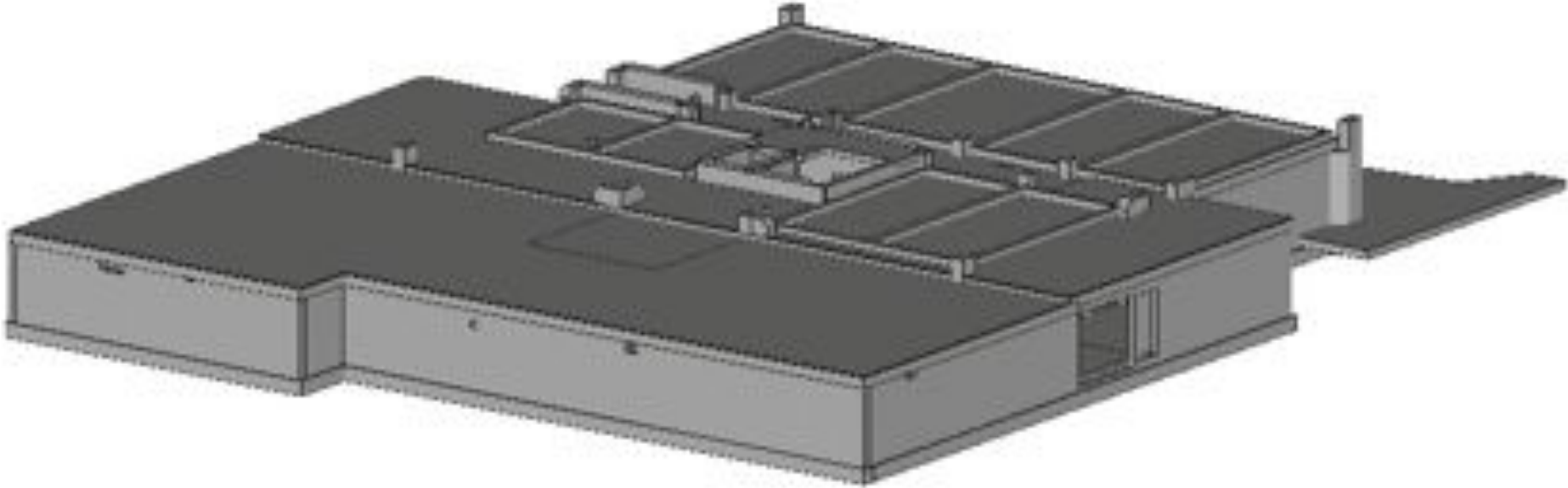
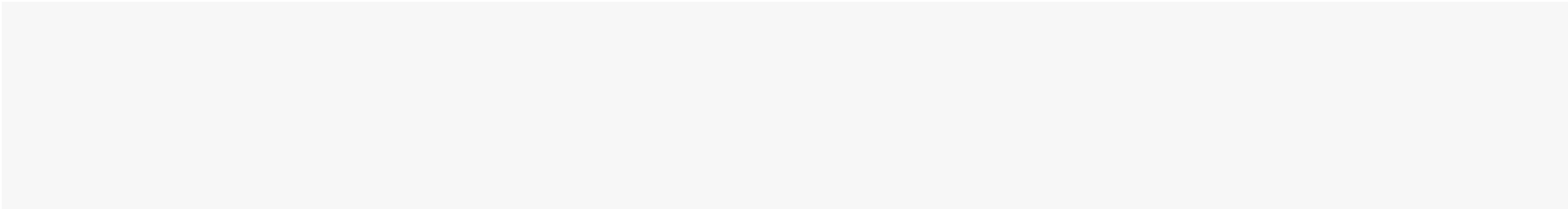
- 1 offices
- 2 residences

Figure D.1 — Evaluation curves for wind-induced vibrations in buildings in a horizontal (x, y) direction for a one-year return period

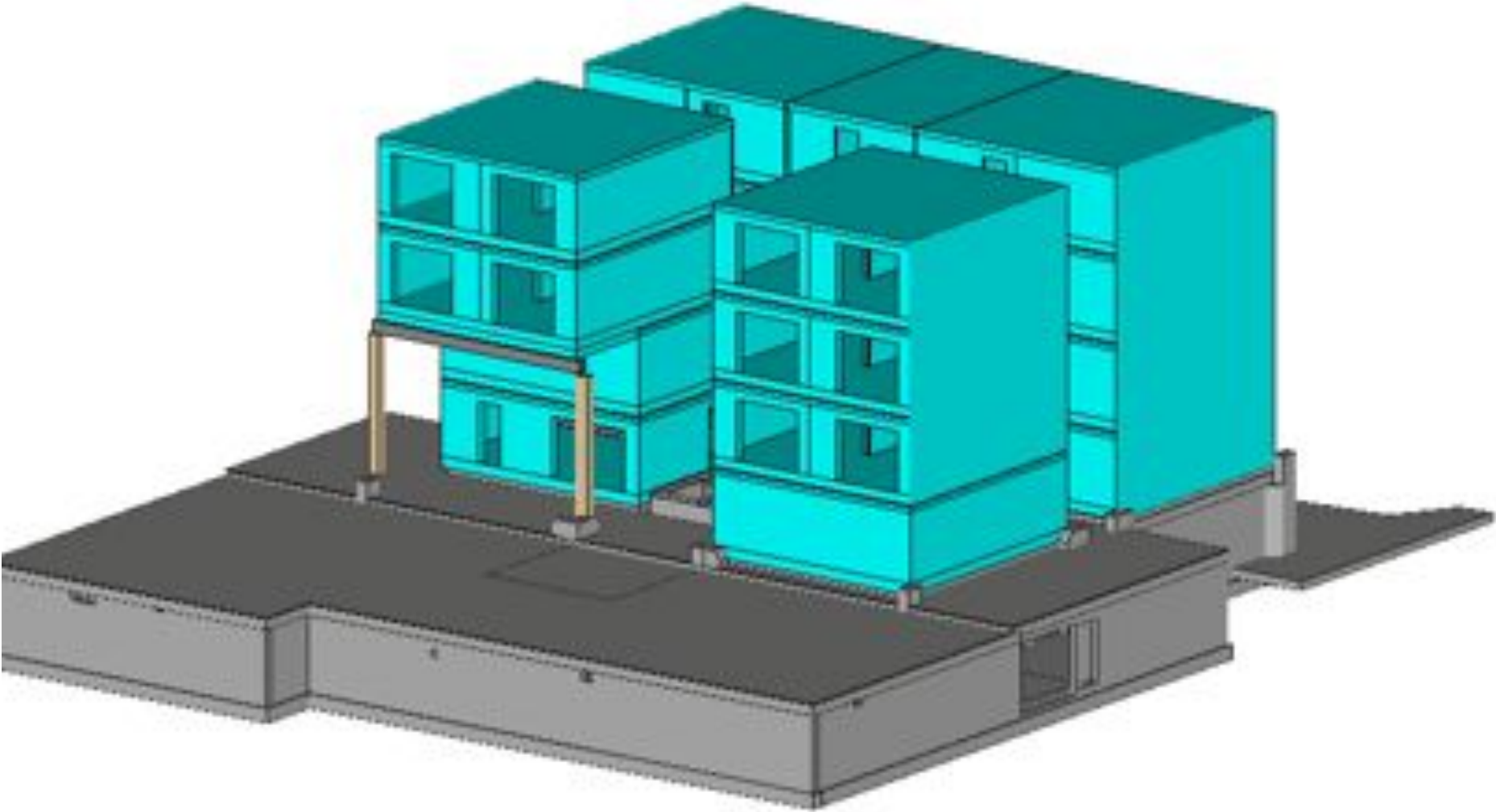
Conclusion, serviceability

- Residents in the top floors might in rare cases feel vibrations, but it is very unlikely that they will become uncomfortable.
- The chosen structural solution for "The tree" using glulam truss works and stacked prefabricated building modules gives a robust design and most probably insignificant effects from vibrations caused by wind exposure.

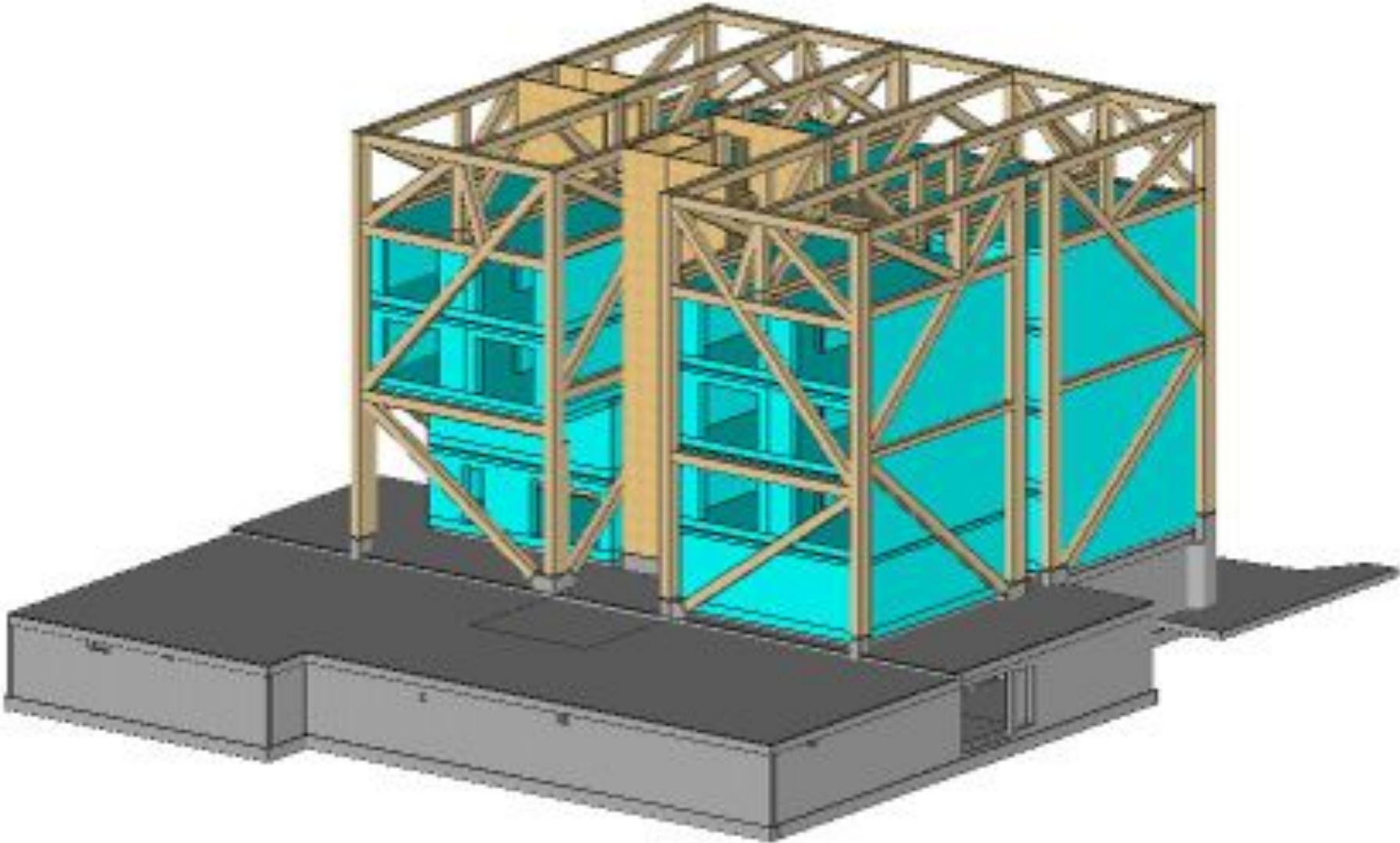
Assembly. Step by step



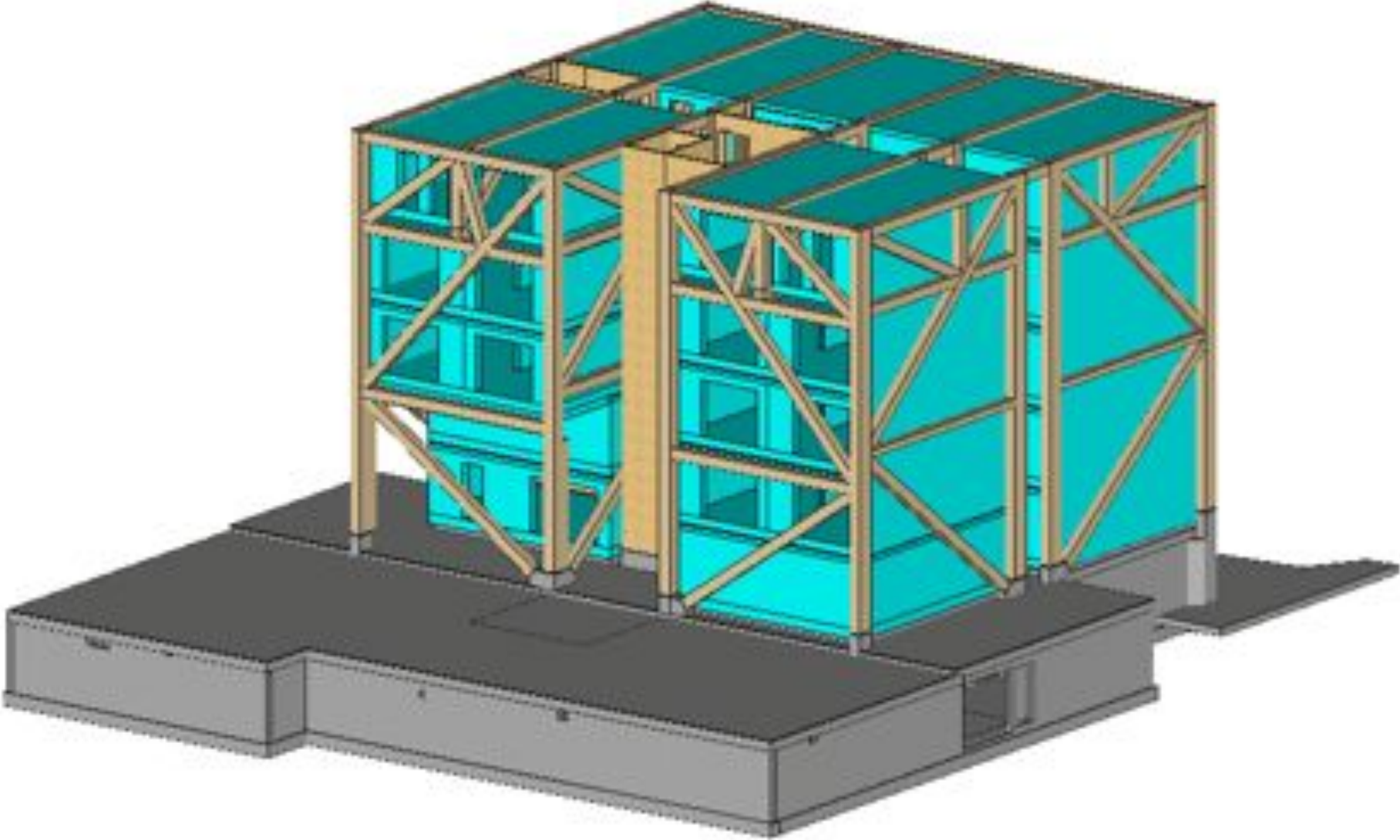
Assembly. Step by step



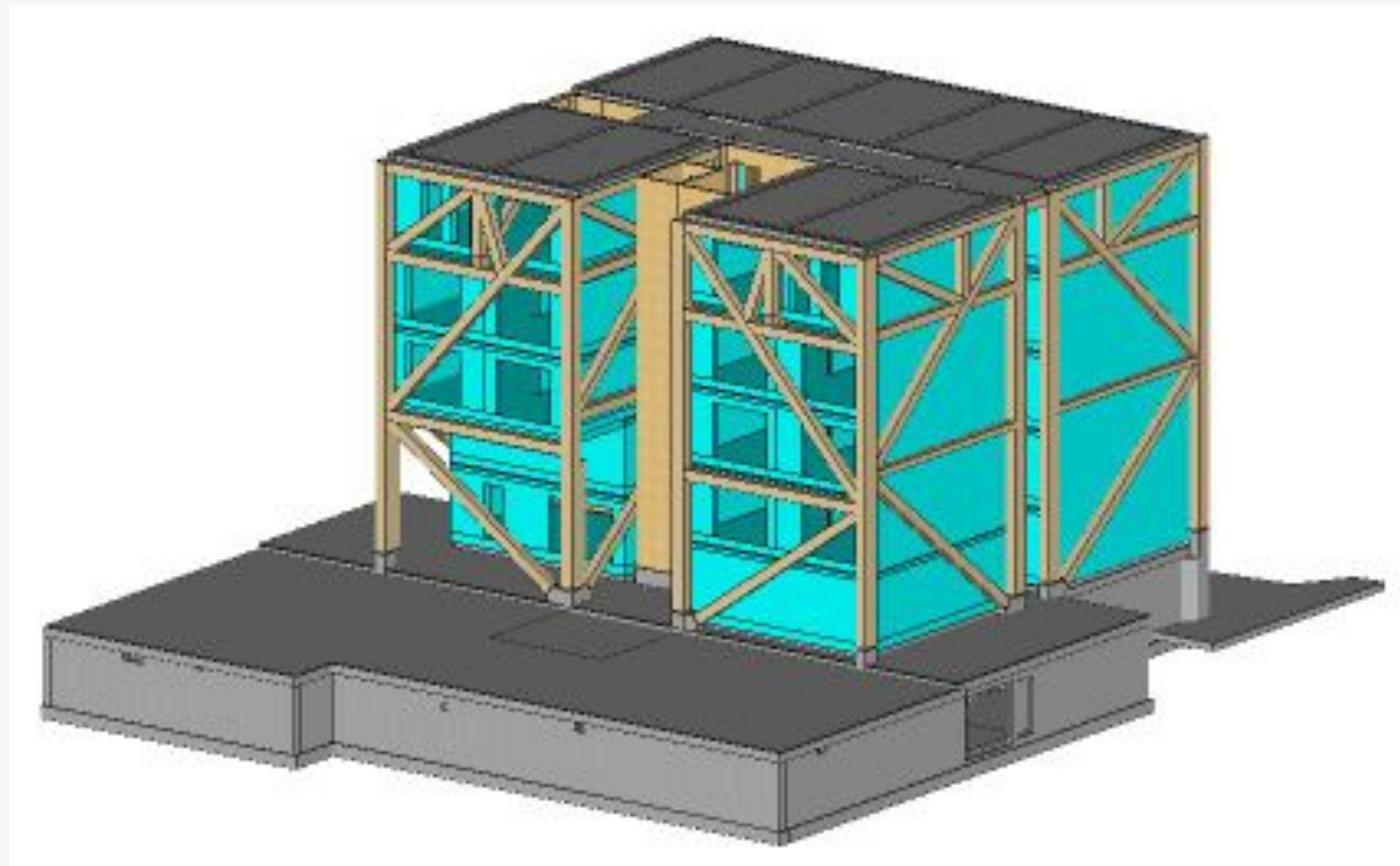
Assembly. Step by step



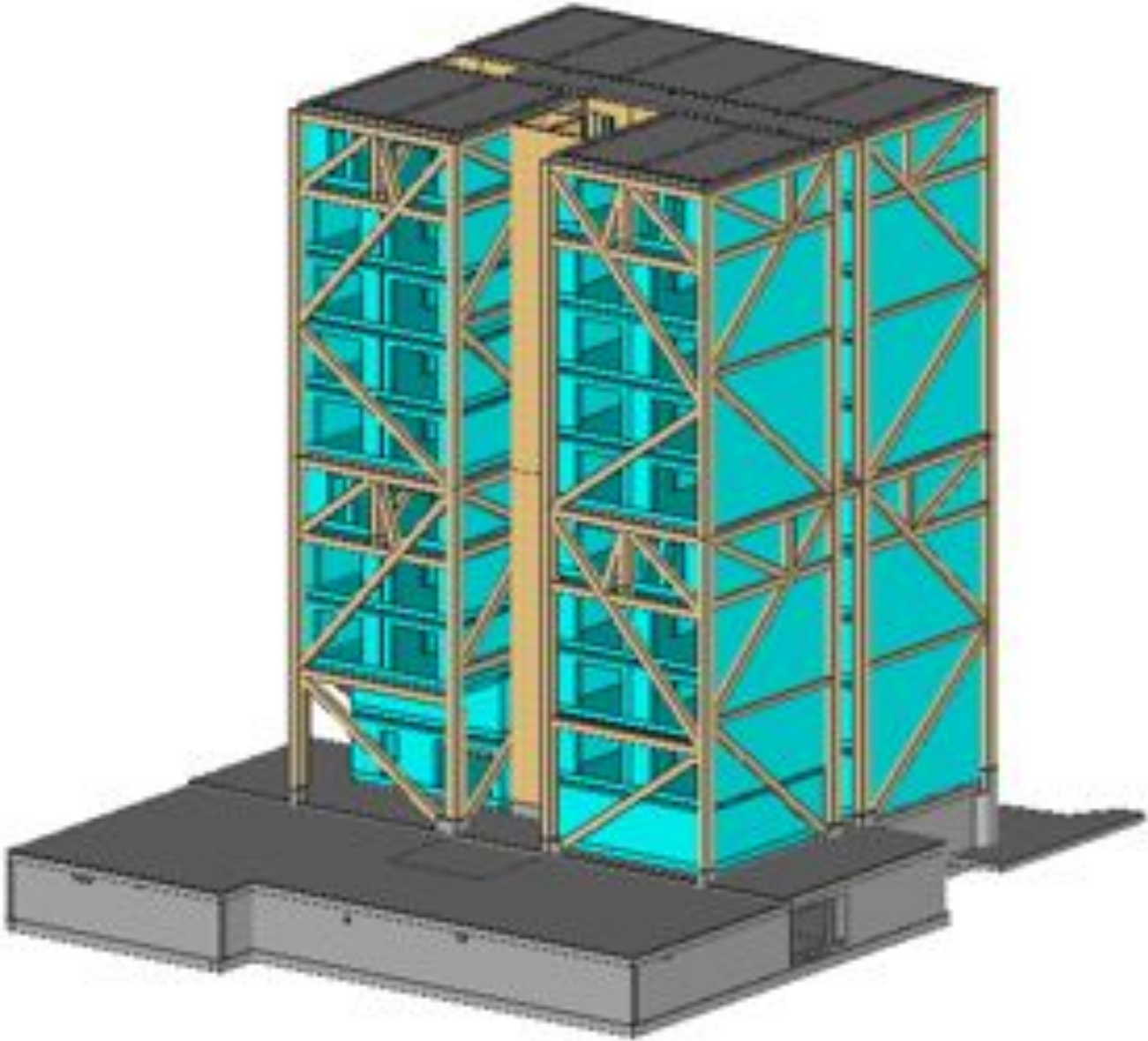
Assembly. Step by step



Assembly. Step by step



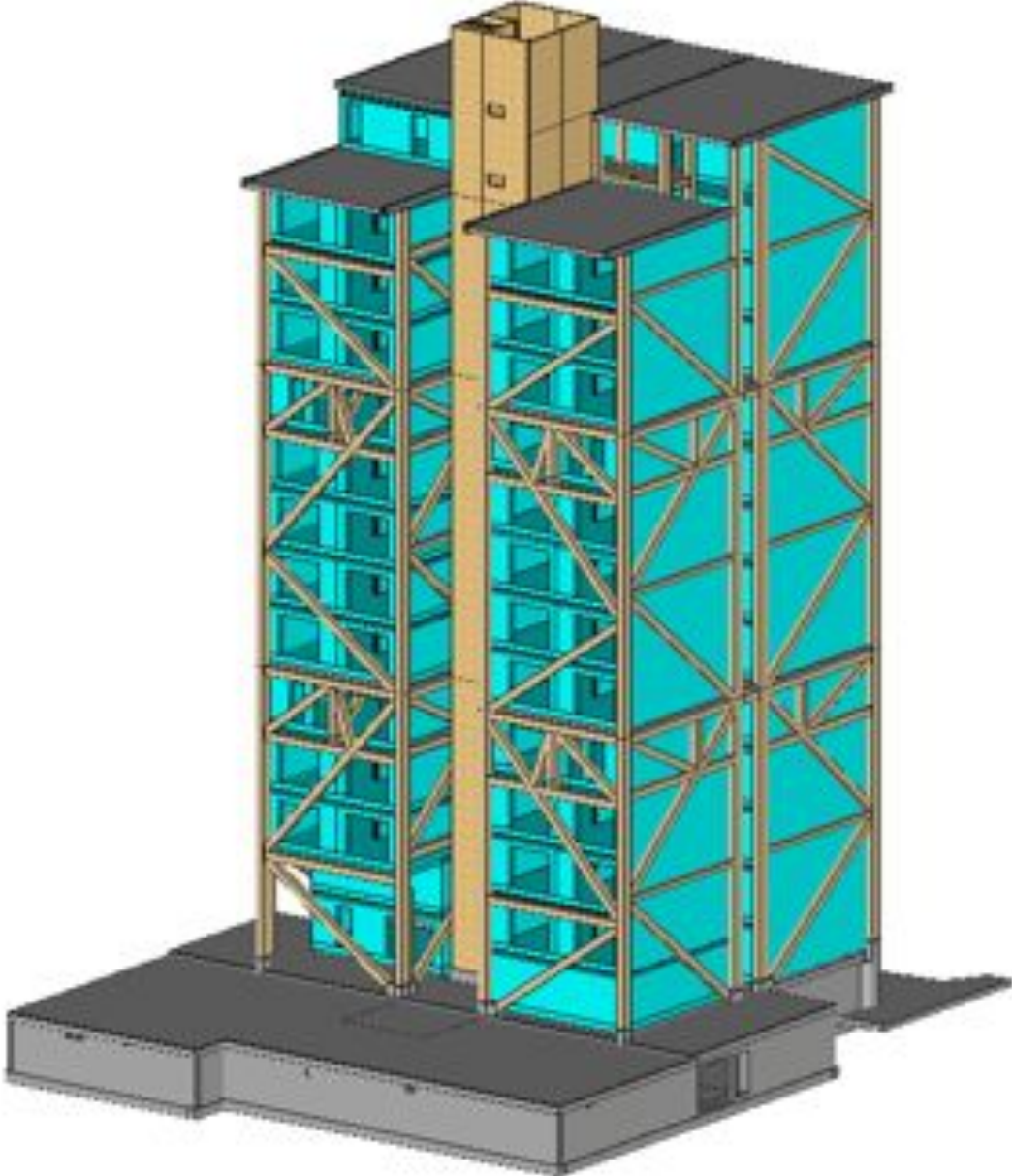
Assembly. Step by step



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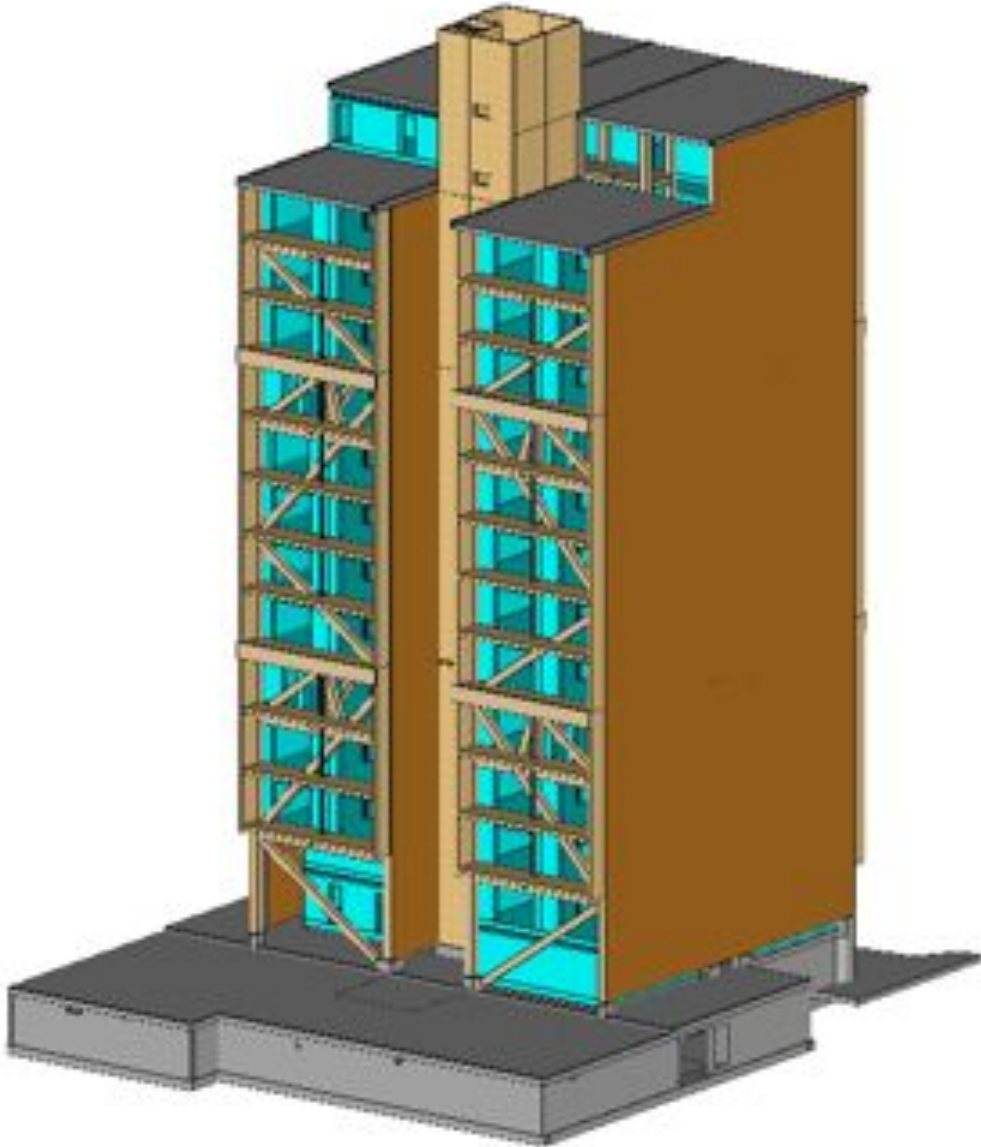
Assembly. Step by step



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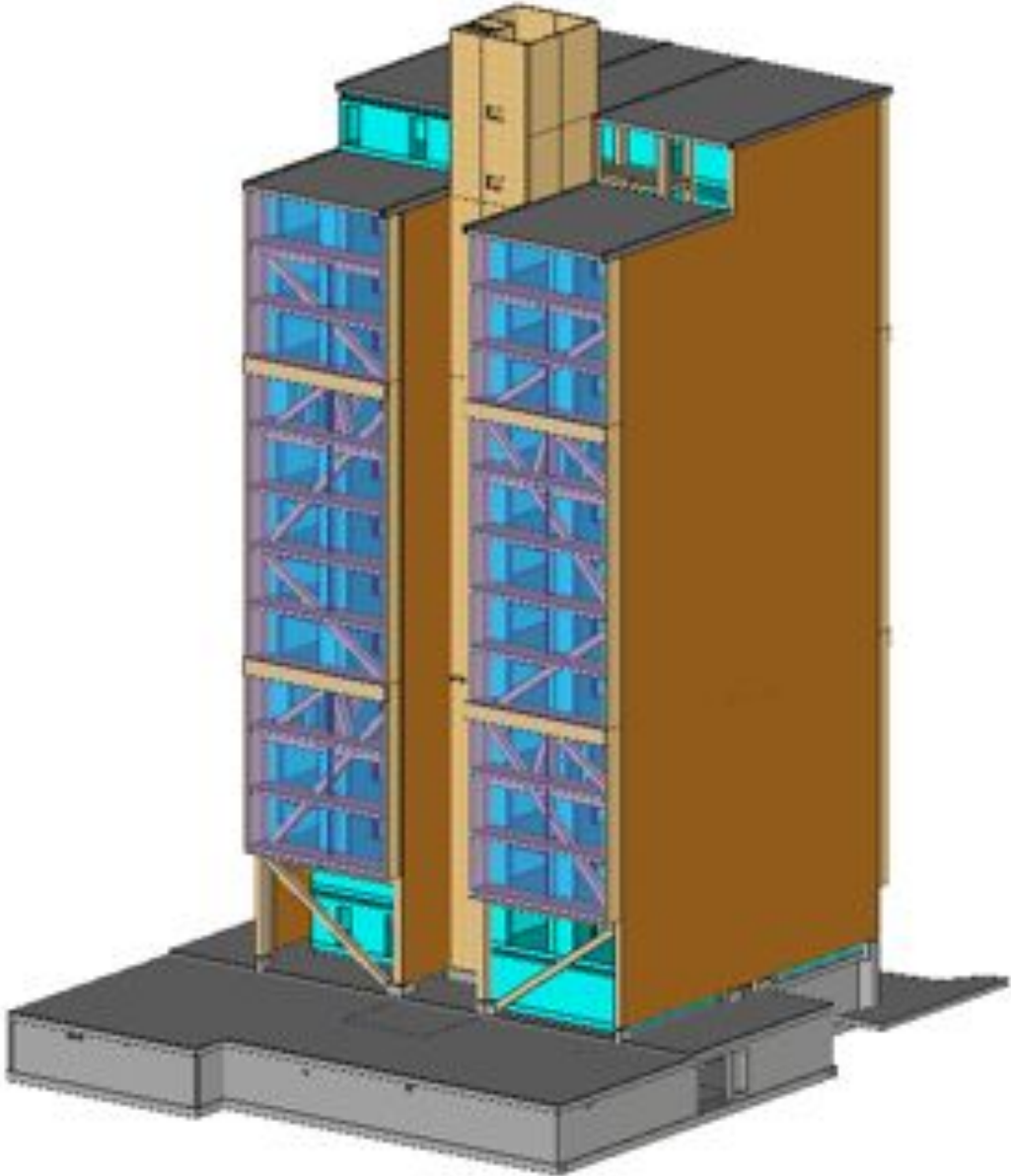
Assembly. Step by step



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Assembly. Step by step



Toward taller wood buildings. Chicago. Nov 2014



Picture taken 2 months ago



Toward taller wood buildings. Chicago. Nov 2014

Picture taken 1 month ago



Toward taller wood buildings. Chicago. Nov 2014

Webcam in operation

You can follow the construction process and check out videos using this link:

http://www.sweco.no/no/Norway/Nyheter/2014/Webcam_Treet/

Google *Sweco+webcam*



Costs

Construction costs are comparable with similar building in steel or concrete. But, BOB do not reveal construction costs or budgets at this time.

Treet is a pilot project, and costs for development and innovation have been financed by BOB.

Average price for apartment: US\$ 7700/sqm = US\$ 715/sqft

Main challenges

- Comfort criteria. Low weight -> higher accelerations
- Obtaining structural data for building modules
- Safe work operations in the air
- Avoiding moisture during erection
- Designing maintenance friendly solutions
- Getting the fire concept approved and implemented
- Project economy. Risk control to avoid overpricing from suppliers not familiar with the concept

Conclusive remarks

Timber high-rise is a good answer to sustainable building in urban areas

The chosen concept is robust and feasible

It's possible to build lower and higher with this building system

Feel free to challenge the world record!





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Make a visit to Bergen next year!



**Thank you for
your
attention!**