

World of Volvo, Gothenburg - Pushing the Boundaries

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1. Purpose of the Building and Architectural Intent

1.1 General

The World of Volvo is a unique experience center and meeting place for the famed Swedish brands, Volvo Cars and Volvo Group in Gothenburg that puts its focus on Scandinavian landscape, environment, and traditions.

After winning the interview competition for World of Volvo in late 2018, Henning Larsen started with the development of this new landmark building for Gothenburg.

"This project is incredibly special to us," says Søren Øllgaard, Design Director at Henning Larsen. "With its deep connection to Scandinavia, from its landscapes to its architectural tradition, World of Volvo has given us to the opportunity to explore the profound relationship between architecture and the natural environment."



Picture1: Rendering - Southwest view

World of Volvo will unite the brands of Volvo Group and Volvo Cars to share the history, tradition, and future of the famed Swedish brand in a single structure. It will be an embodiment of the Volvo brand values and aspirations.

"We commit to create a landmark, a new icon and destination in the city centre of Gothenburg. We also commit to gathering people in an inspiring meeting place reflecting Volvo's human centric approach and perspectives. Our aim with World of Volvo is to deliver a premium experience in a place where we combine entertainment; exhibitions, talks, conferences, and music, as well as food, drinks and shopping says Magnus Wrahme CEO at World of Volvo.

Located in Gothenburg's Event district (home to many of the city's museums, parks, and entertainment venues), the project is expected to be completed in late 2023 and open to visitors in 2024.



Picture 2: Rendering – Interior view to one of the tree trunks

1.2 Allemansrätten

World of Volvo is designed around the Swedish concept of “Allemansrätten”, (Jedermannsrecht in German) denoting the fundamental right that all citizens share to nature: the right to roam freely on any land (public or private), showing consideration for nature and for others. This tenet has become not just a right, but a central part of the Swedish ethos and one that lives in citizens, businesses, and organizations alike – Volvo included.

The circular form of World of Volvo, encompassing both care of nature and consideration for people, encourages visitors to make their own experience both inside and outside, regardless of whether they hold tickets to the exhibitions inside.

“Our goal was to give form to something very essential to the Swedish spirit. World of Volvo’s circular form, the timber materiality, its integration with the landscape, and, fundamentally, its openness – these things are all parts of a core collective identity,” says Martin Stenberg Ringnér, Associate Design Director, Sweden.

World of Volvo’s timber construction is at once the most forward-facing and most traditional element of the project. While Sweden (like many Nordic countries) has a long tradition of timber construction, World of Volvo takes a decidedly modern approach. The beams and columns are built from glulam timber. Computer-controlled fabrication allows the curved glulam pieces to be cut with a high degree of precision. Rigidity and continuity in the structure is guaranteed with metal connectors that can be hidden inside the wooden members. The floor and roof slabs are made of locally sourced CLT, cross laminated timber.

1.3 Embracing Swedish Nature

The reference to nature in the arcing “branches” and roof “canopy” is by design, with the concept for the structure centered around the idea of The Mountain (the landscape and building’s base) and The Tree (the building itself.)

The large landscape that surrounds the building brings the nature of Sweden to the center of Gothenburg, covering the area in delicate flowers and native plants that bloom between, rocky outcroppings and meandering paths. And just like in the landscapes across the country, visitors are encouraged to inhabit the landscape however they like, keeping in mind the principle of *allemansrätten*: leave no trace.



Picture 3: Landscape on top of main roof plus pavilion

The approach brings a native piece of Swedish nature to the middle of the city of Gothenburg. The landscape, from the Swedish quarries and the wooden structure, built with the pine trees, moss, and shrubs of the Swedish forest, make up the nature surrounding World of Volvo.

Growing out from the Mountain are three vast “Trees”, their trunks large enough to contain small exhibit spaces, vertical circulation, brand exhibition, and service functions. The open space between the trees is left largely empty, save for sculptural stairs (the fertile Swedish forest floor) that link the level and exhibit items that dot the floor. The interior space blends smoothly with the outdoors, a floor-to-ceiling glass façades creating a seamless transition into the sprawling nature beyond.

A fundamental conceptual target was to build a meeting place. What a fabulous idea to create with three tree trunks a memory to the meeting place many years ago (as per picture 4)



Picture 4: "Meeting place" - many years ago

1.4 A New Icon for Gothenburg

Located along Mölndalsån, the site for World of Volvo links to a promenade that traces the stream's eastern bank up to Gothenburg's city center. A number of green and functional cross-links of different types connect both sides of the river, allowing visitors to wind their way towards the site as they choose. While these links promote physical accessibility for walking and cycling, they also restore Mölndalsån's and visual connectivity.

On the other side of World of Volvo site passes the E6 highway, from which travellers will catch a high-speed glimpse of the project's tilted roof and exhibitions inside (Picture 5). Whether passing from the east at 80km/h or from the west at 5km/hm the building doesn't fully reveal all its spaces from within. It is up to the visitors to make their way and determine their own experience.



Picture 5: Rendering – northeast view from the highway

2 Design, Fabrication and Install of the Timber Structure

2.1 Total Stability

When WIEHAG joined the design team, the total stability of the timber structure was first challenge to solve.

The vertical loads are transferred from the roof beams to the faced columns and tree trunk columns.

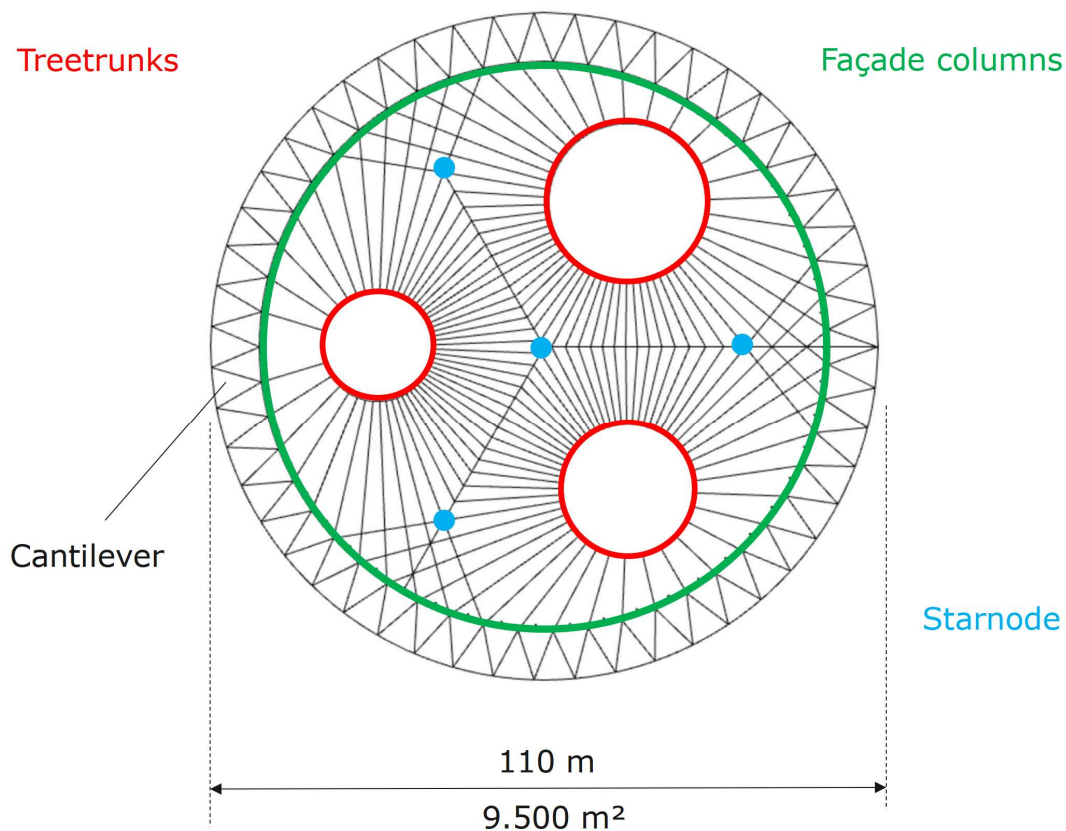
As there is another building (the pavilion) standing on top of the main hall, plus a quite organic shaped park landscape on the main hall roof, the loadings onto the main hall structure rolled out as fairly extreme.

The beam layout of the main hall has a kind of regularity (see picture 6). WIEHAG tried out several options of where to make the beams continuous, where to splice them and where to put pinned or moment rigid connections. At the end of the process, we decided on rigid star nodes in the location of the worst deflection, and to make all beam junctions as moment rigid. This means there is not a primary / secondary hierarchy, as it is a moment rigid grid.

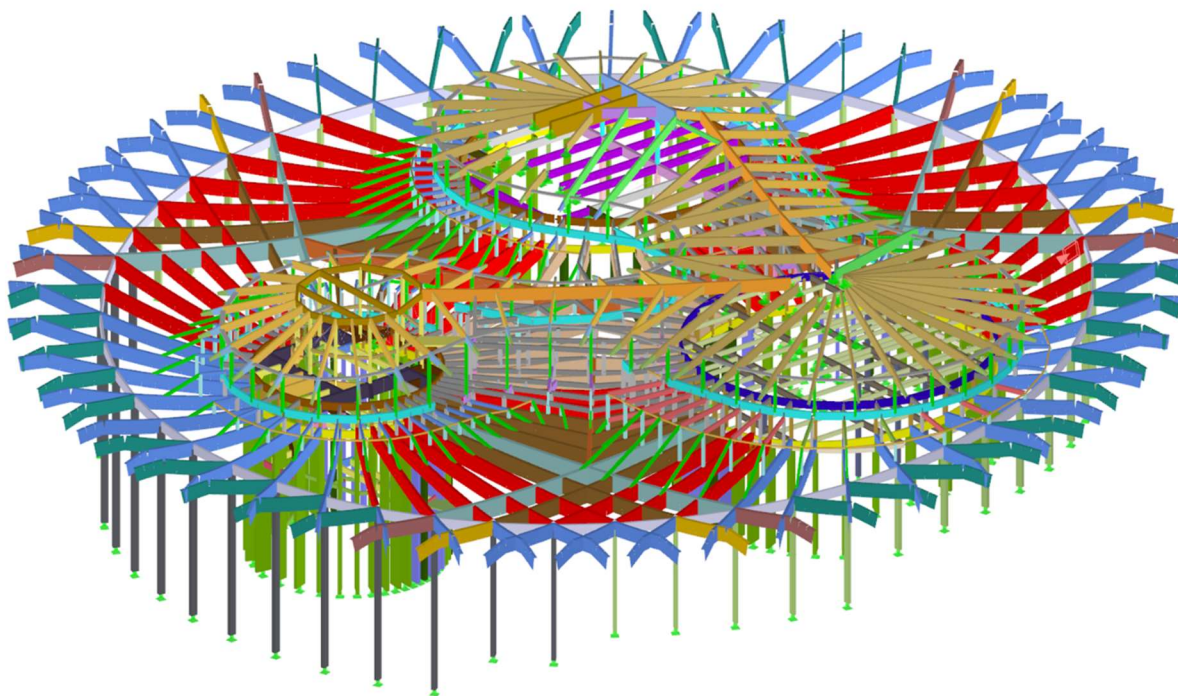
There was a strong architectural requirement for "no bracing" in the façade line, and whilst bracing in this outer circle would have been an immense help with achieving total stability, it would not have met the architects vision: Plus, if it had been easy, WIEHAG would not be on the job!

Therefore, the total lateral stability is achieved with a combination of portal frames with moment rigid corners, and the diaphragm action of the CLT roof deck.

The cylindric form of tree trunks with the tension ring on top also gives some lateral stability, as it works similarly to a huge vertical tube. All columns are pinned at the base connection using WIEHAG's neat factory fitted connectors.



Picture 6: Plan view – Beam layout of main hall



Picture 7: Total 3D structural model (Dlupal)

2.2 Details

The corner connection of column to beam is not only the architectural signature detail, but also the most important structural connection. With forces of up to 2,300 KNm being taken by this connection.

We decided on a machined curvature, rather than to manufacture it as a bended solution, which would have resulted in very thin 15mm deep laminations, in lieu of the standard 41mm deep lamination that Glulam is manufactured from.

Steel plates with inclined screws take the tension and in combination with a defined compression zone, the moment can be transferred from the beam to the column. Screws for shear forces and very long reinforcement screws perpendicular to the grain, complete this highly engineered detail.

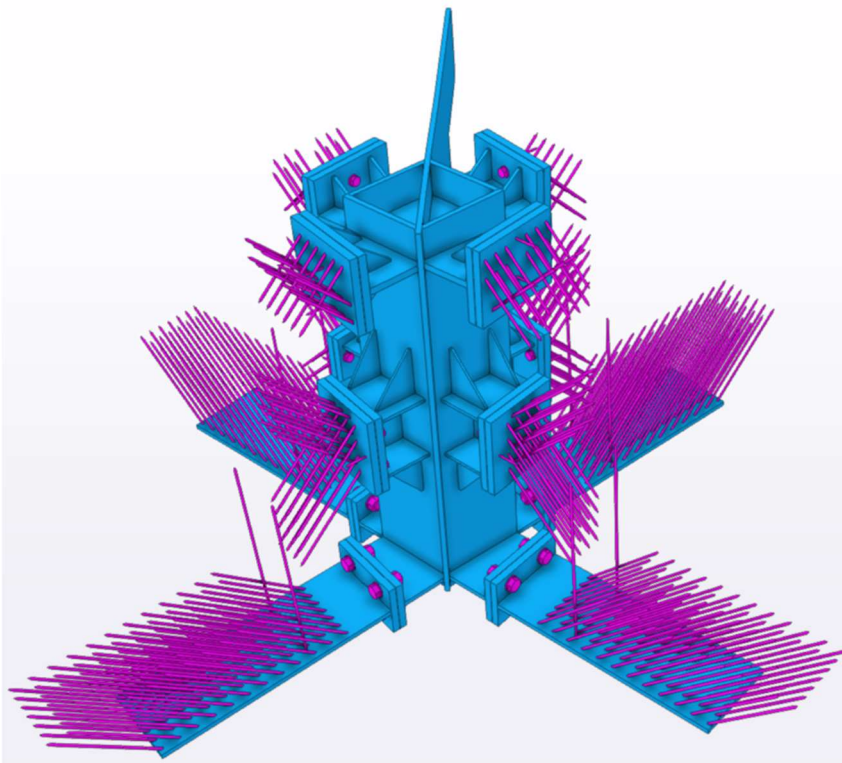


Picture 8: Curved corner connection during installation



Picture 9: Tree trunk corner as signature detail, all steel connectors are embedded

The Star node turned out to be a real beast (see picture 10)! As you can see the moments lead to high tension forces at the bottom and plenty of screws. We analyzed the node itself with FEM to ensure that we have the proper plate thickness.



Picture 10: Star node

If you are working with these high reactions, you have no chance with minimally invasive or standard connectors. Instead, it automatically leads to using really heavy steel nodes and very long screws.

The steel parts are all embedded and preassembled, meaning that almost all of the screws are precision installed at the factory. However, some bolts are site fixed, and therefore you need to get access to them during the installation phase. To cover these access areas, we used more than 4,000 timber infill panels made of three-layer boards (see picture 11). They are all test fitted in the factory to match with the direction of the grain. On site they have been removed and temporary fixed just next to the connection. We have learnt through experience that this is a good idea, as it avoids a logistics nightmare or puzzle game! However, the exposure to UV light could lead to lighter marks on the beams surface where the boards have been temporary fixed (like a visible hand on a sunburn). Therefore, this exposure to UV should be as short as possible.

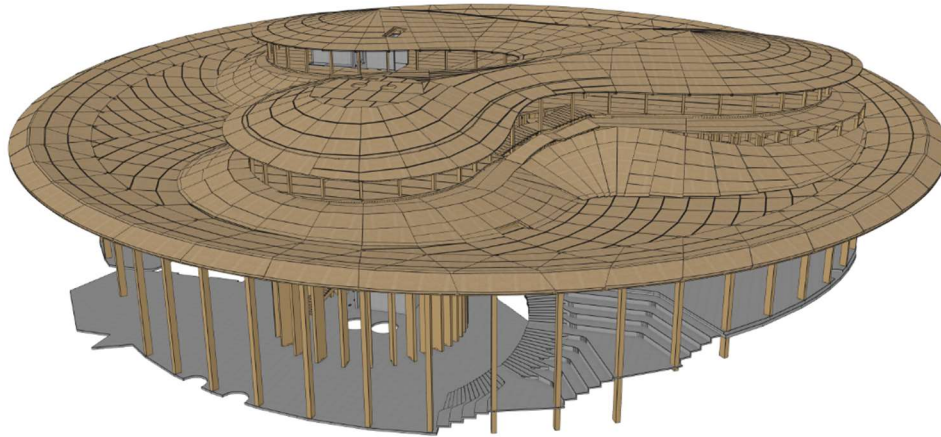


Picture 11: Cover plates around star node

2.3 CAD Model

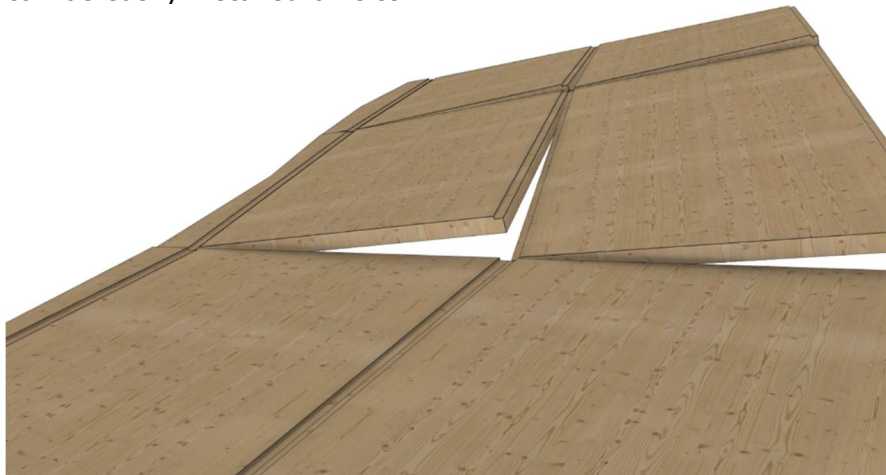
How do you start the CAD design on such a complex organic structure which goes over various levels? You need to start somewhere with a frozen line or frozen points: in our case that was the top line of the roof beams in the main hall and the column base points. Two of WIEHAG's engineers worked for more than a year to complete the 3D model, shop drawings and installation drawings. In total almost 9,000 drawings have been generated by WIEHAG for the timber structure.

Cadwork and parametric design were combined to create the 3D model, and the cloud-based BIM platform "Trimble Connect" was used to coordinate the timber model with other trades, which was vital to effectively deal with interfaces of the different packages.



Picture 12: 3D CAD model

The requirement to warp the CLT roof slabs, raised the question of how to implement that in the model? If you draw it warped in the model you also require additional flat shop drawings for fabrication. So, we decided instead to only draw it flat in the model. This means only three points of the panel are sitting on the glulam, which looks a bit funny, but works in the end! (See picture 13). We also tested the warping with a mockup to be sure that it can be easily installed on site.



Picture 13: Close-up : CLT - Warping

2.4 Fabrication & Shipping

The glulam is made of PEFC certified European Spruce, with a strength class of up to GL30c. Most of the glulam's is block glued due to the wide cross-sections.

Although one of our five giant CNC machines was completely reserved for this job, it turned out that this was the bottle neck during the fabrication process. However, we had factored in for a decent buffer of the product, which was stored at our factory and prevented any production related delays on site.

The pre-assembling of steel parts at the factory is very important in order to enable a quick and safe installation on site, as well as resulting in clean and neat connections.

The Glulam was shipped 1,400 km from WIEHAG's Factory in Altheim, Austria to Gothenburg. Thanks to Stora Enso's Swedish facility in Grums, whereas the CLT only had to travel 220 km. The max beam length of 33m was not a real challenge as the final route from the

motorway to the site was wide enough for the turning circle of the vehicles. WIEHAG organized the permits, escort cars and night deliveries which were required for delivering these long span elements with the minimal disruption. Obviously, only Volvo trucks were used for all deliveries of this package!

2.5 Installation

Three tower cranes were available for all of the trades, so effectively WIEHAG could use on average 2 tower cranes at any one time. Numerous MEWP's of different sizes provided safe access to the connections.

The 2,200 Glulam and 2,750 CLT single items were installed within 28 weeks. This is a really speedy mixed rate of only 20 minutes per item, using two cranes and 2 crews.

Only 65 printed installation drawings were provided for the crew on site, which is very few in relation to the scale and complexity of the project, and underlines how much prefabrication as carried out offsite by WIEHAG.

Nowadays tablets and mobile phones are complementing the large printed drawings, plus "Trimble connect" and Stora Enso's software "CLT360" were also of great help with coordinate the installation, and illustrates how the industry is embracing this new technology.



Picture 14: Birdsvie during installation of timber structure

The minor challenges that occur on any project were quickly solved with screensharing between WIEHAG's engineers in Austria and the team on site.

As water is the greatest enemy of timber, proper water management and temporary protection is vital to maintain the quality of the timber structure during the installation phase. A factory applied two pack clear hydrophobic UV coating was used to protect the glulam during the rainy days in Gothenburg.

The joints of the CLT were taped in one go with the installation. But of most importance was the good coordination with WIEHAG and the roofer, who was closely following us to

apply the watertight membrane. On days with a sunny forecast, we could even forget about the temporary tapes as the roofer was so quick!

Please see picture 14 where you can see the black bituminous membrane which was adhered onto the CLT to form a weather tight barrier.

2.6 Summary

WIEHAG are globally acknowledged as one of the leading pioneers in timber engineering, and are constantly seeking to push the boundaries using this sustainable, renewable, low carbon material. With the combination of scale and complexity, the World of Volvo is definitely one of these projects, elegantly demonstrating what is possible with sustainable timber design. The team has created an outstanding building that is sure to influence and encourage forward thinking clients and Architects to build in timber for year to come.

"Architecture is currently in the midst of a timber renaissance, with new milestones in timber construction being reached at breakneck pace," explains Filip Francati, Lead Design Architect at Henning Larsen. "But despite strides in structural development, aesthetic expression hasn't kept pace. World of Volvo has been an exciting opportunity to push the boundaries and we hope that it can set a new standard for the many ways we can use timber in architecture."

To make projects like this happen needs early engagement, collaboration and teamwork between all parties (plus a bit of luck!). Henning Larsens Architects approach met exactly with the clients requirements, and where brave enough to decide on timber.

Lindner Scandinavia led by Stefan Abrahamson, provided the key package of works for the project, including WIEHAG's structural timber, the ceilings and the façade. Their contribution to the whole process was crucial to keep the project on track.

The local builder BRA Bygg conducted this complex orchestra of so many different trades to a beautiful piece of music!

And most important of all, the great and generous idea of Volvo to invest in such a high-quality landmark building to the city of Gothenburg.



Picture 15: Teamwork; Design workshop incl mock up presentation at WIEHAG's factory

2.7 Impressions



2.8 Facts

Project name: World of Volvo

Client: World of Volvo

Location: Gothenburg, Sweden

Typology: Experience Center and meeting place

Concept: 2018

Construction Start: 2020

Expected Completion: 2023

Inauguration: 2024

Size: 22,000 m² ; 110m Diameter, 6000m³ of mass timber

Certifications: LEED Gold and WELL Gold

Main contractor: BRA Bygg

Architect: Henning Larsen

Landscape: Henning Larsen

Renders: Kvant1

Clients Structural Engineer (ground/concrete/steel): Optima Eng. AB & BRA Teknik

Façade and Interior claddings by Lindner Scandinavia AB

Timber Structure: Engineering, Production & Installation by WIEHAG GmbH