Clubhouse at Great Northern Golf Course

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Summary

The clubhouse of Great Northern Golf Course is a modern building with elegant structures.

The roof structure is a special structure inspired by folding a piece of paper – not into long rectangular planes, but instead into triangular planes. The elegant timber roof structure floats on cantilevered steel columns protruding from a natural stone wall.

Visually the roof structure is split into two layers which sit, one on top of each other. The bottom layer is the primary load carrying structure made out of laminated timber frames, and the top layer is the cover with wooden shingles on timber purlins that extends beyond the bottom layer.

The façade is designed using structural glazing with hidden connections to the roof structure and the natural stone walls. 12m high glass fins support the façade with elegant joints.

Keywords: Elegance in structure, folded roof, laminated timber, timber connections, structural glazing, glass fins, analysis.

1. Introduction

The overall architectural concept was to create a unique roof structure reflecting the surrounding terrain with tall marked rises varying from 4 to 9m towards west and less marked rises towards the east.

Three visual materials dominate the project: Natural stone, timber and glass. The natural stone is a part of the heavy base of the building, visualizing the stability of the building. The timber roof structure has the appearance of a tree growing out of the stone base. The glass structure is the invisible link between the natural stone walls and the roof.

Visually the roof structure appears to float over the massive stone walls, with a minimum of slender support columns.

2. Design and structures

The roof structure is the most significant part of the building. The overall form was designed by the architects and then further developed and designed by the engineers using parametric design tools such as Grasshopper, hand calculations and Finite Element Analysis (FEA) programs.

Each fold of the structural part (in the following called trusses) consists of a triangular laminated timber frame with a fan of smaller laminated timber beams inside the frame. The fan of laminated timber beams spread out from the bearing point at the column and stretch up to the upper part of the frame as shown in fig. 2.1.

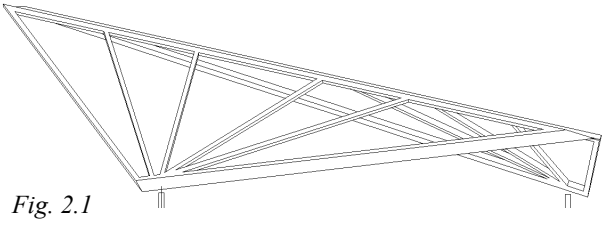

Fig. 2.1

The global design of the roof structure is first done by hand calculations and simplified design models. The results from the hand calculations are then verified/quantified by FEM design programs. The roof structure is stabilized by cantilevered columns fastened to the natural stone walls and cores.

The connections in the trusses between the frame and the fan beams are made with cut-outs as seen in traditional Nordic techniques. These connections also appeal to the layman and satisfy a certain intuitive feeling for the transfer of forces. The steel columns appear as if they only just touch the roof structure inside the columns perimeter, which gives the impression of an ultra-light roof structure.

The eaves are held up by purlins, that cantilever out from the underlying trusses. The purlins have a smaller cross section towards the fascia, which matches the reduced stress in the purlins and gives the cover of the roof a very slim expression.

The bearing elements in the roof structure along with the eaves, have a natural hierarchy which is visually satisfying. The proportions in the structure make sense and the size of the elements become a physical representation of the way the forces change throughout the structure.

Apart from the implicit stability design, ultimate limit state design and fire safety design, a numerous amount of serviceability limit state designs have been carried out. Deflection from both loads and moisture content in the wood have been analysed for each month of the year.

The façades are primarily made of natural stone walls and structural glazing. The west façade is up to 12m high with structural glazing and glass fins, which is an elegant way to build a façade with a minimum of visible structures.

3. Conclusions

The result – though still under construction – is a beautiful and elegant structure. The triangulated folded roof with the fan of laminated beams is a unique roof structure. The hierarchy in the roof structure make sense to even the layman as it satisfy a certain intuitive feeling for the transfer of forces.

3D modelling and parametric design has been essential in solving the complex geometry as the cover and the structural part has the same overall shape but different extends, height and batter.

Having glass fins and structural glazing as a façade system is an elegant and minimalistic way to support a very high façade.

The finish of the structural members and connections is of very high quality due to the dedicated contractors and the keen eye of the client and his consultants.

4. Acknowledgements

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Architects	E+N
Engineers	Søren Jensen
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Steel	Bjarne Knudsen
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Concrete	Hansson & Knudsen