lukas nordström
master thesis

DESIGN OF TIMBER STRUCTURES IN A PARAMETRIC ENVIRONMENT

12.273799 E 63.042831 N - STRUCTURAL AND CONTEXTUAL WOODEN DESIGN

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As awareness of the environmental and architectural benefits of building with wood increases, it becomes desirable for use in more complex projects, where demands on high performance require greater design flexibility. This requirement can be met by more closely integrating design and production in new work flows, which are made possible by recently accelerating developments of physical and digital design and production tools. We see a shift from mass production to mass customization, where digital information enables machines to tailor each individual part of a structure with no loss in efficiency.

The aim of this project is to investigate how a new parametric work flow could influence the design process of timber connections. Rather than using today’s relatively linear and interrupted sequence, we will look at the possibilities created by working in a single digital environment for design, analysis and production. Our objective is to link this parametric platform into existing production possibilities.
Analysis model with input parameters

Options with different input data

Optimal configuration according to weight function

Forces

Boundary conditions

Production time

Max stress

Average stress

Weight function
70% production time
20% maximum stress
10% average stress
12.273799 E 63.042831 N
- Structural and contextual wooden design
  in a parametric environment

ARCHITECTURAL THESIS

This master thesis is aiming to show an example of what architecture with vernacular references executed with high tech design and production methods could be. The context in this case is chosen to Sylarna and Jämtland with characteristic seasons, here cold and windy winters changes into flourish summers with almost no darkness.

Jury comments

John Ross, Foster + Partners, “Impressed by the project, the dedication and the analytical approach to the project especially (...) Beautiful structures informed by natural resources and state of the art qualities”

Daniel Norell, Senior lecturer Chalmers former Zaha Hadid Architects, “Very strong project, integrated way of analysis and design (...) Competition winning qualities and strong academia concept”

Mika Määttä, artistic Professor Chalmers, “Very good analytic and design work, perfect outcome, (...) Dynamic collaborator.”
WHERE?

JÄMTLAND - SWEDEN'S MOST ACCESSIBLE WILDLIFE NATURE

WHY?

A NEW MOUNTAIN STATION AT SYLARNA FOR THE SWEDISH TOURIST ASSOCIATION

The Swedish tourist association has a long tradition of hosting hikers in the Swedish mountains. A mountain station is a place for hikers to rest for the night, eat dinner, and have a sauna after a long day outside. Sylstationen was the first station to be built in 1897. Many new stations have been built along with the growing interest for Swedish nature. Today’s station is not modern in terms of energy usage and changing needs for hikers. Severe snow problems make the entrances unusable during winter season.
HOW?

LEARN FROM BUILDING TRADITIONS
TAKE ADVANTAGE OF NEW DESIGN AND PRODUCTION TECHNOLOGY

BUILDING ORGANISATION
- A CLUSTER INSTEAD OF ONE VOLUME

BUILDING ADOPTION TO CLIMATE
- A BUILDING LIKE A CHAMELEON

BUILDING STRUCTURE
A FOLDING PLATE STRUCTURE

BUILDING PRODUCTION
A FILE TO FACTORY PRODUCTION

BUILDING FROM LOCAL BUILDING TRADITIONS
TAKE ADVANTAGE OF NEW DESIGN AND PRODUCTION METHODS

WINDSHeltered SPACES AERODYNAMIC SHAPE BROAD BASE REDUCES GIVES HORIZONTAL STABILITY

FOLDS STIFFENS THE SIDES FROM BUCKLING

ROOFLIGHT PROVIDES NATURAL LIGHT

LAYER ON LAYER INSULATION ADAPTING TO SEASONS

CONTACT WITH NATURE OUTDOOR AND INDOOR SPACES
Sylarna rises above the Jämtland mountains like a crown with its jagged peaks. The station is located a day’s journey on foot or on skis from the nearest road. It’s a special feeling to approach the site from the open Jämtlännska landscape to finally be surrounded by Sylmassivets tops have arrived at the station. The trip from Storulvån creates a journey from a horizontal to vertical, where one finds himself incredibly small in the ratio of the mountains and the expanse enormous size. The large scale and the distinct seasons is something that is special to Sylarna.

The station is located well within Sylarnamassivet. High peaks surrounding the building as you look early in the trek from Storulvån which is the most common host route for visitors. The placement on the shelf provides a clear target for fjällvandraren and risks while not becoming over snowing if the building is well thought out. Location is also good from a route standpoint and ski touring and more of sylmassivets peaks are within easy reach.
1:10 000 model over the local context
How do you build 1400m² in a sensitive and beautiful landscape without losing the character of it?

Instead of one solid volume the program is divided into several building volumes. Each unit has a specific function. The organisation is influenced by a traditional Sami camp.

program model study - dividing 1400m²

A Sami settlement
Total program 1420 m²

Accommodation 495 m²
Hotel facilities 925 m²

TOTAL PROGRAM

BUILDING TYPES

FACADES

BUILDING PROGRAM

High standard housing
3 units
2-4 + 2-4 persons

Dormitory housing
3 units
10 persons

Single room housing
5 units
2-3 persons

Restaurant
Kitchen
Self service kitchen
Lounge area

Reception
Rental
Office

Sauna hut
Changing rooms
Relax room

Visitor center
Staff facilities

Total program 1420 m²

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The ordering of the volumes is based on the parameters in the environment such as sun, wind, and snow accumulation. On the site, the dominant wind direction is from the south. Each local cluster creates an arc shape towards south, in order to create a semi-private space in between, get maximum sunlight without blocking the neighboring buildings with accumulated snow on the leeward side of the building. The biggest buildings which will accumulate the most snow are placed in the furthest back from the wind direction. Paths from the housing volumes are following the lee side of the building towards the main building.
1. Two apartment building
2. Dormitory building
3. Single room building
4. Restaurant and lounge building
5. Reception and entrance building
6. Sauna
7. Visitor center
8. Staff building
9. Path
10. Maximum accumulated snow
BUILDING IN DETAIL

The build up of the volume is similar to a winter clothing made of multiple layers. Each layer has it’s specific function. The structure is of a folded late type using the plate-stability of a CLT (cross laminated timber) board to stiffen the sides from buckling. The panels are connected without any nail in order to be able to dismount the structure like an old timber build and mount it somewhere else. Natural light in the building is provided by a large opening in the top. The opening is towards the south in order to gain maximal light and heat. The angle of the roof creates an extra airflow which minimizes the snow accumulation on the roof. The steel mesh capture snow in the winter time providing an extra insulation layer when most needed. The ventilation system in the building is completely based on natural ventilation. The air intake is controlled by an opening in the facade and sucked down by the under pressure in the building. The outlet is trough the chimney. The whole building is a answer to the environment it is placed in.
BUILDING LAYERS

STRUCTURAL LAYER
3 layer CLT 100mm

INSULATION LAYER
WOODWOOL 200-500mm
workable material that easily is cut by a knife

SUPPORT LAYER
Roofing battens in steel and plywood as air gap layer

WIND AND MOISTURE LAYER
Steel sheets vertical mounted

CONNECTION DETAIL OF CLT PANELS
The detail is influenced by traditional timber houses mounted without any nails. Steel wedges are inserted to lock the CLT panels in place. This gives the possibility to easy dismount and reuse the structure.
ROOF BUILD UP
- GLAS CLIMATOP®2 Ultra
  U value 0.45
  +6.5m

WALL BUILD UP
- STEEL MESH
- STEEL SHEETS 1mm
- METAL BATTENS
- AIRCAP
- PLYWOOD
- WOOD WOOL 200-500mm
- PHASE CHANGE MATERIAL
  3 LAYER CLT PANEL 100mm (30 40 30 mm)
  +5.5m
  +5.0m
  +4.5m
  +4.0m

FLOOR BUILD UP
- SINGEL
- WASTEWATER TANK
- FRESHWATER TANK
- METAL WIRE ANCHOR
- METAL STUD
- PLYWOOD
- WOOD WOOL 300mm
  5 LAYER CLT PANEL 160 mm
  STEEL FOUNDATION LEGS, HEIGHT ADJUSTABLE
  FRESH AND WASTE WATER TANKS
  +3.5m
  +3.0m
  +2.5m
  +2.0m

PATH BUILD UP
- FRESHWATER PIPE
- WASTE WATER PIPE
- ELECTRICITY PIPE
  STEEL PIPE
  PIP INSULATION
  DIAMOND CUT STONE FROM THE SITE
  +1.5m
  +1.0m
  +0.5m
  +0.0m

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The climate on site has characteristic seasons and it is something that the life cycle of the building has to adapt to. Long cold winters with a lot of snow is ideal for transport reasons. Short and flourishing summers is the only time when construction can take place and therefore prefabrication is of great importance.
OUTSIDE AND INSIDE

The building are shelters in the mountains and the materialization of the building is a contrast where the facade made of steel sheets covered by a metal mesh harmonize with harsh nature. The inside of the building is covered with warm wood.

By the use of small volumes, both inside and outside spaces are created naturally. The local clusters creates semi private spaces outside the building for relaxing after a long day in the mountains.