Multi-Story Wood Architecture: Contemporary Case studies

Western Wood Buildings Workshop: 29-30 March 2012; Joe Mayo, Mahlum

Top: Traditional timber building near Raggal, Austria. Photo by Emily Woods
Bottom: Community Center St. Gerold by architects Cukrowicz Nachbaur

Above: Interior of Community Center St. Gerold. Photo by Emily Woods
The AIA Seattle Fellows and Honors Committee offers an annual travel scholarship to young professionals entering the architectural profession. The Emerging Professionals Travel Scholarship seeks to expand the experience and leadership opportunities of young professionals, encourage cross-cultural dialogue in the profession, and share knowledge from architecture practice around the globe with members in Puget Sound. Through a $5000 grant, the scholarship supports travel for the purposes of research.

This research was made possible by an Emerging Professional Travel Scholarship provided by AIA Seattle which allowed travel through Europe to interview leading thinkers and designers involved in innovative wood architecture who generously shared their experiences in this fascinating field.
Wood Building Types:

- All wood building
- Wood structure with non-combustible core using composite construction (differential movement must be accounted for).
- Wood structure sitting above non-combustible podium level.
- Wood bearing walls with non-combustible floor system
- Non-combustible building with wood facade elements.
- Wood structure with isolated non-combustible core (requires expensive doubling of vertical structure)
Case Study: Stadthaus

WAUGH THISTLETON ARCHITECTS / TECHNIKER ENGINEERS / KLH UK

- 8-stories of CLT over 1-story of concrete designed by Waugh Thistleton and Techniker Engineers with CLT provided by KLH UK
- All partition walls are load bearing CLT for redundancy
- To deal with progressive collapse each CLT floor plan spans multiple walls so if an interior wall is removed the floor can cantilever or double span
- Double CLT elevator and stair core is able to achieve a 120-minute fire rating
- All interior walls are clad with two layers of gypsum for fire protection

Source: Detail Magazine
Source: Techniker Engineers
Case Study: Stadthaus

- Shared walls between units achieved 60 minute fire rating
- 30 minute walls inside residential units
- All interior walls are clad with two layers of gypsum for fire protection
Case Study: Bridport House
EURBAN, KARAKUSEVIC CARSON ARCHITECTS, STORA ENSO

- Up to 8-stories full of wood: ideal structural system because of light weight of wood and siting over storm relief sewer
- CLT walls and floors using interleaved interface to relieve perpendicular to grain crushing
- Cores also constructed from CLT
- 90 degree shift in structural wall orientation starting at the 3rd floor
Case study: City Academy

3-story CLT school designed by Sheppard Robson with Ramboll Engineers and CLT provided by KLH UK

Internal steel frame with load bearing CLT exterior walls

Contractor, Kier, praised speed and cleanliness of CLT system

Kier estimated 4-6 months savings in construction time
REIULF RAMSTAD ARKITEKTER (RRA)

- 20-story, 80 m (over 260 ft) timber Barentshouse in the far northern town of Kirkenes, Norway
- The town is significant for its involvement in the Barents Region and cross cultural ties between Norway and Russia. The building is a response to the close relationship between the country’s that make up the Barents Region and their shared culture and history of wood
- No formal height limits for wood in Norway

Source: RRA
Barentshouse

- Plan is principally organized around the main core (concrete, but could be wood)
- Glue laminated post and beam structure with posts ranging from about 28” square at outside wall to about 20” square in section on the interior
- CLT floor system with ceiling structure containing insulation for sound and fire and technical services like fog sprinklers
- Two-floor horizontal sectioning in the middle of the building that will in principal compartmentalize and separate the building into distinct parts. This is also a centre for technical facilities, shortening the distance to the upper parts of the building, compared to a single technical base on ground level
- Glue laminated beams for bracing elements
- Designed as concrete core but could be wood
- Curtain wall skin with projecting wood boxes at conference or gathering spaces

Source: RRA
Växjö’s Modern City of wood

- From 1888-1994 no wood building in Sweden could be taller than 2 stories
- Swedish government now has a timber promotion program and there is a rich interaction between timber companies and academia developing new wood products and building systems
- The new Välle Broar district, at about 25 acres, is the same size as the Växjö city center and university district. The plan calls for 1,500 apartments (100,000 m2 of real estate), urban density, carbon neutral focused on wood construction

Source: Växjö Kommun
Växjö’s Limnologen
Arkitekt Bolaget, Linnaeus University,
Martinson Byggsystem

- Limnologen, at the time of completion, was the tallest timber building in Sweden.
- The project consists of four eight-story buildings containing 134 apartments.
- Each building is 7-stories of wood construction over a 1-story concrete podium level.
- Most building elements prefabricated off site by Martinsons Byggsystem.
- At the beginning of construction a tent structure was erected that contained the building, protected it from weather.
- A crane inside the tent lifted prefabricated building elements into place as they arrived.

Source: Arkitekt Bolaget
Växjö’s Limnologen

The three main load-bearing wall types for Limnologen include:

- the 3-layer CLT used at exterior walls,
- timber framed walls separating internal apartments and
- 3-layer CLT interior walls.
- Walls arrived fully glazed and insulated, leaving only exterior cladding and interior finishes to be completed on-site.
- Each floor at Limnologen is constructed from 30 prefabricated Martinsons Byggsystem floor elements made-up of 3 layer CLT and T-shaped glulam beams placed at 600 mm centers (about 24 inches)

Source: Johan Vessby at the Linnaeus University

Source: Martinson Byggsystem AB
Växjö’s Limnologen

- Large buildings using a timber floor system can be challenging for acoustics, especially for flanking transmission and impact sound transmission.
- Walls are discontinuous to reduce flanking transmission
- A polyurethane sealant used between the walls and floor flanges as well as using Sylomer to reduce sound transmission where the flange rests on the wall.
- The ceilings are all self-supporting on timber beams below the main floor structure. Being attached to the walls rather than the floor allows the ceiling to reduce the spread of sound.

1. 521 mm floor system:
   - 14 mm parquet flooring
   - Underfloor heating cut into load bearing floor:
     - 70 mm CLT slab
     - 45 x 220 mm glulam beams
     - 170 mm rockwool, with services installed
   - 1.2 m sound insulating element:
     - 45 x 220 mm timber framing
     - 70 mm rockwool and sprinkler
     - 28 x 70 mm battens
     - 2 layers 13 mm gypsum board

2. 390 mm exterior wall system:
   - 12.5 mm gypsum board
   - 45 mm mineral wool
   - 85 mm laminated wood element
   - 195 mm mineral wool insulation
   - Moisture diffusing air barrier
   - 28 x 70 mm battens
   - 25 mm laminated timber panels

Source: Detail Magazine
Kaden Klingbeil’s E3

- Germany’s first 7-story wood building (6 stories of wood over 1 story of concrete)
- Heavy timber post and beam with infill bretsttapel walls and floors with poured concrete topping slab
- The assemblies were fire tested to reach a 90 minute rating
- 3 steel connector types insert seamlessly into CNC cut wood structure

Fire protection scheme included:

1. Short escape routes
2. Fire resistant construction through the use of large dimension timber encapsulated with non-combustible material
3. Smoke detectors installed in each apartment
4. Transparent fire-resistant coating applied to the underside of each apartment ceiling to restrict the potential spread of flame.

Source: Kaden Klingbeil
Schankula’s H4

- The number of wood buildings in Germany taller than three stories is extremely small.
- The H4 was Germany’s first all wood 4 story building at time of completion.
- For the H4, it took approximately a year of collaboration with Bad Aibling code officials.
- Schankula notes that the common construction system for timber buildings in Germany is a post and beam structure, typically found in large halls or other gathering spaces.
- Massive wood construction provides a simpler solution than post and beam.

Source: Schankula Architekten
Schankula’s H4

- The H4 is a massive wood building, but largely does not utilize Cross Laminated Timber. The only component in the building constructed from CLT is the elevator shaft, which was delivered on-site as a prefabricated component.
- The remaining exterior and interior walls are constructed from load bearing vertical timber posts.
- The posts are arranged next to each other and bound together by gypsum sheathing to create panels up to 12 m in length and 3.2 m in height.
- Wall and floor elements are prefabricated in a local shop and delivered on site with insulation, windows and cladding already installed.

Source: Schankula Architekten
Schankula’s H8

- Germany’s first 8-story wood building

- To obtain permission for eight stories, the authorities placed certain prerequisite conditions on the design team:
  1. The elevator core and egress stair had to be constructed from concrete.
  2. The second condition was for the stair to be open to the exterior and not directly connected to the residential units. This removes the potential problem of smoke in the egress path.

- Each wood floor took only two days to complete, and the entire wood structure was completed in only three weeks.

- Different from the H4, the ceilings are constructed from Cross Laminated Timber.
Source: Schankula Architekten
AUSTRIA

Cree Rhomberg’s 20 Story Timber Highrise

- Make wood a truly urban option
- With Arup and Hermann Kaufmann, developed a hybrid concrete and timber modular building system up to 20-30 stories
- Prefabrication is the most important concept in the CREE system, allowing for fast construction time and cost competitiveness.
- Main prefabricated elements:
  1. Facade
  2. Columns
  3. Hybrid timber and concrete floor

Source: CREE Rhomberg
Cree Rhomberg’s 20 Story Timber Highrise

- Column dimension of 240 mm x 480 mm allowed for structural capacity and also for necessary 2-hour fire rating, calculated by assuming a 0.7 mm/min burn rate during a 1,000° C fire.
- Concrete slabs provide a 2 hour fire rating between floors and are a result of extensive fire testing.
- The concrete slabs compartmentalize the building by protecting the floors below and above with a continuous fire barrier.
- The concrete panels turn down at the slab edge to further compartmentalize each floor and reduce the risk of fire jumping from one floor to the next.

Source: CREE Rhomberg
LCT One

- The Lifecycle Tower One is now under construction in Dornbirn, Austria.
- LCT One will be 8 stories tall, with dimensions of 27 m high (about 90 ft) by 13 m wide (almost 45 ft) and 24 m long (nearly 80 ft), making it the tallest wood building in Austria.
- Not only this, but it will also be the world’s tallest unencapsulated (with gypsum board) timber building.
- As in most European countries, to build with wood at such a height in Austria requires special permissions from the building department. One of these requirements is that the LCT One has a concrete core rather than a wood core.
- The core, in fact, will be one of the few non-prefabricated elements - being site cast instead of precast.

Source: Hermann Kaufmann
Seattle

- Nearly 22 million acres of the 43 million acres in Washington State is forested, accounting for over half of the state’s total land.
- To put Washington state in perspective, at 71,300 sq mi it is well over twice the size of Austria (32,377 sq mi), one of central Europe’s top timber producer.
- Lumber would create the first boom in Seattle and Henry Yesler, with his steam-powered sawmill, became the city’s first millionaire.
- Like many cities Seattle, in June of 1889, burned to the ground.
- Although there were few injuries or deaths, over 30 city blocks went up in flames, including most of Seattle’s business district and waterfront.

Source: Washington State Digital Archive
Seattle

- Wood and masonry was readily available in the Puget Sound region and other fireproof technologies were more expensive and less familiar. Because of this Seattle turned to an approach called slow-burning construction (also called mill construction, semifireproof or fire-resistant) rather than true fire-proof construction.

- The 1899 “A Treatise on Architecture and Building Construction” describes slow-burning construction as:

  "The individual members, such as beams, columns, etc, are so proportioned that they retain strength enough to do the work required of them even after one-third of their bulk has been charred or burned."
1024 E Pike Street in Capitol Hill, Seattle, constructed in 1913

Value Village in Capitol Hill, 1916

613 E Pine Street in Capitol Hill, Seattle, constructed in 1917

Elliot Bay Books in Capitol Hill, 1918

Elliot Bay Books in Capitol Hill, constructed in 1918

Images above courtesy Brendan McKeon
Discussion

- Culture of wood
- History
- Regionalism/Local Materials
- Government involvement
- Technology
- Sustainability/Living Building Challenge
- Fire

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The Bullitt Foundation. Source: Miller | Hull