STRUCTURAL DESIGN AND ASSEMBLY OF “TREET” - A 14-STOREY TIMBER RESIDENTIAL BUILDING IN NORWAY

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ABSTRACT: “Treet” is a 14-storey timber apartment building in Norway which is likely to be built during 2014. The building will be one of the tallest timber buildings in the world. The building consists of load-carrying glulam trusses and two intermediate strengthened levels. Prefabricated building modules are stacked on top of the concrete garage and the strengthened levels. CLT is used in the elevator shaft, internal walls and balconies but is not a part of the main load bearing system. Glass and metal sheeting protect the structural timber from rain and sun. A step-by-step model will be established to ensure a smooth assembly.

KEYWORDS: Multi-storey buildings, assembly, glulam, CLT, building modules

1 INTRODUCTION

“Treet” is a 14-storey timber apartment building that is likely to be built in the Norwegian city of Bergen in 2014.

At present it seems to become the tallest building in the world of its kind. A total of 62 apartments will find their new owners in the building shown in Figure 1.

The building owner is BOB, Bergen og Omegn boligbyggelag, a Norwegian housing association. Glulam and CLT will be delivered by Moelven Limtre and their subcontractor Stora Enso. Prefabricated building modules will be delivered by the Estonian company Kodumaja. The architect for the project is Artec. SWECO Norway is responsible for the technical design and design management.

2 STRUCTURAL SYSTEM

The glulam trusses along the façades give the building its necessary stiffness. The CLT walls are independent of the main load bearing system, and do not contribute to the building’s horizontal stability. Standardized and prefabricated building modules comprise the main volume of the building. The modules are stacked at a maximum of four storeys, and are found on levels 1-4, 5, 6-9, 10 and 11-14.

Levels 1-4 are resting on the deck of a concrete garage. Level 5 is a strengthened glulam storey connected to the façade trusses, denoted “power storey”, which has its own special building modules and carries a concrete slab on the top that acts as a base for the next four levels (6-9) of modules. Then the system repeats itself with an additional “power storey” (level 10) and modules on top (levels 11-14). The roof is a concrete slab. The concrete slabs are incorporated to connect the trusses, but their main function is to increase the building’s mass and hence improve the dynamic behaviour. You can find more on this in [1].
Typical column cross-sectional dimensions are: 405x650 and 495x495 mm, and typical diagonal cross-section is 405x405 mm. The base of the building is a rectangle with length of baselines equal to 23 x 21 m. The height of the building is about 45 m. The maximum vertical distance between the lowest and highest points of the timber components is about 49 m.

All glulam elements are connected by use of slotted-in steel plates and dowels. This is a high capacity connection which is commonly used in bridges and large buildings. The structural timber is with few exceptions covered behind either glass or metal sheeting. This protects the timber from rain and sun, increases durability and reduces maintenance. Climate class 1 is used for most members.

3 FIRE DESIGN
The fire strategy report for this building describes that the main load bearing system must be designed to resist 90 minutes of fire. Secondary load bearings are designed for 60 minutes of fire exposure. In addition several other means of fire protection measures are incorporated, such as sprinkling and elevated pressure in escape stair shafts.

4 MATERIALS
All main load bearing structures in “Treet” are wooden: Glulam is used for trusses. CLT is used for elevator shafts, staircases and internal walls. Timber framework is used in building modules. For the structural design glulam strength classes GL30c and GL30h according to FPr EN 14080 and CLT with bending strength $f_{mk}=24$ MPa are used. S355 steel is used in connections together with acid-proof steel dowels. Spruce is the main species used for the timber parts in this project. Two internal decks as well as the top deck are made out of concrete. Tricoya® wood, corten steel and glass is used in the façades.

5 LOADING
Eurocodes with national annexes for Norway are used to determine the design loads. Wind loading turned out to be the dominating load in the design combinations. The loading from wind is applied as a static load. Wind tunnel tests were not found to be necessary because of the structure’s regular geometry. Bergen is in one of Norway’s earthquake zones, but the ground acceleration is small compared to other countries. According to Norwegian regulations earthquake loads were not necessary to incorporate in the design because wind prevails.

6 ANALYSES AND RESULTS
Robot Structural Analysis Professional 2013 was used for the structural analyses of the building. Excel spreadsheets were used to do the code checks according to [4].

Most structural dimensions are decided by the ULS check. A few elements are governed by fire design. Since the building is relatively light, much attention was put into the dynamic analyses, see [1]. Robot was used for this.

An independent third party reviewer checks the design. “Treet” is also verified in a master thesis at NTNU [2].

7 ASSEMBLY
The assembly of “Treet” is mostly about installing prefabricated elements on site. Optimizing the logistics and installation is important to get a smooth assembly. Kodumaja and Moelven Limtre will use a tower crane as well as a climbing scaffolding system during the building erection. Temporary roofs will be used to protect apartments, joints and timber from moisture during the building process. A detailed step-by-step model will be established to ensure that the building can be built correctly.

8 CONCLUSIVE REMARKS
The detailed design of the building is finished and proves that the building can be built as is. It will truly become an iconic landmark in Bergen city.

REFERENCES