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Climate Challenge Laboratory | Building 313

A seven-story timber building is taking shape

Theme: Wooden construction

DTU Campus Service
The Technical University of Denmark

A seven-story timber building is taking shape

DTU is building the first timber construction building at the university's campus in Lyngby. With its seven-story timber construction, the Climate Challenge Laboratory will be one of Denmark's tallest timber buildings. This requires new solutions and new workflows on site.

High precision. Protection against sun and rain. New workflows. It poses new demands for planning, execution, and collaboration - both in the project team and on the construction site - as DTU builds a seven-story timber structure as one of the first in Denmark.
In this newsletter, Jakob Haugaard Hansen, who is production manager at MT Højgaard, explains how he and the on-site team are handling the challenge. The newsletter also includes mini interviews with Stig Tomasson, structural engineer at Artelia (formerly MOE, ed.), and Per Thomas Dahl, director of CLT Denmark. Both have been involved in the design and planning. Finally, the newsletter provides an update on the construction project and an overview of all involved parties.

Experienced craftsmen build their first CLT building

Uniquely, the Climate Challenge Laboratory consists of both a laboratory section, which will be constructed in concrete, and an office section, which will be in Cross Laminated Timber (CLT). On site, Jakob Haugaard Hansen and an experienced team of craftsmen are mounting the timber elements in the Climate Challenge Laboratory which is the first CLT building they are working with. Prior to this, several months of preparation have gone into ensuring the quality.

CLT-management. Jakob Haugaard Hansen is a production manager with over 20 years of experience in major renovation projects at MT Højgaard. In the Climate Challenge Laboratory, he has the responsibility for CLT construction and the overall responsibility for the work on the construction site.

What is your role?
I have the responsibility for the CLT construction. My task is to ensure that the execution on the construction site is carried out safely and in accordance with the schedule we have with the supplier, CLT Denmark, and the engineers at Artelia. This means that what we have discussed and planned is also what happens on site.

> "There is a lot of attention from all sides, also on the execution process itself. Professional pride also plays a role. It is quite nice to say to a carpenter that we are going to work with wood."
>
> — Jakob Haugaard Hansen produktion manager, MTH

What is your experience with CLT construction?
This is the first time I am involved in the construction of a CLT building of this size. There is a lot of attention towards the construction from all stakeholders, including a keen focus on the construction process. Professional pride also comes into play. It is nice to say to a carpenter that we are going to work with wood. They like the huge dimensioning of the structure. But they are also aware that every step we take must be well-considered. We cannot just do things the way we have been doing for the past 17-18 years when we have been constructing with wooden cassettes (a type of wooden structure). In that sense, everything is put into perspective with the large dimensions we are working with.

What does the wooden structure consist of?
It consists of columns, floor elements, and an atrium staircase. The columns are 50x50 cm cross-laminated timber columns. At the ground floor, they are 5.40 meters high. The columns come with steel fittings so

that the coloumns can be clamped together. When the columns are mounted, we lay the slabs on top of them. The slabs come with slots that are rounded at the corners and cut out in the middle to fit over the columns. Just before we place the roof, we hoist the staircase in and then we close the building of.

What is different in CLT construction compared to a concrete construction?
The tolerances. The timber elements come with their exact dimensions, while concrete comes with its tolerances. Concrete has much larger tolerances than timber. Thus, it is possible to adjust the concrete construction afterwards by cutting out sections. That is not possible in a timber construction. That is why we spend extra time on making the sure the ground floor is built exactly as planned. When the staircase is installed, there is not even space for an adjustment of 3-4 cm. The tolerance is only one cm, and it must slide down just right through the hole in the floors. In other places, timber, and concrete meet. We have

CLT

CLT (Cross Laminated Timber) is a solid wood element consisting of typically three, five, seven, and possibly more, perpendicular layers. CLT has properties like concrete, making it possible to build large and tall structures in wood. A CLT solid wood element is rigid and strong and ideal for long spans such as floor and ceiling slabs. CLT construction can be cost-competitive, especially in multi-story buildings with 5-10 floors, where a high degree of prefabrication contributes to a rapid project completion. In addition, solid wood elements weigh less than concrete, so a smaller and cheaper foundation can be used, and elements and panels can be handled by smaller cranes on the construction site.

Source: træ.dk

CLT and concrete. The Climate Challenge Laboratory is being built as a hybrid solution with a wooden structure and a concrete structure. Photo: DTU

a concrete staircase tower and a large load-bearing concrete wall (module line 11), where the concrete workers have been instructed to carry out strict inspections. This is to ensure that the tolerances are in the millimeters – not centimeters. All the glue-laminated timber is pre-cut and must fit perfectly on site.

99.8% accuracy vs. "timber lengths"

While CLT Denmark delivers timber elements with a tolerance of 1-2 mm, "timber lengths" are used when constructing buildings in concrete. Therefore, there is extra attention paid to the joints where timber and concrete meet. The first challenge was the foundation and columns on the ground floor, which have just been erected.

Has anything surprised you?

No, but suddenly you find yourself in the middle of the drawings. It is so big and heavy. There are such great forces and such large loads at play. Therefore, it is important for us that our schedule is realistic, so we don't just rush through it. What we do at the bottom affects all the way up through the levels of the building. Therefore, we have told our workers, "Take the time you need to do it right. It's better for that is done correct than for us to have to move something later on." The last quality check we did on the columns on the ground floor showed a deviation of a maximum of 3 millimeters on columns that are 5.40 meters high. And when we laid the slabs for the first floor, it was just great. The floors are 18 x 2.95 meters, and they are heavy, but when the tower crane laid the elements down, we could just stand and guide them into place. On top is an RHS bracket, and according to plan there had to be 1 cm all the way around – and that was exactly what we had. So, all the sweat and tears the boys have put into the columns has been well worth it. It is such a joy that it works and a huge pat on the back for those who do the work on the site. It's a success that they have understood that it is not just about going fast, it's about being correct.

How did you manage to make it work?

We have held many "Work Process Assessment"-meetings (in Danish APV) to involve the workers on site. In these meetings, we describe the work we need to do and how it must be carried out - from start to finish. We have held two workshop sessions of 5 hours each, where we have used safety lines, fastenings, fittings, and we have gone through how the decking elements are delivered and who is responsible on the actual day of installation. At the day, we start with a toolbox meeting before the crane operator climbs up into the crane. Here, the craftsmen and the crane operator make an action plan together. We have also created eight billboards, which show how the work should be done. But most importantly, we have emphasized that we do not build anything that we cannot stand behind. If someone does not have the right knowledge, they turn to me or my colleague. If we don't know the answer, we seek knowledge from CLT Denmark or Artelia. When building in CLT, new questions arise, even though we are all experienced.

What could that be?

In CLT construction, the craftsman need to use the right screw. In normal carpentry work, you can always make adjustments to fit, but in CLT, the wood is cut, and you cannot make adjustments. The engineer has also calculated the statics all the way down to nuts and bolts. So, when we start on the first floor, we make some boxes where all the bolts are placed, and we have boards where it is described where they should be used. So, if you are in doubt, you go over and look at the boards.

Tolerances

A tolerance is an object's maximum permitted deviation in weight or measurement from a set measurement or a given standard.

Source: Ordnet.dk

Precision work. The concrete deck acts as a foundation for the tree-house. On site, bolts are molded into the concrete and they must fit with the columns' pre-assembled fittings. Photo: DTU

Blackboards. Boards are set up on each floor. Drawings show the carpenters how all elements must be assembled and with which screws. Photo: DTU

What other measures are you taking to ensure quality?
In addition to MT Højgaard's focus on CLT, we have also asked Artelia for extended technical supervision. This involves both the connections between the CLT elements and the concrete in the structural part, as well as moisture. We are very aware of not building in moisture. Before we start closing anything, there will be extended control as part of our moisture management strategy.

You have a moisture management strategy?
Yes, both MT Højgaard and Artelia measure moisture. We perform a receiving inspection when we receive the timber elements from CLT Denmark, and if they are above 12% moist, they are returned. In addition, we cover the columns in plastic. Our work process minimizes the moisture problem because we are constantly on top of it. In addition, we have ongoing control. Once a week, we jump around on all the columns and carry out moisture measurements. If anything is high or low, we have a contingency plan.

How do you handle rain when constructing the structure?
You can erect the columns even if it's raining. They have a covering around them and are also impregnated to ensure that they do not absorb moisture. We have put a wet-guard on the slab elements. Of course, we also look at the weather forecast and plan accordingly. We have a flexible crew, so while we are erecting the CLT structure, there are days when we come home early, while on other days we extend the workday, making it a little longer, because the weather is good.

"In normal carpentry you can always make it fit, but in CLT the wood is cut and you cannot make adjustments. The engineer has also calculated the statics based on specific nuts and bolts.

So when we start on the first floor, we make boxes with all the bolts and we have boards where it is described where they are to be used. If in doubt, go over and look at the boards."

– Jakob Haugaard Hansen produktion manager, MTH

Experience has led to new solutions
The work process on site has been planned in the design phase - and in close dialogue with the craftsmen and the supplier. Experience from other construction projects has also led to MT Højgaard developing new solutions.

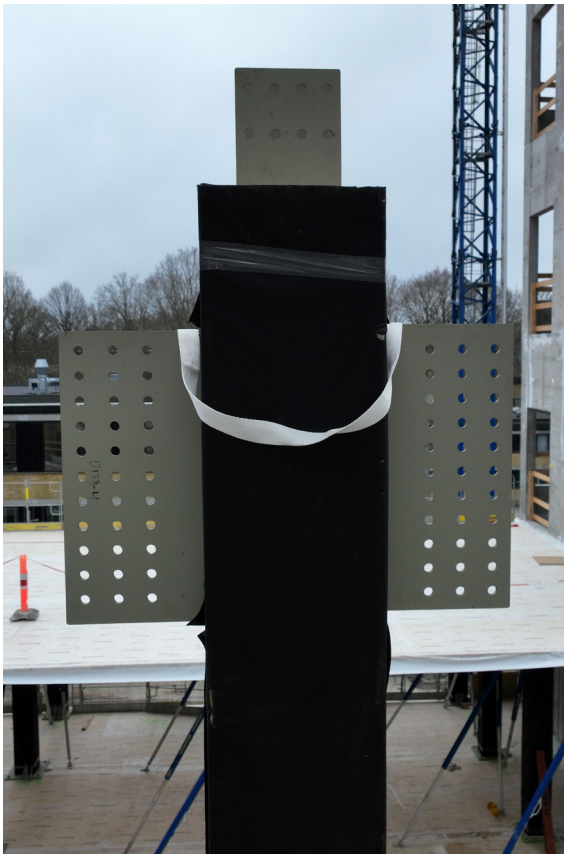
How did you approach the planning?
We have been out to see how CLT structures have been erected elsewhere. Prior to the construction phase, my guys have been involved in the project, we already started 7-8 months ago. On example of the planning is that I picked up columns from the supplier so they could see what we were talking about. Already at that point, we could start getting ready for how to approach the work smartest. We also made models of the steel fittings in MDF (a type of wood panel, ed.). One thing is to look at a drawing, but the fittings weigh up to 150 kg and the models showed how large they are. It's not something you just throw over your shoulder, so it's been an eye-opener.

"We had 1:1 models made of the steel fittings, which weigh up to 150 kg. The models showed how big they are. It's not something you just throw over your shoulder, so it's been an eye-opener."

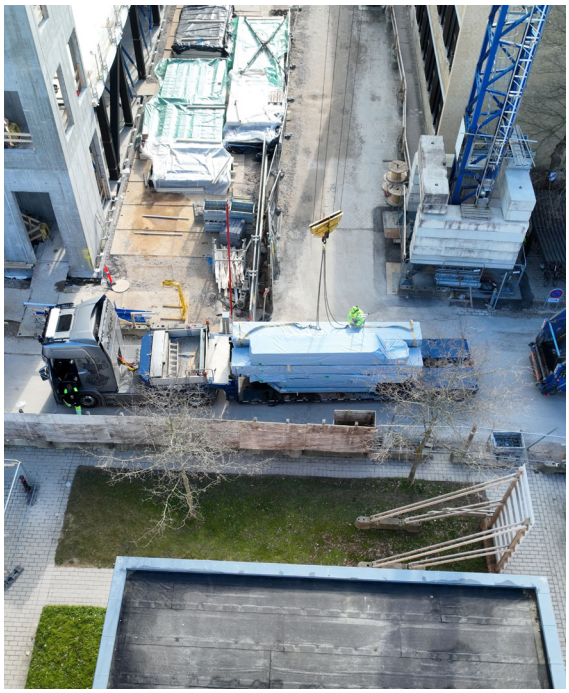
– Jakob Haugaard Hansen production manager, MTH

What solutions has it provided?
Initially, the process was that we bring the wood out here (on site) and put the steel on ourselves, but that process was reconsidered. It has saved us time, but it is also more ergonomically correct to be on a factory floor doing the work properly and precisely rather than being outside exposed to the elements. Now it is assembled when we get it and then we lift it up with a crane.

What new solutions have you developed?
I can give two examples. First, we have made holes for lifting straps in the fittings at the top. There are holes in each corner, and we lift them with straps and bolts that go through the holes, with this solution the person standing on the lift and who takes it off the crane can handle it in one take. In other cases, we have seen solutions with huge steel fittings where you had to stand and pull it after it has been taken of the crane. In another case the lifting device has helped tighten the strap, however the strap went around the edge, as this is where it tightens – however, with the strap around the edge the lift makes an uneven drag. With our solution, it hangs straight the instant you put it down.
The second thing is that we saw some wooden pillars on a construction site. They had caps on the corners, but they were not entirely wrapped. Then they got a color difference due to sunlight. Even though some time had passed, the color change had not faded. So, in addition to having the coating around the laminated timber, we also wrap the pillars.



Fittings. MT Højgaard made a mock-up of the fittings in mdf board (picture left), so that the carpenters could help find solutions for handling the CLT elements on site. The fittings weigh around 150 kg. Photo: DTU



On site. CLT Denmark produces the wooden columns and installs the fittings at a factory. The CLT elements are delivered on trucks in the order they are to be installed on site (picture left). MT Højgaard hoists them off directly from the wagon in a special lifting device (picture right) developed to ensure the elements are lowered straight down and are easy to dismantle for a carpenter. Photo: DTU

The CLT supplier: We deliver in line with the contractor's needs

Per Thomas Dahl, who is the director of CLT Denmark A/S, has worked with timber construction since 2006 in various contexts. CLT Denmark A/S supplies the timber elements for Climate Challenge Laboratory and was involved in the construction project during the planning phase.

What is particularly interesting in the construction of Climate Challenge Laboratory from your perspective?
The construction process is interesting. Because the construction site is small, there is not much space to store materials on site. Therefore, we pre-assemble the fittings on to the glue-laminated timber columns before they arrive at the construction site. We have established an assembly factory for this. This allows us to deliver them as needed by the contractor. We have planned this as a lean-flow down to the last detail – including when the elements are made and how they are packed and placed on the truck. We do this so they can be lifted off in the correct order on site, etc.

"The construction site is small, so there is not much space to store materials. That is why we pre-assemble the fittings on the columns and have established an assembly factory for this purpose."

– Per Thomas Dahl, director, CLT Denmark A/S

The moisture management strategy is also worth mentioning. Many people think that moisture is a big problem with timber construction. However, with solid timber elements, this is not a major risk, if our instructions are followed. And it's not difficult. Together with MT Højgaard, we have developed the plan that is now being carried out. This means that we treat the surfaces of the elements, cover the edges with membranes, protect the end grain of the columns, while MT Højgaard and Artelia measure the moisture when the CLT elements arrive on site and before we close of the construction.

What is your take-away from working on the Climate Challenge Laboratory project?
The good collaboration. It may sound fluffy, but a good collaborative climate means a lot. We put a lot of effort into ensuring a flow in the construction process, as everyone depends on each other.
It is important that each of us live up to our responsibilities, and we strive to do so to the utmost. As a supplier, it has also been positive to experience the curiosity surrounding CLT and timber solutions. It has become more common to think in this direction, and it helps us relax on other projects when we are building high-rise structures with wood. This has been done many other places, so we can do it here as well. Conversely, the need for timber construction in Denmark is likely to primarily be for buildings up to seven stories high.

The engineer: CLT wins on modularity

Stig Tomasson is responsible for constructions at Artelia Group (formerly MOE, ed.) and a certified structural engineer at Climate Challenge Laboratory. He has one year of experience with CLT ele-ments.

What is particularly interesting in the construction of Climate Challenge Laboratory from your perspective?
It is the aim of building the optimal laboratory building. We are building the Climate Challenge Laboratory for the research that takes place in the basement and here the sensitive electron microscopes require extraordinary vibration-free environment. We have built on the experiences from building B310 and B357. On thing that is special about B313 (Climate Challenge Laboratory, ed.) is that we are building an office part and a laboratory part into one building. The two sections have different materials - wood and concrete. Structurally, we use the basement as a foundation for the wooden house, which has given us challenges that we had to solve along the way. You must be very aware of the interface between the two different constructions. For example, we have steel beams with embedded bolts in the concrete slab above the basement, and those bolts needs to match the fittings on the wooden columns. The challenge is that we work with much more delicate tolerances for wood than concrete.

"If you do not build modularly with CLT, then there will be too many variants and different joints, and it is at joints that the wooden construction becomes difficult and expensive."

– Stig Tomasson, structural engineer, Artelia

What have you learned from the Climate Challenge Laboratory?
Gravity is the same for wood construction and concrete construction. What you need to be aware of are the connections and the spans you are working with. In wood construction, you cannot achieve the same spans as in concrete. You get smaller spans, more columns, more beams, and more walls. There are also other acoustic and fire conditions to consider than in a concrete construction. However, CLT wins on modularity. If one does not build modularly with CLT, there will be too many variations and different connections, and it is at the connections that the wood construction becomes difficult and expensive. You also must be really aware of the steel in the connections, they are more imposing than I thought in the beginning. We have worked on them architecturally. They are much larger than usual, so we need to make them part of the architecture and the story of the house.

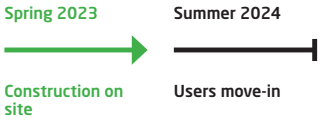
Wood and concrete. The wooden structure rises floor by floor. Photo: DTU

Basic information

Construction work
The assembly of the CLT timber structures is underway and the first floor has been assembled. The CLT assembly is expected to be completed by week 19. On May 16th, there will be a topping-out ceremony.

Project status
DTU CAS is developing the interior design project with consultants and end-users. An artist is developing a sketch proposal for art in the common areas.

Tidsplan



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