

## A CLOSED LOOP OF CONCRETE IN HØJE-TAASTRUP

### - interviews with the partners behind it

The new city hall in Høje-Taastrup Municipality is one of the first major public buildings in Denmark where recycled concrete has been used in the foundation. The recycled concrete stems from part of the residential area Taastrupgaard, which was to be demolished as part of the government's plan for improving socially vulnerable residential areas.

Construction of the city hall began in May 2020 and is expected to be completed in September 2022. The scope of the construction is 8,600 m<sup>2</sup> and the recycled concrete was poured on site. The building is DGNB Gold certified, which means, among other things, that there is a requirement for soil balance. So the soil that was excavated for the city hall construction was used to fill the Taastrupgaard site, where the concrete came from.

**Concrete** constitutes one of the largest waste fractions in construction with over 26 percent of the total amount of waste. – Danish Ministry of Environment 2020

On a global level, cement and concrete production alone accounts for 8 percent of total CO<sub>2</sub> emissions. – Thrane et al., 2019

The city hall will become a new sustainable landmark in Høje-Taastrup C.

The expected CO<sub>2</sub> savings come from:

- Recycling of over 2,000 tonnes of concrete, of which 1,088 tonnes of recycled aggregate is used in the foundation of the city hall
- Halving the transport of the concrete aggregate
- Reduced transport of soil

The construction of the city hall is a demonstration project in the European Horizon2020 project Cityloops, which tests and demonstrates circular construction in collaboration with seven European cities.

The Danish partners in the project are Høje-Taastrup Municipality, Roskilde Municipality, the Capital Region, Roskilde University, the Danish Association of Construction Clients and Gate 21.

Gate 21 has spoken to selected stakeholders in the city hall project. Here they share their experiences about circular construction.

See more about CityLoops at [www.gate21.dk/cityloops/](http://www.gate21.dk/cityloops/)

Enjoy!

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## Taastrupgaard

### Interview with Claus Bjørton – Project manager, KAB

Claus Bjørton is business manager of the housing and administration company AKB, Taastrup (KAB) and project manager for the transformation of Taastrupgaard.



#### **Have you worked with circular construction before?**

No, but I have worked on demolitions where the crushed concrete was recycled as filler under roads and as aggregate. It is more interesting for the residents that the concrete is reused more visibly and concretely, rather than being used as filler, which is more abstract.

#### **What were the economics of recycling concrete from your standpoint?**

The crushed concrete has no value for Taastrupgaard. It is a financial burden because we have to pay to get rid of it. It was therefore financially advantageous for us that Høje-Taastrup Municipality received the concrete. I think we saved about a million DKK.

#### **How did you prepare the tendering materials for the demolition of Taastrupgaard?**

No one had imagined how much concrete was in a residential building from the 70s in Vestegnen (the suburbs west of Copenhagen) — it is a lot. We prepared a tender where the price weighted 50 percent. The other two sub-criteria that had to be factored in were CSR and the process for the residents, because the demolition took place in a residential area. This meant that you did not necessarily win the bid, even if you had the lowest price.

#### **What challenges did you experience?**

The way the world and the value chain are right now, you need to have a 1:1 donor and recipient who enter into an agreement. It has been good to have the municipality involved in the project — it provides reassurance in the handling of the concrete. I do not think that such a project can take place between two private parties yet. With the risk we face, certain questions have come up like: "What if, for example, the municipality no longer needs the concrete — then what do we do? Who is responsible for transporting it from the building site?" It is important to make clear agreements, as we have had in this project.

#### **Was it more difficult to work with recycling concrete rather than status quo?**

No, it has not presented major challenges. It would have given greater challenges to send it to a waste management facility. We got a really good success story out of it — the whole project was characterized by good dialogue. All parties put in the effort to make things happen.

#### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

All parties involved in a construction have a certain responsibility. Circular construction can seem complicated and daunting — which is why the authorities also bear a big responsibility. Broadly speaking, you could say that society has a shared responsibility.

## Interview with Helene Gaarn – former environmental advisor, Wissenberg

Helene Gaarn is a former environmental advisor for Wissenberg, specializing in demolition and remediation of building materials.

### **What challenges did you experience?**

Early in the process, they began to examine the quality of the concrete. The environmental assessment showed that the construction in Taastrupgaard had a very high concentration of PCBs, which meant that parts of the building had to be disposed of as hazardous waste, because we couldn't remediate it. Therefore, it was mostly the in-situ constructions that could be used for the city hall project because they were not contaminated. The surfaces still had to be remediated, but there were no major problems with contamination seeping into the concrete. A quarter of the concrete could be directly recycled. The remaining concrete was cleaned and sent to a demolition waste processing facility where it can be used as road fill.



In terms of reuse, there are challenges with finding market opportunities and with the division of responsibilities. Who takes responsibility for a light fixture that has been installed, and then taken down? There aren't many market opportunities, and there are also costs related to storing them. That's why they chose to have a flea market where they sold the parts of the building that you wouldn't otherwise reuse, for example refrigerators. The earnings went to social initiatives in the neighborhood.

### **What were the economics of recycling concrete from your standpoint?**

Our customer is the housing association, so we work for their best interests. It is a public housing association, which means that you cannot have ambitions that make the project more expensive without extra funding, because the extra cost will land on the residents' shoulders. Our task was therefore to ensure that the project remained price neutral. The price you normally pay for a ton of concrete to be transported away from the building site, is around 100 DKK + transport. It could therefore not be more expensive than that for the municipality to take it over.

### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

The decision will ultimately lie with the construction client, but the consultant must inform about the possibilities. As things are right now, there are plenty of opportunities to get funding to try something out. In all construction cases we need to get a resource coordinator on, who goes in and decides what has value to recycle. It also requires someone who is passionate about it. Projects can quickly get lost in financial and practical considerations. So you need to have someone who wants to recycle and will push through.

### **What recommendations do you have for those considering circular building?**

I think it's really good to think creatively, but you also have to consider early on how to manage the environmentally hazardous materials, and the risk involved in recycling materials. The environmentally hazardous materials can put the brakes on what you end up using. But recycling is the way forward, so we just have to get started.

## Demolisher

### Interview with Mads Søndergaard – Director, Søndergaard Demolition

Mads Søndergaard is the director of Søndergaard Demolition. He is the third generation in the family business and has been project manager on the demolition of Taastrupgaard.

#### **Have you worked with circular construction before?**

Yes, I have worked on recycling and reuse pilot projects before. Waste is a resource - that's something relatively new. When my father was younger, you mixed everything together dumped it in the landfill. Now we are better at sorting because that is regulated by fees. It provides an economic incentive to sort. The Taastrupgaard project is about stimulating the market to find better solutions.



#### **What were the economics of recycling concrete from your standpoint?**

The balance sheet pretty much evened out. We are constantly finding new methods that make the process more efficient and thus more competitive. We view the Taastrupgaard-case as an investment in strengthening our knowledge on more skillful demolitions. After Taastrupgaard, we are working on a new big project. Now we can actually charge money for the concrete because it can be used as aggregate. This is the first time that's happened in my career. Concrete is now seen as a resource and as a raw material with a value like gravel and sand. It is interesting and it changes things in the market.

#### **What challenges did you experience?**

When you recycle materials, you need lots of time and planning. There were not so many challenges in the Taastrupgaard case, as it was a big project with lots of space on the site. It therefore didn't take more time. The main challenge comes with smaller projects with less space to manage the different fractions. There is less flexibility with smaller projects, which can therefore be a challenge.

#### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

If you want it to happen quickly, you need political regulation in the form of requirements. There needs to be penalties for not living up to the requirements and rewards for meeting them. It has to be expensive to not care about the environment. Transport and CO<sub>2</sub> emissions on construction sites must be reduced through, for example, electric and battery-powered machines instead of diesel-powered machines. In tenders, you can't just go for the lowest common denominator. Sustainability also needs to be weighted in tenders, with for example 40 percent price and 60 percent sustainability. Quality affects durability.

#### **What recommendations do you have for those considering circular building?**

Go for the low-hanging fruit first. Start by working with the heavy fractions - better that, than giving up and nothing happens. The municipality had a vision. That made a big difference. The early tests that the municipality carried out of the quality of the concrete was an important prerequisite for this to be possible. There was also a lot of dialogue between parties, which was good because otherwise the project could quickly run aground. Sustainability needs to be factored in as early as possible. Be a market driver yourself. You won't develop if you don't try to do things differently.

## Demolition waste processing facility

Interview with Jette Bjerre Hansen – Sustainability Manager, Norreco

Jette Bjerre Hansen is responsible for sustainability at Norreco. Among other things, she is responsible for the development of new reprocessing technologies and processes for documentation of quality, such as certification of aggregates.



### **What was the process with the concrete aggregate like for you?**

The updated version of the standard for the production and use of concrete in Denmark opened up to using 100 percent coarse aggregate as replacement for new raw materials. It also became possible to use recycled aggregate in all exposure classes. In the city hall project, 100 percent recycled stone aggregates were used in an exposure class corresponding to moderate environmental exposure. For the city hall project, we received a certification which enabled us to CE certify the coarse aggregate. Previously, you would have to apply for an exemption in order to use 100 percent recycled stone aggregate in that exposure class.

### **What challenges did you experience?**

Today, only approximately 50 percent of the crushed concrete can be used as recycled stone aggregate. The remaining 50 percent is made up of the fine fraction of 0-4 mm. We are working on building up sufficient experience in recycling this part of the concrete. We also need to address how we distribute the risk between parties. At one point we faced a high risk in terms of our role in the project. The contractor's advisor was close to not approving the recycled aggregate for the city hall project. None of us had discussed what would happen if the aggregate was not approved for the project in question — who had the responsibility and the risk then?

### **What were the economics of recycling concrete from your standpoint?**

Financially, it still costs more for us to produce recycled aggregate for new concrete. For us, however, we still gained valuable experience. We hope to soon upscale our production, and I'm sure that that will bring down costs. We expect to produce much more recycled aggregate in the future for new concrete, as quality raw materials will become more scarce. It is important that recycled materials be perceived as valuable resources, equal to others on the market — then they will be able to be sold for use in the production of building materials on an equal footing with natural raw materials.

### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

It is a good idea to use high-quality concrete for high value products. It is sustainable raw material management to maintain quality for as long as possible. Everyone has a responsibility — we just have different responsibilities for pushing the agenda. The construction client must be willing to demand recycled building materials. It will create a demand and thus a market.

### **What recommendations do you have for those considering circular building?**

Develop strong partnerships. It is important that you work with someone you can talk to and trust. Then you work together to make it succeed. Make sure you have clear and precise agreements. It has been fun and inspiring to work with circular construction. It is immensely satisfying when you see it succeed in the end.

## Concrete Producer

### Interview with Ib Bælum Jensen – Technology Manager, Unicon

Ib Bælum Jensen is head of technology at Unicon, who were responsible for the concrete production for the city hall.

#### **Have you worked with circular construction before?**

Yes, Sydhavn's Recycling Station. The common factor in the two projects is that the entire value chain is included. It is an advantage to have the entire value chain involved from the start, because you can lean on each other better and talk about things early on. Everything went much faster like that.



There is often a tendency for everyone to only talk about CO<sub>2</sub>, but there are actually 25 different parameters that matter when talking about sustainability. Sand and stone are becoming scarce resources. Recycling saves money on transport and removes the disadvantage of having to secure new materials of varying quality.

#### **What challenges did you experience?**

It was high quality concrete we worked with. The durability is therefore just as good as normal concrete. It can be difficult to find enough space for many tons of recycled concrete because it needs to be kept in production silos. In that period, we can't sell the concrete types that were previously kept in the silos.

Quite extensive documentation is needed to be able to use recycled concrete. We support that, but it means that it takes a little extra time. Currently, it can affect the unit price enormously for smaller projects, but in the case of larger projects it can be well worth it. Today we talk a lot about donor concrete — projects want to use their own recycled concrete. In the future, it should not matter where the recycled concrete comes from. You have to be able to call and order it just like any other building material. Technically speaking, recycled concrete absorbs more water than normal concrete because there are lumps of mortar in it. When the concrete is delivered, it must be fluid so that it is easy to process and move, but this can be solved with a little extra water.

#### **What were the economics of recycling concrete from your standpoint?**

We sold the concrete on roughly the same market terms as normal concrete, so it cost us a little bit. We want to continue working with recycled concrete and gain experience with it. Product development is therefore the most important thing for us right now.

#### **Were there any legal challenges?**

No, everything worked extremely well. Now we have even more experience, so later we may not have to take as many tests. There is no greater risk in this type of product than in anything else. We are already working on the next project, which is similar in size.

#### **What recommendations do you have for those considering circular building?**

Prepare yourself early on and have lots of coordinating meetings where everyone is together. Get sustainability described and demanded in the tendering material from the beginning. I hope the next project will be 10 times bigger – that would be exciting.

## Contractor

### Interview with Michael Eldor Birk – Project manager, Casa

Michael Eldor Birk is project manager at Casa on the city hall project.

#### **What challenges did you experience?**

In general, the recycled concrete does not differ much from normal concrete. The idea is that there should be as few differences as possible. However, you do have to be a little careful with the water-cement ratio, in terms of how fluid the concrete becomes. Recycled concrete absorbs more water than new concrete, so you need to be mindful of how much extra water to add. When the concrete was transported from the plant to the construction site, it absorbed some water which made it less liquid than what we normally use. The water cement ratios varied slightly from load to load, and it can be a bit challenging relation to casting and vibrating.



Normally, you can call up the concrete manufacturer and order an extra truck of concrete if you calculated incorrectly. You cannot do that with recycled concrete. They only mix exactly the amount you order. This is why we hope that recycled concrete becomes an off the shelf item with a standardized crushing process. This would mean that all recycled concrete can be mixed together regardless of where it comes from. This will come as demand increases.

There were a few challenges with respect to whether the concrete was too elastic. Getting the test concrete approved ended up being very last-minute. But with some extra testing of the curing process of the concrete, we managed to get it through.

#### **What were the economics of recycling concrete from your standpoint?**

We choose to look at it in such a way that it makes no financial difference to use recycled concrete as opposed to new concrete. There is some extra consulting and extra tests that make it a little more expensive, but in the long run it won't matter if it is recycled or not.

#### **Were there any challenges in terms of the building standards?**

No, it was okay. It was an okay process for the parties, and the standards have become more user-friendly. It is always difficult to be among the first to use the standard, but we found a way to make it work. The approval process will be easier in the future because we now have agreed on what is needed for the concrete to be approved.

#### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

In general, the greatest responsibility lies with the construction client. They must drive the demand and be part of giving it good publicity. The construction client must put recycling as a requirement in the tendering material, so that everyone bids on equal terms.

#### **What recommendations do you have for those considering circular building?**

The main takeaway from here is that it's not that bad. It can be done. Yes, there were some challenges along the way, but it wasn't so bad. Just do it, it's not as daunting as it might sound. If everyone does it, it becomes easier and it'll be the new normal.



## The New City Hall

### Interview with Erika Yates – Environmental consultant

Erika Yates is an environmental consultant in Høje-Taastrup Municipality and is the demonstration manager for the CityLoops project responsible for construction waste.



#### **Have you worked with circular construction before?**

Yes, I have previously been involved in a Cleantech TIPP project with a focus on circular economy, where different things had to be matched and connected. I learned that it was important to reach out and coordinate between the projects to find possible matches as different contractors and demolishers do not necessarily coordinate. Initially people were resistant to broach the subject because it is easier to just do what you usually do. Many thought it was complicated, but it worked out in the end: we had Taastrupgaard with lots of materials, so we hired Pelcon to analyze the concrete quality to see if you could use it for something. It turned out that it was perfect to use for recycled concrete.

#### **How did you make the tender material for the city hall?**

We didn't have time to add specific requirements for recycled concrete into the tendering material, as it came quite late in the process. A few days before the tender was sent out, I was invited to a steering-group meeting for the city hall project, where I pitched the idea of recycling the concrete from Taastrupgaard into the construction. The tendering documents ended up stating that the client favors sustainability and the use of recycled materials. At first, I hoped that the concrete would be used for the floor. I took a sample of recycled concrete with me to a meeting with the architects, and they were excited about it. Casa ended up bidding on the project — with the entire foundation made of recycled concrete, on Pelcon's recommendation. It went from a thin little floor to a whole foundation. It was fantastic.

#### **What challenges did you experience?**

There was no financial difference for the construction client in using recycled concrete compared to new concrete. One challenge was to ensure clarity and consensus about the precise documentation all parties required, and about who in the end is responsible for the quality of the concrete.

#### **Who bears the biggest responsibility to incorporate recycling into construction projects?**

The biggest responsibility lies with the construction client and the contractor. The construction client has to demand recycling, and the contractor has to be able to deliver it. If more contractors offer recycled materials, it's more likely that construction clients will demand it. The more construction clients demand recycled materials, the more projects contractors can bid on. The supply and demand will go hand in hand.

#### **What recommendations do you have for those considering circular building?**

Take recycling into consideration as early in the project as possible — the earlier, the better. Make specific requirements in the tendering material that are as precise as possible. It's all about good cooperation and partnerships and starting with the low-hanging fruit. At the same time, we also found out it's never too late!

## Interview with Jim Holme Højfeldt - Project Manager, Høje-Taastrup Municipality.

Jim Holme Højfeldt is project manager on the city hall project in Høje-Taastrup Municipality. He is part of the facilities team in the municipality's properties department.



### **Have you worked with circular construction before?**

This is the first circular construction project I have been involved in. There wasn't anything about sustainability and circular economy included in the tender before Erika Yates came in and suggested it. Recycling the concrete from Taastrupgaard also made for a really good story. It's a good story, being able to point at a column and say that it is recycled concrete from the Taastrupgaard social housing. The timing and the materials fit, so it made sense to use the concrete in the city hall. Høje-Taastrup Municipality also wants to brand itself on sustainability and responsibility. Recycled concrete fits in well as the foundation of our city hall.

We couldn't write the recycled concrete in as a requirement in the project, as it came too late in the process. We wrote that the construction client considered it an advantage if bidders focused on sustainability and recycled concrete.

The city hall was also going to be DGNB certified, but recycled concrete does not give that many points towards the certification. However, it results in a strong documentation of the process, which ensures high quality. In DGNB there are also requirements for soil balance. The soil that was dug up on the city hall grounds was therefore transported to Taastrupgaard, where the concrete came from. This led to a close collaboration between the projects.

### **What differences were there in working with recycled concrete compared to new concrete?**

There wasn't a big difference. When it's finished, it looks the same. The difference is just in the approvals — there are a little more audits and a little more meetings when working with recycled concrete rather than new concrete. It was the most controlled concrete I have ever used. You have to start early with all the documentation. Because it was one of the first times that such a large quantity of recycled concrete was being used, it took a little longer. Next time it will go faster.

### **What were the economics of recycling concrete from your standpoint?**

If we had managed to get recycling written in as a requirement the tendering material, it could have given us a price advantage because then it would have been subject to competition in the bidding process. Recycled concrete is not cheaper than new concrete. It's about the same price, but when the demand increases, the price will fall. In conjunction with resource scarcity, it will become more difficult to get new materials. Then at some point it will become cheaper to recycle.

### **What recommendations do you have for those considering circular building?**

The sooner you can get recycling into the tendering material, the better. The collaboration was fantastic. Everyone wanted it and wanted it to succeed. Good cooperation and partnerships are important.