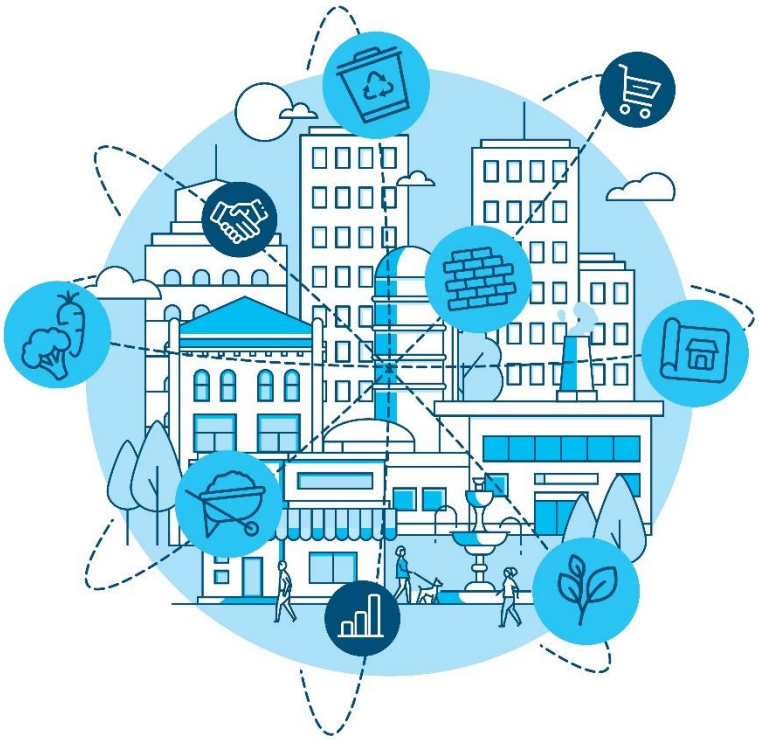
Recycling concrete in Høje-Taastrup

Extract from the Demonstration Report

Municipality of Høje-Taastrup, Denmark



Contents

This text describes Høje-Taastrup's experience in recycling concrete in the demolition of Taastrupgaard housing blocks and the construction of the new City Hall. The sections come from Høje-Taastrup's CityLoops demonstration report available here.

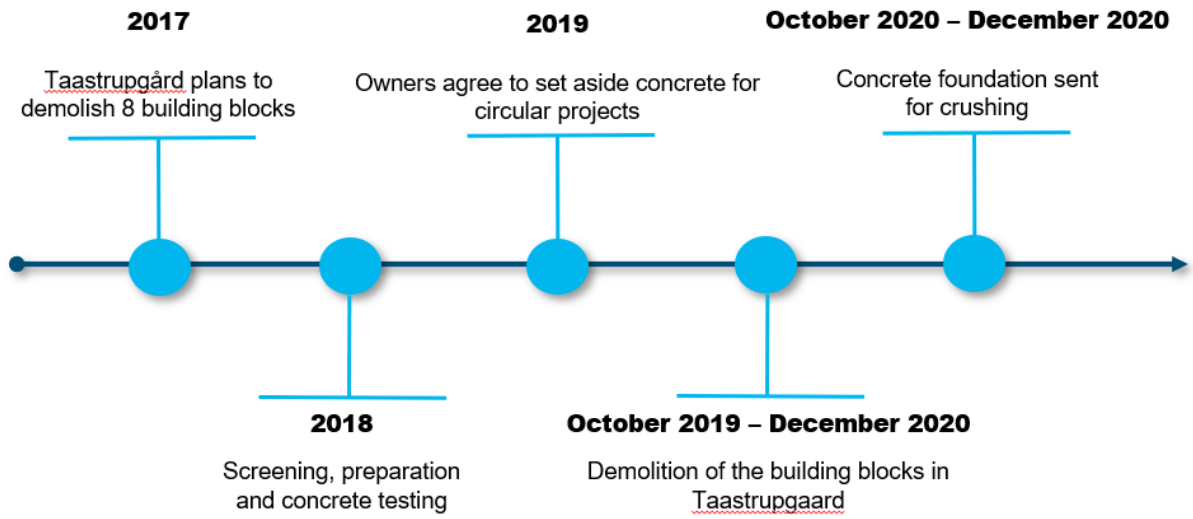
Demolition of Taastrupgård

This demonstration case is the demolition of Taastrupgård. Taastrupgård was built in the beginning of the 1970's with approximately 1.000 housing units. Over the years, Taastrupgård has developed into a social housing area with several challenges. As a part of municipal as well as national action plans to overcome challenges in certain social housing areas it was decided that 8 apartment blocks in Taastrupgård were to be demolished to make room for a new school, daycare facilities and a cultural center within the area.

Taastrupgård was mainly built of concrete, thus the demolition would generate a large amount of concrete with a potential for recycling. The focus of the demonstration case was therefore to find potential building projects in which to recycle the concrete or use it locally as filler.

Taastrupgård

Timeline for demonstration action 3: Demolition of Taastrupgård



Dialogue with stakeholders

Before CityLoops, one of the CityLoops project managers in Høje-Taastrup participated in an EU interreg project, Cleantech TIPP. In this project the municipality had dialogue with KAB, which is the social housing company that runs Taastrupgård, regarding reuse of material from demolition of apartment blocks in Taastrupgård. As an outcome of this project, the quality of concrete in Taastrupgård was tested.

The tests revealed that the concrete from the foundation of Taastrupgård apartment blocks was of such a great quality and enough of it was not contaminated with PCB or other harmful substances, that those parts would be suitable for reuse as aggregate in production of new concrete. Pelcon, a concrete specialist, tested the concrete and recommended use of either 20 % recycled aggregate or 100 % recycled aggregate (which at the time would have required a special dispensation - the revised concrete standard, DS/EN DK NA which came into effect in 2021 makes this no longer necessary) and developed a recipe for use of concrete from Taastrupgård as aggregate. The demolition was to generate approximately 25 000 tons of concrete.

KAB was open to the idea of the concrete being recycled and after extensive dialogue with the CityLoops project manager, ended up including an option in the tender which involved the uncontaminated concrete being transported to a location determined by the municipality, and received at no cost (the savings for future construction companies purchasing this aggregate and the reduced transport distance was meant to cover the cost). Eventually, KAB opted not to use this option and instead made a separate agreement regarding the concrete. In this agreement, KAB agreed to earmark 10 000 tons of clean concrete from the demolition of the apartment blocks to recycling projects facilitated by us.

Concrete flow - demolition with separate collection of recoverable concrete

The demolition contractor, Søndergaard Nedrivning demolished the apartment blocks. KAB encouraged reuse of concrete in the contracting process. Søndergaard agreed to deliver the earmarked concrete from the demolition to other projects.

Both KAB and Søndergaard saved money through the concrete recovery, since the projects that received the concrete received it for free.

Approximately 2000 tons of the 10000 earmarked tons of concrete were transported to Norrecco and crushed for use as aggregate. This resulted in 1088 tons of aggregate (a portion of the concrete ends up being pulverized in the crushing process and cannot be used as aggregate, hence the reduction of mass of concrete when transforming it into aggregate). It is crucial that the concrete is uncontaminated - both chemically but also with other waste materials (soil, pipes, insulation, etc.) in order to produce a high-quality aggregate when crushing it. Initially, the first few truckloads (approximately 100 tons) contained too much soil

and foreign material, so Norrecco ended up having to do extra sorting, extracting usable concrete blocks from the pile. In order to remedy this situation and avoid receiving more concrete mixed with soil and other waste, Norrecco requested that Søndergaard deliver larger chunks of demolished concrete (1 m x 2 m blocks instead of the typical 40 cm x 40 cm pieces) in order to reduce the quantity of soil and mud and ease the drying of the wet materials and sorting process for Norrecco. Once the concrete was crushed and sieved, it was delivered to Unicon (concrete mixing company) to be blended into concrete ready for pouring into the city hall foundation.

Unicon was very satisfied with the cooperation and dialogue but considered the relatively small quantity of the recycled material as a challenge due to the space it occupies in their silos. In the future, Unicon would prefer to receive larger quantities of recycled materials. Recycled aggregate has to be managed separately, which makes it more difficult to manage in small quantities compared to the required effort.

Some more of the concrete from the demolition was used in road stabilization locally – 6000 tons (4000 tons on the Taastrupgård site and 2000 tons in Høje-Taastrup C (the development area around the new City Hall)). The concrete that was used as filler on-site in Taastrupgård was crushed at RGS Nordic (a waste management/treatment company). The CityLoops project managers suggested that the concrete be crushed on-site in Taastrupgård and, as environmental authorities, were also willing to grant the required permissions with terms about noise restrictions and other disturbances. However, KAB decided against crushing on site due to the risk of annoyances like noise and dust for the residents of Taastrupgård.

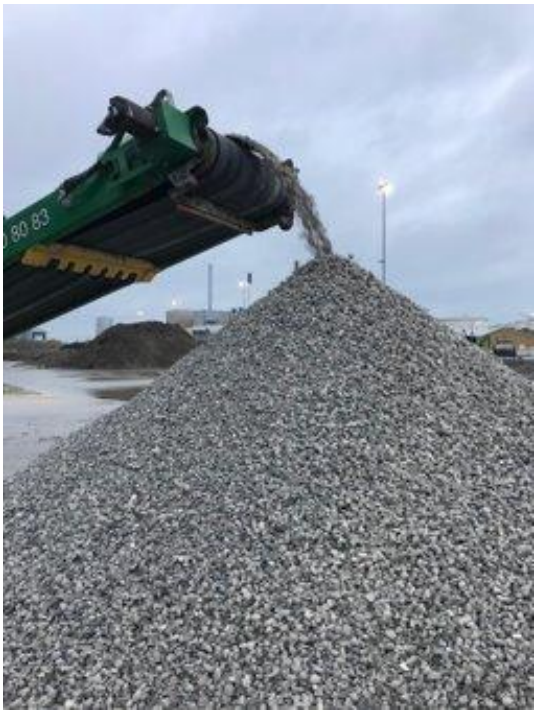
The concrete that was used as filler in Høje-Taastrup C was crushed on-site at Høje-Taastrup C, resulting in substantial transport savings.

Demolition of Taastrupgård

Lessons learned

- It was possible to recover approximately 10.000 t concrete for local recycling (2.000 t recycled aggregates and 6.000 t recovered materials). This saved money (see business case section) and CO2 emissions.

- Local crushing of concrete for the city hall foundation would have saved more CO2-emission from transportation but this was not possible in this case.
- Reduction of transport distance and CO2-emissions by on-site mixing of the concrete instead of using prefab concrete should be required. However, the project did not include this opportunity. Future projects could consider integrating this into their planning.
- It was a problem to keep the demolished concrete free from soil, mud, and other materials. To facilitate the drying and cleaning process, Norrecco required bigger sizes (1 – 2 m) than the normal size (0,3 – 0,4 m).

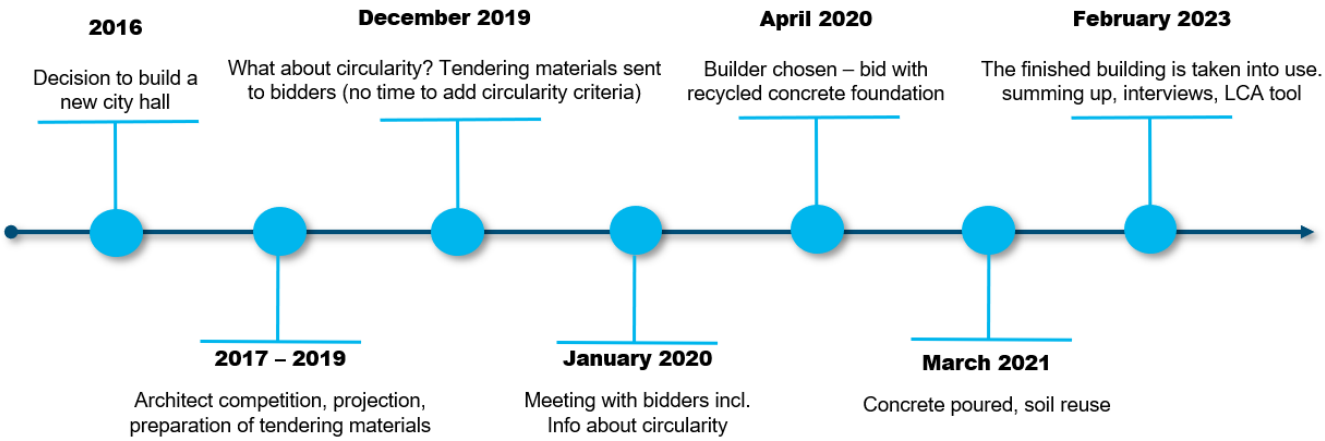


Transformation – crushed concrete for aggregate

Construction of the new city hall

In 2016 it was decided that Høje-Taastrup would build a new city hall due to the need for extensive renovations in the existing city hall. The new city hall would be located in the planned urban development area Høje Taastrup C (HTC) as a way of kickstarting its development. At the same time, a part of the Taastrupgård neighborhood was earmarked to be demolished. The CityLoops project managers saw the opportunity to use material from the demolition in the construction of the new city hall. Therefore, the focus of this demonstration action was to recycle material from the demolition of Taastrupgård into the construction of the new city hall.

Timeline for demonstration action 2: New city hall



Planning and decision-making process

The municipal department of properties and internal service (CEIS) was in charge of the construction of the new city hall.

The architectural design competition took place in 2018. The winning design was chosen at the end of 2018. It was decided by the steering group that the city hall would aim for DGNB Gold certification.

There was no obligatory procedure at that time that would lead a dialogue to take place between the properties department and the environmental department regarding the project or the tendering process and as such the environmental department did not have any influence over the decision-making process. In 2018 there was however a short meeting between the properties department, the manager of the environmental department and the climate department where environmental issues were discussed. There was however no formal structure or mandate upon which various environmental initiatives could be considered and the meeting therefore did not result in any concrete changes to the project. There were no further collaborations between these departments at that stage of planning.

Soon, the plan to DGNB-certify was discarded due to economic considerations. In response to this decision, the CityLoops project managers as well as others in the environmental department and the internal sustainability group maximized pressure on the steering group of the new city hall. In mid-2019, the steering group returned to the initial plan in favor of DGNB certification. The environmental department was at the time not informed about the considerations that led to opting for DGNB certification in the end but have since been told that it was a result of the pressure put on the steering group.

The decision to go ahead with DGNB certification opened the door to new initiatives being considered in the city hall project. Selected employees (among others, one of the CityLoops project managers; the head of the environmental department; and the climate department) were invited in autumn 2019 to brainstorm about how potential initiatives could be implemented to obtain additional DGNB points. The CityLoops demonstration manager pointed out that the municipality had access to concrete from Taastrupgård (see section 3.2 above), which could be used as recycled aggregate. This opened the door for dialogue, and the project manager from the properties department was open to hear about the possibility of using recycled materials.

The decision to go through with DGNB certification came relatively soon before the tendering material was to be published, so there was very little time to integrate potential changes into the material. Just a few days before the material was published, the CityLoops demonstration manager was invited to a steering group meeting to pitch the idea of integrating recycled materials, specifically recycled concrete, into the construction. The initiative was welcomed by the steering group, on the condition that it would not be more expensive. Due to the timing, no specific criteria or requirements were added to the tendering material regarding recycled materials. Instead, information was added about Høje-Taastrups involvement in CityLoops and intention to promote circular economy.

Procurement: Tendering process for construction of new city hall

At the very last moment circular suggestions/options (but no requirements) were added to the tendering material. They were as follows (translated from Danish):

"Høje-Taastrup Municipality is involved in the project CityLoops, which is a Horizon 2020 project, with the aim of promoting circular economy within construction projects. The project must contribute to future-proofing the construction market to be able to meet the increasing demand for recycled materials in buildings.

In connection with the construction of the city hall, the municipality requests that reusable/recyclable materials are used wherever possible. We have a particular focus on the use of recycled concrete since we have access to a large amount of concrete waste from a local demolition, Taastrupgård (up to approx. 25,000 tons).

The concrete has been tested to assess the recycling potential. It is determined to be well suited for use as aggregate in new concrete or in new tiles.

Approximately 2000 tons of concrete are set aside for use as aggregate in tiles in the new neighborhood Høje-Taastrup C. The same type of recycled tile may be used on the city hall grounds.

In addition, the floor in the atrium of the city hall could also be made of concrete with recycled aggregates from the local demolition project. Recycled concrete may also be used for elements such as benches etc. on outdoor areas.

If the contractor sees opportunities for the inclusion of additional recycled elements such as panels of recycled wood, the municipality can, if necessary, help the contractor to identify a local source for these materials.

The municipality's involvement in the CityLoops project means that we, among other things, can contribute by offering access to advice regarding any special measures when using recycled concrete, preparation of the concrete recipe for recycled concrete, coordination assistance in connection with securing access to the concrete from the demolition, etc. The concrete will be stored within approx. 10 km from the construction site and as a rule are stored in pieces of up to 50 cm"

At a meeting in the beginning of January 2020, the 5 pre-qualified bidding contractors were informed that initiatives including recycled materials would be positively considered in conjunction with other bidding criteria, and that the municipality had access to concrete from the demolition in Taastrupgård. However, at the same time, the tendering material contained stipulations that could potentially block the use of recycled materials: namely, that well-tested materials should be used.

The contractor that ended up having the winning bid had investigated the possibility of using the recycled concrete in their construction and ended up proposing using recycled concrete in the foundation of the new city hall as a part of their offer.

Concrete flow

Crushed concrete from demolition of 8 housing blocks transformed to recycled aggregate concrete (100%) in concrete foundation of new city hall, Høje Taastrup, 2021. CityLoops HTK demo-project 2.

The winning contractor CASA contacted the concrete expert Pelcon and the waste management company receiving the concrete for crushing (Norrecco) to discuss the opportunities for using recycled concrete and concluded that the recycled concrete would be suitable for aggregate in the foundation of the new city hall.

In addition to the direct effect on the circular economy the case would be a great story to tell in a transferred meaning – the municipality standing on a solid foundation of recycled material from a social housing area in which the municipality made a great effort to develop.

The steering group were worried about the aesthetics of the building if the concrete were to be used as a visible floor in the atrium - if it didn't turn out right, it would be the first thing visitors would see. In addition, it did not suit the architect's design suggestions for the floor, so this idea was abandoned.

With extensive testing and coordinating between parties, a concrete foundation with 100 % recycled aggregate was poured at the beginning of 2021.

The donor concrete from Taastrupgård (see section 3.2 above) was crushed by Norrecco and received a CE-certification as the first recycled concrete aggregate certified under the new Danish standard which permits the use of up to 100% recycled aggregate in concrete, which came into effect in January 2021. In order to certify the aggregate, Norrecco needed to document their procedure for producing recycled aggregates and document that it lives up to the two standards for aggregates: DS/EN 12620 and DS/EN 206 DK NA. Tests are conducted on each batch of aggregate to ensure it has the necessary quality. The certifying body conducts audits to ensure that the aggregate and producer live up to these criteria.

Once crushed, the aggregate was temporarily stored until it was time for it to be mixed into concrete and transported to the construction site for pouring (the aggregate is combined with sand, cement and water to be prepared for pouring).

Administratively, the process met some obstacles due to the risk aversiveness of the contractor's consulting engineer. The consulting engineer called for several rounds of extra tests on the concrete, despite extensive existing documentation on its quality. This caused several delays and there was a risk that they would not accept the use of the recycled concrete. In the end, the concrete specialist Pelcon ended up taking responsibility for the quality of the concrete by writing a statement saying that the concrete had the required quality. Pelcon was sufficiently confident in the concrete to agree to this, despite it implicitly meaning that they took on the risk, as it was the only way forward to succeed with the initiative. Another factor that sufficiently subdued the advisor's risk aversiveness was the fact that Norrecco opted to get the aggregate CE-certified as part of their investment in product development in offering recycled aggregate as a product.

The resources saved were 1088 tons of concrete diverted from the waste stream or 27 truckloads. The raw materials would have otherwise been extracted from the seafloor north of Poland or from a quarry in southern Sweden. The recycled aggregates in the new concrete saved approximately 6,6 tons CO2, which result from reduced transport distance (approximately 25 km in total rather than 100 km total). The CO2 savings are greater when concrete is reused intact, because even with recycled aggregates you have to add carbon-intensive cement to get new concrete. See detailed calculations in section 4.2 Impacts.

Pouring of concrete foundation with 100 % recycled aggregate, photos: Unicon

Other flows

Wood

Wood from offcuts/ industrial processes (extra cuttings, excess materials that were unused) has been used as facade panels around the new city hall. This was not a part of the specific demonstration project delineated in the CityLoops regime, but a bonus that came with the momentum of the increased awareness of closing the loop of material flows.

Furniture

The municipal sustainability group got involved in the city hall furnishing team to lobby for as much direct reuse of furniture from the old city hall as possible. This initiative was further supported by the current supply chain issues and inflation as a result of the war in Ukraine, since furniture producers were not able to live up to supply chain demands. It was however decided by the municipal board of directors that the bulk of the furniture in the new city hall would be new. It was estimated that approximately 10 % of the furniture in the new city hall is reused from the old city hall. Other municipal departments such as schools, daycares, nursing homes etc. as well as associations for sports and leisure were invited to pick up furniture for reuse before the building was finally stripped and the remaining furniture was disposed of.

New city hall with outside wooden panels from offcuts (ground level and roof terrace)

Local reuse of excavated soil

Concurrently with the construction of the new city hall the department of properties took over the area in Taastrupgård where eight apartment blocks were demolished to build a new school. In order to modulate the terrain in the area after demolition, a large amount of soil was needed. The project manager for construction of the school and the project manager for the construction of the new city hall realized that the timing would be almost perfect for reusing excess soil from the city hall construction at the area in Taastrupgård where the school was to be built. Therefore, they contacted the CityLoops project manager who is also an authority on soil in the environmental department in order to clarify if there were any legal or other barriers to reusing the soil locally. Since the soil was uncontaminated and geotechnically suitable for the purpose of modulating the terrain, there were no concerns or barriers for reusing the soil.

However, it turned out that the soil had to be stored intermediately for a couple of weeks, which the CityLoops project manager helped find a suitable area for.

Approximately 9.000 tons of soil from the construction of the new city hall was reused in Taastrupgård. CO2 calculations revealed that almost 30 tons of CO2 were saved from transporting the soil a shorter distance.

Lessons learned

The key lesson learned is that successful recycling of concrete and use of 100% recycled stone aggregates in new concrete for the foundation of the new city hall was possible.

Natural resource and CO2 savings

Concrete aggregate

The main goal of recycling concrete for the city hall foundation was avoiding raw material extraction. However, using the recycled aggregate still resulted in approximately 6.63 tons CO2 savings due to reduced transport distance. The concrete was transported approximately 25 km to Norrecco to be crushed. It would have been transported this approximate distance for crushing even if it were not to be recycled as aggregate. This transport distance is therefore not factored in to the total distance. It was then transported to neighbouring Unicon, and then 25 km to the construction site. Normally, aggregate would be extracted from a quarry in southern Sweden or from the ocean floor north of Poland, estimated to have CO2 emissions in both cases approximately equivalent to 100 km based on information from Unicon. The savings were calculated using the CityLoops CO2 calculator for soil as this calculation is based on transport distances. With 25 km transport of 1088 tons (approximately 27 truckloads) from the source rather than 100 km, 6.63 tons of CO2 were saved, and approximately 2025 km avoided truck transport. Local crushing of concrete for the city hall foundation would have saved more CO2 but in this case logistical barriers prevented this. It would have furthermore required on-site mixing of the concrete, which the project did not include. Future projects could consider integrating this into their planning.

The resource savings were considerable. 1088 tons or 27 truckloads of concrete aggregate was used instead of raw material from these gravel pits or sea floor.

These calculations were not used in decision making in this case, rather done afterwards for reporting and reflection.

CO2 and material savings calculations could easily be applied predictively and should be considered being used in future projects – construction as well as demolition – in the tendering process. Truckloads of soil/concrete savings are easy to communicate and understand as way of illustrating savings potential.

Concrete filler

The 2000 tons (50 truckloads) of crushed concrete from Taastrupgård used locally in Høje Taastrup C as filler also resulted in CO2 savings. It is estimated that standard recycled filler would have come from approximately 25 km away instead of 3 km away, saving 1100 km of truck transport. Using the CO2 calculator for soil this amounts to a saving of approximately 4.06 tons CO2.

For the 4000 tons crushed concrete from Taastrupgård used on site to stabilize the ground in conjunction with construction of the new cultural center in Taastrupgård, there is a net 0 CO2 saving in terms of the transport of the materials. As KAB did not want to crush the concrete on site, it was transported to a standard waste treatment plant for concrete, where it was crushed and returned to the site (not necessarily 1:1 the same concrete - concrete from other sites was likely also used). Thus, this is the same process as if the crushed concrete filler had been purchased as a good instead of just transported back and forth.

Soil

Approximately 9.000 tons of soil from the construction of the new city hall was reused in Taastrupgård. CO2 calculations revealed that almost 30 tons of CO2 was saved from transporting the soil a shorter distance. This corresponds to 257 truckloads avoiding 5667 km of truck transport.

Totals

In total Høje-Taastrups participation in CityLoops has resulted in raw material savings of 1088 tons of granite and approximately 40.7 tons of CO2 savings. 8792 km of truck transport was also avoided, as well as the subsequently avoided particulate pollution, road wear and tear, noise pollution, reduced traffic, etc.

Stakeholder engagement

The use of recycled concrete as aggregate in the foundation of the new city hall was a result of a great collaboration between the department of properties, The CityLoops project manager in the municipal environmental department, CASA, KAB, Norrecco, Søndergaard Nedrivning, Unicon and Pelcon.

Interviews with stakeholders were performed upon completion of the project resulting in a Q&A pamphlet (translated from Danish). See Appendix A.

Organizational factors

As a construction client the municipality has now built some capacity in reusing materials in construction. However, no procedure currently exists in the municipal operations to ensure that necessary parties coordinate their efforts to ensure circularity and sustainability are considered. In order to ensure that reuse of material is considered in future municipal constructions it will be included as a strategy in the future citywide sustainability strategy and action plan which the CityLoops project managers are in charge of.

Project planning

Early incorporation of sustainable initiatives into the project planning process is favorable, but this demonstration action showed that it is never too late. A last-minute, minor addition to the tendering material opened the possibility for using recycled concrete and emphasized the focus on sustainability, and this change was pivotal for incentivizing the contractors to consider recycled materials.

Legal factors

Modulus of elasticity is a measure of concrete's elasticity. Eurocode 2 for design of concrete structures refers to this elasticity based on measurements from the 1960s, when standard concrete typically contained a higher proportion of aggregates, which gives a lower elasticity. Modern concrete of a given strength therefore does not correspond to the values for elasticity referred to in Eurocode 2. However, current regulations state that if needed, modulus of elasticity should be measured in recycled concrete. This creates a problem because the modulus of elasticity for recycled concrete – like modern concrete – does not correspond to the values listed in Eurocode 2 – but usually the discrepancy goes unnoticed as it is normally not measured. Given the allowance to measure elasticity in recycled concrete, the city hall contractor's consulting engineer opted to request this. The results showed the expected discrepancy from Eurocode 2. In order to compensate for the discrepancy, the consulting engineer called for additional reinforcing bars (steel inside concrete). From a technical perspective, these extra reinforcing bars were unnecessary as the information that led to this recommendation is outdated.

In order to attempt to address this problem of outdated knowledge and practice, Pelcon (concrete expert and consultant on this project) is lobbying to change the practices surrounding measures of elasticity so that they more closely reflect real-world requirements. Changing these practices would contribute to reducing barriers for the use of recycled concrete, which currently faces extra testing and scrutiny.

Norrecco worked to get the recycled aggregate CE-certified, which helped in the approval process of the concrete. The fact that the aggregate material was certified and thoroughly documented contributed to its being accepted by the consulting engineer.

Risk and responsibility

A very important lesson learned is to assess who has the responsibility for the quality of the material and thereby who will take the risk at an early stage. Risks must be identified and communicated about as early as possible. In this case the final decision regarding responsibility for risk was done at a very late stage which almost obstructed the whole initiative.

Concrete standards and quality are complex and depending on the required function of the concrete, the relevant quality parameters can vary substantially. In future projects it would be helpful to clearly outline which parameters are relevant and at what quality levels. This would avoid the problems encountered regarding module of elasticity: it is not a relevant parameter in a foundation, but is relevant in long, narrow structures such as columns.

DGNB as incentive for circular soil handling

The DGNB criteria with regards to soil played an important role and was an incentive for local reuse. Most DGNB points are given for reuse on site, though some points are also given for keeping soil within a certain distance from the site. The intermediate storage of soil was done to account for discrepancy in timing in order to secure local reuse and thereby get DGNB points.

CITYLOOPS

CityLoops is an EU-funded project focusing on construction and demolition waste (CDW), including soil, and bio-waste, where seven European cities are piloting solutions to be more circular.

Høje-Taastrup and Roskilde (Denmark), Mikkeli (Finland), Apeldoorn (the Netherlands), Bodø (Norway), Porto (Portugal) and Seville (Spain) are the seven cities implementing a series of demonstration actions on CDW and soil, and bio-waste, and developing and testing over 30 new tools and processes.

Alongside these, a sector-wide circularity assessment and an urban circularity assessment are to be carried out in each of the cities. The former, to optimise the demonstration activities, whereas the latter to enable cities to effectively integrate circularity into planning and decision making. Another two key aspects of CityLoops are stakeholder engagement and circular procurement.

CityLoops started in October 2019 and will run until September 2023.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 821033.