
Photo:
Mad arkitekter for Entra

Reuse and transformation
Findings report

KA13 - Kristian Augusts gate 13

Foreword

This experience report was prepared by the reuse team for the KA13 project, with Anne Sigrid Nordby (reuse consultant) as the main editor, and Randi Lunke (reuse coordinator) and Rune Andersen (project manager) as co-editors and storytellers.
All planners, contractors, suppliers and tenants have provided important contributions to the report by sharing their experiences and various facts from their inclusion in the project.
Traversing this reuse project has been like wandering off the beaten track, with many detours along the way.
While based on a variety of sources, the report is mainly grounded in the feasibility study for reuse in KA13 – conducted in the preliminary project phase – and on the experience reports provided via the FutureBuilt workshops.
Practical/technical opportunities and challenges are discussed in relation to the reuse of certain building components, and through this report, we have endeavoured to justify the conclusions we made, as to why reuse of a component was, or was not, pursued.
The reuse team are aware that factual errors may occur in this report, and that certain details may have been omitted.
It must also be noted that the experiences gained through the KA13 project are not necessarily directly transferable to other projects. However, we hope that all who read this experience report will enjoy it and be inspired to contribute to the green transition by further pursuing reuse options themselves.
We have tried to cultivate this track ourselves – that is to say, areas of the industry in need of updating – and believe that by doing so, it will be easier for others to follow in our footsteps.

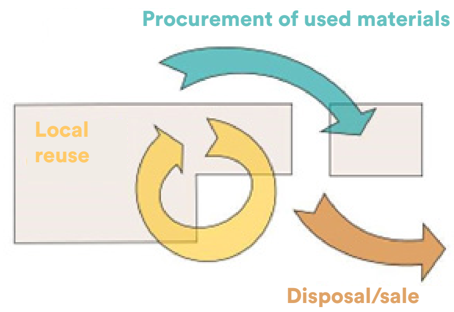
1 INTRODUCTION

1.1 THE PROPERTY OWNER'S EXPERIENCES ENTRA, by project manager Håvar Haugen Espelid

Kristian Augusts gate 13 was purchased by Entra in 2016 as part of the plans for the Tullinløkka area of Oslo. Several feasibility assessments were carried out for the property, for which options were considered as to whether a new building should be built, or whether the original building should be renovated and converted. Based on the feasibility studies, it was decided that the project would go ahead as a reuse project, in which the aim was to renovate the existing building and add an extension using as many reusable elements as possible. Entra was fortunate in having Spaces as not just a tenant but a
collaboration partner – something that certainly contributed to the overall realisation of the project. Entra's own goals – of being at the forefront of environmentally friendly solutions and always having a pilot project in its property portfolio – played a significant role in the decision to make the project a full-scale reuse project.
In the time leading up to the initiation of the reuse project, it was important for Entra to receive assistance from other actors in the industry, as well as cooperative partners who could assist us in helping achieve the reuse process, and who also believed in such a project. We had envisioned a picture of how we wanted the reuse to take shape and outlined a number of issues that may arise during this process. Regardless of how well prepared we were, we've had many surprises along the way.
The project has been demanding in every respect, and the planning phase ended up lasting longer than is normal for an ordinary construction project. Acquiring the necessary products proved demanding, as was obtaining the documentation required for both the technical aspects and finding a way to trade the products legally.
One of the key factors of our being able to complete the project – and having done so with such a great deal of reuse – is that of the persistence that our tenants, consultants and contractors have shown throughout the process. Such a project as this has never been seen before in Norway, and it is no coincidence that it was this particular group that were able to come together and complete this work of art. Entra is extremely satisfied with what the designers and contractors managed to deliver here, and hope that the reuse work that we have started through KA13 will contribute to ensuring further industry advancement when it comes to the reuse of construction materials.

1.2 BACKGROUND FOR THE REPORT: GOALS FOR REUSE

With the backdrop of the high environmental ambitions for Kristian Augusts gate 13 (KA13), our goals for this project were set early on in the planning, to ensure a high degree of reuse for as much of the building as possible, including its load-bearing structures. The outer walls of the existing building were mostly preserved, except for the windows. The 7 storey extension and a new roof terrace above the ground floor/courtyard were to consist of as many reused materials as possible.
The strategies and solutions employed for this were adapted throughout the project via interdisciplinary processes in which every relevant trade was involved. Initially, a long series of building components were examined for reuse, and as the project progressed, lists for the procurement requirements of second-hand materials from other buildings were drawn up. The professional advisors (ARK, RIB etc.) set the quantities and requirement specifications for these lists.
Alongside the development of the building, FutureBuilt launched its own programme and created its first set of criteria for circular buildings. KA13 was the first pilot project that applied this work in practice, meaning that it now exists as the first building to have met all of FutureBuilt's criteria for circular buildings.



There were 3 different material flows in KA13. These material flows are color-coded throughout the report, and the results for how elements were reused are indicated according to the relevant color, in reference to the material flow in question.

1.3 PARTIES INVOLVED IN THE PROJECT

1.3.1 Property owner organisation

Initiative leader and project manager	Entra ASA
Tenant	Spaces
Project manager, project planning group leader, building manager, environmental consultant and reuse coordinator	Insenti AS
Architect	Mad arkitekter
Interior designer and the tenant's representative	Scenario Interiørarkitekter
Reuse consultant, BREEAM , environment, energy, LCA, natural light, surface water, ecology and landscape architect	Asplan Viak
Plumbing and heating consultant, shelters and environmental surveying	Norconsult
Electrical consultant	Heiberg & Tveter AS
Geotechnics and concrete condition consultant	Multiconsult
Structural engineering and building physics consultant	Rambøll
Fire consultant	Fokus Rådgivning AS
Acoustics consultant	Brekke & Strand Akustikk AS
Lift consultant	HeisConsult AS
ITB coordinator	EvoTek As
BIM coordinator	Pro-Consult AS
Independent inspections	B Consult AS, Firefly AS
FDV-web	CuroTech AS
HSE coordinator	Sweco
Legal assistance	Kluge Advokatfirma AS

1.3.2 Contractors

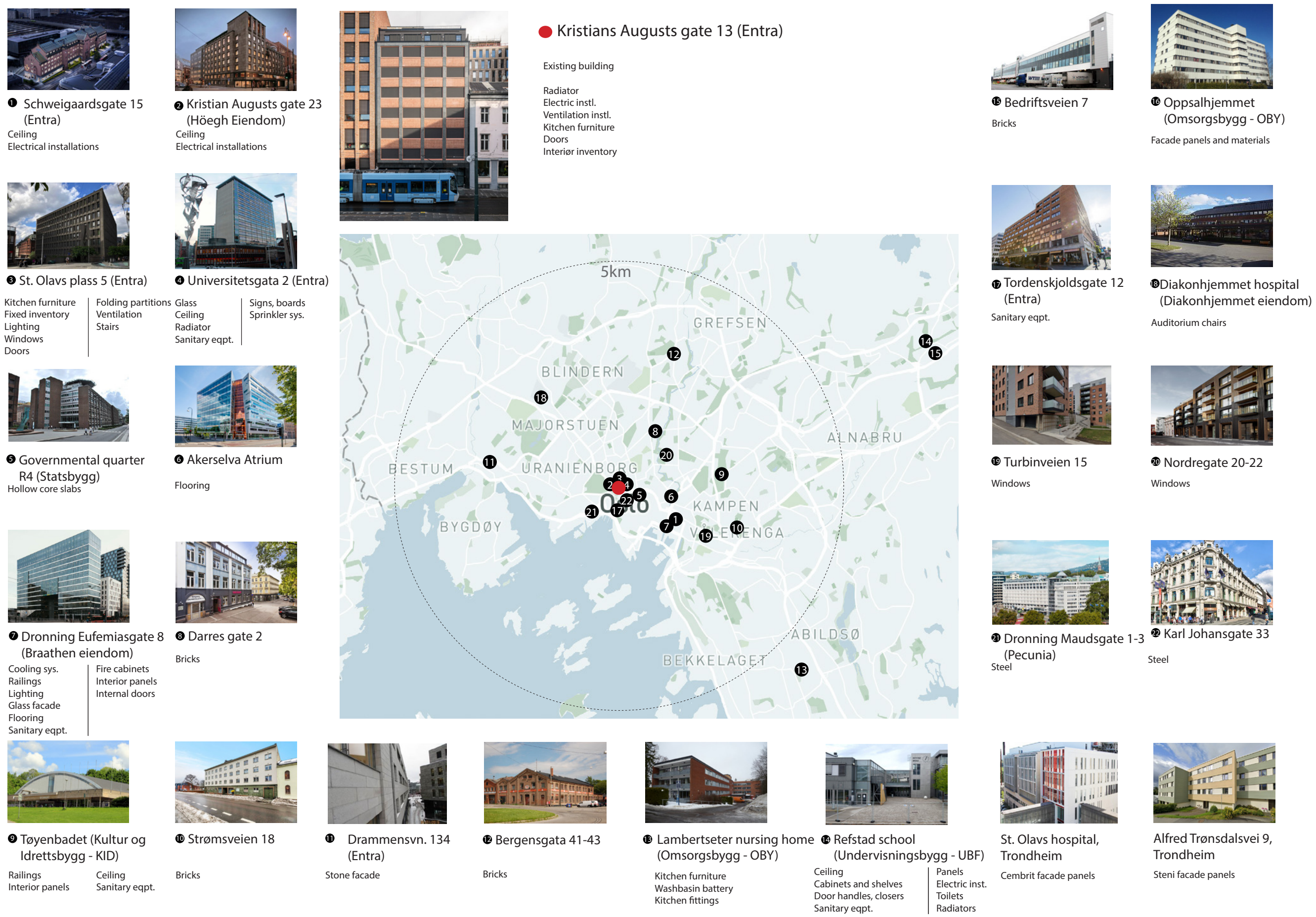
Construction work and the main contractor	Haandverkerne AS
Demolition work, steel and concrete work (closed building shell for the extension)	Øst-Riv AS and Stokke Stål AS (UE)
Ventilation work	Energima AS
Plumbing	Oslo-Akershus Rørleggerbedrift AS
Electrician	Kontakt El-installasjon AS
Automation, fire, and safety	Schneider Electric Norge AS
Locks and fittings	Låsekspressen AS
Floor surfaces	Oslo Tapet & Gulvbelegg AS
Glass walls	Creo-Nordic Prosjekt AS
Wooden modular walls	Termowood ASA
Amphitheatre stairs	Trappemakeren AS
Paving stone and decking installation	Ellingard Naturstein AS
Lift and lifting tables	Thyssenkrupp Elevator AS
Access systems	Høyden AS
Green roofs and planters	Bergknapp AS

1.3.3 Contractors and other participants in the value chain: who/where/how

A long series of contributors have played essential roles in obtaining used and residual materials for this project, as well as for the processing and modification of these such that KA13 could be supplied with good quality, second-hand products. The value chain for used materials is not well established, and many new avenues through various different areas have been paved through our work on this project.

The used building materials were sourced from over 25 buildings, which were either buildings undergoing demolition/renovation or building parts that had just been used temporarily. The illustration below shows where the nearest "donor buildings" are located.

Then there is a review of how the project came into contact with the various buildings/building owners and other actors relevant to the procurement and processing of used materials for this project. A full overview of the different types of reused building materials, and the number/quantity of these, is presented in subchapters in the report. A summary of the results is provided in the form of a table, and illustrated in chapter 8.



Map of the donor buildings in Oslo. Illustration: Mad

ENTRA BUILDINGS

Entra had its own buildings undergoing renovation, of which building components were taken from. These include:

- Universitetsgata 2
- St. Olavs plass 5
- Schweigaardsgate 15
- Tordenskjoldsgate 12
- Drammensv. 134

Private building owners:

- Dronning Eufemias gate 8 (Braathen Eiendom). Through Resirqel, we were given the opportunity to contact Braathen Eiendom – who were in the process of completely renovating the “PWC building” in Dronning Eufemias gate 8 (DEG8) – to see which used elements the building had available for reuse. Following the inspection, the fire doors to the stairwells were identified as suitable for reuse in KA13. Via an agreement with the building owner and the demolition contractor for DEG8 (Betonmast) our contractor was given access to remove what we wanted, free of charge.

- Kristian Augusts gate 23 (Höegh Eiendom). The building had been recently purchased from Entra by Höegh. Höegh also wanted to develop Kristian Augusts gate 23 (KA23) as a reuse project, and conducted a reuse survey. Elements that they did not see potential in reusing for KA23 were made available for KA13, and Entra thus ended up obtaining the used ceiling panels and some electrical materials.

- Diakonhjemmet Hospital (Diakonhjemmet Eiendom).
  Project manager for the St. Olavs plass project for Entra later facilitated contact with an environmental consultant from Norconsult, regarding
  the renovation of Diakonhjemmet Hospital (Diakonhjemmet Eiendom) where we found the auditorium seats that suited the project.

Public buildings:

- Regjeringskvartalet R4 (Statsbygg/Veidekke)
  In connection with the demolition of buildings in the Government Quarter (Regjeringskvartalet R4 and Møllergata 17), Statsbygg held a dialogue meeting on 12th March 2019. The purpose of this was to establish contact with those in the market who may make use of building components and demolition materials from R4 and M17. Veidekke served as the demolition contractor for the project, and their reuse consultant Resirqel had mapped out the reuse potential of the buildings, which was presented at the meeting. As a result of this meeting, processes were then established for the disposal of building components from the demolition, such as hollow core slabs. The price and progress for removing these were eventually discussed directly with Veidekke.
  In addition to KA13, several other actors were interested in buying the hollow core slabs from the Government Quarter demolition project.

- Refstad School (educational facility - UBF)
  The reuse consultant read in the Dagsavisen newspaper about the planned demolition of the then 11-year-old school that had been incorrectly designed and had structural damage, and was later sent a report from the reuse survey that had been conducted by Multiconsult. Asplan Viak got in touch with UBF and arranged an inspection. The photos from this inspection, alongside the reuse report, provided the basis for discussions within the planning team, and the subsequent inspections carried out alongside ARK, IARK and several of the contractors. In regard to the removal of the suitable building components, we were met by UBF with a very positive attitude and were even allowed to store the dismantled goods in the classrooms before they were collected for use in KA13.

- Oppsalhjemmet and Lambertseters Sykehjem (nursing homes – OBY)
  In connection with Rambøll’s investment in establishing a recycling platform (Rehub), Rambøll initiated a collaboration with KA13. We entered into an agreement in which Rehub could test its platform by searching for used products on behalf of KA13, while our reuse consultant was assigned the task of providing an assessment of the platform’s interface and user-friendliness. Rambøll received a list with the number of items that we were looking for, and some of these were found in the Oppsalhjemmet and Lambertseter sykehjem nursing homes owned by OBY. The collaboration resulted in the acquisition of kitchen units for the mini kitchens, as well as the metal façade panels for KA13.

- Tøyenbadet (public swimming pool – KID)
  In 2017, Asplan Viak conducted a reuse survey of Tøyenbadet in connection with an Enova inspection, and thus had photos and an overview of the possible reuse items prior to its demolition. This material was presented to the planning group, and further inspections were carried out alongside ARK, IARK and the contractors. KID were positive about dismantling and selling various components, which included 12 large reflectors that had been installed on the large roof of the swimming pool hall, which we removed and reused in the KA13 light shaft.

DELIVERIES OF USED MATERIALS THROUGH CONTRACTORS/SUBCONTRACTORS:

Øst-Riv delivered the closed building shell for the extension and procured both the used steel and used bricks from buildings that were undergoing demolition/renovation. The used bricks were obtained from:

- Strømsveien 185
- Bergensgata 41–43
- Bedriftsveien 7
- Darres gate 2

Øst-Riv obtained the used steel from:

- Karl Johansgate 33
- Dronning Mauds gate 1–3
  Stokke Stål worked as subcontractors for Øst-Riv and procured steel from both residual stock and temporary steel used for various projects, including:
- Hegnasletta 4 (Sandefjord)
- Tornsangeveien 25 (Fornebu, Bærum)

The reuse contractor Resirqel assisted the project through the procurement of used materials and the rental of storage space at their premises in Vollebekk, Oslo. A large delivery came in the form of 26 used windows from a project in Kværnerbyen (Turbinveien 15). Resirqel also delivered two windows in other formats to the project and furthermore presented catalogues of several other potential second-hand products for use from various buildings they had surveyed during the course of the project. The windows they sourced came from:

- Turbinveien 15
- Nordregate 20–22

Other second-hand suppliers:
While searching for façade panels, Insenti came across an advertisement on the Finn.no website offering a warehouse of used Cembrit panels. The purchase of the panels was privately arranged. The panels had been incorrectly mounted (screwed in too close to the edge) but this had no effect on our use, as they were divided into smaller panels anyway. The panels originated from:

- Emergency- and Heart-Lung center, St. Olav's University Hospital in Trondheim

In connection with the FutureBuilt workshops based on the planning of the façade, we contacted the manufacturer Steni, a façade expert. It turned out that Steni, in addition to sitting on significant residual stock that could be used in the project, were also in the position to offer used panels from a renovation of apartment blocks in Trondheim:

- Alfred Trønsdalsvei 9 (condominium), Trondheim

In addition to supplying both the used panels and the residual materials, Steni also helped with the cutting and processing of the façade panels for KA13.

Residual stock suppliers
Parkettstudio delivered the residual stock of strip flooring for the ground floor. This consisted of both residual products and materials returned from incorrect orders.
Bergersen Flis delivered c. 340 m2 of ceramic tiles from their residual stock for the walls and floors in the toilets and bathrooms.
Berg Studio delivered Bolon vinyl flooring from residual stock. This has been installed in the internal staircase between floors 7 and 8.
Processing and modification of used materials
The company Trappemakeren received the wooden handrails from Tøyenbadet and used these to build the amphitheatre stairs. The wooden slats from the sauna, also sourced from Tøyenbadet, were used as slats beneath the amphitheatre stairs.
The cabinetmaker company LUN received wooden slats from Refstad school and modified them to fit where they were needed: inside the booths on the ground floor and in the walls of the cinema room in the basement. LUN also sourced the used auditorium seats for the cinema room and supplied the reception desk made of partially used Corian panels.
Lighthouse remodelled the glass domes from St. Olavsplass 5 for the reception.
CreoNordic supplied the office fronts in a combination of new and used glass, and they also obtained 25 used office doors. They also supplied the glass railings, including used glass panels from St. Olavsplass 5.

1.4 ASSESSMENT POINTS

The assessment criteria for reuse included: practical/technical implementation, costs and environmental assessments. These points also provide the basis for the descriptions of the experience report. Various aspects of the implementation of the individual reused elements have been described (more or less) chronologically in accordance with the progress of the project:

- Practical/technical implementation includes:
- Procurement (search, inspections, contributors)
- Assessment of challenges, possible offers
- Environmental pollutants
- Consequences of the plan
- Quality assurance
- Processing, repairs
- Documentation
- Responsibilities/agreements
- Transport, storage spaces
- Quantity and location in KA13
- Installation, removability
- Costs
- Environmental assessments
- Learning points

In connection with the feasibility study prepared for the preliminary project (2018), an RIM assessment of the costs and environmental impact (in the form of greenhouse gas emissions) was carried out for a selection of reuse concepts. The utilisation of used products was compared to that of comparable new products.
The selection was made on the basis of the relevant products usually having significant potential (environmentally and/or cost-wise), both for KA13 and in general, for similar construction projects.
Two master's degree students at NTNU (Vilde Vår Høydahl and Hanna Walter) – at the same time as the construction process in 2020 – calculated the environmental impact of five reused elements: steel structures, hollow core slabs, windows, chilled beams and ceiling panels. The bachelor's degree students at OsloMet (Katja Jødal, Audun Hansveen and Erlend Hall) compiled the potential costs of four reused elements: steel structures, windows, chilled beams and ceiling panels. Specialist consultants and contractors for various building components provided insight into how we could conduct the assessments.
A few estimated assessments of costs and environmental impacts were also formulated for certain other elements. The results and assessments are provided below each relevant section and discussed in more depth in the final summary chapter.

2 ARCHITECTURAL ASPECTS

2.1 Architects and contractor's experiences

Mad Arkitekter, by architect Noora Khezri and architect/partner/CEO Åshild Wangensteen Bjørvik

Working as the architect in the Kristian Augusts gate 13 project has proved to be very interesting. We sought to show that reusing building materials is not just possible, but also an attractive and future-oriented endeavour. The design process has been more work-intensive than we initially assumed, and together with the project group, we have since acquired a great deal of new knowledge.
KA13 is, in its finished form, exactly as we had hoped, but the story behind it is complicated and colourful. Reuse processes are different than those used in regular construction, and this project was affected by which materials were available throughout the project period and how we could work together to use them. Both decision-making processes and designing processes are more complex in projects aiming for reuse than in normal construction projects. Strategies and solutions for KA13 were tailor-made through interdisciplinary processes involving all trades and parties. The iterative work, and the collaboration between the architects, building owners and other consultants, was even more important and intensive for KA13 than what would normally be expected. All of the participants in this project have shown a deep commitment, and it has been both exciting and meaningful to be a part of the journey.

KA13 has inspired us to rethink all of our other projects. We now see the value of existing buildings and local, reusable materials in a completely different way. We will always strive to consider the benefits of old and "semi-old" buildings, and we will look even more thoroughly for value that can be found in existing buildings, urban spaces and landscapes.

It is our experience that quality in building materials is absolutely crucial in creating a circular construction industry. You could certainly say that "waste is just resources gone astray", but with the low-quality materials in supply, the level of resources was correspondingly low. Reusable solutions (designing for disassembly/reinstallation) is now at the core of this industry in a completely different way than before, and from now on, we will always strive for solutions that offer removal of usable products in our new-builds.

An important aspect of the circular construction industry is that it requires high levels of competence, a lot of creativity and a deeper level of participation, both between the various trades involved in the planning phase and between those who do the planning and those who implement the work. Reuse brings about a more active type of cooperation that is inextricable from the physical world. The keywords here are material, quality, potential and craftmanship. Cooperation between the tradespeople and everyone else on the team has been particularly rewarding, in a completely new and exciting way.

We have also seen that good architecture and aesthetic quality represent great value from a reuse perspective. Creating attractive buildings and urban spaces requires a long-term perspective and a greater willingness to maintain them. A beautiful building lasts as people want to preserve it, meaning that this can, in itself, be sustainable.

By seeing, utilising and further developing the building's best qualities, KA13 has really come into its own. And even though the physical changes to the existing façades have been minimal, the effect is highly noticeable. It's almost as if this somewhat modest building has straightened its back, looked up and found itself.

Haandverkerne (NCC) by site manager Kenneth Olav Christensen

Haandverkerne commenced work in July 2019. This was initially seen as a regular job that would be carried out on ordinary premises, and the expectation was that the environmental goals relating to reuse would – as usual – prove too difficult to implement. When it comes to reuse, there's often a lot of talk and little action, but after a few months, we realised that this project meant serious business.

We had to screw our heads on properly and familiarise ourselves with the reuse branch of the industry. This meant, among other things, that we couldn't just order goods. What should be used? How much? Where should it be collected? And what was sufficiently documented?
We were constantly behind when it came to procuring the products we wanted and often left sitting around and waiting for answers – where and what are we collecting tomorrow? Haandverkerne removed the construction materials from several buildings, including DEG8 and Refstad school. Some things could not be removed, such as

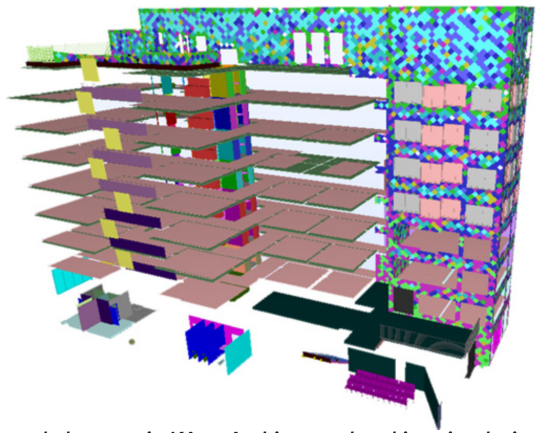
the slate stone in the vestibule of DEG8. But a lot was removed and reused, such as the fire doors, glass panels and a massive volume of ceiling panels. Alongside Haandverkerne, the plumbing, electrical and ventilation contractors also helped out with the dismantling process at Refstad school. The reuse coordinator at Insenti was in charge of managing all the products. She had an intrinsic role in the process and became an important contact for the removal jobs where we just needed to extract a little bit here and there.

The greatest challenge for us was the waiting times: for goods, for the planning, and for clarifications regarding documentation. Usually, the documentation just comes with a new product, but for this project it wasn't that easy. This was fine when it came to products from Entra's own buildings, but for everything sourced externally, it could take time. This was especially the case for the fire doors, as many rounds of documentation were required for these. Next time, it would be advantageous if certain things were made clearer in advance.

When it came to renovating the existing building from 1957 – one with such significant distortions – many problems arose that had to be solved on the spot. The lift was the biggest problem. It turned out that the original foundation for the lift was poor, but this was not discovered until work was already underway. The shaft was narrow and crooked. We had to reinforce the foundation and straighten the shaft. As the building was already on yellow alert (as a dust zone) at the time, this resulted in a lot of extra work.
IARK and ARK both did a good job, but they didn't always agree with each other. This could be challenging for those implementing the work, as you need clear guidelines to follow. There were also a few disputes along the way, such as in connection with solutions for the façade. The chosen sheet cladding meant that twice as many laths had to be mounted as in the originally priced design, and we were anxious about the extra work and time pressure.

But it turned out great in the end, and we are proud to have been a part of all this! IARK and ARK managed to balance the old and the new, without either overwhelming the other.

We became more motivated to pursue reuse during the course of the project. One reason for being able to put up with so much has been seeing the materials actually being reused and that it wasn't all just talk. Entra achieved what they set out to do, but they also had an understanding of the challenges they faced. The chemistry has been good between all of the workers involved in the project, and this has been an important part of the result. We have learned a great deal in regard to how we think about finding practical solutions. Our parent company, NCC, conducted several inspections in order to learn from the project, and we have huge respect for Entra for having taken on this societal mission. There is far too much use and waste in Norway, so what has been achieved here should be done far more.



Reused elements in KA13: Architectural and interior design. Photos from the IFC file. Illustration: Mad Arkitekter

2.2 GLASS FAÇADE
Building part number: 233

2 pieces of glass façade panels (total approx. 25 m²) procured from Dronning Eufemias gate 8 (Braathen Eiendom)
1 glass door (5.7 m²) acquired as surplus stock from Saga Aluminium

On inspection of DEG8, ARK noticed that the glass façade from the 2000s would fit nicely in our ground floor.
Technical assessments: The U-value was within what we could use for KA13. The sizes were about right, and we saw that it would be possible to redesign a few things so that the panels could fit. The façade works as a system (box profile system) suitable for expansion (in both height and width) and for any additions. The new entrance door had to be fitted into the used glass profiles. We didn't see any disadvantages to this other than the fact that used and new glass can have slightly different shades of colour. There were also no challenges in regard to environmental pollutants, provided that we reused the glass panels without destroying/puncturing them.
Extra work was necessary in connection with:

- Inspections
- Measuring the panels
- Assessing where they could be used
- Adjusting fittings, skirtings and railing heights.
- Designing and ordering fitted panels
- Making adjustments/modifications in regard to the colours of the profiles, as these affected the colour concept for the building
- Coordinating with the building owner and tenant regarding a change in solutions (size, divisions of bars and colour)
- Modifying a new door panel
- Energy calculations

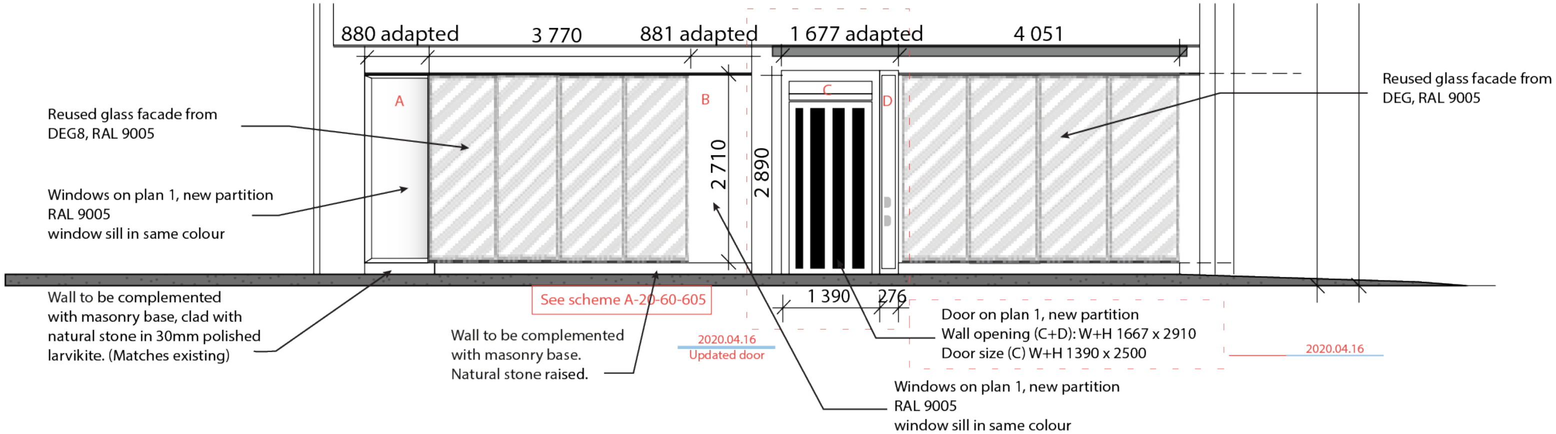
This is a good, well-known and fairly new product, and there has been no need for extensive quality assurance. The panels were dismantled and driven straight to KA13 via Saga Aluminium's workshop. Saga Aluminium AS prepared and completed the panels, and Haandverkerne installed them. The two glass panels from DEG8 were repurposed for use on the ground floor, facing the street.

An outer door with a glass panel was also dismantled from DEG8 and planned for use in the façade facing the back courtyard. This was transported to KA13 but ended up not fitting in with the measurements. Instead, Saga Aluminium procured one glass door from the surplus stock of a previous project.

This type of glass façade is well suited for removal and installation.

Inspection of DEG8, May 2019.
Photo Anne S. Nordby.

The fitted glass panel facing out
onto Kristian Augusts Gate.
Photo Kyrre Sundal



Facade drawing: Mad arkitekter

2.3 WINDOWS IN THE EXISTING BUILDING
Building part number: 234

The existing windows from the 1980s had poor woodwork and were loose around the frame, and it was not possible to repair them. As a result, they could not be retained for use.
In the sketching phase, several suppliers were contacted who could supply new windows based on the existing insulating glass.
The window manufacturers Ventilasjonsvinduet in Denmark and Troll Trevarefabrikk in Larvik could both provide this service, but at a higher price than if we were to procure new windows. In general, the glass incurs only approx. 12%–14% of the production costs, not including the cost of dismantling the existing glass from the frame. Using the insulating glass as external cladding in the new building was also considered.
Concepts were developed in light of this, and discussions were held with the façade supplier StoVentec.

A preparation phase would then be added to the process to satisfy the requirements for safety glass, e.g. foiling of the glass for reuse, as well as adding a new suspension system. These concepts were abandoned for various reasons.
Due to the natural lighting requirements, limiting the size of the window was not an option, and as a result it was naturally very challenging to find used windows that fit exactly into the existing façade openings. All of the windows in the existing building are therefore new.

2.4 WINDOWS IN THE EXTENSION
Building part number: 234

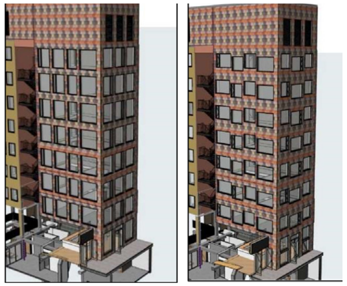
Windows procured via Resirqel:
- 28 windows from Turbinveien 15, installed on floors 4, 5, 6 and 7.
- 2 windows from Nordregate 20–22, installed on the ground floor and floor 1.

2.4.1 Practical/technical implementation
The windows from floors 4–7 in the extension are all reused. These are windows that were incorrectly designed for use in a housing project in Kværnerbyen (Turbinveien 15), which were then bought by Resirqel. The windows could not be opened in one of two bays and were therefore unfit for use in a home. They were dismantled not long after the building work was completed in 2014. The windows were kept in Resirqel's warehouse for two years, until KA13 bought them for this project. Office buildings do not have the same requirements for openable windows, and in this batch of incorrectly designed windows we found suitable, fairly new windows for reuse in the extension.
These windows were smaller than the original windows that had been applied for in the frame search and they had a higher/worse U-value (1.1 W/m²K) than had been assumed in the energy calculations (0.8 W/m²K) Thus, both a natural light analysis and an energy calculation were conducted in order to study the consequences of using these windows in the building. The results showed that it would not be possible to meet the natural light and energy requirements in TEK17 with used windows on all floors. It was therefore decided that new windows would be used on floors 1 to 3. It was then possible to install larger windows and ensure better natural light conditions, as the lower floors receive less daylight than the floors higher up. If we had deviated from the natural light requirements, it would have been possible to utilise the used windows for the entire façade of the extension.
In regard to energy, we received an extra layer of insulation for the outer wall facing Kristian August gate 15 as a compensatory measure. A simple greenhouse gas emission calculation was also carried out in order to see whether the emissions associated with the production of new windows would make up for the additional energy usage in operation over their lifetime. The results were relatively similar when the expected emissions over their lifetime were considered. However, given the urgency in reducing greenhouse gas emissions in the present, the savings on such emissions that can be ensured today must outweigh any potential future savings – a principle that underpins the importance of reuse.

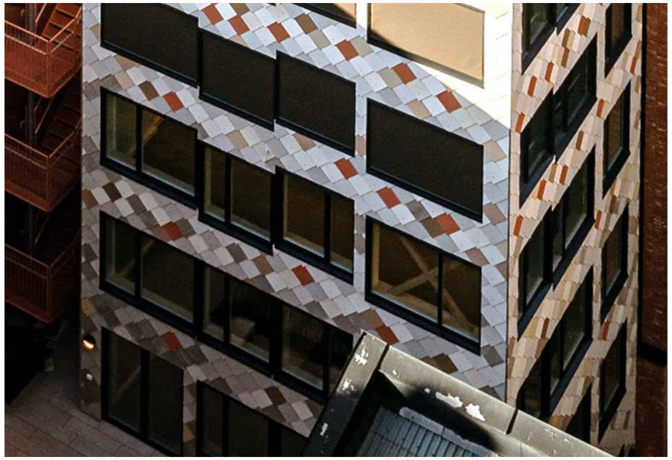
Consequences for planning:
- A new façade concept had to be drawn up as the window heights did not match the planned solution.
- The floor plan/room division had to be changed somewhat in order to fit the changed distribution of the windows. This also had various technical consequences.
- The design of the windows affected the colour concept of the façade and the interior Changing the look of the façade had to be coordinated with the Planning and Building Agency (PBE).
- The IG for this façade was exposed because the type of reused external cladding and windows had not been clarified with the PBE

- The windows were a bit wider than the optimal window width for this façade, such that the lathing/pillar construction was a little more complex/complicated than originally planned.
- RIB had to make new calculations for the pillar construction.

Haandverkerne were responsible for transport from Resirqel's warehouse and for the installation of the windows. The openable panes were allowed to block the opening function in order to ensure against opening/falling.
28 used windows were installed on floors 4 to 7 of the extension. There are 16 measuring 1,488 x 1,588 mm and 12 measuring 2,188 × 1,588 mm. 2 used windows (in other forms) were installed on the ground floor facing the back courtyard and in the meeting room on the first floor. Resirqel were able to provide the relevant FDV documentation and CE labelling for all of the windows.
The windows can be dismantled and reused.



The windows were removed from a housing project in Kværnerbyen. Photo: Resirqel
Extension façade, designed with 1) new windows, 2) used windows. Illustrations: Mad Arkitekter



Completed façade with a combination of used and new windows. Photo: Kyrre Sundal

2.4.2 Costs

In the OsloMet student thesis, it was calculated that reusing windows for KA13 achieves a cost savings of approx. 60% (Jødal, Hansveen & Hall, Oslo Met bachelor's thesis 2020).
The price for the used windows was then compared to the prices for new windows in the Norwegian price index.
The used windows have slightly less insulating capacity than the assumed new ones (U-value = 1.1 for the used compared to U-value = 0.8 for the new). The difference in insulation capacity is partially compensated for in the project through additional insulation installed in the outer wall facing Kristian Augusts gate 15. However, the cost of using extra material for the extra insulation was not included in the student thesis, nor was the cost of any increased energy use during the building's lifetime. Nor were costs relating to the additional planning and administration of reuse for the project included.

2.4.3 Environmental assessments

In the NTNU student thesis, a total emissions saving of 90% was calculated for the reuse of the windows when compared to the purchase of new windows (Høydahl & Walter, NTNU master's thesis 2020).

	Amount	Environ-mental im-pact, new element (A1-A4) *	Environ-mental im-pact used element (A1-A4) *	▼ Environmental savings from reuse
Windows	1,588 x 1,488 mm - 16 pcs. 1,588 x 2,188 mm - 12 pcs.	161.5 kg CO_2-e/pc.	13 kg CO_2-e/pc	90% saving

A1–A4 indicates the first four phases in the life cycle assessment, in which A1–A3 is the Production Phase and includes the raw materials, transport and manufacturing. A4 is the Construction and Installation Phase and includes transport.

It is assumed that the remaining lifespan of the used windows is around 30 years, while it is assumed that the equivalent new windows have a lifespan of 40 years. The results show the environmental impact in the form of greenhouse gas emissions (CO_2 equivalents) per window for both the new and the used windows. In total, the reused windows in the project contribute to a saving of 4.1 tonnes of CO_2 equivalents in phases A1–A4 when compared to the new windows alternative.
The used windows have a somewhat higher U-value than that assumed for the new windows (U-value = 1.1 for used compared to U-value = 0.8 for new).

This is partly compensated for in the project through the use of additional insulation in the outer wall facing onto Kristian Augusts gate 15. This wall has an area of approximately 32 m² per floor, which means increased carbon emissions totalling 61 kg, using the emission factor of glass wool insulation, in phases A1–A4. Extra insulation is thus included in the calculations but it does not fully address the energy loss.

LEARNING POINTS – REUSING WINDOWS

- It is difficult to find used windows with measurements that exactly match the window openings of a renovation project. It is easier to implement the reuse of windows in a new building.
- Older windows can be challenging to reuse due to U-value requirements and the environmental pollutants used in their manufacture in the period c. 1965–1989.
- Newer windows can be found in newer buildings scheduled for renovation or demolition or as a result of faulty deliveries.
- The reuse of windows can be both environmentally friendly and cost-effective. A number of factors underpin the assessment: U-values and energy calculations
- Natural light requirements
- Environmental impact during production
- Potential health/environmental hazards of older windows

  Balancing these partly conflicting factors will determine whether the reuse of windows is possible and desirable in a new building.

2.5 EXTERNAL CLADDING
Building part number: 235

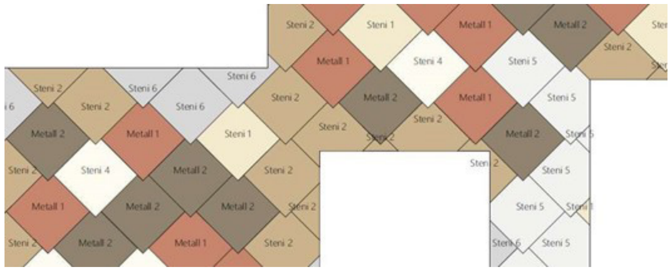
	Finn.no / St. Olavs University Hospital	Oppsal-hjemmet (OBY)	Housing project renovation and surplus stock	DEG8 (Braathen Eiendom)	Refstad school (UBF)
Cembrit façade panels	55 m²				
Metal cassettes on the original façade from 1975		185 m²			
Steni stone composite façade panels, various colours			450 m²		
Steel cladding from the façade				Assessed	Assessed

The table shows the type and volume of used external cladding used in the extensions, totalling approx. 635 m².

ARK made an assessment of potential used products for the façade, with the project eventually landing on thin sheets of metal and façade panels of the Steni or Cembrit type. ARK prepared a simple search description for these panel types which was publicised via Grønn Byggallianse and the project's website. The external cladding used on the extension consisted of a combination of various used materials, including fibre cement panels, Steni panels and metal panels.

- Fibre cement panels:
  The fibre cement panels were sourced from St. Olav's University Hospital (Acute Heart and Lung Centre) due to incorrect assembly. The panels were bought on Finn.no.
- Steni panels:
  Some of the Steni panels were used and were sourced from a housing complex in Trondheim. The procurement, transport and modification of the panels were carried out by Steni. The rest of the panels came from surplus materials at Steni's factory warehouse.
- Metal panels:
  The metal panels came from the Oppsalhjemmet, which was set to be demolished.

ARK tested all of these, as well as combinations of the different types of panels. Several members of the planning group provided a lot of useful input here. The choice of materials provided the opportunity for an interesting façade composition that gives the building its own distinctive character.
Input on the façade was also provided at a course/workshop organised by FutureBuilt/NAL (https://kurs.arkitektur.no/1258632).
Mad arkitekter led the workshop, and the participants' task was to highlight any technical and aesthetic solutions and pitfalls.
In addition to the representatives from ARK and Haandverkerne, the façade vendors Steni and Petal also participated in the workshop.
The participants came up with a wide range of proposals and solutions.
A summary from the workshop is presented in the preliminary experience report from KA13 – the reuse work meetings (20/02/2020)



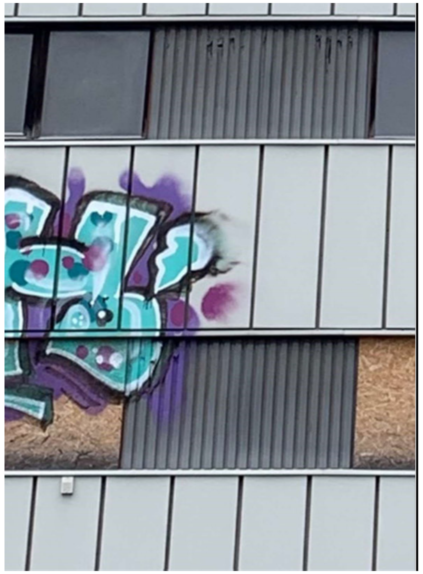
Section, external cladding scheme. Mad Arkitekter

The form, lathing type and suspension method were planned in close cooperation between ARK, Insenti, Haandverkerne, representatives from Steni and Cembrit respectively, and the plumbers.

The Cembrit and Steni panels were cut down to a suitable size. One challenge with the metal panels was that they could not be cut/modified on the construction site once the edges had been folded/bent.
After being cut down to size, the panels had to be sent for surface treatment and varnishing to protect the metal from rust. The backs of the metal panels were varnished and used as the front. The panels were temporarily stored at the construction site, Steni's own factory, Haandverkerne's warehouse and the plumber's workshop.

The metal panels are used only in their full form (40 × 40cm), while the Cembrit and Steni panels were cut on site in order to adjust the corners, edges etc. The reused panels required a good amount of cutting at the construction site and during the processing of the metal panels at the plumber's workshop.
This type of panel cladding is used on all of the façades in both extensions. The table above shows the volume of external cladding used in the façades of both extensions, totalling approx. 635 m2.
The façades consist of over 5,000 panels:
- 401 pcs. Cembrit
- 1,174 pcs. Metal
- 3,819 pcs. Steni

This assembly solution facilitates the easy dismantling and repurposing of the panels.



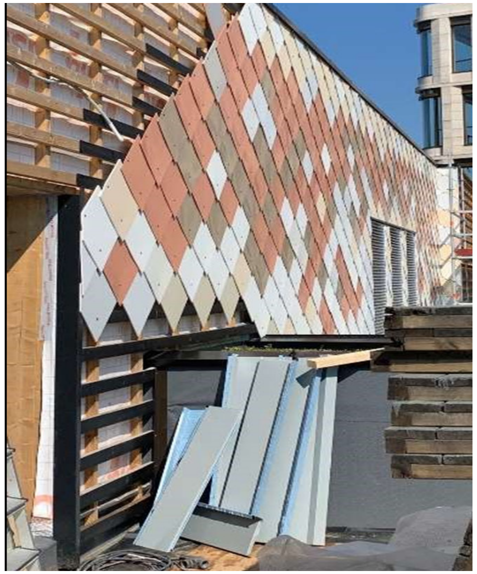


Photo from the inspection, Oppsalhjemmet.
Photo: Randi Lunke
Cutting and installation work. Photo: Anne S Nordby
Façade panels during installation. Photo: Randi Lunke

2.5.1 Environmental assessments
In the NTNU student thesis, a total emissions saving of 97% was calculated for reuse when compared to the purchase of façade panels for the project (Høydahl & Walter, NTNU master's thesis 2020).

	Environmental impact, new elements (A1-A5) *	Environmental impact, used elements (A1-A5) *	▼ Environmental savings from reuse
Façade panels	50.7 kg CO_2-e/m²	1.4 kg CO_2-e/m²	97% saving

****A1–A5 indicates the first four phases of a life cycle assessment. A1–A3 consists of the Production Phase and includes raw materials, transport and manufacturing. A4–A5 consists of the Construction and Installation Phase, which includes transport and installation. Phase A5 is included here to account for the extra laths and joists.***

The façade consists of various types of façade panels (metal, fibre cement and stone composite) of various ages. Around 53% of the panels were surplus materials from the Steni factory's B-warehouse, which presumably would have been sent for waste treatment if they had not been used here.
Due to the variation in the types of panels, the small dimensions of the panels and the relatively complex design, it is a challenge to determine the potential lifetime of the various components or the façade as a whole, but it is assumed that the entire façade will need to be replaced once during its lifetime.
As a new alternative, it was decided to use two different types of panel cladding (fibre cement and stone composite), with the lifespan of the new alternative expected to be around 60 years. One consequence of the decision to use such small formats and many different types of panel cladding for the façade is that it was then necessary to increase the number of laths and joists used for furring. Larger joist and lath dimensions were required than originally anticipated.
This resulted in nearly five times more wood being used in the façade.
The difference – the increased volume of wood – was added to the calculations for the used façade panels in phase A5.
In total, the solution provides savings of 34.2 tonnes of CO_2 equivalents for the project (Høydahl & Walter, NTNU master's thesis 2020).

As a comment on the environmental assessment, some points made by the architects can be noted here that may help provide a more nuanced picture of the given assumptions:

- The calculations are based on significantly more laths being used than in a normal panel-clad façade, but it has not been taken into account that fewer laths and larger panel formats would also have resulted in more cutting and waste of the panels. In addition, larger lath spacing would have required more stability in the panels to prevent them from becoming distorted.

- In regard to their lifespan, it is assumed that the entire repurposed façade will need to be replaced within the next 60 years, while a comparatively new panel façade would have a lifespan of 60 years without the panels needing to be replaced. As 53% of the panels that make up the repurposed façade are surplus materials from Steni's own warehouse, they are, in reality, completely new panels, thus the term "reuse" is misleading here.

- In practice, the façade concept for KA13 will ensure future opportunities for maintenance and reuse in a very good way, both because the façade has been designed to withstand the addition of new colours and materials and because only elements that are damaged or in overly poor condition can be replaced individually. For example, the panels can be dismantled for repainting and then reassembled. The real environmental savings over the façade's lifetime are therefore likely to be higher than the calculated results would indicate.

LEARNING POINTS – REUSE OF FACADE PANELS

- The development of any façade solutions should be conducted in close cooperation with ARK, the suppliers and the contractors

2.6 SEALED INNER WALLS
Building part number: 242

2.6.1 Partition walls between offices: Tewo Flex
The reuse of partition walls was considered. Reuse was deemed difficult due to the sound requirements, sizing, and poor quality in regard to accessing existing partition walls. With this type of building component, there is a lot of usage and disposal of poor-quality products.

ARK assessed the use of solid wood walls, which are more environmentally-friendly and can be dismantled and reused. We got in touch with Made and Termowood to develop such a product further, and they came up with the product Tewo Flex Inner Walls.
A sample was installed, and the tenant responded positively.
IARK ended up going for pine for the interior concept, rather than oak, which had been a part of their original interior concept and requirement specification.
Tewo Flex consists of elements of solid wood and mineral wood insulation and contains no environmental pollutants. Wooden walls are easy to prepare and repair. They can also withstand a lot of wear and tear without the product deteriorating.

One consequence for the design, however, is thicker walls that take up a little more space. As this was a pilot project that included product development, it took a little extra time.
On-the-spot modifications were necessary, and a number of fasteners had to be used (including screws for bases), for which solutions also had to be found.
Strict sound requirements posed a challenge but were eventually met through the use of an extra layer of panelling, which in turn made the walls a little bit thicker.
This could not be carried out in the factory and had to be implemented on site.
The panel is attached to each element such that the elements are all still removable.

However, in the event of future reuse, they should be marked and reassembled in the same order, as the transitions between the elements have been sanded down.
In total, approx. 160 m² of Tewo walls have been installed in KA13. The product has been installed for use as office partitions and as walls between meeting rooms and offices.
The supplier, and the party responsible for the product, is Termowood. The product has been developed for easy assembly and disassembly.
The product is new and comes with the necessary approvals.


Assembly of the Tewo walls.
Photo: Anne S Nordby and Catriona Shine

Completed façade with a combination of used and new windows. Photo: Kyrre Sundal

2.6.2 Internal sealed walls around the vents, toilets etc.
It was considered whether used wooden or steel partitions should be procured for use around the vents and toilets. Wooden studs are commonly used on many construction sites and are likely easier to acquire; however, in our discussions with Haandverkerne, it emerged that it would be difficult to reuse wooden studs for construction purposes.

As wood is stamped only at one end, you rarely find any documentation on those that are in use. The sale of these would have been a challenge anyway.
We received an offer on steel stands from Resirqel (residual storage with documentation) and we considered using these around the lift shaft. However, the width of these was 150 mm rather than the 100 mm required in the plans. As these would have taken up more space, this option was abandoned.
Panel cladding on internal walls is problematic, as the panel cladding is often destroyed during the dismantling process. Not only that, but plasterboard is considered particularly difficult to dismantle and reuse.
ARK considered alternatives to plaster panels, such as façade panels and subpanels. As the project was progressing and
given the need for assistance in the fire and sound assessments (RIBr and RIAku), there was no time to examine and possibly recommend panel walls that could replace the traditional plaster walls.
ARK feels that this would be a good topic for further research! Could a "Gyproc book" be made for panel cladding not made of plaster?

LEARNING POINTS – SEALED INNER WALLS

- Reusing wooden studs is difficult in terms of sourcing valid documentation
- As plaster is difficult to reuse, there is a need to develop standardised solutions for alternative panels that are not made of plaster, such as a "Gyproc book" for non-plaster panel cladding.
- Removable solid wood walls may be a more environmentally friendly alternative.

2.7 GLASS OFFICE FRONTS
Building part number: 243

The delivery of office fronts from CreoNordic included 80 m² of used glass + 25 used doors

In this project, there were strict sound requirements along with the wish to reuse materials. It was assumed that the used fronts had to meet the same requirements as the new fronts. The project got in touch with Bruktrom and found that it was possible to buy used glass office fronts. There was a large number of glass walls with sufficiently good sound quality at Refstad school. The glass was laminated and could be cut to size. Bruktrom was able to provide the remodelling of used panes and the set-up of a sample. However, the glass panes in question at Refstad school were a little too short to ensure a satisfactory result, and we therefore did not pursue this solution.



From the Refstad school inspection. Photo: Anne S Nordby

Disadvantages of glass fronts:
- The project had strict sound requirements, and it was difficult to find used fronts that satisfied the requirements
- It was difficult to find sufficient quantities of the right height; if the height was not right, the skirting board height would have to be adjusted
- It was difficult to find suitable widths, meaning that fitted panels had to be made for either the sealed walls or the glass
- It was challenging to find sufficient quantities of the same type
- Laminated glass is rarely available for reuse – only tempered glass, and this type of glass is not suitable for cutting or modification

Reuse requires additional planning work in order to figure out the correct sizes, fitted panels etc. and fitted panels require processing. Due to the challenges described above, it was decided that the project would use a different supplier/new product.
Along the way, we received a tip from Trefokus that Moelven were working on a leasing concept for offices. We checked this out, and it turned out that they lease entire meeting rooms only, not office walls:
https://www.moelven.com/no/produkter-og-tjenester/multi-room/

Entra had a framework agreement with the glass supplier CreoNordic, which initially sold only new products, but an enquiry was made nonetheless about the possibility of supplying used components. CreoNordic was able to deliver office fronts with a combination of new walls and walls consisting of new frames with used glass, which is why they were then chosen for the project.
CreoNordic procured 25 used office doors.
They transported all of the used glass to their own workshop and prepared the glass there before its installation on site.

Installing the glass fronts/office doors.
Photo: Anne S Nordby and Noora Khezri

Completed installed fronts.
Photo: Rune Andersen

LEARNING POINTS - OFFICE FRONTS

- It is a demanding task to find office fronts with the right measurements and sound requirements
- There are suppliers who can adapt used glass in the manufacture of new office fronts
- Laminated glass can be cut.
- Tempered glass cannot be cut.
- In office fronts, tempered glass is more commonly used than laminated glass. In the past, there were safety requirements for tempered glass that measured above a certain height, but this can be addressed today by using laminated glass.

- Checklist for reusable office fronts, Glass:
  - Avoid using tempered glass as this type of glass cannot be cut to fit new dimensions.
  - Use fixed module widths on the glass. This way, it will be easier to plan ahead when reusing the glass in the future.
  - Increase the thickness of the glass to a min. of 12.76 in order to meet any future requirements for sound reductions. Doors:
  - Use the standard dimensions M10x21 as much as is possible, avoid doors with special heights
  - Limit the types of surfaces used (wooden structures + paint)
  - Use door leaves with a min. sound requirement of 35 dB

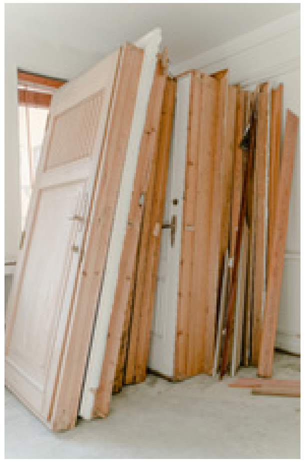
2.8 INNER DOORS
Building part number: 244

	KA13 (Entra)	U2 (Entra)	Refstad school (UBF)	DEG8 (Braathen Eiendom)	St. Olavs plass 5 (Entra)
Existing doors, 5th floor	10				
Existing doors for the utility rooms, floors 1–7	7				
Inner doors with sound requirements		Assessed	Assessed		
Stairwell door in glass, metal frame and glass panel on the upper part, BK EI2 30-Csa (B30S)				7	
Oak doors to the toilets					16
Handles incl. escutcheons			7		
Door closers			4		
Lock cylinders			30		

A total of 17 of the existing doors were repurposed for use in KA13, and a total of 23 used doors were acquired from other projects. In addition, various locks and fittings were acquired and reused.

2.8.1 Existing doors in KA13

17 of the existing doors in KA13 were reused. 7+4 (all of the utility room doors + 4 doors from the 5th floor) were kept in their original position. The rest of the doors were moved to new walls. The doors on the 5th floor are only green soap washed. The rest of the reused doors have been cleaned and surface treated.




Existing doors, Photo: Kyrre Sundal

2.8.2 Inner doors from other projects

The contractors and consultants searched for used doors in accordance with the door scheme provided by ARK. It was possible in a few instances to adjust the height and width and change the stricter sound or fire requirements or other materials and the direction of impact, but this had to be assessed by ARK in each case. The option to adjust where necessary depends on the position of the doors in the plan; any changes to the interior concept or layout – even small changes – can have consequences. However, it turned out that it was difficult to find doors that fit in perfectly.

There were many doors of a similar type at Refstad school (UBF) that would be suitable for KA13 in terms of frame dimensions and sound requirements. These were in good condition and of sufficient quality. The doors, however, had a kick plate at the bottom, which was not included in the specification. As ARK/the tenant did not want kick plates on the doors, reuse of these doors was not possible. Instead, the door handles, incl. the escutcheons and door closers – which were all in good condition – were picked up from Refstad and reused for other doors in KA13.

A number of doors were stored in the basement of Universitetsgata 2 (Entra) and considered usable in KA13. However, these doors were not used in the project either. On some of the doors, the door leaf had separated from the door frame and it was thus difficult to figure out which door leaves and frames belonged together. The doors had also been mixed up with other doors that were being held for local reuse in U2. The doors were partially wrapped but did not have any documentation or marking with relevant information such as their origin, sizes or usage.

Fairly late in the project, oak doors were found in St. Olavsplass 5 (Entra) that were deemed suitable for use in the toilets of the existing building. However, the doors were of different dimensions, which had consequences for the project as all of the cut-outs had already been carried out on site and therefore needed to be changed. Upgrading the existing doors was a possible alternative, but this was decided against due to the uncertainty as to whether this would be good enough.


Oak doors from St. Olavsplss 5.Photo: Norconsult
Reused oak doors fully installed in KA13.
Photo: Rune Andersen

2.8.3 Fire doors

Through Resirqel, we gained access to Dronning Eufemias gate 8 (DEG8 or the “PWC building”), which was set to be completely renovated. Betonmast was the turnkey contractor for the renovation of DEG8, which was owned and operated by Braathen Eiendom. Following the inspection, the fire doors to the stairwells were identified as suitable for reuse in KA13. The KA13 project entered into agreements with Betonmast to allow our contractors access to the building in order to dismantle and remove components.

We could not find certification signs on the stairwell doors with fire requirements, but the fire consultant did not believe this meant the doors lacked classification. The building owner’s FDV documentation was reviewed.

It was a little unclear who the supplier of the doors was on the basis of the FDV documentation, but it eventually turned out that the doors had been provided by Norske Metallfasader, Stange.

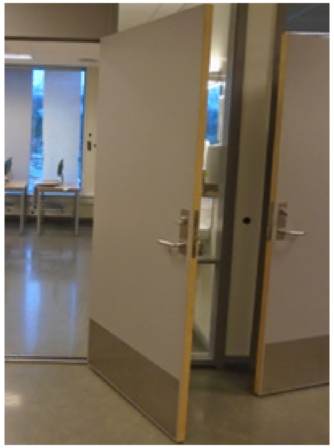
Another issue was that there was a glass panel above the stairwell doors in DEG8, and it was only the doors themselves that we needed for KA13. As the fire doors into the stairwells were attached to the glass panel above, the steel had to be cut above the door if these were to be used in the project. It was also necessary to replace the lock plates. The question was whether the doors would then need to go through recertification after being modified so as to meet the fire requirements. We received an answer to this from the fire consultant at Fokus Rådgiving: The door supplier should be able to say whether the doors can be modified and whether they still hold their certification. In practice, these doors will probably be good enough with potential reinforcement above the door after the glass panel above them has been removed. The fire consultant may be able to confirm whether the product will be good enough, but that cannot be type-approved unless the supplier is involved. Fokus Rådgiving had come across modifications in the past – such as 6,000 doors for SIO, who had to change the lock plates – and felt that it was important to continue pursuing reuse on a general basis. As an alternative, it was suggested that the project apply for exemption from the City of Oslo Planning and Building Services in regard to the overall goal of resource efficiency.

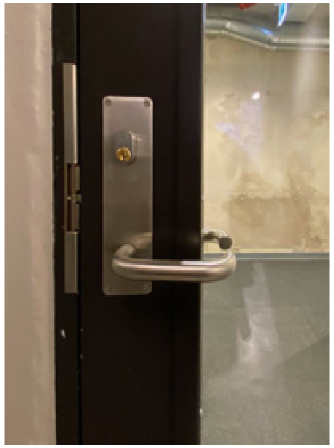
Afterwards, we established email correspondence with the manufacturer, Norske Metallfasader in Stange. When asked if we could keep the fire certification after removing the glass panels, the answer was yes. We did not need to reinforce the frame, but it was important that the sealing between the frame and the door opening be done properly. By the time we received a response to this, we had missed the initial deadline for dismantling the components from DEG8. However, we were given an extended deadline in order to remove the fire doors.

Under supervision of PBE (May 2020), an extra round was taken in order to collect the assembly instructions for the fire doors. It emerged that the suppliers of the respective steel profiles and glass for the doors had different recommendations in regard to the options we had for processing and recertification. The doors were eventually approved and documented by RIBr and the lock and fitting consultant. The conclusion is that it is important to employ a fire consultant on site who can provide clear advice.

1–2: The door panel from DEG8 with the overlying glass panel removed and the door installed in KA13 with a new lock cylinder. Photo: Anne S Nordby

3: Used fire door, fully installed and varnished. Photo: Rune Andersen





Classroom doors, Refstad school. Photo: Anne S Nordby
Used handles/signs from Refstad, installed on the new fire doors for floors 1–7 (west of the stairwell). Photo: Annethe Thorsrud

A total of seven stairwell doors from DEG8 wereb processed (glass panel above the door removed and the lock plate replaced) and varnished for use in the stairwell for floors 1–7. The used doors are installed on the east side of the stairwell. On the other side of the stairwell are the new doors we acquired. The used handles and escutcheons from Refstad school are mounted on the new doors.

2.8.4 Locks and fittings

7 handles and escutcheons were reused in the stairwells for floors 1–7 (facing west). The door closers were refitted on a total of 4 doors in the basement, the ground floor and floor 7. 30 used lock cylinders are mounted on doors throughout the building. When lock cylinders were reused, the internal component was removed and rebuilt. Everything that was reused in the locks and fittings in KA13 came from Refstad school.

LEARNING POINTS – INNER DOORS, INCLUDING LOCKS AND FITTING

- Detailed/traditional door schemes should be created and possibly adjusted by ARK before and during the materials search
- When used doors are being measured, the frame dimensions, light openings and potential fire/sound specifications must also be recorded.
- Doors that are stored must be marked with all measurements and specifications, and door leaves should not be separated from their frames
- It may be possible to retain certification after changes are made to certified products in accordance with instructions from the supplier. In order to approve the new use of fire doors, the fire consultant must be on site and provide clear advice.
- Handles, signs and door closers etc. that do not require processing can be cost-effective products to reuse if the equipment is not too worn.
- When reusing lock cylinders, access to the system (the master key) must be procured from the owner in order for it to be rebuilt

2.9 FLOORING
Building part number: 255

2.9.1 Parquet

Approx. 100 m² of oak strip flooring from Parkettstudio AS's surplus warehouse was laid on the ground floor.

The oak parquet was assessed at an early phase, during the search for used materials, specifically through avenues such as the Grønn Byggallianse (GBA) newsletters. At the time, the specifications were:

- 15mm single-strip oak parquet (variants would be considered)
- Minimum 4mm top layer
- Must have been laid as floating flooring before, not glued to the substrate
- Area 431 sqm
- 275 lm oak floor skirting also applicable

There were no offers from GBA members, but later in the project IARK received an offer for wooden parquet from surplus stock at Parkettstudio AS. The materials came from Denmark, and the label is from Hørning Massiv Eik Natur patterned slats H/V (16 × 70 × 420mm) + Hørning Massiv Eik Natur planks (16 × 100 × 800-2600mm).

The parquet was laid on raised platforms on the ground floor. IARK decided to lay this partly as herringbone to make it more visually interesting, as well as in decreasing lengths where this best suited the directions of the plateaus. The supplier pointed out that the materials used for the herringbone in the centre are a mixture of different cut-offs and returns that had been lying around the warehouse for a long time. A small portion (c. 20m²) was incorrectly delivered to another customer, who was supposed to receive shorter slats. The materials used for the frame and steps are a combination of cut-offs/surplus materials from a job carried out in January, as well as some materials that had been stored in the surplus corner of their warehouse that were around 2 to 3 years old.
98 m² of oak parquet was delivered for the project, but some materials were not usable and were eliminated along the way. The parquet was matte varnished after it was laid.

The parquet slats during installation. Photo: Rune Andersen

Polishing the parquet. Photo: Anne S Nordby

2.9.2 Glass concrete

Approx. 600 m² of concrete floor made with recycled façade glass was installed on the ground floor and in the basement.

Pounded glass (façade glass) was used in the floor screed for the ground floor and basement. The floor was supplied by Betotec. IARK visited Betotec's warehouse and assessed several samples that had been laid with a concrete and glass floor. Norsk Gjenvinning supplied the glass used in the floor screed. The glass came to Betotec in many different sizes, so these had to be separated and sorted before glass of the correct size could be thrown into the liquid floor screed. In total, around 600 m² of glass concrete was laid on the ground floor and in the basement, which used approx. 600 kg of pounded glass.

Glass concrete: Concrete floor with recycled façade glass. Photo: Kristine Aassved Storeide

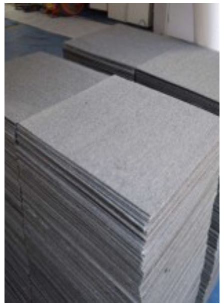
2.9.3 Carpet tiles

Floor	Type	From (used/remaining stock)
1st floor	Tarkett Tercel Tescom Interface Composure colour 303100	Reused from Akerselva Atrium Reused, returned from the Netherlands to the manufacturer
2nd floor	Interface Composure, colour 4169002	Incorrect order, Entra's surplus warehouse
3rd floor	Dessi Linon, colour 9097	Tarkett's surplus warehouse
4th floor	Dessi Linon, colour 9097	Tarkett's surplus warehouse
5th floor	Dessi Linon, colour 9097	Tarkett's surplus warehouse
6th floor	Interface Scandinavian Collection, colour 303100	Reused, returned from the Netherlands to the manufacturer
7th floor	Interface Scandinavian Collection, colour 4169002	Incorrect order, Entra's surplus warehouse

The carpet tiles that were either used or from leftover stock were laid on floors 1–7 and totalled approx. 2,200 m².

It was somewhat of a challenge to find a sufficient number of the same type, but for the most part we succeeded in placing one type across the entirety of each floor. It was also challenging to maintain a sufficiently good standard of carpet tiles for reuse. As some of the carpets for reuse were difficult to get completely clean, a new search was conducted in order to find carpets to replace those not of a high enough standard. We were successful in the reuse of carpet tiles in KA13 because the square meterage per floor is relatively small and the tenant/IARK accepted a variety of carpet tiles on the floors.





Selection of carpet tiles from Entra's warehouse stock. Photo: Anne S Nordby

Completed carpet flooring. Photo: Rune Andersen

2.9.4 Bolon covers

8 m² of Bolon covers from the residual stock in Berg Studio's warehouse were laid in the internal staircases etc.

The Bolon vinyl flooring was chosen for the internal staircase between the 7th and 8th floors, as well as for the landing and the pantry kitchen on the 8th floor. The covers came from stock remaining after the retailer Berg Studio renovated its showroom. IARK chose to use a light colour in the staircase for the first and last step. The reasons for this were an insufficiency of just one type of cover and this solution's ability to satisfy the markings required for universal design. So the path here changed a little along the way.

Bolon flooring (vinyl) installed on the stairs. Photo: Annethe Thorsrud

2.10 CEILING
Building part number: 256

2.10.1 Wooden studding
It was considered whether wooden studs should be used for nailing work in the ceiling. As studding does not have strict requirements for constructive strength, it appeared easier to reuse wood for this rather than for other construction purposes.

For example, we had access to large quantities of wooden studs from Refstad school. It would, however, take a lot of time to dismantle and clean these, and we also lacked storage space for them. In this respect, time got away from us.

Reusing wood is perhaps something that should be looked into more closely for future reuse projects. When it comes to manufacturing new wooden materials, the form of documentation used should also be considered. As new wooden studs are stamped only at one end, this is not a good marking method if potential reuse is to be considered. In the case of reuse, there should also be different requirements for quality assurance methods and the necessary documentation of what the wood is to be used for, such as:

- New use as studs in an inner wall, or possibly an outer wall
- Horizontal nailing into a wall
- Nailing, interior ceiling
- Exterior lath façade

2.10.2 Wood wool cement panels
Wood wool cement panels for the visible part of the ceiling were also assessed for second-hand use. There were several places to procure these, including in large quantities at Tøyenbadet – a result of a renovation from 2008. We mostly found panels with a depth of 50mm. For the office ceilings, we needed panels with a depth of 25mm because of the room height, but the 50mm panels could have been used in the toilets and cloakrooms. Haandverkerne had, however, bought enough new panels for these rooms from Tøyenbadet when the need for used panels arose.

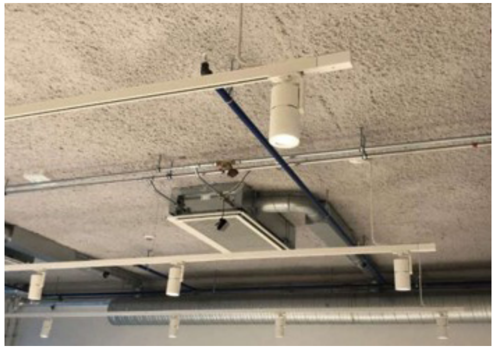
Reusing wood wool cement panels is a very good environmental measure to take as there are no recycling schemes for wood wool cement panels due to the combination of the materials used: wood and cement. It emerged that shavings from the new panels had to be handled as residual waste at the waste facility as they could not be used for energy regeneration given the material's unfavourable combustion processes. The project sought a way to establish a return arrangement with the manufacturer, but without success, as the scale was not large enough and it had not been set as a premise at the time of purchase.

2.10.3 Surface, ceiling: Cellulose spray

Cellulose spray, based on recycled paper, used on the ground floor ceiling and basement ceilings: approx. 600 m²

For the ground floor and basement ceilings, a recycled product was chosen: ThermoCon cellulose spray. The product consists of ground-up recycled paper combined with a water-based glue and is sprayed onto the ceiling. Specifications for installation in KA13 are ThermoCon SB. The spray is of a light grey colour and it is applied as a 40mm thick layer. In total, approx. 600 m² of cellulose spray was applied.


Raw material of ground recycled paper. Photo: Kristine Aassved Storeide



Application of the cellulose spray and the completed ceiling. Photo: Rune Andersen

2.10.4 Ceiling panels in mineral wool, used for sound absorption

	U2 (Entra)	SG (Entra)	KA23 (Höegh Eiendom)	Refstad school (UBF)
The ceiling panels are made of mineral wool applied in two layers in an area of approx. 1,500 m²	10%	30%	10%	50%

The mineral wool ceiling panels were used for sound absorption on top of the fixed wood wool cement panels. All of the mineral wool ceiling panels are reused.

Mineral wool panels are a particularly common type of panel used in ceiling systems and can be found in a number of current renovation/demolition projects. Haandverkerne dismantled 16,800 insulation panels (60×60 cm + some of 60×120cm) from various buildings. The depth of the panels was between 15 and 20mm. The majority of these were transported directly to the site as required and then installed. This was an easy job, but it did take time due to the numerous adjustments/cuttings that had to be carried out for the pipes and electricity.

The mineral wool ceiling panels were used for sound absorption on top of the fixed wood wool cement panels. Photo: Anne S Nordby

2.10.5 Costs, sound absorption

In the OsloMet student thesis, a cost picture was compiled for reuse of the ceiling panels for sound absorption compared to the cost for use of the fixed wood wool cement panels. Reuse of the ceiling panels for this purpose was estimated to be 63% more expensive than use of a new alternative (Jødal, Hansveen and Hall, Oslo Met bachelor's thesis 2020).

In this case, the new alternative was calculated on the basis of 50mm mineral wool, which would also have resulted in a simpler installation process. The figures include an estimate of the extra time required for installation but not for the administration involved in searching, coordinating and collection etc. The price for the new 50mm mineral wool ceiling panels, fully installed, was sourced from the Norwegian price index. In the student calculations, the cost of dismantling amounts to approx. 13% of the total, the cost for transport to KA13 came to approx. 7% and the cost of installation totalled approx. 80%.

	Environmental impact, new elements (A4) *	Environmental impact, used elements (A4) *	▼ Environmental savings from reuse
Ceiling panels	0.65 kg CO_2-e/m²	0.01 kg CO_2-e/m²	98% saving

**The only emissions included in the reuse process for ceiling panels are those associated with transport in phase A4*

The only emissions included in the reuse process for ceiling panels are those associated with transport in phase A4, as all the dismantling and work needed to carry out any adjustments were completed without a need for energy-consuming equipment. The 50mm thick mineral wool was used as a comparable new product. In total, the solution provides savings of just over one tonne of CO_2 equivalents.

There is an additional environmental benefit in extending the lifespan of ceiling panels, as today there are only poor waste management solutions for such panels. As the panels consist of different layers, they cannot be separated and are thus not suitable for recycling.

LEARNING POINTS

- We received many comments along the lines of "It is not possible to reuse ceiling tiles as they break so quickly." However, system ceiling tiles can be reused. If they are removed and reinstalled carefully, their functionality will not be impaired. In addition, many building materials can be reused in places that are less visible but where the materials' properties can be put to good use.
- The progress plan for purchasing new materials is vital when it comes to being able to use second-hand products that turn up in the course of a project.
- The calculated results for costs and environmental impact are highly dependent on the processes that are included.

2.11 Amphitheatre stairs
Building part number: 285

Approx. 250 lm of handrails from the railings in Tøyenbadet were dismantled so as to make the amphitheatre stairs.
Approx. 15 m² of ceiling slats from the sauna in Tøyenbadet were used to cover the underside of the amphitheatre stairs.

We searched for used wood, among other things, that could be used for the large amphitheatre staircase. Glulam beams of various dimensions were found at Refstad school, and ARK adapted/redesigned the amphitheatre's stairs in accordance with the size of these beams. However, the demolition of the school was postponed, which did not align with KA13's progress plan. Later, at an inspection of Tøyenbadet, sturdy handrails were found that could be used. The staircase carpenter was thus given the task of repurposing these old handrails into amphitheatre stairs. The wooden slats from the Tøyenbadet sauna were used to line the underside of the stairs.

A specialist company was brought in to make the stairs. Trappemakeren designed the staircase on the basis of drawings provided by ARK.

The workpieces were delivered by Tøyenbadet in planks of various sizes directly to the factory in Valdres. The workpieces/planks were glued together in large segments and manually and mechanically adjusted according to the plan drawings. The stairs were then cut to the correct size on a CNC machine. Smaller parts for the stairs that needed to be glued were made at the factory. All of the parts for the stairs were then sanded with a wide-band sanding machine. Assembly and surface treatment were carried out on site.

All of the wooden parts of the amphitheatre stairs were made of used materials sourced from Tøyenbadet. The underside of the amphitheatre stairs are clad with wooden slats sourced from the ceiling of the sauna.

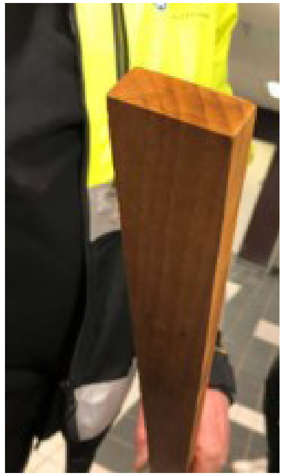
Completed amphitheatre stairs.
Photo: Rune Andersen

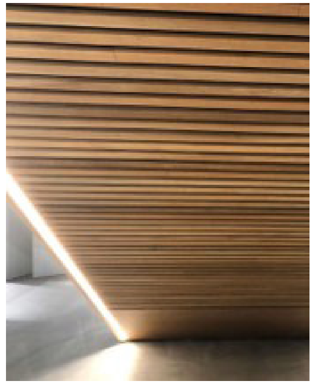
Wooden ceiling slats, Tøyenbadet sauna.
Photo: Catriona Shine

The sturdy wooden handrails are from the Tøyenbadet railings.
Photo: Anne S Nordby

Side wall with visible end wood.

Photo: Randi Lunke





Dismantling and QA. Photo: Rune Andersen
Completed underside of the amphitheatre stairs.
Photo: Rune Andersen

2.12 RAILINGS (INTERIOR)
Building part number: 287

2.12.1 Mesh grids from Tøyenbadet

38 mesh grid panels from Tøyenbadet (KID) were used/modified for the railings

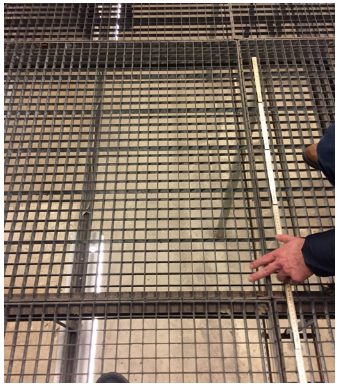
ARK described the mesh grids as railings for the following reasons:

- Mesh grids have the desired transparency
- Mesh grids are climb-proof, as railings must be in accordance with the building code (TEK)
- Mesh grids are often of a form/size that corresponds well with sensible formats for railings
- We have found that used mesh grids are easily available and removable

Suitable mesh grids were found at Tøyenbadet, where they were in use as flooring in the mezzanine of the technical room. The mesh grids' transparency was suitable for their use as railings: the mesh width came to 35×35, with the profile height at 25mm. 38 panels of 990 × 1,490 mm were removed from Tøyenbadet by AF Decom.

The length modifications were a challenge as the mesh grids were galvanised and not suitable for processing. The grids had to be supplemented with balusters and handrails. RIB were involved in the attachment process.

Jomek and Haandverkerne implemented this work. The removal and reinstallation was unproblematic.


1–2: Mesh grids were used as flooring in the technical room at Tøyenbadet, which is where the measurement took place during inspection. Photo: Catriona Shine.

3: Mesh grids in use as railings in KA13. Photo: Anne S Nordby

4: Completed railings against the light shaft.
Photo: Rune Andersen

2.12.2 Staircase railings from Refstad

11 used glass panels from the railings in St. Olavsplass 5 (equivalent to approx. 24.5 m^2 of glass) were used in the new railings

Haandverkerne dismantled the panels, and CreoNordic carried out the installation. Used glass has been installed in the new steel profiles. The adjusted panels are made of new glass.


Glass railings, St. Olavsplass 5. Photo: Norconsult
Glass panel with new frames in KA13. Photo: Rune Andersen

3 Interior

3.1 INTERIOR DESIGNER AND TENANT'S EXPERIENCE

Scenario by the interior designers Annethe Thorsrud and Kristine Aassved Storeide

When we entered into the contract, both the tenant and the landlord were in agreement and aware that this was going to be a challenging and educational journey. This was true in respect of both the goal for reuse being ambitious in itself and the tenant having a clear design profile that mustn't be ignored.

The vision was clear: if we could achieve our goal with a demanding tenant with a clear brand in their flexibility and design, then anyone could!

Looking back now, when we are more or less finished in terms of planning and construction, we see three main points as the most challenging from an interior designer's perspective:

Onboarding/Concept
It is a complex task to visualise and portray an overall concept with so many unknown factors that just have to fall into place along the way. This demanded a lot of everyone, but, most of all, it demanded trust in the process and in Int Ark's ability to see the whole picture.

Search for and access to materials
As there were few search platforms for recycled materials, there was clearly a feeling that we had to forge our own path. For the building-specific/fixed components – such as doors, sinks, toilets – the best results came mainly from buildings set to undergo renovation or demolition. For elements intended for the branding and design, the situation wasn't quite as simple. This challenge was met by contacting the dealers and suppliers we would normally work with, such as tile suppliers, specialist carpenters and lighting/furniture dealers. The responses from all of them were incredibly positive. We hope that the process will now give both the suppliers and ourselves the incentive to actually establish a database of surplus goods that would not normally be resold or sent back.

Project planning and building for reuse
Renovation is basically a process in which one has many considerations to take into account, but when designing with the use of second-hand elements in mind, the process is more like putting together a puzzle that is missing many of its pieces.
It is clear from our experience that it is important to ground the entire value chain and team working on the project in an understanding of what is important to the project and the purpose of the "journey".

This is just as important for the consultants as it is for the contractors. We encountered discussions and situations on several occasions that could have been avoided had we spent more time sharing our goals and vision. This applied to everything, such as the painter painting walls that weren't meant to be painted, because he wanted to deliver the best result and we wanted to keep the original walls' distinctive character and originality. Or the consultant who modified the design of the technical components for each planned room, while we needed full flexibility that follows a system, not a floor plan.

We are grateful for having been given this professional challenge and we have learned an incredible amount from all those involved in the process. Our conclusion is that in order to achieve such a vision, everyone must be creatively future-oriented and have a positive outlook.

3.2 EXISTING SURFACES
Building part number: 246

3.2.1 Existing plaster walls

780 m² of the existing wall facing the neighbouring building was cleaned, lightly plastered and dust-bound

The existing wall facing the neighbouring building (Faculty of Law of the University of Oslo) and two of the walls facing the stairwells from floors 1–7 were retained in their entirety. The walls here consisted of several layers of plaster, wallpaper and paint. The walls were cleaned and lightly sanded, the screws etc. removed and the walls then dust-bound. The idea was to maintain the walls as they were, with wear and tear from days gone by left visible.

Some of the walls had more recent layers of white paint. These were sanded down even more such that they were left with a more “worn” surface and matched the walls on the other floors. On the 3rd floor, the walls were given a coat of glazing in order to soften the strong colours used on this floor. On the ground floor, the wall was plastered, and this wall was also kept plain.

One challenge for IARK was to follow up with the painter to ensure that not too much paint was applied. Some of the original walls “disappeared” when the painters used a little too much paint.

The existing wall was cleaned, sanded down and dust-bound. Photo: Rune Andersen and Anne S Nordby

3.2.2 Pine panelling and units
46 m² of the existing pine cladding and units were retained and partially relocated

The offices on the 5th floor had a rather special design with panelling, units and doors in pine. This was kept as it was but with a few modifications.

The existing profiled pine cladding was also retained on the wall facing the neighbouring building. The cladding inside the offices was removed and on the wall facing the neighbouring building it was supplemented so that the cladding requirements were met. The cladding was washed thoroughly with green soap.

The original inventory was also kept as it was in three of the offices. The units varied from office to office, but they mostly consisted of pine cupboards and shelves that surrounded the wall as well as the original door. The units were in good condition, and it was therefore desired that they remain. The units were thus thoroughly washed with green soap, then kept as they were as IARK was very satisfied with the colour and surface.

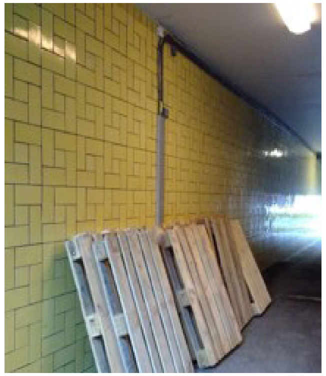
The pine cladding and units were kept and were partially relocated. Photo: Catriona Shine, Rune Andersen and Anne S Nordby

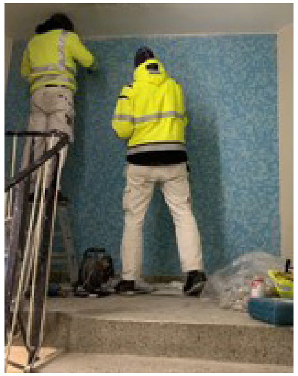
3.2.3 Ceramic tiles

70 m² of the original ceramic tiles in the entrance hall and on the stairs were retained

The ceramic tiles were retained to support the idea of reuse. Some of the tiles were in fairly good condition and required little preparation, while others were in worse condition and required major supplementation.

The yellow tiled wall in the old entrance was in relatively good condition, with only minor damage, and for the most part it was just given a thorough clean. The blue tiles in the stairwell were also in good condition but took more time to clean. The pillars with the original red mosaic were in poor condition and were damaged further during the construction period. These had to be cleaned more and repaired in places where the tiles were missing.





The original tiles were uncovered, cleaned and supplemented. Photo: Anne S Nordby (1), Randi Lunke (2) and Catriona Shine (3)

Some costs were incurred in removing plaster, cleaning tiles and making repairs. These were primarily labour costs.

3.2.4 Environmental assessments, original surfaces

No new materials were used for the treatment of the walls facing the neighbouring building. Repairs were carried out only on the existing wall. Only "kind" chemicals were used, such as dust-binding chemicals. The process for the chosen solution had less of an environmental impact than the alternative, e.g. fully plastering the walls, would have had.
Reusing the wooden cladding/units and the ceramic tile surfaces was also considered to have a positive environmental impact when compared to purchasing new alternatives.

LEARNING POINTS – ORIGINAL SURFACES

- One challenge in this respect was preventing the painters from painting too much and maintaining the desired character of the existing walls with plaster.
- Any original tiles to be reused must be taken care of during the construction period, as they can easily be broken and damaged.
- Tiles that are partially or completely hidden by things such as plaster can be restored to a high standard, but this is time-consuming work.
- It is difficult or impossible to supplement tiles with similar new tiles in the case of damage. Other alternatives must be considered.

3.3 RESIDUAL TILES

Building part number: 246

Approx. 340 m² of ceramic tiles were procured from remaining Bergersen Flis stock for use as both floor and wall coverings (mosaics) in all of the toilets and the shower areas in the changing rooms.

3.3.1 Practical/technical implementation

The search for ceramic tiles was carried out at Bergersen Flis and Fagflis. Bergersen Flis were very enthusiastic about being a part of the project and were able to contribute large quantities of tiles. 16 pallets of tiles of various sizes and types were delivered to the construction site. In total, this amounted to approx. 340 m² of tiles. Around 100 different articles of tiles were delivered to the project. The tiles were mainly sourced from surplus stock, as a result of the products being discontinued, being part of incorrect orders or just being product samples.

IARK visited Bergersen Flis' warehouse in Kolbotn for an inspection and selected suitable tiles for the project. These were mainly tiles in warm and cold shades of grey, as well as black tiles to match the interior concept and satisfy requirements for UD in the accessible WCs. In addition, Scenario wanted decorative tiles in various sizes, colours and patterns.

Based on the 16 pallets that were delivered, Scenario came up with various "test patterns" for placing tiles on the construction site so that the tiler would have a template to base their design on. Traditional planning was replaced by on-site inspections and reviews, as there was no full overview of the tiles and quantities of each tile delivered and documenting this would therefore have been impossible. The tiler followed the template as closely as possible, with the concept changing in places as some tiles were used up and others were found in new pallets.
Scenario were responsible for quality assurance of the design so that this would be kept in line with the desired concept.

One particular challenge when laying the tiles was their various levels of thickness. Any tiles that were disproportionately thick and/or heavy were rejected. Tiles that required a special kind of glue or needed to be cut with a wet saw were also rejected.

Tiles left over from KA13 were passed on to Höegh's project in KA23, where they were looking to do something similar with their project.

1-2: Selection of surplus tiles and test laying.
Photo: Kristine Aassved Storeide

3: Completed mosaic of surplus tiles in the toilets.
Photo: Kristine Aassved Storeide

3.3.2 Environmental assessments

The tiles had not been used before but came from surplus stock. In order to assess the environmental savings, one must look at what would have happened to the tiles if they had not been used for KA13.
Bergersen Flis stated that a majority of the 100 different variants would have ended up as waste, as they represented many small bits from various production batches and could not be sold via traditional channels. The quantities per article were too small to resell. A few of the tiles would have been used as samples, but there is also a limit as to how many samples they actually need. Some of the tiles could have been sold on a "last chance to buy" site or on Finn.no, but this would have been only a small quantity.
The conclusion here is that, by using ceramic tiles from leftover stock, you can use a resource that otherwise would have been mostly just thrown away. As ceramic tiles have a relatively high environmental impact during their manufacture, their reuse could provide valuable reductions in greenhouse gas emissions. By working to create new designs, the interior designers could also influence preferences regarding what is aesthetically acceptable for the concept. In this respect, if "surplus designs" do become trendy, it would be great for the environment!

LEARNING POINTS– REUSING LEFTOVER CERAMIC TILE STOCKS

- New and exciting designs can be created through the use of various types of surplus tiles
- Planning can be challenging. Solutions must be shared and quality assurance must be carried out regularly throughout the project so that the desired visual concept is achieved.

3.4 WOODEN SLATS
Building part number: 246

Approx. 760 lm. of wooden slats procured from Refstad school's corridor ceilings were used for the booths and the cinema room

Wooden slats from Refstad school were assessed early on in the project as a good opportunity for reuse. IARK visited Refstad with Haandverkerne to carry out an inspection and the slats were approved for use as cladding. The slats were thus dismantled and transported to the warehouse in Vollebekk. An inspection by cabinetmaker LUN was then arranged in the warehouse, from which the slats were transported to LUN's workshop for processing.

Early on in the project, 2+2+2 panels with wooden slats were also procured from U2 without a set purpose for use. Scenario, however, wanted to move away from using these, as they were not made of a type of wood that fitted the overall concept, and instead prioritised the slats from Refstad.

The slats procured from the corridors in Refstad were of good quality, made of pine, treated with white lacquer and considered usable in their original form without significant processing. LUN adapted the slats for the areas where they were planned for use, such as in the inside booths on the ground floor and the walls in the basement cinema room.

One challenge was that the slats had a lot of existing screw holes that did not correspond with the new screw positions.

Various alternatives were considered here for plugging the holes, but it was decided to keep the holes as they were and instead assess what measures could be taken on site.

The wooden slats have been a great resource for this project and have provided the opportunity to use aesthetically pleasing sound absorption that has few consequences for the project. In total, there are approx. 760 lm of wooden slats repurposed for this project, found in the:

- Booths: c. 400 lm
- Cinema room: c. 360 lm

Wooden slats dismantled from the ceiling in the corridors of Refstad school. Photo: Anne S Nordby
Storage and production at LUN. Photo: Lars Ulrich Nielson

Installation in KA13. Existing screw holes that were kept. Photo: Kristine Aassved

Completed booths and cladding made of used slats on the back wall of the cinema room. Photo: Rune Andersen

Some costs were incurred in the dismantling, transport and storage of the slats, in addition to costs related to processing the slats at the cabinetmaker's workshop.

Repurposing the wooden slats extends the lifespan of the woodwork. This helps bind the carbon in the building rather than releasing it into the atmosphere during combustion, which is what usually happens when handling wood.

LEARNING POINTS – REUSING WOODEN SLATS

- Wooden slats can be used for various interior design purposes and are easy to work with
- It can be challenging to assess the quantities and plan for new use when the slats come in varying lengths.

3.5 KITCHEN UNITS
Building part number: 273

The interior kitchen units were acquired from:
Lambertseter sykehjem (OBY):
- 7 drawers
- 7 cupboards with shelves
- 5 vanity units with washbasin

St. Olavsplass 5 (Entra):
- 2 vanity units with washbasin

3.5.1 Practical/technical implementation
Through the Rehub project (Rambøll), we came into contact with Omsorgsbygg (OBY), who were set to demolish Lambertseter sykehjem. Rambøll had carried out a reuse survey and let us know about the opportunities for repurposing materials for KA13, including things such as identical kitchen units on 7 floors. The units came with base units with a width of 60cm, which aligned with the sketches provided by IARK and which were also relatively new.

The dismantling of the kitchen cabinets and the faucets was carried out by Haandverkerne and the plumbers alongside work conducted by the emergency response team. 2 base cabinets were missing, as some of the cabinets sustained damage. We did, however, find an opportunity to complement the cabinets in St. Olavs Plass 5. The fittings from Lambertseter sykehjem and St. Olavs Plass were transported first to a warehouse in Vollebekk, then to the construction site. IARK and LUN carried out an inspection in order to assess the standard of the fittings. The fittings were considered good enough for reuse.

LUN manufactured new fronts, linings and bases in 15mm plywood to adhere to the sketches provided by IARK. The original plan had been to reuse plywood for the temporary barriers set up on the construction site, but this was too thin and unstable for use in this way. LUN also produced the worktops, backboards and wall shelves, as well as the ceiling components above the kitchen. The plywood used for the fronts was matte-varnished and will withstand the usage of the premises well.

The kitchen units/fittings from Lambertseter sykehjem. Photo: Rehub/Rambøll

Fully installed cabinets with new fronts made of 15mm plywood. Photo: Lars Ulrich Nielson/LUN and Anne S Nordby

LEARNING POINTS – KITCHEN UNITS

- Most of the cabinets are of the same dimensions, so it was relatively easy to use the cabinets from different places together.
- If you are going to reuse plywood from the construction site for kitchen cabinets, this must be clarified early on so that the panels have a minimum depth of 15mm. It may generally be a good idea to invest in more expensive provisional building materials for the construction process so that they can be reused in the finished building

3.6 AUDITORIUM SEATS
Building part number: 276

40 auditorium seats were removed from Diakonhjemmet Hospital (Diakonhjemmet Eiendom)

34 seats were reupholstered and reused in the basement auditorium

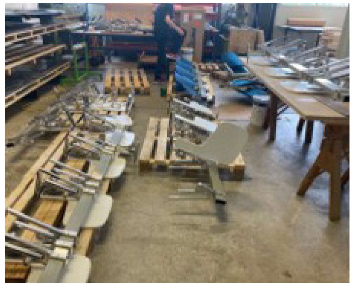
Several solutions were considered here, including the use of auditorium seats from Refstad school and from St. Olavs Plass 5. Several issues were at play in this decision, including the fact that the way the seats were attached to the floor posed a challenge for reuse. The seats at Refstad school were used in an amphitheatre, and it would therefore be arduous to adapt them for installation on a flat floor.

The auditorium seats from St. Olavs Plass 5 were interesting as they were original seats from the era when KA13 had been built, but the environmental clean-up report showed phthalates in their upholstery. As waste, phthalates require special treatment, so we discussed with the environmental surveyors, through Asplan Viak and Norconsult, whether there was still any possibility of reusing the seats. Whether to pursue reuse in such a case is often a matter of choosing between the indoWor climate (supply of non-low-emission materials) and the reuse value, and where the former might be partially compensated for by increased air flow and increased cleaning frequency. No samples were taken of the upholstery, but if this is pursued, then it should be done in order to get an overview of the phthalates in the material and their quantity so as to make an assessment. However, in the case of KA13, it turned out that the chairs were too high to be mounted on a flat floor anyway, thus the solution was abandoned.

We then found auditorium seats at Diakonhjemmet Hospital, in the two auditoriums used by the Borgen branch of VID college. The seats are believed to be from 1991 and were in good condition. They were attached to a horizontal steel profile (4–6 seats per steel base) that was screwed to the floor.

The Østheim contractor dismantled 40 seats, which were sent to the furniture upholsterers (LUN) to be reupholstered. The seats were of varying quality and size. This was addressed by placing the highest seats at the back of the room, and the existing steel rods were cut down in order to fit the new arrangement. It was decided not to use the attached folding tables. The seats and backs were given new upholstery and textiles. The chairs were given a little extra padding in both the seats and the backs for increased comfort.

The chairs were installed in the basement auditorium.



Reupholstering of the auditorium chairs by LUN.
Photo: Lars Ulrich Nielson

LEARNING POINTS – AUDITORIUM CHAIRS

- The type of fastening for the chairs is essential when it comes to assessing reuse.
- The amphitheatre chairs are not necessarily suitable for flat floors and vice versa.
- The height and shape of the chairs and any additional folding tables must be considered on the basis of the new situation.
- Worn textiles can be reupholstered
- Phthalates in the upholstery can be assessed for reuse, even if this requires special treatment after use.

3.7 OTHER UNITS

It was decided early on that the special design would be based on pine. This is based on the Tewo walls, windows, linings and window sills all being made of pine. In addition, we considered the fact that it was easier to obtain pine plywood and solid wood than oak, for instance. A search was therefore conducted for used solid pine, plywood and veneered surfaces. It turned out not to be that easy to get a hold of, as wood is a material that is usually treated neither with great care nor with reuse in mind.

A search was also carried out for marble slabs, plastic slabs and Corian and steel slabs. 7 + 7 pcs. (1.25 × 2.5 m + 1.25 × 1.25 m) of perforated steel panels were found and dismantled at Tøyenbadet. The slabs were a part of surfaces used during a 2008 renovation and were in good condition. The slabs were assessed for use as shelves in KA13.

There was also a wish to reuse benches from Henrik Ibsens gate 53, but due to a lack of access to storage spaces, these could not be included.

Slatted blinds from DEG8 were assessed with reuse at KA13 in mind. As we had varying heights and widths to consider for the windows, we contacted the manufacturer about the possibility of adjusting these. The original manufacturer of the slat blinds (Notto Tekstil & Solskjerming AS) probably had not received a request for reuse before, and it was clear that restitching the panels and adapting the railings etc. would be significantly more expensive than buying new products. When the interior designers ended up choosing another solution for the blinds, it wasn't necessary to proceed with this solution anyway.

3.7.1 Cloakroom lockers

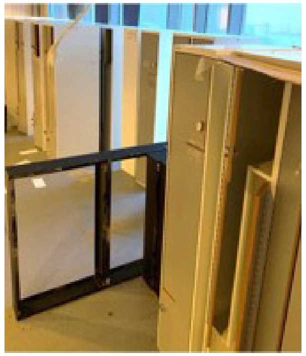
34 Z-lockers (17 double) obtained from Refstad school (UBF).
20 (10 double) reused for the cloakroom in the basement.

We were able to select lockers and other units from Refstad school after the other schools in Oslo marked the equipment they wanted to take. There were many changing room lockers left over, and we chose those that were in best condition. The lockers were stored at Vollebekk until they had to be moved to the Posthuset building in Oslo due to the rental contract expiring at the warehouse in Vollebekk.

3.7.2 Corian reception desk

The reception desk followed a clear design profile for Spaces, which is not usually deviated from. The desk is made of Corian plates. Corian is a material that can be easily reused/upcycled by welding smaller pieces together into larger components and new designs. We chose to deviate slightly from the design profile in terms of which colour of white to use in order to reuse the Corian plates from other used reception desks.

50% of the top of the reception desk is made of repurposed materials from Visit Oslo in Østbanehallen. The reception desk was manufactured by LUN.



1-2: The lockers in the changing room at Refstad school and in storage.
Photo: Anne S Nordby and Randi Lunke
3: Corian reception desk.
Photo: Rune Andersen

3.7.3 Café counter

The exterior cladding of the café counter is made of ceramic tiles from Bergersen Flis' surplus stock.

DESCRIPTION OF CAFE COUNTER:
All pine board is to be priced as pine plywood, white pigmented and matt lacquered. It is desired that all Pine board is to be sourced from reuse sources, and can vary in finish and size.
It is desired that uniform pine (plywood or solid) be used for each object/fixed fixture. Final execution is to be clarified once availability of reuse materials is identified and documented.
All corners are to be mitre joints .

MATERIALS AND COLOURS
Kitchen furnishings are to be delivered by Commercial kitchen supplier. A price is requested for; the production of the finish and cladding around the counter, along with the mounting of the reuse tiles on the fronts.

Countertop: 10mm brass + edging in brass

Tiles: Reuse. Tiles not to be priced, only mounting and adjustments.

3.7.4 Boards

2 traditional school boards sourced from Refstad school (UBF) were repurposed for the reception area on the ground floor.

The boards provide an overview of all of the building's tenants and the text can be easily replaced. The boards add an aesthetic twist in that they support the idea of flexibility and reuse. The boards did not incur any costs or have any environmental impact beyond those for dismantling, transport and storage.

School boards from Refstad school.
Photo: Kristine Aassved Storeide

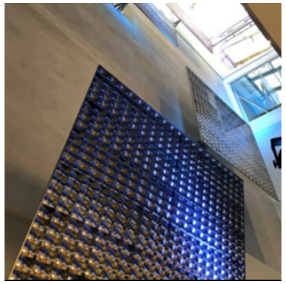
3.7.5 Reflectors

12 reflectors were dismantled from Tøyenbadet (KID). 7 were reused in the light shaft.

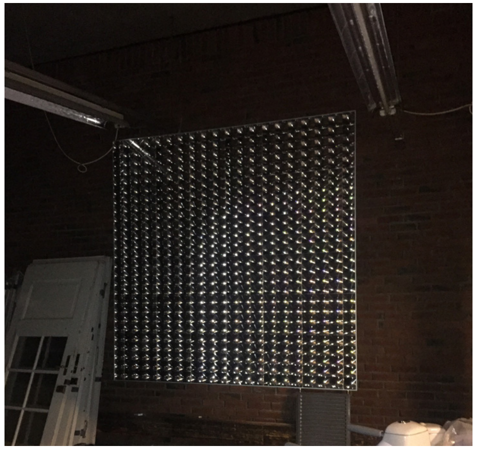
12 reflectors that were hanging above the pool at Tøyenbadet, where they had been used to illuminate the pool area, were dismantled by AF Decom. 7 were installed as a decorative art element in the wall in the light shaft between floors 1 and 7 of KA13.

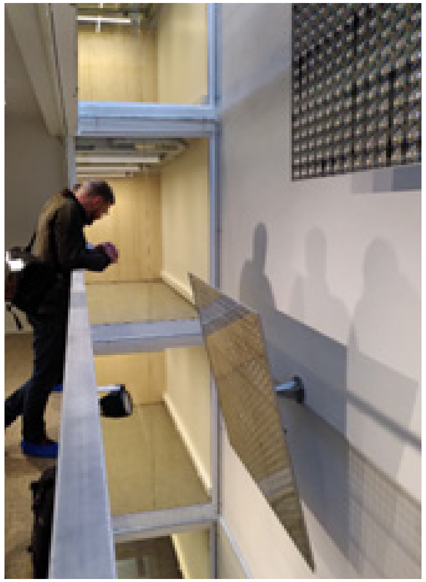
A test was carried out using spotlights in order to assess the location and type of light to use to illuminate the reflectors. Spotlights with RGB lights were chosen for this and were placed on the panelled edge of the light shaft on each floor. The spotlights were bought new.

The brackets were shortened so that the reflectors could be attached closer to the wall and be tilted up and down for the desired effect. No repairs were required for the reflectors. The reflectors were temporarily stored in the Posthuset building after being dismantled from Tøyenbadet.



Light shafts with reflectors.
Photo: Rune Andersen





The reflectors were dismantled from the ceiling in Tøyenbadet, stored and eventually mounted to the light shafts at KA13.
Photo: Anne S Nordby and Catriona Shine

3.7.6 Costs

The reflectors were installed on the ceiling of Tøyenbadet and were complicated to remove. The dismantling process was therefore costly. In addition to these removal costs, there were costs associated with transport, storage and installation. There will also be running costs going forward for the extra electricity used by the spotlights. As this will be used as a decorative art element, it is difficult to assess the costs in relation to any other alternatives.

4 Structural engineering
4.1 STRUCTURAL ENGINEERS: CONSULTANTS' AND CONTRACTORS' EXPERIENCE

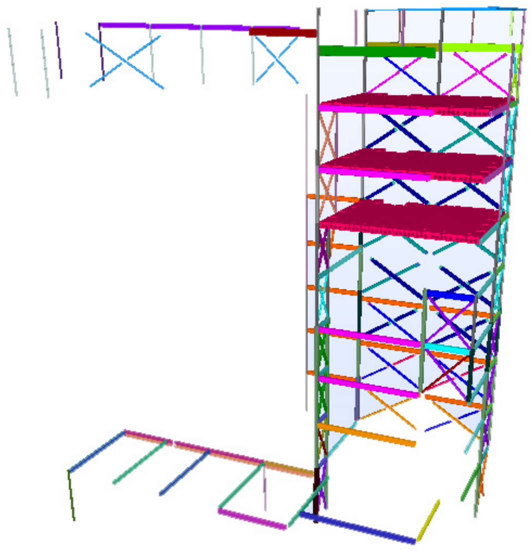
Rambøll by Asbjørn Christiansen and Christian Gamst

The assignment sounded exciting, as we were being given the opportunity to participate in a project in which the consultants generally had little experience. It offered both an opportunity to use the project for our own experience and a great reference for future reuse projects. The challenges here related to the choice of construction solutions, and we believed it possible to bring in building elements that were both suitable and reusable.

Experience:
- We had particularly extensive dialogue with the contractor responsible for procuring the steel elements.
- Reuse of hollow core slabs from one building was easier to handle, but capacity control requires extensive documentation.
- We had to deal a frequent waits for clarification in this project, regarding which elements could be used as well as whether the elements had to be processed or supplemented with anything else.
- Close follow-ups by RIB and the supplier are a prerequisite for any successful project.
- The scope of work was much greater than what is usual for a regular engineering project and thus it is difficult to estimate in terms of a fixed price.

Øst-Riv by Mats Mauer Pettersen
The project differs from a conventional demolition/building project in that small and large R&D jobs were carried out simultaneously, which was key to the deliveries. This naturally increased the complexity of the project, and it demanded a lot more in terms of the organisation and good cooperation to keep to the progress plan. The project provided us with a valuable learning opportunity, and it was inspiring to be involved in such a flagship sustainability project. Our experience can hardly be summarised in simple bullet points, but we will attempt to do so anyway:

- Removing the elements required different, more tentative work processes than in conventional demolition. There were more manual operations involved, which makes projects like this more time-consuming. This then also results in more demanding logistics.
- There was a "treasure hunt" for materials when these were not sourced directly from Kristian Augusts gate 13. Demolition projects with work orders that include dismantling are still the exception. It was therefore demanding to find time and space for dismantling alongside all the other ongoing projects and not at the expense of progress in those respective projects. This meant limited access to used materials.
- The project required close cooperation with the project planners so that the materials we had access to throughout the project could be included in the sketches. An example is alternative steel profiles, as it was not possible to get hold of the original profiles included in the plans.
- Delivering used building materials has required more careful transport methods and temporary storage. These are tasks not usually handled by a contractor and for which the material suppliers tend to take responsibility.
- When the project began, little was known in the industry about the regulations for documentation of used building materials. In this respect, Øst-Riv, in cooperation with the rest of the actors in this project, built up an understanding of the possibilities and limitations within the current regulations.
- Øst-Riv, with Stokke Stål as subcontractor, arranged for a number of material properties tests to be carried out. This has been a valuable experience that we can use in future reuse and repurposing projects.
- The project came up with a method to test the properties of used steel that has been far more effective than the method we were familiar with at the start of the project.



Reused elements in KA13: Structural engineering.
Photos from the IFC file. Illustration: Mad

Quality control and documentation of load-bearing structures were also topics discussed in a series of working meetings under the auspices of FutureBuilt. Processes relating to steel and concrete were discussed for this project, with the help of various contributors, including the Steel Association, the Kontrollrådet for Betong (certification body for concrete) and Sintef. A separate experience report from these work meetings was prepared by FutureBuilt on 20/02/2020.

4.2 STEEL STRUCTURES
Building part number: 222 columns + 223 beams

Karl Johansgate 23 (Øst-Riv)	Approx. 3 tonnes: dismantling of temporary steel bearings
Dronning Maudsgate 1–3 (Øst-Riv)	Approx. 7 tonnes: dismantling of the top floor
Stena Stål Gjenvinning (Stokke Stål)	Purchased approx. 4 tonnes: 3 tonnes of hollow sections and 1 tonne of angles. Previous purpose – unknown. The steel was delivered as surplus materials for recycling
Agility Group (Stokke Stål)	Purchased approx. 22 tonnes: 18 tonnes hollow profiles and 4 tonnes of beams and angles. Projects unknown. Agility Group produces offshore installations, for which it receives surplus steel. In this period, Stokke Stål had to search for suitable profiles. Surplus stock is usually sent for recycling.
Stokke Stål	Approx. 23 tonnes from remaining stock: 17 tonnes hollow profiles and 6 tonnes of beams and angles. Stamping steel from the Grans project in Sandefjord. Temporary steel from Dronning Mauds gate. Temporary steel from the Oksenøye project in Fornebo. Temporary steel from previous projects.

In total, approx. 57 tonnes of used steel was procured from the workshop. Approx. 45 tonnes of used steel was used in the finished building out of a total of approx. 64 tonnes of procured steel (reused and new). All of the used steel is believed to have been sourced from the Oslo area/Eastern Norway and transported via the workshop/ warehouse at Stokke Stål in Vestfold to the construction site at KA13. The steel has been used as reinforcements to the existing building and as supporting structures in the new extensions

4.2.1 Practical/technical implementation
The steel structures consist mainly of cold and hot-formed hollow profiles, I-beams, H-beams and HSQ beams.
Approx. 70% of the steel structures in KA13 are made of recycled steel. Øst-Riv and Stokke Stål began collecting the used steel before the project started and spent much time searching for sources that potentially had steel lying around. The steel came from various sources: Demolition projects, surplus from previous projects, temporary structures and private waste companies.

Øst-Riv acquired approx. 10 tonnes of used steel from buildings they had demolished. The steel came from the following buildings in Oslo: Karl Johansgate 23, where temporary steel was used for support, and Dronning Maudsgate 1-3, where the top floor was dismantled. Stokke Stål bought in used steel from Stena Stål Gjenvinning and Agility Group. Previous purposes/projects for this steel are unknown, but it is believed to have originated in Eastern Norway. All of the elements were transported to Stokke Stål's workshop in Vestfold, which also contributed steel from its own residual stock. This took the form of temporary used steel and incorrect purchases that would normally be recycled.

Buying in all the steel prior to the start of the project brought about both logistical and financial challenges. Managing the full traceability of used components with specific properties required more space and time than usual, and extra land was rented (land from a nearby farmer) in order to sort the steel into different batches. All end plates, foot plates, heels etc. were acquired as new, as these are difficult to find second-hand. It is also disproportionately expensive to adapt steel as such.

Liquidity problems can arise if you end up having a lot of capital wrapped up in buying materials, but in this project this was solved thanks to the long-term good relations between all involved and their common interest in achieving a shared goal.

Steel storage. Photo: Stokke Stål

Dismantling of steel in Dronning Mauds gate 1–3. Photo Thomas Lindseth
Analysis of chemical compositions with an OES-spectrometer. Photo: Stokke Stål

The acquisitions took place in close dialogue with RIB, which provided feedback throughout the process on whether the steel could be used on the basis of the projected foundation or whether there was any possibility of redesigning the plans. When redesigning for the larger dimensions, ARK, RIV and RIE assessed the dimensions against the projected room heights, crossing of guidelines etc. RIB updated the materials lists with the selected dimensions and had, at all times, control over any missing steel.

4.2.2 Quality assurance and documentation
The procedure followed for testing was designed by Stokke Stål in cooperation with PRO Development, who produced a small report on the testing methodology and process. The project also received good assistance from the Norwegian Steel Association, which was knowledgeable about the requirements and standards in force at the time.

The profiles were sorted into test groups by their origins and qualities, and a tracking system with individual reference numbers was used. All profiles were tested with a UCI durometer to confirm batch homogeneity.
The chemical composition of all profiles were then investigated using a portable OES spectrometer. The durability tests were conducted by Stokke Stål, while the spectrometer analysis was carried out by Mantena AS.

On this basis, the steel could be divided into 13 test groups/batches. For each batch, a sample was taken (cut into approx. 30 cm) and sent for destructive stress and shock resistance testing at a Sintef lab in Oslo. The test samples were handled as waste after the testing. The test results provided information about the material, making it possible to take control of the steel welding works.

Stokke Stål CE then marked the steel and issued a performance declaration for the steel once the assembly work was complete. QA and routines for this are carried out in accordance with NS EN 1090-2. This was carried out and documented in the usual way. Responsibility for delivery lies with Øst-Riv. RIB marks/tags the used steel elements in the BIM model.

4.2.3 Processing, repairs
Heels etc. were removed. The steel was further processed through sandblasting and priming. Priming would have been carried out on the steel anyway, but the sandblasting was an additional process that was chosen for the used steel. Sandblasting was carried out at the Stokke Stål warehouse. A recyclable blowing agent was used (which can be reused 50 to 500 times). Any environmental toxins from previous surface treatment of the used steel were removed through sandblasting and dealt with by Stokke Stål. Approximately 70 hours were spent on sandblasting for all of the steel.

The production was no more difficult than for new steel, but it did take longer. Most of the time was spent ensuring full traceability throughout the process. The sandblasting and priming were probably less effective than for new profiles, which meant slightly more production time and energy consumption than for new.

Some additional splicing was necessary in order to achieve the correct length of the components and to avoid waste.

4.2.4 Assembly, disassembly
According to the project objective – designing for reuse in future projects – RIB considered using the underlying beams with bolt connections to the supporting columns. It turned out that such a design for this project would conflict with the tall windows required to provide maximum light to the façades.

The I-profiles and H-profiles were originally intended for use as support beneath the concrete deck, but the height of the beams reduced the light coming in from the windows. Hat profiles were therefore used, which are installed into the same horizontal layer as the hollow core slabs. I-profiles and H-profiles are advantageous in that they can be bolted into columns, but bolting is not common for junctions between hat profiles and columns. The bolt solution was therefore designed and implemented only for the rear wall in axis A, which has no windows.

In KA13, the extension had to be adapted and match the floor heights of the existing building. With a greater floor height, where it is not necessary for the windows to go all the way up to the edge of the roof in order to get enough daylight, a bolted solution would be a simpler alternative.

Installation of the used steel on site.
Photo: Stokke Stål

4.2.5 Costs
In the OsloMet student thesis (Jødal, Hansveen and Hall, OsloMet bachelor's thesis 2020), the price of acquired reused steel totalled approx. 86 NOK/kg. When the student thesis was being written, however, there was not a complete overview of all construction costs connected to the recycled steel. It turned out that the cost of the recycled steel was somewhat higher, up to 100 NOK/kg. This figure includes searching for reused steel, purchasing, dismantling, scanning/testing, processing, temporary storage, transport and assembly. Assuming a new price of 67 NOK/kg, the reused steel was thus around 49% more expensive than the purchase of new steel.

The time spent on planning (RIB) and project management were not included in these calculations. The additional planning time is estimated as about twice as long as for similar projects, where optional profiles are used. Hopefully, this experience will be beneficial for future projects by enabling them to implement more rational processes.

4.2.6 Environmental assessments
In the NTNU student thesis, a total emissions savings of 97% was calculated for the reuse when compared to purchasing new steel for the project (Høydahl and Walter, NTNU master's thesis 2020).

	Environmental impact New elements (A1–A4) *	Environmental impact, Used elements (A1–A4) *	Environmental savings through reuse
Steel columns and beams	2.5 kg CO2-e/kg	0.07 kg CO2-e/kg	97% savings

**A1–A4 indicates the first four phases in the life cycle assessment, in which A1–A3 is the Production Phase and includes the raw materials, transport and manufacturing. A4 is the Construction and Installation Phase and includes transport.*

The results show the environmental impact in the form of greenhouse gas emissions (CO_2 equivalents) per kg for the use of new and used steel. The new steel is assumed to have a recycling rate of 13%.

The calculations are based on the reuse of approx. 45 tonnes of steel. The reuse of steel clearly benefits the project the most, through total savings of approx. 110 tonnes of CO_2 equivalents. The process that made the biggest contribution to the greenhouse gas accounting through reuse was the preparation of the steel, including the cutting and sandblasting of all surfaces. This constitutes 67% of the emissions in connection with reuse (Høydahl and Walter, NTNU master's thesis 2020).

LEARNING POINTS – REUSE OF STEEL

- Access to used steel is a major challenge today. Finding the correct dimensions is demanding. By scaling up the second-hand steel market, this issue could be resolved.
- Communication with the designer about access to different profiles and flexibility in design is considered crucial to the project's success.
- Reuse requires careful disassembly and handling, which also require more time for the demolition
- The test procedures developed for the project, with a limited number of destructive tests, significantly reduce the costs associated with the testing.
- There is already a standard that can be used for the recertification of used steel: NS EN 1090-2. This applies to the fewest building materials!
- Bolting the steel elements rather than welding them may require greater height and thus come into conflict with the height of the floor and the natural lighting

4.3 WOODEN STRUCTURES

Building part number: 222 columns + 223 beams

Diverse original beams of approx. 4×4-inch timber: Disposal to the company Driftwood

In connection with the demolition of the structure on the roof of the existing building, some of the original structural timber was dismantled. Alternatives for internal use in the project were discussed, such as cobblestone floors, but these ideas were not implemented.
A stack of beams of approx. 4×4-inch timber was therefore given to the company Drivved, who make interior products from old wood. Most of the materials were used as table tops for two of the dining tables, where they were laid in a pattern as there were very few beams of good length. The materials were cut, sanded and wire brushed. The tables were then treated with matte hard wax and now find themselves with satisfied customers in a cabin in Larkollen.

Surplus after demolition: A stack of structural timber transformed into beautiful tables. Photo: Driftwood

4.4 BRICK FIRE WALLS

Building part number: 232

A total of 30,000 bricks were obtained from four demolition projects under the auspices of Øst-Riv:

- Strømsveien 185 (year of construction: unknown, but before 1955)
- Bergensgata 41-43 (year of construction: 1913, 1947 and 1981)
- Tine Kalbakken, Bedriftsveien 7 (year of construction: unknown, but before 1955)
- Darres gate 2 (year of construction: 1930/1940s)
- Approx. 20,000 of these bricks were used in KA13

4.4.1 Practical/technical implementation

It was decided that, for the wall facing the neighbouring building (Faculty of Law of the University of Oslo), used bricks would be acquired as a solution for a fire wall/stone cladding in axis A/6-8. Øst-Riv acquired bricks from various buildings that they had demolished. Everything was transported from the demolished buildings to Øst-Riv's warehouse in Slemmestad, where the cleaning and preparation were carried out.

The quantity of bricks made available for the project was originally estimated at 30,000. The quantity was eventually reduced due to the total weight being too much for the foundations. In addition to the weight of the brick wall, there was also an additional load from the used hollow core slabs. Leca was therefore used for the fire walls on three of the falls. This meant that approx. 10,000 stones were not used.

4.4.2 Quality assurance and documentation

Knut Johannesen, mason/adviser of Et Godt Råd AS, assisted in determining the age and assessing the quality of the brick. The stones came in varied archaic formats and thus predated the current Norsk Format (NF) being introduced as standard. It can also be assumed that all of the bricks predate 1955, as lime mortar was used, which is very rarely used in new builds. Mathias Apelseth of Kluge Advokater assessed the reuse of the brick in relation to the requirements for legal conversion. For bricks, there used to be little or no requirement for documentation, and bricks predating 1994 are not subject to the requirement for a CE mark.

Et Godt Råd were further used in the preparation of procedures for QA in cooperation with Øst-Riv, the mason Rolf Holm and Insenti. The procedures included testing at Sintef. The bricks were tested for what are considered to be essential properties to satisfy the required performance for use and thus TEK. The test report contains the results relating to compressive strength and suction tests and comments on the bricks' resistance, which is part of the FDV documentation. The test results were inspected by the relevant advisers, who confirmed that they met the requirements of the technical regulations.

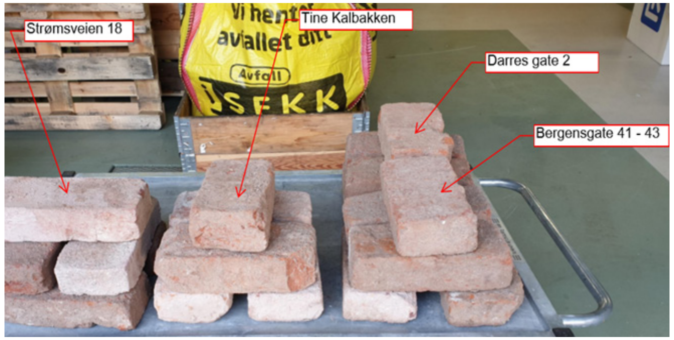
The tests included a number of the performances that you can get today in a performance declaration for new brick, and the performance of new brick is probably better documented now than when it was first sold.

The brick wall is self-supporting and borders the heated area. Issues regarding compressive strength, moisture resistance and insulating ability are therefore of less relevance here than for bricks used in external walls or walls with greater requirements for constructive properties.

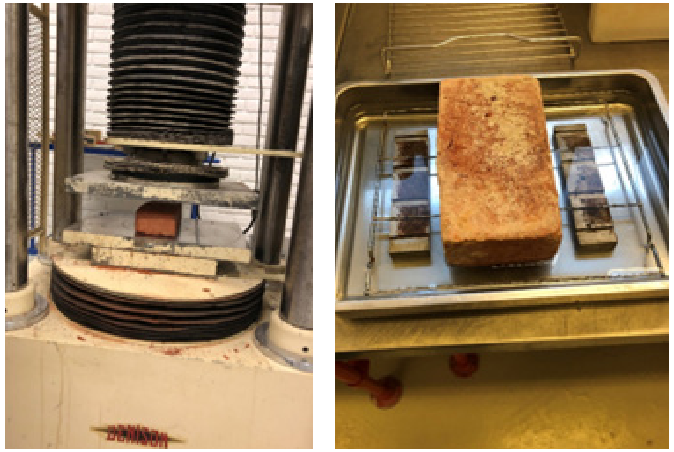
Environmental surveys were carried out in all of the buildings from which the brick originates. Brick does not normally contain dangerous substances in itself, but they can occur in paint, screed and plaster. The brick used was confirmed as being free of environmental toxins above the specified limit values. Øst-Riv was responsible for the delivery, including responsibility for carrying out the tests.

4.4.3 Processing, repairs

Whole bricks were picked from piles following the demolition, then shaken in screeners to remove the coarsest from the mortar. Fine cleaning was then carried out with a hammer for the stacking of pallets. The lime mortar was porous and easy to remove. An inspection was also carried out in connection with the implementation of this, in order to check that no damage had been caused to individual stones. Stones of possibly more recent formats were removed from the batch.



Bricks from four different buildings. Photo: Øst-Riv



Testing at Sintef in Oslo: pressure and suction testing respectively. Photo: Sintef

4.4.4 Masonry/removability

Second-hand bricks have been used on 4 floors (floors 1–4) – a total of approx. 135 2. Leca was used in floors 5–7; otherwise it would have been too heavy for the foundations. (In addition to the weight of the fire wall, added loads also came from the used hollow core slabs.)

A brick wall one-stone thick was built diagonally between the columns, and the wall sits flush with the steel exterior. The exposed steel was protected from fire, but according to RIBr, it was not necessary to plaster the brick wall for fire safety purposes. On the outside, facing the neighbouring buildings, the wall was built with an externally suspended stone wool panel.

A type of mortar based on natural hydraulic lime was used: Mørtel-NHL 3.5 0–4 mm. Lime mortar is weaker and more elastic than cement mortar. If lime mortar is used in the masonry, then the bricks are removable. This means that the bricks can be used in the next round of renovations too, should it be necessary to demolish the wall.

Construction and completed fire wall. Photo: Rune Andersen

4.4.5 Costs

The price per stone was initially 9 NOK each for the stones sorted and stacked onto pallets after the demolition and rough purification. This was an internal Øst-Riv price, which does not reflect the demolition itself. Then the warehouse rent, further cleaning and QA process by the bricklayers and Sintef were added to the cost. The bricklaying job itself cost no more using used brick than had new bricks been used. The company's cost for a completed brick wall with a depth of 1 stone was approx. 7,500 NOK/m². The alternative for use today would be:

1. Landfill. Delivery of the brick waste to the landfill represents the costs associated with both transport and delivery.

2. Use as filler. It costs money to process the masses into filling material, but you save on transport if you can use the masses on site or only need to transport them shorter distances. It depends on the logistics of the project, such as what this consists of.

3. Crushing and recycling, such as for a sedum roof. Recycling of sedum roofs is a promising pilot project that Øst-Riv and Norsk Gjenvinning are working on. The aim is to be able to compete with the landfills and make brick waste a step up in the waste hierarchy.

The upscaling of the market for purification and selling of used bricks will require investment in production equipment. It is uncertain what the price for used brick would be if more industrial processes were involved.

4.4.6 Environmental assessments

We made a brief estimate of the greenhouse gas reductions through use of reused brick on the basis of figures from GamleMursten in Denmark. GamleMursten calculated that each reused brick saves the environment 0.5 kg CO_2. In KA13, approx. 20,000 bricks were used. This corresponds to greenhouse gas savings of approx. 10 tonnes.

LEARNING PONTS – REUSE OF BRICKS

- QA procedures and documentation of the reuse of constructive elements should be drawn up in close collaboration with relevant external material experts and trade unions, along with the project planners, contractors and suppliers
- Documentation of the exact year of production and where the stone comes from (producer) has been a challenge, but due to the formats, there has been little doubt as to the stone's years of origin predating the introduction of rules for conversion.
- CE marking for bricks has not been carried out in Norway, but GamleMursten in Denmark has established a procedure for this.

4.5 ALTERNATIVE FIRE WALLS IN COMPACT WALL ELEMENTS (ASSESSMENT IN THE PRELIMINARY PROJECT)

Building part number: 232
It was considered earlier on in the project whether concrete elements should be used in the fire wall facing the neighbouring buildings. This was thought to be built up with compact wall elements, which could have been acquired second-hand. The solution was later replaced with steel and brick, and thus the reuse of the compact wall elements was not pursued further. However, as part of the feasibility study, an assessment was made of the costs and environmental effects of reusing such elements.

The estimated price for used compact walls was approx. 150% of the price of new. The cost of reusing compact walls is higher than using new compact walls due to the following factors:

- Need for careful installation
- Sawing of modules for adapted new wall lengths and room heights
- Installation: Need for drilling and cementing of the iron reinforcement, as well as casting between the elements to obtain a monolithic structure
- QA procedure: Need for an overview of the reinforcement of the reused elements to continuously check for stretch connections in the wall panel

In retrospect, RIB has commented that the problem with compact walls that do not use steel diagonals entailed disproportionately large costs in terms of connecting the elements with grouting between the elements.

The environmental assessment showed that it would be possible to achieve approx. 80% savings when reusing compact walls when compared to using new compact walls. Reuse would provide an approx. 25% increase in material use, would need drilling in and fixing the grouting into the iron reinforcement, and would require casting between the elements to achieve a monolithic structure. In addition, the reused walls had to be cut to size in order to match the room height of KA13.

4.6 HOLLOW CORE SLABS
Building part number: 251

21 hollow core slabs (type HD265) were acquired from Regjeringskvartalet R4 (Statsbygg/Veidekke)

The hollow core slabs were already cut at approx. 6.5m long and 1.20m wide. They were used in the floor dividers on the top three floors (covering the 4th–6th floors) in the extension. This corresponds to an area of approx. 160 m²

4.6.1 Practical/technical implementation

In connection with the demolition of buildings in the Regjeringskvartalet (R4 and Møllergata 17), Statsbygg was invited to a dialogue meeting, in cooperation with Veidekke and Resirqel, that was held on 12 March 2019. The purpose of this was to establish contact with those in the market who may make use of building components and demolition materials from R4 and M17. As a result of this meeting, processes were established for the disposal of, among other things, hollow core slabs from the demolition. The price and progress for removing these were eventually discussed directly with Veidekke. In addition to KA13, several other actors were interested in taking the hollow core slabs from the Government Quarter demolition project.

It is not common to hoist out hollow core slabs in such a way that they are kept whole in the removal process. As a rule, they usually have to be crushed anyway, and the iron reinforcement is separated from the concrete. Øst-Riv, however, have experience in the removal of whole hollow core slabs from the renovation of The Hub due to the very narrow construction site there. Together with RIB, Øst-Riv described a safe process for hoisting out the entire hollow core slabs as a whole.

In R4, the span of the hollow core slabs was about 11m and they were laid out on prefabricated LB beams along the building's outer walls. The slabs had a height of 265mm and an additional screed of 8cm. It was decided that this screed would not be removed, as it was firmly attached to the substrate and removal was considered too extensive a job. It was decided to use used elements on only three of the floors. Extra weight from the screed meant that the columns did not have the capacity for a heightened load. In addition, the used elements were very expensive compared to the new hollow core slabs. The screed also resulted in a reduced ceiling height when compared to the original plan.

The environmental clean-up report for R4 documented that the hollow core slabs did not contain any environmental pollutants.

4.6.2 Quality assurance and documentation

The quality control and documentation of the steel and concrete load-bearing structures were topics at the core of a series of work meetings held under the auspices of FutureBuilt. Processes for working with the concrete elements were drawn up with help from several contributors, not least the Kontrollrådet for Betong (certification body for concrete) and Sintef. A separate experience report from these work meetings was prepared by FutureBuilt on 20/02/2020. Sintef described the QA process followed for this project and created a flow chart for it.

Further meetings were held with Veidekke to plan the testing and documentation and to assess how we would practically carry out the dismantling and transfer of the hollow core slabs. Meetings were also held with Skanska, as Skanska has been conducting a simultaneous process to investigate the possibilities for the reuse of hollow core slabs. Attempts were made to obtain the original documentation from R4, but the correct documentation could not be obtained. The hollow core slab elements were first visually inspected by RIB and the project manager. A slab was then pre-cut to make it possible to measure the depth of the slab and the cross-section of the tension cables (tension reinforcement), then record the number of tension ropes and measure the slab covers.

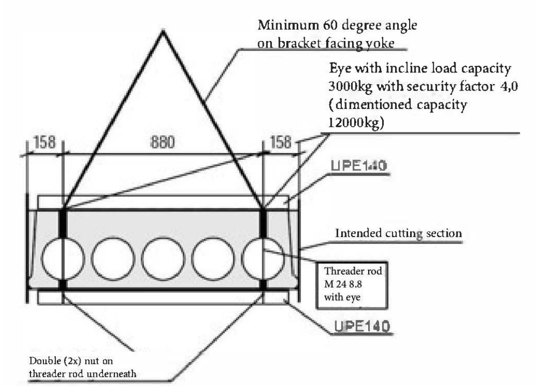
Drilling samples were also taken and sent to Sintef's lab in Oslo. Sintef analysed the samples for carbonation and chloride content. RIB were then sent the analysis results from Sintef and confirmed that the content was of sufficiently good quality. On this basis, calculations were made which showed that the slabs were of sufficient capacity.

The need for CE-marking was discussed in the work meetings organised by FutureBuilt. The conclusion was that, as there is no harmonised standard for reuse of building materials, there could therefore be no requirements for CE or DoP. The calculations from RIB showed that the capacity was more than fulfilled to be able to document properties that meet requirements according to the building code (TEK).

In the contract with Veidekke, it was specified that Entra assumed the risk of direct costs when carrying out any orders from the Norwegian Building Authority regarding the legal planning and building requirements for documentation of the products. A similar agreement was also designed in regard to taking over ownership of building materials from other building owners.

4.6.3 Hoisting, transport and installation
Veidekke cut the hollow core slabs from the inside of the support beams, dismantled them and hoisted them out of the elements in R4. The joint casting between the elements had to be cut open so as to loosen each element. The bows off-loaded the elements during the sawing process. Specific yokes were produced for the hoisting, as regular clamps could not be used due to the screed/extra height. Holes were drilled for the placement of eye bolts, to be attached to the steel profile (UPE) underneath.

The hoisting was carried out quickly and without any problems. Øst-Riv was responsible for transporting the slabs via the warehouse in Follestad to be prepared for installation (cleaning the grout off and cutting them to the correct length) and then transporting them onwards to the construction site for installation. The hollow core slabs use traditional fixings. They are located on the hat profiles facing the façade and on the H-beams facing the other sides. Joint grout was used between the elements.



Lifting yoke for the hollow core slabs. Working drafts, Rambøll.

Hoisting the hollow core slabs out of R4.
Video clip from NRK

Lifting the hollow core slabs into place.
Photo: Mattias Johnsson

Hollow core slabs in R4, Regjeringskvartalet.
Photo: Anne S Nordby

Underside of the finished slab, used elements.
Photo: Rune Andersen

4.6.4 Costs
Costs related to the used hollow core slabs were incurred during various phases of the procurement. There were great uncertainties associated with the exact figures, as this is a pilot project with many different operations that require a lot of planning prior to implementation. Extra time for the RIB planning and project management was also significant. This resulted in large general costs that had to be distributed over a relatively small number of elements.

The costs of the procurement consisted of the following items:
1. Dismantling by Veidekke (in reference to the prepared procedure this included the extra rigging and operations, inspection of the building, bracing, stamping, drilling, sawing and hoisting)
2. Testing by Sintef
3. Transport, cutting, processing, cleaning, preparing and installing by Øst-Riv
4. Extra planning (RIB) and administration (Insenti)

The cost of procuring the hollow core slabs for this project (points 1–3) was estimated as approx. 5–6 times the price of new hollow core slabs. In addition, extra planning and administration were required. If reuse becomes more industrialised in the future, it will probably have a significant positive effect on the cost of reuse.

4.6.5 Environmental assessments
In the NTNU student thesis, a total emissions savings of 89% was calculated for reuse when compared to purchasing new hollow core slabs for the project. (Høydahl and Walter, NTNU master's thesis 2020).

	Environmental impact, new elements (A1–A4) *	Environmental costs, used elements (A1–A4) *	▼ Environmental savings from reuse
Hollow core slabs	124.9 kg CO2-e/t	13.9 kg CO2-e/t	89% savings

A1–A4 indicates the first four phases in the life cycle assessment, in which A1–A3 is the Production Phase and includes the raw materials, transport and manufacturing. A4 is the Construction and Installation Phase and includes transport.

The results show the environmental impact in the form of greenhouse gas emissions (CO_2 equivalents) per tonne for both the new and used hollow core slabs. A total of approx. 96 tonnes of used hollow core slabs were used for this project, and reuse of these provided the project with a total savings of approx. 10.9 tonnes of CO_2 equivalents.

Transporting these made the greatest contribution to the greenhouse gas accounting in regard to reusing hollow core slabs and accounts for up to 90% of the emissions. As the slabs are heavy, this subsequently resulted in a higher intensity of emissions through transport. It would still take a lot for the reuse of the slabs not to pay off from an environmental point of view. In fact, they can be transported at least 890 km before the emissions equal the emissions had the project sourced new slabs, with the assumptions based on this analysis. The dismantling and processing resulted in minimal emissions. (Høydahl and Walter, NTNU master's thesis 2020).

LEARNING POINTS – REUSE OF HOLLOW CORE SLABS

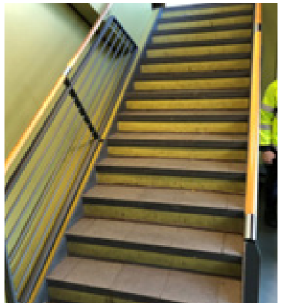
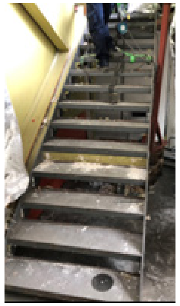
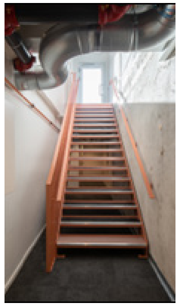
- The dismantling of these required careful planning in order to maintain the stability of the "donor building" throughout the process and to ensure the safe release and hoisting of the elements.
- Space must be set aside for temporary storage in order to process and prepare the slabs for installation.
- Procedures for QA and documentation for the reuse of structural elements must be drawn up in close collaboration with the project planners, contractors and suppliers, along with the relevant material experts and trade unions.

4.7 INTERNAL STAIRCASE FROM FLOOR 7 TO FLOOR 8

The steel staircase between floors 7 and 8 was procured from St. Olavsplass 5 (Entra) and processed by Stokke Stål.

A new staircase was needed from the 7th floor to the roof terrace on the 8th floor. Two steel staircases of different widths were found at St. Olavsplass 5 (Entra) and assessed. One of these fit well in regard to width but was a little too short. Stokke Stål dismantled and transported the staircase to Stokke for cleaning, modifying, sandblasting and varnishing. In order to fit as needed in KA13, the stairs were fitted with four extra steps at the top. The staircase was then painted a new colour, and a new handrail was made.

The project showed that it is entirely possible to reuse steel stairs, but in this case, more modification was required than first expected. In terms of the costs, it was therefore a relatively expensive solution.

1–2: Stairs before and during dismantling from St. Olavs Plass 5. Photo: Rune Andersen
3: Reused staircase, processed and installed in KA13. Photo: Kyrre

5 Pipes and Ventilation

5.1 PLUMBERS: CONSULTANTS' AND CONTRACTORS' EXPERIENCE

Norconsult by Christoffer Siopan Engtrø, Oslo Akershus Rørleggerbedrift (OAR) by Anders Sand and Energima by Lasse Nikolaisen

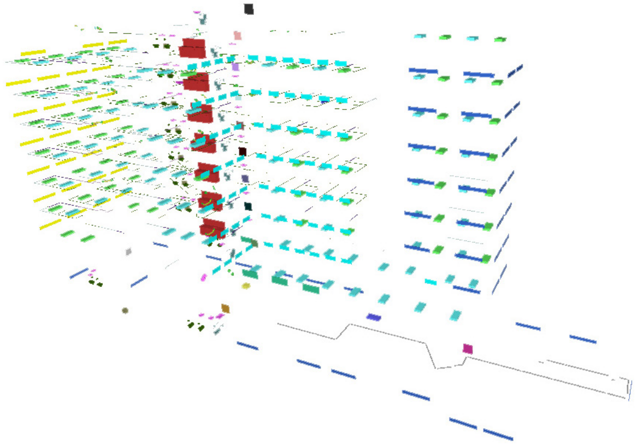
KA13 has been an exciting project to work with, but we have also faced a number of challenges. Prior to starting the project, we didn't know what equipment would be available, what its quality would be, and what might be necessary in terms of processing before being transported to the construction site. And how much extra work would reuse actually entail?

It has been challenging to motivate our workers to work with old pipes. In a project like this, we found the pace of work would slow down due to having no control over the parts, having to handle equipment of outdated sizes and lengths and having to do a lot of extra joining. The pipes had to be cleaned as, for example, there were old taps with plumbing hemp. Similarly, a lot of the ventilation ducts were dirty and dented, and there was little motivation to reuse these. The result meant pursuing rarely used channels. If the contractor had previously worked on projects like this, meaning they had experience procuring second-hand products, then they could, for example, have found long ventilation shafts from other projects. This may be possible to initiate in future projects.

One of the problems here can be traced back to the fact that disassembly, transport and storage have not been given enough attention in the industry. Ideally, professionals should be employed to dismantle the equipment, not ordinary demolition contractors, who are not used to having to consider the preservation of the product's quality. For example, pipes were often recut into smaller components in order to fit in the lift and transport, and this of course meant that it took a lot of time to rejoin them afterwards. OAR handled pipes with a length of 70–220cm, while standard lengths are 3m, 5m and 6m. (Those of 6m are often cut in two.) Even though it is more expensive to use separate contractors for dismantling, this would ultimately provide a better solution. There is no point in delaying the costs from the disassembly phase to the assembly phase.

There were also major differences in terms of type of equipment used. For example, the reuse of chilled beams and radiators worked well. These are expensive components that are motivating to work with. The cooling beams are of a type in common use that we come across all the time, meaning that both the planning and installation of these were straightforward. The radiators are crooked in some places relative to the windows. When reusing, you have to adapt the building to the product rather than the other way around, and one has to think according to this mentality as reuse gradually becomes more widespread in more projects.

The logistics have been a challenge in that there were numerous rounds of information about the products and you would have to travel and collect the goods yourself every now and then. It was thus difficult to keep track of what was where. When new equipment is used, it's normally delivered daily in Oslo by a wholesaler/ supplier. In this case, we missed being able to have a database of available used products and a warehouse to use for intermediate storage. In connection with a database, you could have a number system for the types of products that are available and have a direct tag to the FDV.



Reused elements in KA13: Pipes and ventilation. Photos from the IFC file. Illustration: Mad Arkitekter

5.2 SANITARY EQUIPMENT
Building part number: 315

	Number	Acquired from
Basin mixers	15	Lambertseter sykehjem
Basin mixers HC-sink	7	Universitetsgata 2 Tøyenbadet
Kitchen taps	8	Lambertseter sykehjem
Sinks	34	DEG 8 Universitetsgata 2
Basin HC	8	Universitetsgata 2 Tøyenbadet
Toilets	14	Refstad school Universitetsgata 2 Tøyenbadet
HC toilet	10	Universitetsgata 2 Tordenskiolds gate 12 Tøyenbadet DEG 8 Refstad school
Arm supports HC toilet	9	Refstad school Tordenskiolds gate 12 Universitetsgata 2 Tøyenbadet
Utility sinks	8	Refstad school Resirqel
Faucets for the utility sinks	3	Tordenskiolds gate 12

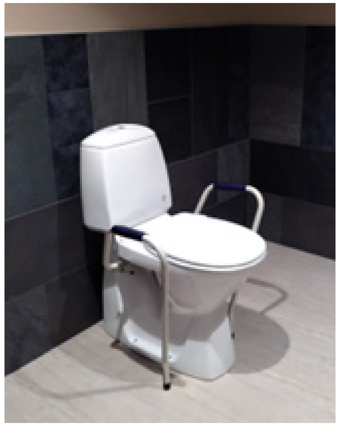
5.2.1 Practical/technical implementation
Procurement of the used sanitary equipment for KA13 included toilets, basins, basin mixers, kitchen taps and utility sinks. Equipment was searched for in Entra's own buildings and during inspections of other buildings.
Some equipment was found before the piping was decided on and before the interior designers had made their assessments. This meant that some of the equipment was rejected. This was the case for the toilets with p-traps, as s-trap toilets had already been prepared for on the construction site. Certain elements, such as the shower faucet and some of the basins and utility sinks, had to be purchased new.

Used sanitary equipment has not been especially complicated in general in terms of project planning. The interior architect was asked about the type of washbasins and the placements of these.

Quality assurance was carried out by RIV and the contractor (OAR). The equipment was cleaned and purged. A lot of the equipment was sourced from Entra's own property. The contractor (OAR) was responsible for assessing and approving the technical quality. A lot of the equipment is like new and has the original documentation. The focus was thus on technical quality. The toilets do not have the water-saving qualities (flushing volume) that we would normally request when purchasing new.

The sanitary equipment was sourced from several different buildings, meaning that it was a challenge to find storage space for all of it along the way. Some of the equipment had to be moved several times without being properly packed, so some of the items were not treated particularly well.

The sanitary equipment was installed in the usual way and is generally removable.



The sanitary equipment in its original building, in storage, and installed in KA13. Photo: Anne S Nordby

5.2.2 Costs

After the dismantling, storage/moving, purging, extra planning and counting, there was no financial gain from reusing sanitary equipment for this project. However, if the plumbers had dismantled the equipment and assessed what was

worth taking care of from the start, we could have ensured the right quality then and avoided any surprises in terms of procuring the wrong equipment. It would have also been an advantage to have a warehouse for storing the equipment. With better logistics, it would have been possible to achieve financial savings.

LEARNING POINTS – USE OF SANITARY EQUIPMENT

- The contractors must have control over the number and type being dismantled, transported, stored and placed. This can be demanding!
- It should be the plumbers who dismantle the equipment, as then there would be a greater chance of ensuring the right quality and better logistics.
- Storage must be planned. Protecting the elements while they are being transported and stored must also be taken care of so that no accidents occur.
- The sanitary equipment had a higher replacement rate than anticipated and seems to have been seen as "low-status objects". Why is this kind of equipment not reused in renovation projects?

5.3 RADIATORS

Building part number: 325

	KA13 (Entra)	U2 (Entra)	Refstad school (UBF)
Original radiators	98		
Lyngson radiators, type Ludvig		45	7

5.3.1 Practical/technical implementation

The original radiators in KA13 were reused in this project, and a search was carried out to find used equipment that could supplement those in the basement and the extension. The radiators deemed suitable for the project were found in Entra's Universitetsgata 2 (U2) building. The radiators from U2 were long, and in some places in the building we had to supplement the radiators with smaller versions. We were able to do this with those we found at Refstad school. We required different sizes to fit with the division of rooms, windows and capacity.

For reusing the old radiators already present in KA13, a capacity assessment was carried out: could they provide enough heat, and would this be the same after an additional coat of paint? One challenge with these radiators was that the heating effect decreased when replacing oil (80 degrees) with district heating (60 degrees). However, this was taken into account in the energy calculations. In the event of lower heating requirements due to the replacement of windows in the existing building, this balances out – at least a little bit.

When it was ensured that the radiators had the necessary capacity, it was necessary to carry out a quality assurance check as to whether the radiators were affected by wear and tear or rust and whether the material was too weak.

All of the radiators were transported to a storage room in the Porthuset building, with access to water and drains for testing and preparation. The radiators from U2 were temporarily stored in the basement of the U2 project before being moved on to Posthuset.

The quality assurance of the existing radiators in KA13 was carried out with compression testing. The exteriors of the radiators were further processed through dry ice blasting at the workshop, which was followed by painting and a change of valves. The newer radiators from U2 and Refstad just had to be flushed through, then some were painted while the rest kept their original colour. Some of the radiators were not sufficiently well packaged or taken care of after the surface treatment and thus some sustained damages. These had to be repaired on site.

By reusing radiators from KA13 and U2, there was no question about buying new, and the radiators from Refstad were of a similar type to those available on the market today anyway. The contractor (OAR) was responsible for assessment and approval of their use and supply of the FDV documentation.

The radiators were installed in the usual way and are generally removable.

Original radiators in KA13.
Photo: Anne S Nordby

Storage prior to flushing and compression testing. Photo: Anders Sand

Completed installation after processing.
Photo: Randi Lunke

5.3.2 Costs
New radiators can be relatively expensive, so with good logistics, reuse could be beneficial.

LEARNING POINTS– REUSE OF RADIATORS

- Radiators are easy to dismantle and, with the proper storage and handling, it is easy to successfully reuse them.
- Packaging and protecting the elements during transport and storage must also be taken care of so that no accidents occur.
- Many people were pleasantly surprised at how good the radiators looked in the end. Some thought that we hadn't actually reused the radiators because they looked new!

5.4 FIRE HOSE CABINET
Building part number: 331

12 fire hose cabinets with roll acquired from Dronning Eufemias gate 8 (Braathen Eiendom)

After an inspection of Dronning Eufemiasgate 8 (DEG8), fire house cabinets were one of the many items found which were deemed suitable for reuse in KA13. Haandverkerne dismantled the elements, and this worked well.

During the quality assurance testing, the quality of the house was checked to ensure there were no cracks etc. One issue here was that legionella can grow in water left in pipes over time. This was not specifically checked, but it is something that should be kept under control. In general, fire hoses must be inspected annually. If it can be documented that they were tested in the last year, then it should be possible to reuse them in another building as well. Their lifespan can be long. Even antiquated fire hoses work well.

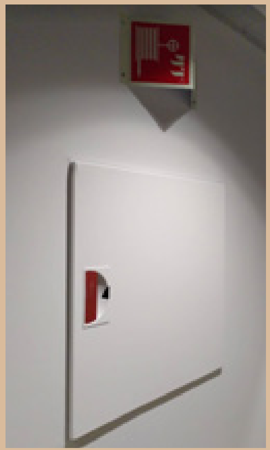
In-built fire hose cabinets were initially planned, but the cabinets available in DEG8 were surface mounted. This was dealt with by Haandverkerne, who built a box for the cabinet to fit into. The cabinet door protrudes somewhat from the wall. The solution wasn't ideal, but it was accepted.

The fire hose cabinets were stored by Resirqel in Vollebekk before being transported further and installed in KA13. Nothing specific has been done with the cabinets. The hoses were included in all of the cabinets. Some of the shut-off valves were replaced. The entire system was compression tested after installation and approved for use.

RIV and the contractor (OAR) assessed the quality and have approved them for use. The cabinets were installed in the usual way and can therefore be dismantled as before.

LEARNING POINTS – REUSE OF FIRE HOSE CABINETS

- Fire hose cabinets are items commonly reused.



The used fire hose cabinets from DEG8 installed in KA13. Photo: Anne S Nordby

5.5 METAL PIPES
Building part number: 332

5.5.1 Heating pipes
Large quantities of good quality metal pipes were found at Refstad school, and, technically, these could have been reused in KA13 as both heating and sprinkler pipes. OAR participated in the inspection of the school and surveyed the scope.

Heating pipes are not normally supplied with documentation from the manufacturer, only the documentation for the standard that the pipes have been tested to. Through the FDV system, it emerged that the pipes were manufactured in accordance with the Norwegian Standard for threaded steel pipes, with reference to NS 5587, and welded pipes, with reference to NS 582. In January 2011, however, a new standard was introduced, EN 10255, which must be adhered to in regard to threaded steel pipes. Welded steel pipes must be documented in accordance with NS-ISO 4200. Entra's lawyers (Kluge Advokatfirma AS) clarified that we did not have sufficient documentation for the sale of the pipes, as the standards had not been adhered to.

5.5.2 Sprinkler pipes

	Quantity from U2 (Entra)
Sprinkler pipes DN25 DN32 DN40	approx. 200 metres, estimated distribution as follows: approx. 150m approx. 30m approx. 20m

Sprinkler pipes were dismantled during the renovation of Universitetsgata 2 (Entra), soon after which it was clarified that they would be suitable for reuse in KA13. Øst-Riv dismantled the pipes from U2 and they were transported to storage in Follestad.

Later, the pipes were transported from Follestad to the basement of Posthuset (Biskop Gunnerus gate 14) for quality assurance. However, some of the pipes had to be discarded of due to rust. They had been stored under the tarpaulin in Follestad, which encouraged rust. The pipes were then temporarily stored in the Posthuset building until they were used in KA13. The quality assurance testing consisted of compression testing and flushing.

There were quite a few that were too short, which led to a lot of joining. Experience suggests that pipes in poor condition should be removed from the batch at the start so that you can focus on finding and using pipes of longer lengths and less joining is required.
According to the documentation requirements with reference to DOC, reusing the pipes here is fine as the pipes are Entra's property so no sale involved. Overall, however, the result of reusing the pipes was somewhat paradoxical – due to the lack of documentation at the time of the handover, the pipes from U2 ended up being used rather than the higher quality pipes from Refstad.

Used sprinkler pipes, dismantled from U2. Photo: Christoffer Siopan Engtrø

Storage in Follestad. Photo: Anders Sand

Used sprinkler pipes, completed installation. Photo: Anne S Nordby

LEARNING POINTS

- In order to reuse the pipes, this intention should be made clear at an early stage of the project so that the contractor can also help obtain an overview of all the options.
- You don't have time to search for documentation in the production phase!
- Due to a lack of documentation at the time of the handover, the project ended reusing pipes from U2 rather than the higher quality pipes from Refstad.

5.6 AIR DISTRIBUTION
Building part number: 364 + 362

	KA13
Circular ventilation ducts	125 – approx. 6.5 metres 160 – approx. 3.5 metres 200 – approx. 2 metres 250 – approx. 0.5 metres
Sound absorbers	2

A variety of ventilation equipment was dismantled during the demolition at KA13, which was then stored on the building's first floor. After a review conducted by Energima, the equipment was sorted roughly into the following categories:

- All straight and circular ducts were sorted and cut into "full reusable lengths". Number and length were recorded. The cut-off was disposed of in the metal waste.
- All elbows without any damage were put aside. Elbows that had sustained damage and that were not considered suitable for reuse were disposed of in the metal waste.
- We did not have use for square ducts. Not considered to have value for other projects. Disposed of directly as metal waste.
- Other sorted equipment. Equipment that had dents etc. separated from that which was "whole and undamaged" (i.e. none of this was immediately disposed of).

Used, round ventilation ducts and duct elbows – dismantled and roughly sorted in KA13. Photo: Anne S Nordby

In order to achieve cost-effective reuse of the ducts, these needed to be at least 2 to 3 metres long. This is because the ducts are reasonably priced for purchase but cost a lot to join – especially as there are many different years and manufacturers. The contractor carried out the inspections at U2 and St. Olavs plass, but almost none of the ducts found were the right length for reuse, so their reuse was considered inappropriate. They also looked for ventilation valves, but only found ones that would not fit, on top of which they had a lot of unsightly marks etc.

As different surfaces/appearances were to be expected on the reused ducts and the new ducts, a test was carried out to see whether we could include some of the parts when we fitted the test room. The pipes and elbows that had been painted were kept painted and installed alongside the new unpainted products. The result was discussed with the tenant and assessed as fine.

This ended with most of the old ducts from KA13 being discarded, including a number of square ducts which had no potential for reuse in other projects either. There were also a few lengths of round ducts that were intact, some of which had sustained damage.

Some of the elbows + some of the straight ducts from KA13 were reused. The used ducts and elbows were cleaned with compressed air and a brush, then sealed with a plastic lid so that the ducts could be installed in the same way as a new duct. The reused ducts are concentrated on one floor.

5.6.1 Costs

The round ducts with smaller dimensions are more affordable to purchase. In the project, it was estimated that it cost approx. twice as much to reuse these. The bucket valves and elbows are sold at a higher price and are therefore considered to have more economic potential when reused.

LEARNING POINTS

- The contractors should contribute to the search for used elements from the start of the project, as they have good opportunities to obtain equipment from other projects.
- Ventilation ducts should have long, straight stretches (at least 2 to 3 metres) so that they can be reused.
- The bucket valve bends may have more economic potential when reused.

5.7 CHILLED BEAMS

Building part number: 375

185 chilled beams were acquired from Dronning Eufemiasgate 8 (DEG8), Braathen Eiendom.
135 were installed in KA13

5.7.1 Practical/technical implementation

The chilled beams for comfort cooling were acquired from Dronning Eufemiasgate 8 (DEG8). RIV observed that this was the right type for usage for KA13 and assessed the quality of the chilled beams as good as new. Type: Parasol 1200, Swegon: 1192A-HF.

The FDV documentation from the building owner was reviewed, and a product data sheet was found for the beams that noted much of the performance of the product on the basis of given dimensioning parameters. Upon contacting Swegon, we also received a construction material declaration for the product, as well as assembly materials. As far as the CE marking is concerned, the Parasol chilled beams from 2007/2008 did not have this. Nor was this obtainable from the manufacturer for the newly manufactured chilled beams.

185 chilled beams were dismantled, packaged well and transported to the rented storage space in Vollebekk.

The combination beams from DEG8 were intended for ceiling installation. If everything were to be bought new, then perhaps other types with visible technology, as in KA13, would be chosen. The beams were installed in a test room in KA13 alongside other equipment for assessment by the interior designers. The beams were not painted or varnished as the interior architects felt that the colour matched the rest of the interior.

The beams did not require any other processing but were flushed with water once fully installed in the building. OAR sourced the pipes for the chilled beams for KA13 and Energima installed the beams themselves. The chilled beams have been installed on every floor. A few new chilled beams were bought in because of the requirement for certain passive beams and also the need for some smaller version in order to avoid collision with the steel walers on the 7th floor. The final number of installed chilled beams in KA13, sourced from DEG8, totalled 135 pcs.

Chilled beams in DEG8.
Photo: Anne S Nordby.

Transport stage.
Photo: Anders Sand.

Complete installed beams in the test room of KA13.
Photo: Christoffer Siopan Engtrø

5.7.2 Costs

In the OsloMet student thesis, it was calculated that the reuse of chilled beams resulted in financial savings of approx.
66% when compared to the cost of purchasing new. (Jødal, Hansveen & Hall, Oslo Met bachelor's thesis 2020).

The cost of storage came to approx. 3% and the cost of transport via the warehouse was approx. 9% of the total cost of reuse. The costs of dismantling at previous buildings was estimated at approx. 81% of the total sum, but any price difference between dismantling and regular demolition is not reflected here. On the other hand, the extra time for planning (RIV) and project management is not included in the calculations either.

5.7.3 Environmental assessments

In the NTNU student thesis, a total emissions savings of 95% was calculated for the reuse when compared to the purchase of new chilled beams for the project. (Høydahl and Walter, NTNU master's thesis 2020).

	Quantity	Environmental impact, new element (A1–A4) *	Environmental impact, used element (A1–A4)	▼ Environmental savings from reuse
Chilled beams	138	173.4 kg CO_2-e/pc.	8.9 kg CO_2-e/pc.	95% savings

**A1–A4 indicates the first four phases in the life cycle assessment, in which A1–A3 is the Production Phase and includes the raw materi-als, transport and manufacturing. A4 is the Construction and Installation Phase and includes transport.*

The results show the environmental impact in the form of greenhouse gas emissions (CO_2 equivalents) per piece for both the new and used chilled beams. In total, the reused chilled beams used in the project contributed to saving 22.6 tonnes of CO_2 equivalents in phases A1–A4 when compared to the new alternatives.

The used chilled beams were approx. 11 years old and were assessed as being of the same quality as new. The expected lifetime for both reused and new chilled beams is set at 30 years. The largest contributions from the reused products came from the use of lifts for dismantling and temporary storage.

LEARNING POINTS

- You may be lucky and find large numbers of the elements you need!
- Flexibility in choosing a ventilation solution is an advantage
- The combination of complex components and easy disassembly can contribute to the financial profitability of reuse

5.8 FAN COIL UNITS
Building part number: 375

2 fan coils were procured from Dronning Eufemiasgate 8 (DEG8), Braathen Eiendom.
1 pc. was put into use in the computer room in the basement

Two fan coils were found in Dronning Eufemiasgate 8 of the Climaventa Home System type.
Documentation for the fan coils was extracted from the building's FDV. The fan coils were dismantled and put into storage in Vollebekk.

Energima did a visual inspection of the equipment and assessed that both fan coils were dirty and showed signs of poor maintenance in relation to changing/cleaning the filter. This often affects the fan, which will then operate with too high a pressure drop. In turn, this significantly reduces the lifespan of the ball bearing, meaning that the condition was uncertain. The elements were also too large to be placed as had been drawn up and thus had to be placed on the wall. It was eventually decided that one (which was in better condition) could be used in the computer room and that the other would be kept as a spare in case the first required parts.

As there was no documentation of any maintenance completed, the functional responsibility may become diffuse. And it can be expensive to fit a used fan if it doesn't work. A fan coil unit costs 2 to 3 times as much as a chilled beam, and its usual lifespan is between 2 and 10 years. In general, it is more beneficial to reuse a chilled beam than a fan coil unit as the beam does not have a rotating component and is thus less prone to faults and to wear and tear.

The reused fan coil unit installed in the computer room in the basement. Photo: Rune Andersen

6 ELECTRICITY AND LIFTS

6.1 ELECTRICIANS: CONSULTANTS' AND CONTRACTORS' EXPERIENCE

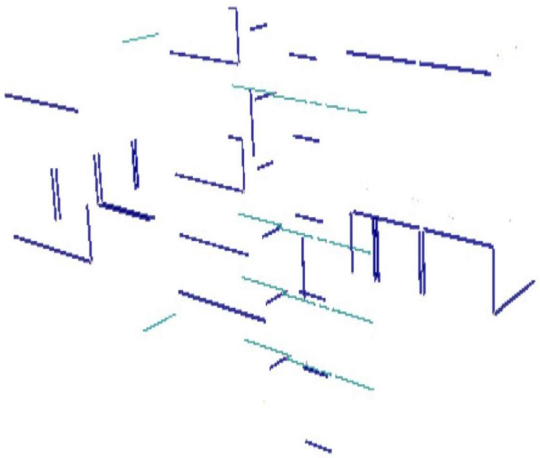
Heiberg & Tveter by Mats Slotta and Kontakt Elektro by Lars Østbøll

The consultants, contractors and suppliers in this project were all encouraged to seek out opportunities to establish circular value chains. However, as the standard for energy-efficient equipment has undergone rapid changes in recent years, little of the E/E equipment that was found was deemed suitable for reuse.
The project planners certainly see the value of reuse when equipment is between 5 and 10 years old, but when it comes to things such as emergency lighting used in the event of a fire, equipment quickly becomes obsolete. After all, it wouldn't be good to stumble in the event of a fire alarm/evacuation! The reuse of elements such as fire/emergency lights from Refstad school was considered. These were 11 years old, thus the warranties had expired. In addition, these often contain fluorescent tubes, which are being phased out. As a result, it was, of course, safer to use new equipment. Warranties usually expire after 5 years and the data sheets are difficult to find. After several years of use, disassembly and transport/storage, who can guarantee that such equipment will work as it should?

The search was primarily for equipment/products within the electrical field that did not contain electronics, such as cableways, cable protectors, ladders and wall ducts. In this regard, there were several options to choose from. Vertical power distribution units were assessed for use in the preliminary project, for the supply of electricity/data cables in the offices. The vertical power distribution units are not mounted to the wall so they can be easily moved around. There are many types available for use, and the concept is well-suited for reuse as they function as independent units without screws/clamps and can easily be pulled out of the socket. For a while, there were many used vertical power distribution units available to get a hold of. There has been some reuse internally at Biskop Gunnerusgate 14 (Entra), achieved by rotating the workplaces there. However, the tenant did not want this solution in KA13, so it was not further pursued in this project.

The contractors were asked to find used elements while working in the building, but the selection and time they had was limited. It would have been easier if they could have collected reusable elements over time in a warehouse, which you could then pick from for reuse in new projects. The contractor does not usually store products like this as it incurs significant costs, and instead they try to order the exact quantities they need for each project. Reuse has not been a focus before. Products that are not used in a project are usually returned to the supplier, such as unused lighting units, while commodities such as cables, boxes etc. are usually moved from construction site to construction site.

In general, not only the project planners but also the contractor should be involved earlier on in the project in order to assess what is possible and what they can achieve through circular solutions.



Reused elements in KA13: Electronics. Photos from the IFC file. Illustration: Mad

6.2 CABLEWAYS AND CABLE LADDERS

Building part number: 411

Used cableways (10cm width) have been reused internally in KA13: 23 pcs. of approx. 2.5m – total approx. 57.5m

As equipment/products that did not contain electronics were designated as the most important sources in regard to reuse opportunities within the electrical trades, the preliminary project focused on searching for cableways of various widths, cable protectors, ladders and wall ducts. Various cableway lengths and dimensions were found and recorded in KA13. However, the design of the ceilings had not been completed by this time. The conclusion then was that we should not use the cableways in the offices due to installation considerations (difficult access and little space to work with) but instead use the cable protectors. IARK wanted cable protectors with covers to be used.

As a result, a number of cableways were thrown away. Some of the cableways from KA13 could, however, be used in the toilet corridor. A few metres with a width of 10cm were reused on each floor. A total of 23 pcs. around 2.5m long were found to be reusable.

A lot of time was spent in the preliminary project in creating a solution with a suspended ceiling, but this didn't work out. If there had been a suspended ceiling, there would have been greater freedom of choice for things such as mixing suppliers as the equipment would not be visible above the ceiling.

Several cable protectors were found in KA23, Refstad school and SG15, but they were not the right type and therefore could not be used with a cover. Various solutions were later installed in the test room and discussed with the tenant.

Cableways after dismantling. Photo: Randi Lunke

6.3 WALL DUCTS
Building part number: 411

	Schweigaardsgate 15 (Entra) Kristian Augustsgate 23 (Höegh Eiendom)	Refstad school (UBF)
Plastic wall ducts	90 lm. dismantled and reused in KA13	
Steel wall ducts		75 lm. dismantled and assessed

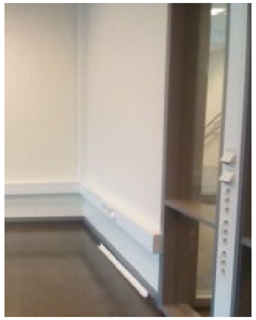
6.3.1 Practical/technical implementation
The project required many running metres of wall ducts for the installation of electrical and data cables (TEK-123 electrical wall ducts). Wall ducts were found that could be dismantled and reused in several buildings in which inspections were carried out, including: Schweigaardsgate 15 (Entra), KA23 (Höegh Eiendom) and Refstad school (UBF).

Approx. 90m of wall ducts were dismantled from SG15 and KA23. These were made of plastic. Approx. 75m of steel ducts were dismantled from Refstad school. The ducts from SG15 and KA23 were transported directly to KA13. This was a bit of a problem as there was actually a lack of storage space there. The ducts from Refstad were transported to a few different locations for temporary storage. After closer inspection, however, the steel ducts from Refstad could not be used in the project as they looked a little too different. There is no difference in quality or lifespan for plastic/steel ducts, but steel can easily get scratched whereas plastic tends to look nicer for longer.

Quality assurance testing was carried out by the contractor, who checked the ducts during the dismantling process. The ducts were checked to ensure they did not have holes etc. in them, but some scratch marks were accepted. They were not cut to size, just used as whole lengths. The ducts were dried after they were dismantled and then washed after the construction period. There was a slight difference in colour in certain places. This was addressed by using ducts from the same room together.

In regard to environmental pollutants, XRF measurements of the wall ducts were carried out in KA23 and no lead was detected. There were various types of ducts there, but we took only those that were relatively new. In Schweigaardsgate 15, the ducts were also relatively new, so there was no risk of lead.

In terms of project planning, the type of duct we used in the end was of little consequence. Guideways can be drawn up regardless and the model and material they are made of it are not usually indicated. There was no documentation for the ducts, but a few electrical numbers were found on the old and new ducts so it was decided that the same documentation could be considered valid.
The installation was carried out with the new ducts, and removability was ensured.




The wall ducts at Refstad school. Photo: Anne S Nordby

Plastic wall ducts in KA23 and the XRF measurement. Photo: Jennifer Lamson

6.4 PLUG SOCKETS
Building part number: 411

29 triple plug sockets were removed from Schweigaardsgate 15 (Entra) and reused for the project

Triple plug sockets found in Schweigaardsgate 15 (Entra) were of the type projected for use in the project. These were dismantled and transported to KA13. Triple plug sockets were also found in Refstad school. These were included along with the metal ducts but were later rejected. The sockets did not fit the plastic ducts and were therefore not used.

As the plugs were Entra's own property, no sale was involved, which simplified things in terms of documentation.

6.5 LIGHTING
Building part number: 442

10 ceiling lights (glass domes/pendants) dismantled from St. Olavs plass 5 (Entra)
6 were remodelled at Lighthouse and reused in the reception

However, as the standard for energy-efficient equipment has undergone rapid changes in recent years, not much of the lighting equipment found was deemed suitable for reuse. It is primarily LED lighting that is in demand these days, and fluorescent tubes are being phased out. As LED technology is only about 5 to 10 years old, you could say that "fortunately" not much LED lighting is available the market. Among other things, the lighting equipment was also assessed at Schweigaardsgate 15 (Entra): 23 pcs. Fagerhult Pleiad Evo Combilume. But this had the wrong type of light source (fluorescent tubes) and was not dismantled.

Later, 10 large glass domes/pendants were found in St. Olavs plass 5 (Entra) and IARK thought they were well-suited for the reception in KA13. However, there were 3 fluorescent tubes in each bulb, so reusing them required remodelling. An electrician (Kontakt Elektro) checked whether the inside could be replaced. Kontakt Elektro assessed that it was safe to remodel and carried out the first experiment with one of the ceiling lights, installing an LED light chain in the centre of the dome. The result was assessed along with Scenario and approved by everyone involved. The remaining lights were then ordered from St. Olavs plass 5 and remodelled. Unfortunately, four glass domes cracked during the dismantling procedure, as they were old and could not withstand much. It didn't take more than a small crack before it all went downhill.

The remodelling of the ceiling lights was left to Lighthouse. Remodelling the lights is not something that Lighthouse usually does, but they were able to accommodate the order from Entra as a large customer. In regard to the contents of the lights, only the metal was reused. Otherwise, it is all new electronics and new cables. The new electronics took up more space than the old did.

The lights were to be used as accent lighting and had to be dimmable. This required an extra module. A total of 6 lights were remodelled by Lighthouse, and the new materials used inside the lights is documented below.

Lights are generally removable. During demolition, everything is usually completely dismantled and sorted by source material.

Dome ceiling lights from St. Olavs Plass 5.
Photo: Anne S. Nordby

6.6 LIFTS
Building part number: 621
An assessment was carried out early on in the project alongside the lift consultant (HeisConsult) as to whether it would be possible to reuse parts of the lift that were already on site. The supplier of the original lift was asked whether they would accept equipment from an upgrade in 2009 free of charge in return for taking on the dismantling job (including management and lift machinery), but they declined. It was then confirmed that it was not possible to lease a new in Norway.

In U2, several lifts were to be replaced, and Entra checked whether one of these could be reused in KA13. However, several factors made this difficult:

- The shaft dimensions did not fit
- There were special requirements for shaft depth in KA13
- The lift from U2 was built in accordance with the EN81-1 standard, while the standard in force today is EN81-20

6.7 ENVIRONMENTAL AND COST ASSESSMENTS, ELECTRICAL COMPONENTS AND LIFTS

6.7.1 Environmental assessments

Electrical/electronic (E/E) products often have a big environmental impact during production, as they consist of plastic and a variety of metals and the products also have a relatively short lifespan in the building. E/E products, as well as lifts, are also complicated and expensive products so it is demanding to sort the materials at source and to recycle/dispose of them. Reuse, or alternative ownership, models (leasing, etc.) can therefore be very interesting in an environmental context.

All electronics are usually delivered and approved upon reception and, in terms of environmental pollutants, they may include PCBs in old lights/fluorescent tubes. Potential for reuse and remodelling must therefore be assessed on a case-by-case basis.

6.7.2 Costs

As far as the wall ducts and protectors are concerned, nothing was saved by their reuse. The working time and transport required were costly. This would have presumably also been the case had the project bought in new ducts.
In regard to the ceiling lights, cost savings are possible when the same lights are used over and over again. In a few years, it will hopefully be possible to reuse LED lighting. Reusing old lights does, however, quickly become more expensive than buying equivalent lights new.

One measure that could promote the cost-effectiveness of pursuing reuse would be access to storage space for demolition projects, where reusable equipment could be sorted straight away.

LEARNING POINTS, ELECTRICAL COMPONENTS AND LIFTS

- A number of electronics-related products do not actually contain electronics and which may be well suited for reuse, such as cableways/protectors/ladders, wall ducts and vertical power distribution units
- New requirements for energy-efficient equipment mean that few E/E products are suitable for reuse; however, the inside of old lights can be replaced with LEDs.
- The lift is a large, expensive element with a large footprint, which unfortunately provided few to no opportunities for reuse or the pursuit of alternative ownership models (leasing etc.) in Norway.

7 LANDSCAPE

7.1 Landscape architect`s experience

Landscape architect: Asplan Viak AS by Janicke Ramfjord Egeberg.

Kristian August gate 13 has been an exciting, challenging and innovative project. As the contracted landscape architect, I became involved in the project at a later stage, with a view to finding good solutions as soon as possible in the process. In order to quickly arrive at suitable solutions, I got in touch with Bergknapp and Protan, who are leading suppliers of solutions for both blue and green roofs. A separate experience report for landscaping that describes these solutions has been prepared.
In connection with the blue-green roof, a concept was developed for the terrace floor, which included the reuse of materials from other buildings and which also enables future reuse opportunities of the various elements that the floor is built of. Used façade stone slabs and wooden slats were placed on plastic pedestals made from Aaltvedt paving slabs – these are both durable and height-adjustable so they can be easily adapted for potential reuse. The pedestals can also be reused, as these are particularly durable.

A search was conducted for used wood and steel materials for the planters and benches, but nothing suitable was found. Thus, recycled steel was used instead for the planters and benches, while the seating surfaces are made from slats of recycled plastic. The concept is a result of a successful collaboration during the production phase between Bergknapp and Nordic Steel, who entered into the partnership specifically for the purpose of this project. In order to obtain more reused materials, it would be beneficial to have a large network of project planning landscape artists to call upon throughout the project. This offers great potential for the acquisition of used elements from other projects proceeding at the same time.

7.2 TERRACE FLOOR

7.2.1 Terrace floor on the 2st floor

Approx. 85m² of granite façade slabs from Drammensvn 134 (Entra) were used on the

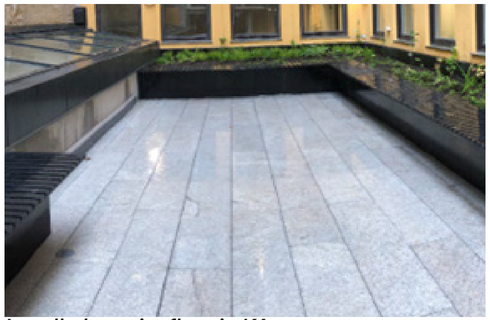
terrace floor on the 2st floor.

Raised terrace floors are usually made with stone slabs 3cm thick. This matches the ordinary stone cladding used on façade, which is also often 3cm, so this type of stone was searched for. Entra's building at Drammensvn 134 in Skøyen had exactly this type of stone facing in granite, and this stone façade was ripe for repair/demolition due to defects in the fastenings and the danger of it falling. The stone slabs therefore could not be used on the façade. The fact that the stone slabs had to be dismantled came up conveniently and a portion of the stone slabs were reused in KA13.

The stone slabs were used as flooring on the 1st floor roof terrace. The roof terrace functions as a blue roof, and the stone slabs thus lie/rest on the pedestals. The pedestals are height-adjustable and have an adjustable head so that they can be adapted for unevenness and differences in height. It is also easy to readjust their height with a screwdriver in the opening between the slabs, even after they have been laid. Ellingard Naturstein carried out the work, and a test floor was set up beforehand, which was inspected and approved. Placement of the pedestals was planned so as to ensure several things, such as the covering being locked into the walls. A check was conducted to ensure that the 3mm gap opening between the stone slabs allowed enough space for water to drain through to the roof below. The calculation was carried out by Multiconsult.

*Façade in Drammensveien 134.
Photo: Noora Khezri*

*Ellingard Naturstein testing the floor.
Photo: Rune Andersen*

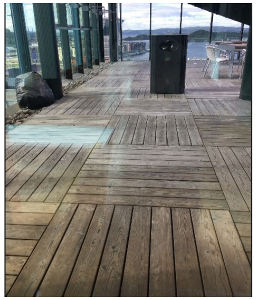


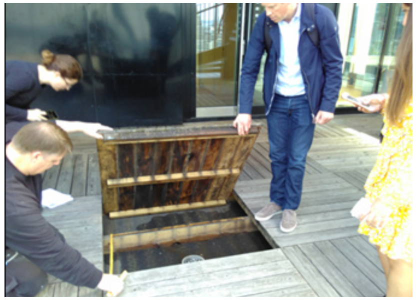
*Installed granite floor in KA13.
Photo: Janicke Ramfjord Egeberg*

7.2.2 9th floor decking

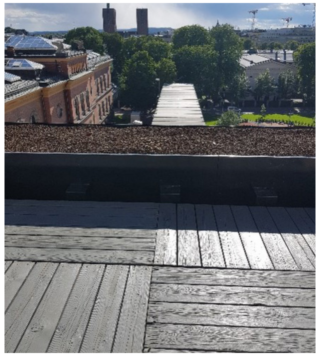
Approx. 100 m² of decking from DEG8 (Braathen Eiendom) was used as the terrace for the 9th floor.

The wooden decking (slats) was found during an inspection of DEG8, then dismantled by Haandverkerne. These were used for the 9th floor roof terrace. The slats were temporarily stored at Haandverkerne's own warehouse in Sem, Asker. The best slats were chosen and the surface then painted in a shade of grey. Ellingard Naturstein carried out the task of adapting the wooden slats and installing them on the pedestals the same way as the roof terrace had been installed on the 2th floor, as this also functions as a blue roof.





Wooden decking, DEG8. Photo: Noora Khezri Measuring during the inspection. Photo: Anne S Nordby



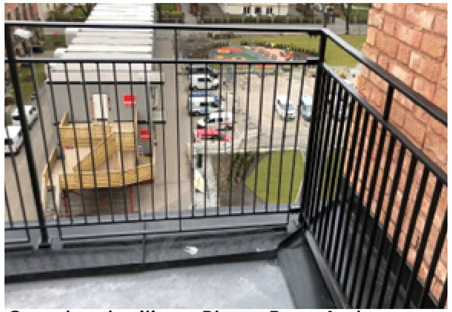
*Complete installed floor in KA13.
Photo: Janicke Ramfjord Egeberg*

7.3 RAILING (EXTERNAL)
Building part number: 287

7.3.1 Existing railings on the 8th floor roof terrace.

The existing railings around the 8th floor roof terrace were preserved and upgraded

Railings on the 8th floor, original situation. Photo: Anne S Nordby



Completed railings. Photo: Rune Andersen

The existing railings around the 8th floor roof terrace were preserved and upgraded according to TEK17 requirements by doubling the density of the slats. This was assessed by ARK and carried out by Jomek at the workshop.

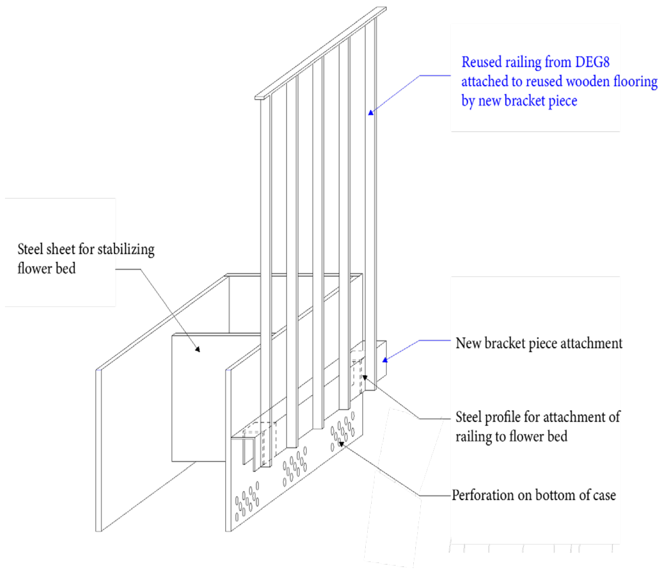
7.3.2 Railings on the roof terrace, 2th and 9th floors.

The railings on the 2th and 9th floor roof terraces were reused from DEG8 (Braathen Eiendom)

The railings on the 2th and 9th floor roof terraces were reused from DEG8. Jomek and Haandverkerne carried out this work. All of the railings were used as they were and are still reusable for another potential round of reuse. The parapet and flower boxes were prepared with fixing brackets so that the railings could be reassembled at the same angle as originally fitted to the bottom of the railing. It was decided to attach the railings on the 2th floor to the outside of the parapet, which entailed extra challenges regarding the roofing around the attachment point and more complicated adaptation brackets, meaning that RIB had to get involved.

The metal slat railings from Refstad were also assessed along the way. Here, there were high railings on the terrace facing outward to the fire escape staircase in galvanised steel. However, it was brought to light by the plumber that these would release gases hazardous to health during the welding process, so adapting them was not recommended.

Railings from the roof terrace in DEG8. Photo: Anne S Nordby



Details of the fastening to the plant boxes. Mad Arkitekter.

Finished installation of the 9th floor railings. Photo: Janicke Ramfjord Egeberg

7.4 PLANTERS AND BENCHES

7.4.1 Planters

A search for used steel panels was carried out for the planters, but no suitable panels were found. Steel for the planters was instead supplied by Nordic Steel and assembled by Bergknapp, then delivered to and installed in KA13. The panels for the planters are comprised of 80% recycled steel.

The sketches from LARK were further developed by Bergknapp and Nordic Steel, who prepared the production sketches. The components were then screwed together, so it would be easy to dismantle and possibly reuse the products later.

The planters before filling with soil. Photo: Janicke Ramfjord Egeberg

7.4.2 Benches

Hardwood slats were sought for the benches but nothing suitable for an outdoor environment was found. Instead, Bergknapp was able to deliver slats of recycled plastic in the form of panels that were then cut into slats. The slats consist of 100% recycled materials. The components were screwed together, and the benches are removable.

The seat panels made of recycled plastic are mounted onto the steel panels. Photo: Janicke Ramfjord Egeberg

7.5 SOIL MIX WITH COMPOST

Bergknapp supplied a lightweight soil mixture with a high proportion of recycled materials. Porous lava rock (from Iceland) is the main component, and the mixture also contains compost from various sources (garden waste, slaughterhouse waste etc.). Machine-made sand is used instead of natural sand and is crushed residual rock left over from blasting etc. The soil mixture does not contain any artificial fertiliser. The mixture is called recycled soil.

This type of peat-free soil mixture has several advantages. It is important to prevent the use of peat in soil mixtures as the extraction of peat destroys ecosystems, takes away the “swamps” in the landscape (which absorb rainwater and bind greenhouse gases) and generally causes large greenhouse gas emissions in the procurement process. By using local resources instead, such as compost, biochar and crushed masses of construction waste (bricks/concrete), the soil can not only reduce emissions in its procurement process, it can also help bind and capture carbon through biochar, microorganisms and plant growth.

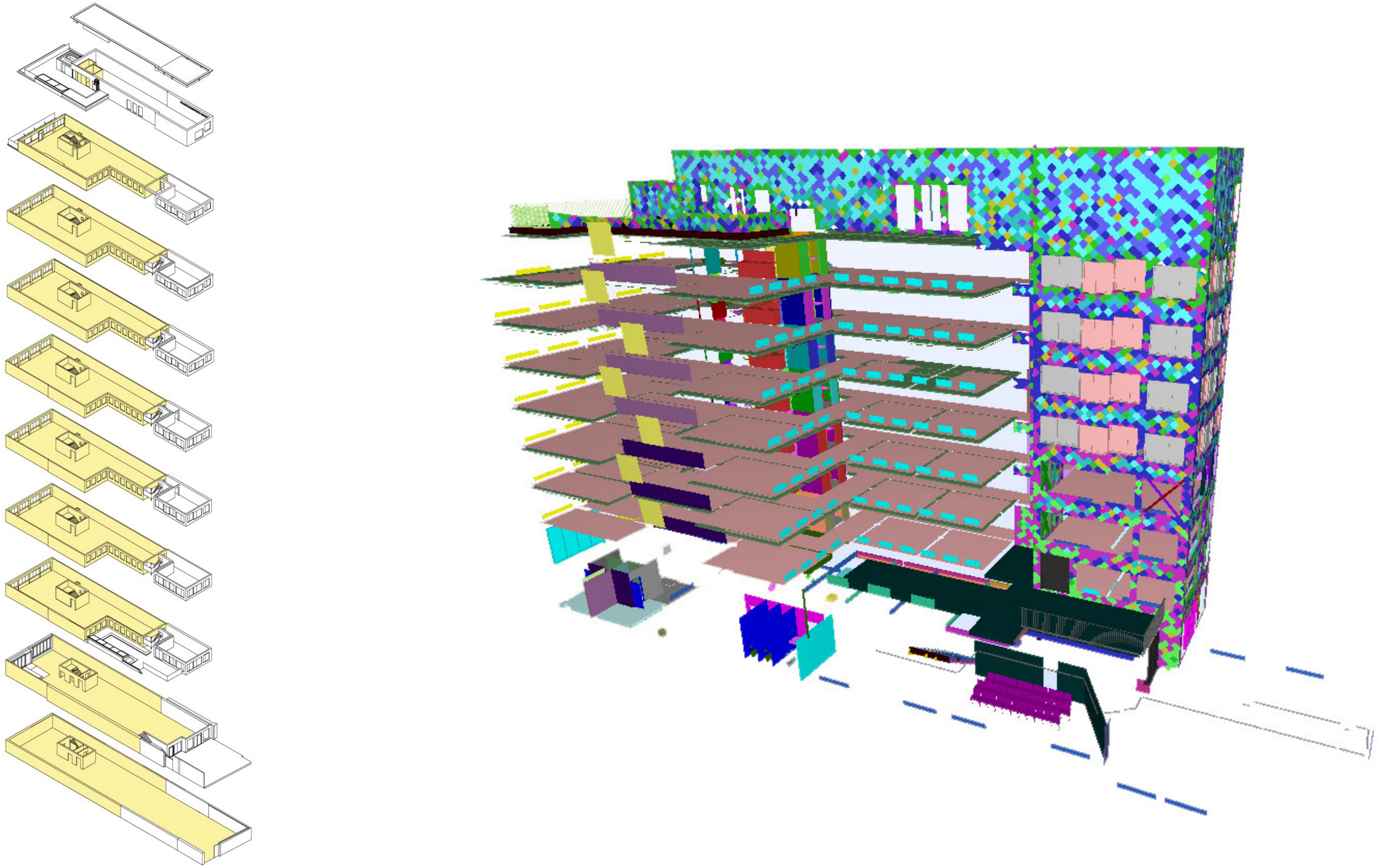
Producing soil in this way could provide an answer to the construction industry’s current waste problem. Several producers are now experimenting with different solutions and undertaking to make 100% recycled soil mixtures in which everything is locally produced.

Recycled oil from Bergknapp. Photo: Rune Andersen

Recycled soil placed on the roof. Photo: Rune Andersen

8 Summary

8.1 RESULTS



Reuse/renovation of existing building mass and acquired reuse elements in KA13, all trades. Illustrations: Mad Arkitekter

Ref. chap.	Building part	Component	Quantity	Unit	Process
2.8	Inner doors	Utility room doors and heavy wooden doors	17	pcs.	
3.2.1	Existing walls	Walls facing the neighbouring building and stairwell	780	m2	Cleaned, washed and dust bound, surface treatment avoided
3.2.2	Existing walls	Pine panels	46	m2	Panels dismantled and installed on the new wall. Thoroughly washed. Some fixed units were also retained.
3.2.3	Existing walls	Ceramic tiles	70	m2	Retained on some walls and columns. Cleaning and repairs.
5.3	Radiators	Original radiators	98	pcs.	Dismantled/compression-tested, dry ice blasting, painting
5.6	Air distribution	Ventilation ducts	125 – approx. 6.5 160 – approx. 3.5 200 – approx. 2 250 – approx. 0.5	m m m m	Cleaned.
5.6	Air distribution	Sound absorbers	2	pcs.	
6.2	Electrical installations	Cableways	Approx. 57.5	lm	23 pcs. approx. 2.5m, width 10cm.
7.3.1	Railings (external)	Existing railings, 7th floor terrace.	Approx. 18	lm	Slat density doubled at the workshop.

Overview of locally reused building components, described in the report

8.1.2 Procurement of used building materials

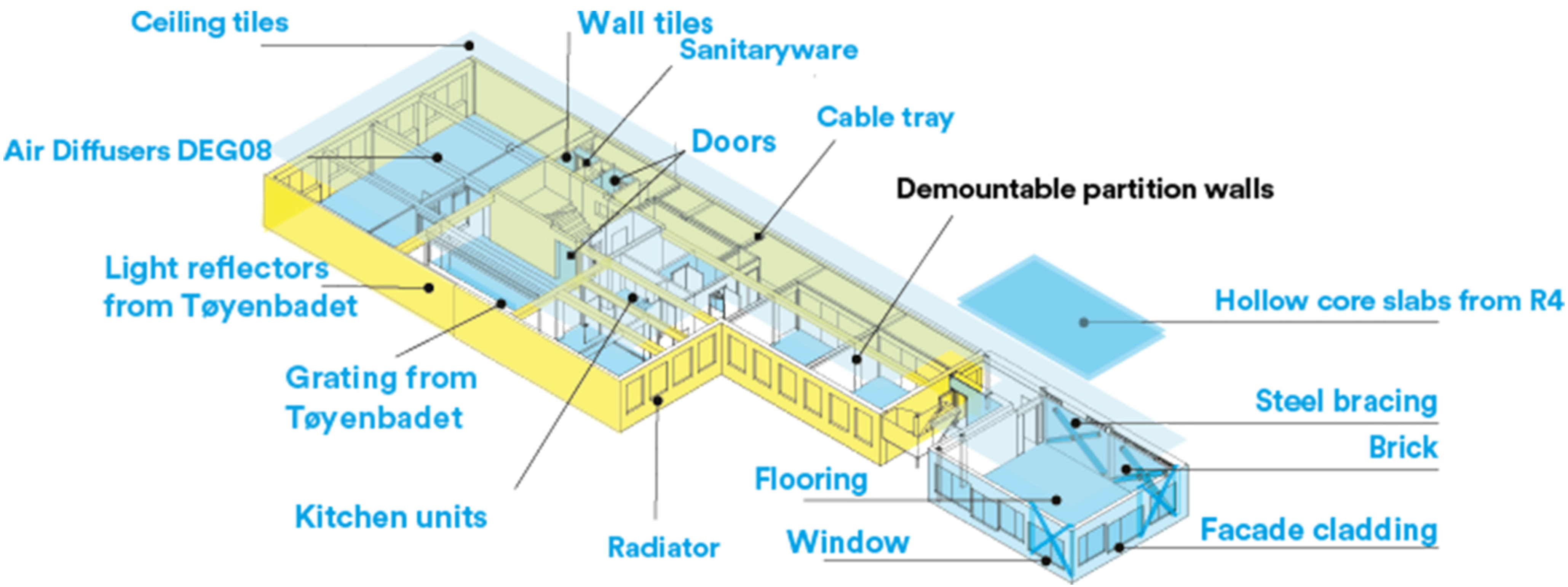
Ref. chap.	Building part	Component	Quantity	Unit	Original location/owner/facilitator
2.2	Façade glass	Glass façade	Approx. 25	m2	DEG8 (Braathen Eiendom)
2.2	Façade glass	Double glass door	Approx. 5.7	m2	Saga Aluminium – surplus
2.4	Windows	Window 2 panes	2	pcs.	Resirqel: ● Nordregate 20-22
2.4	Windows	Window 2 panes	16	pcs.	Resirqel: ● Turbinveien 15
2.4	Windows	Window 2 panes	12	pcs.	Resirqel: ● Turbinveien 15
2.5	External cladding	Cembrit Metal panels Steni	401 1151 313 3381	pcs. pcs. pcs. pcs.	Cembrit: St. Olav hospital/Finn.no Metal panels: Oppsalhjemmet (OBY)/Rehub Steni: ● Housing project renovation in Alfred Trønsdalsvei 9, Trondheim ● Surplus stock
2.7	Office fronts	Glass office fronts with doors	80 25	m2 pcs.	CreoNordic, from the following projects: ● U2 ● Haakon 7 gate ● Langkaia ● Surplus and incorrect orders

2.8	Inner doors	Fire doors Oak doors to the toilets	716	pcs. pcs.	• DEG8 (Braathen Eiendom) • St. Olavs plass 5 (Entra)
2.8	Inner doors	Door handles incl. escutcheons	15	pcs.	• Refstad school (UBF)
2.8	Inner doors	Door closers	10	pcs.	• Refstad school (UBF)
2.9.1	Floor surface	Oak parquet	Approx. 100	m2	• Surplus, Parkettstudio AS
2.9.2	Floor surface	Screed	Approx. 600 incl. approx 600	m2 kg	• Crushed glass façade from Norsk Gjenvinning
2.9.3	Floor surface	Carpet tiles	2200	m2	• Surplus Entra • Reuse the Netherlands • Surplus Tarkett • Reuse Akerselva Atrium
2.9.4	Stair covers	Vinyl stair covers	Approx. 8	m2	• Berg Studio
2.10 4	Ceiling	Plate ceiling 25 mm	Double layer approx. 1500 m2	m2	• SG (Entra) • KA23 (Höegh Eiendom) • Refstad school (UBF) • U2 (Entra, surplus)
2.11	Internal stairs	Amphitheatre in wood, built from reused wood materials	Approx. 150 railings + slats from Approx. 35 ceiling	lm m2	Tøyenbadet (KID)
2.12	Railings	Railings from reused 1 lattice grates and new balusters	38	pcs.	Tøyenbadet (KIB)
2.12 3	Railings	Glass and steel railings incl. reused glass panels	11	pcs	St.Olavs plass 5 (Entra)
3.3	Inner walls	Tiles,toilet wall and changing rooms	Approx. 200	m2	Bergersen Flis (surplus)

3.3	Floor surface	Tiles, toilet floor and changing rooms	117	m2	Bergersen Flis (surplus)
3.4	Inner walls	Wooden slats for the interior cladding and interiors	760	lm	Refstad school (UBF)
3.5	Kitchen units	Modules for the mini kitchens	28	pcs.	Lambertseter sykehjem (OBY), 26 pcs. St. Olavs plass 5, 2 stk
3.6	Units	Auditorium seats	34	pcs.	VID Campus Borgen (Diakonhjemmet Eiendom)
3.7.1	Units	Changing rooms, z-lockers	20	pcs.	Refstad school (UBF)
3.7.4	Units	Chalkboards	2	pcs.	Refstad school (UBF)
3.7.5	Units	Reflectors	7	pcs.	Tøyenbadet (KIB)
4.2	Steel structures	Structural steel divided into - Detail, steel beam n - Detail, steel assembly - Detail, window trusses - Steel beams - Steel assembly - Steel columns - Window trusses	Approx. 45	tonnes	• Karl Johansgate 23 • Dronning Maudsgate 1–3 • Stena Stål Gjenvinning • Agility Group • Stokke Stål/ Øst-Riv
4.4	Fire walls	Bricks	135	m2	Øst-Riv, from the following projects: • Strømsveien 185 • Bergensgata 41-43 • Tine Kalbakken, Bedriftsveien 7 • Darres gate 2
4.6	Hollow core slabs	Hollow core slabs elements, 21 pcs	Approx. 160	m2	Regjeringskvartalet R4 (Statsbygg/Veidekke)

4.7	Internal stars	Steel staircase between the 8th and 9th floors	1	pcs.	St. Olavs plass 5
5.2	Sanitary equipment	Basin mixers Basin mixers HC-sinks Kitchen fittings mini kitchens Sinks Toilet Basin HC HC toilet Arm supports HC toilet Utility sinks Faucet for Utility Sink	15 7 8 34 8 14 10 9 8 3	pcs.	Equipment acquired from projects: Universitetsgata 2 (Entra) Lambertseter sykehjem (OBY) Refstad skole (UBF) DEG8 (Braathen eiendom) Tøyenbadet (KID) Tordenskiolds gate 12 Resirqel
5.3	Radiators	Lygnson type Ludvig, long	45	pcs.	U2 (Entra Eiendom)
5.3	Radiators	Lygnson type Ludvig, short	7	pcs.	Refstad school (UBF)
5.4	Fire hose cabinet	Externally mounted with hose	12	pcs.	DEG8 (Braathen Eiendom)
5.5.2	Sprinkler pipes	Steel pipe sprinklers, 25 Steel pipe sprinklers, 32 Steel pipe sprinklers, 40	Approx. 150 m approx. 30 m approx. 20 m	m	U2 (Entra)
5.7	Comfort cooling	Chilled beams	135	pcs.	DEG8 (Braathen Eiendom)
5.8	Comfort cooling	Fan coil units	1	pcs.	DEG8 (Braathen Eiendom)
6.3	Electrical installations	Electrical wall ducts: 45 pcs. 2m	90	m	Schweigaardsgate 15 (Entra), KA23 (Höegh Eiendom)
6.4	Electrical installations	Plugs for wall ducts, triple	29	pcs.	Schweigaardsgate 15 (Entra)
6.5	Lighting	Large dome ceiling lights/pendants	6	pcs.	St. Olavs plass 5 (Entra) New light sources.
7.2.1 7.2.2 7.3.2	Roof/terrace Roof/terrace Railings external	Granite façade stone used as terrace slabs Wooden decking slat railings on the roof terrace 2+9 floors	85 100 Approx. 40	m2 m2 lm	Drammensveien 134 (Entra) DEG 8 (Braathen Eiendom) DEG 8 (Braathen Eiendom)

Overview of acquisitions of used building parts described in the report. Donors/donor buildings for procurement of used building parts are further detailed in chap. 1.



Typical floor: Reuse of building parts. Illustration: Mad

8.1.3 Disposal of used building materials
The disposal of used building materials did not concern many of the elements. Most of what was useable in the existing building was reused in KA13.
A stack of 4×4 timber beams from the existing part was given to the company Drivved. Furthermore, some surplus materials from KA13, including old teak doors from the stairwell and some used doors from the 5th floor, were managed by Entra for possible use in the neighbouring building, KA11. There was also a surplus of some acquired used elements. If Entra itself does not find a use for the surplus, it may be appropriate to dispose of the materials via a third party.

LEARNING POINTS, RESULTS

- The quality and lifespan of the building materials are important in both new and old buildings. Reuse (incl. disassembly, transport, processing and reassembly) requires high-quality materials.
- Elements particularly suitable for repurposing are:
- Products that require little preparation
- Homogeneous products Products with documentation
- Elements that are more difficult to reuse:
- Lighting, due to rapid development in technical properties Technical products without documentation, such as pipes.
- Steel and concrete load-bearing structures are complicated and expensive to reuse, but this is where the most savings can be made, in terms of environmental impact
- Woodwork:
- Documentation is complicated for load-bearing structures that require classification, but it is simpler if the woodwork (e.g. wooden slats used for the cladding or handrails prepared for the stairs) is bought in new.
- Where reuse of structural wood was considered in KA13, the project's progress ran away from us so it did not become a core focus area. As the reuse of wood does not provide the greatest environmental savings, this was considered an appropriate prioritisation.
- Reuse of structural woodwork is recommended for other projects, preferably in the form of dialogue with others involved with the industry who work in similar processes, as has been the case for the work with steel, concrete and masonry in KA13.

8.2 PRACTICAL LEARNING POINTS
Experience of the planning and project group management w/Rune Andersen, Insenti

Assisting in this project's planning and project group management has been challenging but very educational and exciting.

Insenti assisted Entra throughout the process, from the purchase of the property and the decision-making phase on how to implement a reuse project to the preliminary project, implementation of the project itself and the project's completion.

At the start of the summer of 2018, one of the tasks was to bring together a team of advisers known for having the motivation needed and the right attitude for this particular project. Mad Arkitekter was already involved, and then Asplan Viak was chosen as the environmental consultant as they also had knowledge of reuse in the construction industry.

We started our work by defining the project, inspecting the building and ascertaining what was possible when pursuing reuse. The building owner, Entra, had an idea of what might be possible and had an idea of how far we could take it. A number of ideas were then put forward, including considerations such as leasing agreements. There was a wish for the extension to be built with used materials and used building parts to the greatest extent possible, and talks were therefore initiated early on with Øst-Riv to discuss the possibility of using structural steel and hollow core slabs from demolition projects.

Several advisers were engaged from a variety of disciplines, and everyone involved shared a process of transformation from approaching the project through traditional planning to thinking more about reuse. Seeing possibilities rather than limitations quickly became a part of our mindset. We began surveying KA13 and carrying out a feasibility study while other conditions for the project and environmental requirements were being clarified.

We had now embarked on a project no one had undertaken before. This meant we had to think about how exactly this should be organised going forward and which processes would be necessary. It was necessary to establish a number of contacts that could assist with the procurement of used building parts. As a result, we got in touch with Resirqel, who came on board as an advisor and broker of used building parts, and explored the market for ongoing renovation and demolition projects.

A collaboration with FutureBuilt was then initiated, through which the criteria for reuse were set out and a programme set up for a series of workshops where innovative solutions could be discussed. In the process, it emerged that the regulations were not favourable for the use of second-hand building parts in construction, so it was considered a good idea to look at how we could deal with these issues in a series of meetings with relevant actors in the industry.

Along the way, several issues arose that had to be resolved. Among other things, the need became apparent early on for a good system in place to register and maintain an overview of used items acquired for the project. It became necessary to hold separate meetings to obtain more of an overview and to keep control of the situation, thus the new role of reuse coordinator was identified as important for the project. The role was filled by Insenti, who, with Asplan Viak as reuse consultant, had specific responsibility for acquiring and documenting used building materials and coordinating with the planners and contractors.

The project planning was demanding, and there were major challenges with some reused elements that could have ended up having purposes and qualities different than originally envisaged. Used building parts could turn up at a late stage in the project, so the decision-making process and planning required meant the schedule had to be adjusted. It was particularly important to maintain a good collaboration with the tenant Spaces throughout the project, and all decisions that had an impact on how the building functioned and that were of a visual nature were dealt with in consultation with the tenant's interior designer, Scenario.

Progress planning and progress control were also demanding on this project, as many used elements in the project appeared late in the scheme of things and often necessitated replanning. It has also been quite a challenge financially to maintain control over everything, as the costs of procurement, logistics, documentation, processing and installation have been unpredictable. It has been neither easy nor desirable to stop processes already underway. In particular, the search for and testing and processing of structural steel and hollow core slabs – which became relatively expensive – can be ruled out.

8.2.1 Organising the project

The forms of contract used for this project were general contracts and shared contracts, and the client entered into contracts with around 15 contractors. Implementation of the shared contracts meant closer dialogue between each of the contractors than would have been possible with a total contract and can be an advantage in this type of contract where a lot of things are added along the way.

Suitable, accessible storage facilities are important for a flexible reuse process to succeed. There was not much storage and rigging area available in KA13, and all of the reuse elements ended up having to be stored at external premises. In this project, we made use of several storage rooms that were made temporarily available (e.g. the basement of the building next door, which was undergoing the U2 project, and the storage room at the Vollebekk factories), which we had to move out of during the course of the project, before the elements were ready to be moved to the construction site. This resulted in unnecessary time use and costs for moving and increased the risk of incurring damage and losing control of reuse elements. Everyone involved in the project gained a lot of experience here, as we learned that when disassembling from one site, priority should be given to protecting and marking each element to a high enough standard that it is possible to have a sufficient overview of the components for reuse before they are to be installed on the new site.

The labelling of the elements should be reflected in the overview of the planned reused elements. The preparation processes that need to be carried out for the reused elements should also be planned out. For example, the radiators were transported to a storage room with access to water and drains so that the pressure testing and flushing could be carried out while they were still in storage.

One challenge on the construction site was the follow-up of a clean and dry construction site (the RTB process in Norwegian), as the contractor had to make adaptations and carry out dusty works in order to adapt the reuse elements in zones where work involving dust was eventually limited.

In order to ensure the good use of resources and good adaptations when reusing, it is important that the contractors and workers help with finding creative solutions. It can be an advantage to make use of the knowledge that the tradespeople have and give them the leeway to carry out their craft, as opposed to going through an architect and advisers when this isn't necessary. Greater competence in circular solutions is needed throughout the industry, among planners, contractors and suppliers.

LEARNING POINTS, PROJECT ORGANISATION

- The contractor contracts (building owner-managed shared contracts) are a form of contract that reduces challenges by way of changes implementable as a result of the reuse process.
- The contractors eventually joined the inspections to find potential reuse elements for procurement, which ensured a more direct process of finding solutions for how to process the items.
- Reuse requires greater competence on all levels and the space to find and assess solutions that fit the current situation.
- A plan for protected transport and storage should be drawn up before disassembly and packaging as well as a plan for how the reuse elements should be labelled and registered.

8.2.2 Process and schedule

The planning, administration and implementation of the project has proved more time-consuming and thus cost-driven when it comes to reuse, especially for certain reuse elements. For several reasons, reuse entails a more complicated planning and construction process than a regular construction project does. Used elements cannot be ordered to measure or with specified properties, and they may come to the project at a late stage. This has resulted in more assessments being required of planners than necessary for a normal project, or we have had to make very quick decisions about quality, price and scope. The planning was divided into stages so as to follow the progress on the construction site, and this sometimes meant that deadlines were overrun.

In order to realise the reuse of construction elements (steel, hollow core slabs and bricks), the project required a lot of extra time. It has been necessary to establish new routines for quality assurance. Additionally, a lot of time was spent examining the regulations
with regard to documentation requirements.
At the same time, significant reductions in greenhouse gas emissions were achieved through the use of these elements. One can thus argue that this project has been an important reuse pilot project, and hopefully the next project can reuse elements such as steel structures, hollow core slabs and bricks without the extra effort.

It has been necessary to revise the progress plans for on-site construction more frequently than in traditional projects, as several elements were introduced into the process late in the planning. In several cases, purchases were carried out close to the critical line in order to provide extra time to search for the reusable products. In some instances this led to the discovery of reused elements, while in other cases new items had to be purchased.

There are great differences in times needed for the disassembly and installation of various elements. Elements that can be used “as they are”, such as windows, are less time-consuming to reuse than elements that require processing. There is little difference between dismantling a window for reuse instead of disposal, and fitting a reuse window involves the same work as for fitting a new one. In contrast, reuse processes such as cutting and adapting used façade panels and the necessary pressure testing, flushing and surface redecorating of radiators are more time-consuming.

8.2.3 Information management
In the preliminary project, lists were made of building elements for local reuse and current reuse that had been searched for. Excel forms were then used to keep track of this and were continually updated.

The project lacked a separate IT tool to manage the large quantities of information on alternative used elements in KA13 and other buildings we acquired elements from. In parallel with the project, Entra and Asplan Viak were developing and testing a database tool for mapping reusable products. This was used to register the items in stock at Entra’s properties, including U2, in the summer of 2019. This was also used to map out St. Olavsplass 5 with a group of students from AHO in January 2020. However, as the tool was not yet fully developed, the project decided not to adopt this database as a source of information for the planners.

For larger reuse projects, there will be a need for a separate IT tool to handle the large quantities of information about alternative second-hand elements. In the long run it’s hoped that such a tool can be connected to
planning tools and BIM. Here, it is likely that some other actors would have to be involved in the value chain, and programmers would be free to develop data-based solutions for reuse.

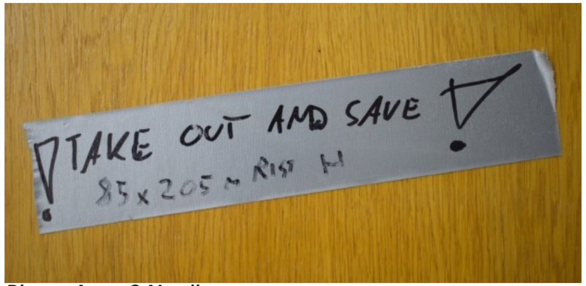


Photo: Anne S Nordby

When the project commenced, there was no central marketplace where you could just search for suitable second-hand building materials. The project was dependent to a great extent on using its contact network and making direct contact with renovation and demolition projects. In addition to the reuse consultant recording any concrete opportunities for the planning group, all of the actors in this project were given the task of looking for used products in their networks and would then go on joint inspections of current demolition/renovation projects. We also received assistance in finding used building materials and contact points for reuse from Resirqel early on in the project, and eventually from Rehub too.

Insenti, by way of the environment and recycling coordinator, became the “hub” for getting an overview of the elements and keeping a list of the reused materials in the project. Various questions had to be answered before a final decision on reuse could be made. These could have to do with anything from quality assurance and options for processing and adaptation to formal requirements for documentation. Information was disseminated from the reuse coordinator to the planners and then coordinated with the contractor. Occasionally reuse would be rejected, and the project would end up ordering a new version instead. For example, the doors with kick plates were rejected for aesthetic reasons, as the kick plates could not be removed without leaving the surface in a state that made it difficult to repair.

LEARNING POINTS, INFORMATION MANAGEMENT

- It should be made possible to screen and remove used products found unsuitable for the project for whatever reason before the detailed plan is finalised, preferably before the products' removal from their place of origin. It would therefore be appropriate to have a central reuse consultant/coordinator who can coordinate information with planners and those making the decisions and who ca make decisions themselves about opportunities at an early stage.
- For larger reuse projects, there will be a need for a separate IT tool to handle the large quantities of information about alternative second-hand elements. In this regard, programmers would be free to develop their own data-based solutions

8.3 QUALITY ASSURANCE, DOCUMENTATION AND RESPONSIBILITY

8.3.1 Current regulations

Several regulations govern the reuse of building materials:

- The building code (TEK) sets documentation requirements for products in construction so that project planners have the information they need to recommend products (new as well as used) for use in building. It is unclear what the minimum documentation requirements are.
- Substances hazardous to health and environment must be removed from circulation. This can be achieved through environmental mapping and potential remediation according to TEK, chapter 9–7 Surveying hazardous waste and environmental remediation description.
- The Building Product Regulation (BVF, made applicable through regulations on documentation of building products - DOK) sets requirements for the sale of building products. The requirements set out in the BVF are aimed at the production and sale of new products and are not adapted for used building materials. Internal reuse (within an organisation, such as within Entra) is not affected by the Building Product Regulation.

8.3.2 QA and documentation

In a series of working meetings under the auspices of FutureBuilt in the spring of 2019, the spotlight was on quality assurance, documentation and the practical implementation of the reuse of a selection of building products. When it comes to meeting the technical requirements set out by TEK, there are of course various ways of carrying out quality assurance and documenting the technical quality of a building product, depending on the type of building product/part and the requirements of the building in question. Entra further engaged the law firm Kluge to investigate the risks involved in the sale of used products. On the basis of their input, quality control and documentation were drawn up for various used building parts for KA13. The processes for each product are described in the experience report.

Most of the used products for KA13 were produced and sold for the first time before the Building Product Regulations (BVF) came into force in 2014. The regulation had previously focused on ensuring the technical quality of the building product. In some cases, documentation was obtained from the drawing archive or FDV system. The first step was then to check for compliance between the documentation and the used building product. After that, a quality assurance procedure was established for estimating whether and to what extent the building product met the current requirements, as well as whether the product had deteriorated at all during its lifetime. In some cases, it was then appropriate to order a repair, further processing and possible replacement of parts.

These steps, as well as the visual inspection, physical testing and preparation of a new project planning basis, were carried out primarily by a specialist consultant, potentially in collaboration with external material experts/industry participants (e.g. Norsk Stålforbund, Kontrollrådet for Betong, Sintef). Where the product required special certifications, QA checks were carried out to ascertain that the product was in line with

guidance from the manufacturer and/or certification body. The inspection results from both RIB and the contractor were served as a basis for the FDV and BIM models.

In the contract with the building owners, who transferred the used building products to Entra, it was advised – following guidance from the lawyers at the Kluge law firm – that they further specify that Entra assumed the risk of direct costs when implementing any orders from the Norwegian Building Authority regarding planning and construction laws and their additional requirements for products.

8.3.3 Supervision by the Planning and Building Agency (PBE)

In April 2020, KA13 received a letter from the PBE containing a notice of inspection of product documentation applicable to windows, doors, glass panels and insulation. PBE asked for product documentation showing that the project's construction products satisfied the requirements set in the documentation regulation for construction products (DOK). The requirement is that we must have a suitable documentation system in place for products that are and products that are not CE marked. The letter was intended for the responsible contractor and addressed to Haandverkerne. Haandverkerne provided the requested documentation for the new elements. Insenti compiled and supplied the documentation for the reused elements.

The documentation delivered for inspection included documentation handed over from the projects the specific elements were procured from and documentation sent directly by previous suppliers that we had direct contact with. Documentation related to the tradability of certain elements (DOK) was not necessarily available among the traditional FDV documentation. Often this involved a lot of time and a fair bit of detective work.

Insenti compiled the documentation and Kluge Advokater assisted with an assessment of the status of the product in question in relation to the requirements for tradability prior to the submission. Together, they did a thorough job of explaining the project's understanding of the requirements for documentation on the reuse elements in light of the documentation regulations (DOK). The inspection was closed, and according to a letter from the PBE received by Haandverkerne, no significant discrepancies were found.

The project was well supported with legal aid for interpreting the regulations and requirements for documentation on the various building products, especially the products from periods before the DOK regulations came into force. One question the project has reflected on is how far one should go to obtain documentation. The project prioritised its efforts in the quality assurance of technical properties.

8.3.4 Reflections and further recommendations

Significant time and resources were expended on the work required for the documentation of the reused elements. Together with the Kluge law firm, Entra publicly addressed the issue of unclear regulations, including by way of articles published on Bygg.no and in Dagens Næringsliv. Although the materials are technically good enough, they do not satisfy the Building Product Regulations' legal requirements for sale. And, if you do not comply with the rules, you risk not only the recall of the construction product but also a potential fine and prison sentence.

It is backwards that the responsible party for disposing of the used materials has the same responsibility as the manufacturer of new building materials. The obligations set out in the regulations are, in practice, very difficult – or even impossible – to comply with. This means that building owners who demolish a building and want to let others use the used materials are reluctant to give them away. Paradoxically, many new building products do not come with the type of documentation necessary for them to be reused either.

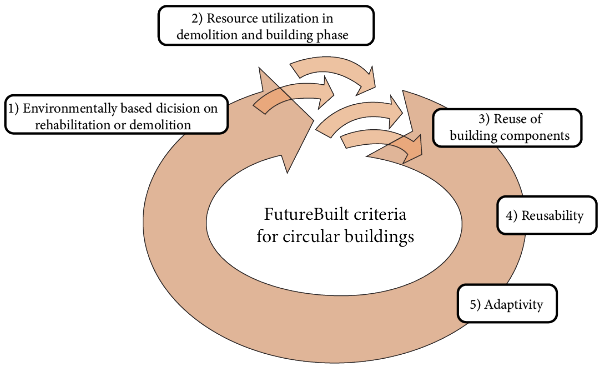
The authorities need to take action and change the rules here or allow scope for the rules' interpretation so that they are more in line with the interpretation of the rules in other EU countries and these brake blocks can be removed. We hope that KA13 will remain a tower of inspiration. It is up to the Norwegian authorities to ensure that the path we have forged does not become overgrown, and that reuse can be the obvious choice in the future.

LEARNING POINTS: QUALITY ASSURANCE, DOCUMENTATION AND RESPONSIBILITY

- There are different ways of conducting quality assurance and documenting construction products in accordance with the technical requirements outlined in TEK, depending on the type of construction product/building part and the requirements for the building in question. Collaboration with a specialist consultant and potentially with an external material expert/member of the industry may be appropriate. In the case of any special certifications, the QA procedure should be checked against the guidance from the manufacturer and/or certification body.
- The requirements of the documentation regulations (DOK) are perceived as rigid, although it is also unclear how they are applied. Legal assistance may be useful in interpreting this. Working with documentation in accordance with the requirements outlined in DOK can consume significant time and resources, and questions inevitably arise with regard to the cost-benefit effect.
- Paradoxically, many new building products do not come with the type of documentation needed for these products to be made reusable in the future.

8.4 ADAPTABILITY AND REUSABILITY

In order to reduce greenhouse gas emissions and keep material resources in circulation for as long as possible, the focus increasingly should be on the preservation and transformation of building stock instead of its demolition, as well as on the reuse of building elements within the demolition process. The inclusion of adaptability and reusability in the planning process thus becomes particularly relevant. Strategies for adaptability and reusability are set out as separate points in FutureBuilt's criteria for circular buildings (points 4 and 5). Although the focus in KA13 was primarily on the reuse of building elements (point 3), reusability and adaptability were also implemented in various ways.



Project planning with reuse in mind involves designing buildings so that components can be dismantled and reused during a renovation or demolition, either locally for use in the same building or externally for use in a new building. Planning for adaptability (adjustability) involves designing buildings so that the buildings can change function and use without any major material interventions. Current strategies for reusability and adaptability vary from building component to building component. Various functions, not least expected lifespan, are decisive to which measures are pertinent to ensuring good, long-term resource management.

It can be simple but effective to plan for changes from the start. The tenant, Spaces, run an office hotel and base their office solutions on adaptable solutions as they remodel their space more often than others. Mad and Scenario looked at various factors where circularity is considered over a building or product's lifetime. They also implement this in other projects and have seen that it has great value.

Experience and discussions about reusability and adaptability are described in further detail below in the defined measures/strategies taken. As reusability also had a quantitative requirement in FutureBuilt's criterion no. 4),

a list of building materials in KA13 that are considered reusable is given at the end. The list consists of both used and new items.

However, it will be a few years before any functional changes take effect and we can conclude the extent to which the measures implemented have proved useful. Hopefully, adaptable buildings will lead to buildings being renovated in future rather than demolished, and hopefully reusable solutions will provide good resource utilisation of the material resources if a building (or parts of it) is to be demolished.

8.4.1 Generality and elasticity
Generality of a building allows it freedom to change its function without incurring major interventions and costs. It also depends on, among other things, access to natural light, ceiling height and communication principles. Elasticity is a building's ability to expand or reduce areas within a given geometry, such as its ability to section or add extensions.

KA13 was, both before and after the renovation, built and arranged for knowledge-based workplaces.
The workplaces are located in offices and larger team rooms, as well as on the open-plan floors. In addition, there are common areas with meeting/conference rooms and social zones on the ground floor, in the basement and on the roof terrace. Cores with vertical communication, as well as toilets and mini-kitchens, are centred on the part of the building with the least access to natural light. All of the offices, team rooms and meeting rooms have well-distributed natural lighting and general access from the communication zones so that the rooms can be used and rented out independently of each other. This contributes to good generality.

The existing building has been extended by one floor in order to make room for a technical room and the roof terrace on the 8th floor. This was possible through reinforcement of the load-bearing structures of the floor below. The general floor plan allows for vertical flexibility and could have allowed for the addition of several other floors, but this was not a concern of this project for other reasons.

However, storey height has been a limiting factor for other solutions, such as the choice of ventilation options.

The experience from KA13 indicates that when planning for a new building, it is generally better to choose higher ceilings as they will enable the use of a variety of ventilation solutions, along with removable/bolted junction points for steel, that do not affect the amount of natural light.

8.4.2 Flexibility
Flexibility relates to freedom to reorganise the usable area independent of the support system/core, e.g. arranging for the relocation of non-load-bearing walls, hole punching of covers and energy upgrading of outer walls. Flexibility may also concern room solutions and individual elements. KA13 is above average in terms of its flexibility when compared to the industry standard. A number of solutions and building components contribute to this.

Steel structures (used and new) have been assessed in regard to their bolting rather then the welding so as to provide removability. However, implementation of steel structures came into conflict with ceiling height and window openings in terms of capacity to provide sufficient daylight and have thus been designed and implemented only for the rear wall in axis A, which does not have a window.

The brick wall facing the neighbouring building was constructed using lime-based mortar. Lime mortar does not bond as strongly to the brick as cement-based mortar does, which is an advantage when the wall is to be disassembled, as the brick can be more easily removed and cleaned for fresh use. In addition, lime mortar is more hygroscopic (moisture-buffering) and flexible/elastic (capable of absorbing small movements) in use.

Sealed walls between offices have been built such that every other wall is a fixed wall where technical elements have been installed in accordance with the guidelines and the other walls are flexible walls. The flexible walls consist of Tewo elements. These are insulated solid wood cavity elements with a tongue and groove function that ensures the elements are kept together tightly while being easy to assemble. The construction system consists of generic modules for the sake of short construction times and possible reuse in the next round. In addition, in this project top beams were installed on the ceiling where it may be useful in the future to put up new walls, so these have the potential to be built without having to touch the ceiling or technical equipment. These measures contribute to the internal walls and technical facilities being able to function as independent systems in the building.

Technical installations in the office section followed a well-thought-out and continuous grid, meaning that each module – based on a standard cell office – contains exactly the same technical components in the same location. This helps to maintain flexibility and ensures that the walls can be assembled and disassembled as required without moving any heavy technical installations. The strict adherence to such a system means there will always be sufficient air, light and sprinkler coverage, whether for one module or three modules combined.

As mentioned above, the top beams fastened to the ceiling have been added to this system where it may be appropriate to put up new walls either for a corridor or between the modules. The solution contributes to great scope of movement for changes, without generating large volumes of waste during demolition or costs for renovation.

Laminated glass was used for the office fronts with glass facing the corridors. Laminated glass can be cut to size, which is an advantage for enabling reuse where the walls are at different heights. In this project, office fronts for one of the floors were made from used glass that had been modified. All new glass bought for the project was laminated and can thus be adapted for new use in a potential next round of renovation. This will be the theme going forward and is also the case for Entra's other projects.

Carpet tiles were acquired partly second-hand and partly from Entra's surplus warehouses. All of the carpet tiles are removable. They are glued to the substrate but with an adhesive that allows the tiles to be taken up and installed again. Some of the used tiles had a different system for mounting, but these were also removable. This system consisted of a fastening tab in the corner that could connect four tiles together.

The steel grids from Tøyenbadet, which were used for the railings around the light patio, are bolted down. This allows for disassembly and potential future replacement.

The external cladding consists of various types of panel products (both used and taken from surplus warehouses) and is specially designed for flexible attachment. The various boards have been cut to a standard module of 40×40cm. This format provided the smallest possible gap for the Cembrit boards, which had a width of 120cm. For the metal panels, the small format was advantageous, as it provided the least risk of buckling when the panels were being processed. The panels were screwed to the rear horizontal laths with 2 invisible and 1 visible screw. Here, the various suppliers came up with a screw standard that could be used for all panel types. The façade solution chosen for this enables the replacement of individual panels during their lifetime and possible reuse in the next round.

8.4.3 Robust, homogeneous materials without substances harmful to health or the environment

Using robust, long-lasting materials provides great value when compared to using cheap, poor-quality materials.
Today's rental market, where contracts often last a maximum of 10 years, is constantly changing and leaning toward shorter rental periods. This means a lot of use and disposal if the industry does not shift its strategies toward more circular solutions. For example, office premises often have very large volumes of glass office fronts, often made of poor-quality materials. 10-year-old walls are usually scrapped on the basis of 100% linear economics and thinking. It is difficult to fit linear solutions, where materials use does not satisfy acoustic or longevity requirements, into circular thinking

Conscious choices have been made in this project in relation to the use of robust and durable materials. This also applies to reused components. This increases the likelihood of the materials in the building having a long life and being reused again should the building be renovated or demolished. Certain used products were rejected because their remaining lifespan was assessed as too short or the risk of operational challenges was assessed as too great. An example of this was the used white goods.

The existing façade facing Kristian Augusts gate was repaired and improved. Some of the natural stone slabs were replaced with new slabs. The tiles were washed and repaired and given new joints in some places. The new windows had lacquered aluminium with integrated blinds, making them more robust than the previous solution, which had external blinds. The façade will be fully maintainable in the future as well. The existing plaster façade facing the back courtyard was also repaired and replastered. The façade panels used on the extension were chosen with a long lifespan in mind.

The outdoor flooring on the 1st floor consists of granite stone slabs, and the floor on the ground floor was cast in glass concrete. These types of floors are of high quality and have a long service life. Glass concrete is very durable and can be maintained by sanding, surface treatment and possible local repairs, which can be repeated many times.

The ceramic tiling used in the bathrooms is a very robust material choice. Nevertheless, the tiles are firmly glued to the wall and thus do not constitute a particularly flexible solution. It was therefore decided that the tiles would run halfway up the wall.

The bathrooms and toilets therefore have a robust surface only where absolutely necessary. In the event of subsequent renovations, fewer tiles will be wasted than would be the case had the tiles covered the entire wall.

In the offices, the wood wool cement slabs have been installed directly on the ceiling. The installations below are open, without ceiling panels. As the ceiling panels are relatively fragile and prone to damage, this option provides a more robust solution that also simplifies maintenance.

Brick is an example of a material that is robust and has a long technical life, and which can also be built (for example with lime mortar) so that the components are reusable for several generations of the building.

Homogeneous materials, all components of which are made of the same materials, are advantageous in that the material wears evenly and there is no need to separate components during waste treatment. Solid wood is a homogeneous material chosen for use in the project, such as for the flooring and units. Wooden floors on the ground floor (elevated areas around the entrance/ reception) consist of parquet. This material is durable and can be maintained with sanding and surface treatments that can be repeated many times. The decking used on the 7th floor terrace is also made of solid wood. The Tewo walls consist of a combination of solid wood and wood fibre.

Surface treatments were avoided where unnecessary to avoid further wear or degradation of the materials. The existing external walls facing the neighbouring building on the 1st to 7th floors were simply plastered and dust-bound. The walls have therefore been given a robust design that can withstand impact.

Use of substances harmful to health and the environment have generally been avoided. Not only does this provide an environmental advantage in itself, avoiding such substances also contributes to simpler waste treatment and possible reuse in the next round.

8.4.4 Available documentation

In the marking of reused elements, the contractors have indicated the reused elements on the sketches and the designer has then tagged these elements in the 3D model with their own "tag", indicating that a given element has been reused. In addition, all reused elements were tagged according to an interdisciplinary marking system with TFM numbers. Through the use of TFM numbers, the elements then have a direct link to the FDV system, where documentation has been collected about all of the products. The documentation consists, for instance, of product information, assembly instructions and maintenance advice, and EPDs/environmental information, as well as the performance declaration and CE label where relevant. Collecting documentation for the reused elements was carried out for a variety of reasons, including to show compliance with the TEK building code and the regulations on documentation of building products (DOK).

8.4.5 Manufacturer agreements, returns scheme, processing by the supplier etc.

Throughout the project there was dialogue with various suppliers about the potential for entering into special agreements that could promote the circular flow of materials. The project is aware that in other countries – such as the Netherlands – it is possible to enter into leasing agreements for elements such that the supplier retains ownership of the products and is thus responsible for their maintenance and replacement. This business model could contribute to an improved resource economy, as the supplier would have an incentive to take the best possible care of the products. Known leasing agreements relate to carpet tiles (Interface), lighting (Philips) and lifts (Mitsubishi). None of these manufacturers/suppliers have similar offers available in Norway.

The existing wall systems in KA13 were in relatively good condition, but reuse was not possible due to sound requirements. A return scheme with the supplier Modulvegger was looked into but was not possible as they had no system in place to handle the sale of reused products. Modules that have to be remodelled or dismantled in order to insert new glass are more expensive than producing new ones, and a total calculation of the cost would have depended on how large a proportion we could use without further preparation. Instead, we turned to a distributor of used wall systems, The Recycling Giant.

In connection with the use of Bergersen Flis' residual stock of ceramic tiles for the tiles in the bathroom/toilets, the project was left with surplus stock of its own. Following an agreement with Bergersen Flis, the project passed this stock on to Höegh Eiendom, who wanted to make similar use of it for KA23.

The project also looked into opportunities for the used products to be repaired and modified by the original, or even new, suppliers. This applied to the existing windows in KA13, the vertical blinds taken from DEG8 and the wall system and glass fronts.

The existing windows in KA13 were not appropriate for reuse due to the poor woodwork and lack of tightness around the frame, but contact was made with several suppliers who could supply new windows based on the existing insulating glass. The window manufacturers Ventilasjonsvinduet in Denmark and Troll Trevarefabrikk in Larvik could both provide this service, but at a higher price than if we were to procure new windows. In general, the glass incurs only approx. 12%–14% of the production costs, not including the cost of dismantling the existing glass from the frame. Using the insulating glass as external cladding in the new building was also considered. Concepts for this were developed in the sketching phase, and discussions were held with the façade supplier StoVentec. A preparation phase would then be added to the process to satisfy the requirements for safety glass, e.g. foiling of the glass for reuse, as well as adding a new suspension system. These concepts were abandoned for various reasons.

The original manufacturer of the louvered curtains dismantled from DEG8 had probably not received a reuse request before, and it was clear that restitching the curtains and modifying the railings etc. would be significantly more expensive than buying new products. However, it was decided to be inappropriate to pursue this further.

Several attempts were made to remodel the used office walls/glass fronts, but it proved difficult to obtain glass that met the project's sound requirements. This also depended on the height of the glass matching the heights in KA13 or on the glass being laminated (not tempered) so that it could be cut. There was a large volume of glass of sufficiently good sound quality at Refstad school. The company Bruktrom worked on solutions for putting this glass into new frames, but the frames in question were a little too short for a satisfactory result. It was CreoNordic who finally delivered the office fronts, together with the new and used glass and the 25 used glass doors. CreoNordic further supplied the glass railings, including used glass panels from St. Olavsplass 5.

8.4.6 Reusable elements

FutureBuilt's criteria for circular buildings (v2, 2020) means there is a requirement for 10% of the added elements in renovation projects to be reusable. Reusability can refer to both used and new elements added to the project. The documentation requirements for a reusable element are:

- When designing circular buildings, an account must be given as to how strategies for reusability have been applied. For a component to be considered reusable, it must, as a minimum, use:
- Robust and homogeneous materials without substances harmful to health or the environment
- Reversible connections between components so that these can be disassembled without incurring damage
- Layered construction such that components can be dismantled independently of the adjacent layers
- For a component to be considered as reusable, the following information must be available:
- FDV documentation
- EPD (where available)
- Information about the building system with instructions for disassembly
- Clear markings of components (where possible and relevant)
- Marked, visible and accessible attachment points (where relevant)

Below, two lists have been provided of building materials in KA13 that are considered reusable. One list consists of elements where reusability was the focus and which have been specially treated, and the other list consists of elements where reusability is a common solution for the element type. When it comes to windows/doors, sanitary equipment and radiators, for example, these are usually mounted so that the elements removable. If the elements also consist of robust and homogeneous materials without substances harmful to health or the environment and have their product documentation, they can be considered reusable.

Chap. 8.4, especially 8.4.3–8.5.4, explains how strategies for reusability have been applied in this project. As described in chap. 8.4.3, in general, the added elements used in this project are made of robust materials that do not contain substances hazardous to health or the environment. However, different solutions have been used for installation. Some elements have fully reversible connections and layered construction that allow the dismantled independently of their adjacent layers, while other elements do not – or only partially – satisfy this criterion.

As regards information/documentation, as described in chap. 8.4.4, all of the elements (used and new) are tagged in the BIM model and have FDV documentation. This is considered satisfactory for future internal reuse in Entra. Special documentation for the sale of items to external parties in accordance with DOK is not considered relevant here as Entra primarily wants to reuse its own elements in the same building or in other buildings in its own building portfolio. There is also no general requirement for documentation in accordance with DOK in the FutureBuilt criteria for circular buildings.

Products that are being phased out of circulation do not count as reusable items. For example, this applies to ceiling panels used for sound absorption over the wood wool cement boards. The ceiling panels have been modified and pushed into place between the laths. They therefore have a different quality now than they had originally.

Documentation is a difficult point when it comes to reusability. Metal pipes (heating pipes and sprinkler pipes) are an example of a product with a long lifespan that can be dismantled but which is not commonly supplied with documentation that makes it possible to sell them for reuse later. As the situation currently stands, the metal pipes are seen as reusable only within Entra's organisation.

Ref. chap.	Building part	Component	Quantity	Unit	Justification for reusability
2.5	Façade elements	Cembrit, Metal and Steni	5394	pcs.	Removable, fixed screws. Flexible format for new application.
2.6 1	Non-loading-bearing external walls	between the offices: Tewo	approx. 125	m2	Laminated glass can be cut; this enables processing and reuse
2.7	interior walls	glass	approx. 400	m2	
2.9 3	Floor surface	Carpet tiles	approx. 2200	m2	Glued to the substrate with removable carpet glue/tape
2.10 2	Ceiling	Wood wool cement panels railings with	1500	m2	Screwed to laths, removable
2.12 1	Railings Steel	Railings with lattice grates Columns, beams	38 approx. 15000	pcs kg	Lattice grates have been preserved in full and attached with bolts to framework; removable Steel is bolted to the back wall in axis A, and this is fully removable.
4.2	constructions Non-loading-bearing	window trusses			
4.3	external walls surface,	Bricks	135	m2	Brick wall with lime mortar: can be disassembled and cleaned Slats are screwed into the existing boreholes. Various seating booths were considered and alternatives to plug the holes, but it was decided that the holes would be kept as they are , and to instead do the measuring on site
3.4	cinema room	Wooden slats	approx. 760	lm	Laid on the plastic pedestals, not screwed down. The pedestals can also be reused as they are both durable and adjustable in height
7.2 1	Roof/ terrace	granite used as terrace floor	85	m2	
7.2	Roof/ terrace	wooden floor	approx. 100	m2	

Ref chap.	Building part	Component	Justification for reusability
2.3	Non-loading-bearing	All windows and facade glass	Windows and facade glass are generally removable and can be reinstalled
2.8	External walls non-loading-bearing	Doors, various types	The doors are generally removable and can be reinstalled
2.12 3	Interior railings Handrails	Glass and steel railings	Glass is attached with clamps and is removable
3.2.2	Inner walls	Wooden panels	The panels are screwd in with collated nails that can be removed and rein-stalled
3.5	Furnishing	Kitchen cabinets	The kitchen cabinets are removable and can be reinstalled
3.7.1	Furnishing	Cloakroom lockers	The cloakroom lockers are removable and can be reinstalled
3.6	Furnishing	Auditorium seats	The auditorium seats are removable and can be reinstalled
3.7.5	Furnishing steel	Reflectors Columns, beams.	Reflectors are removable and can be reinstalled The welded steel is also reusable if you cut the loose parts – something this project has proved.
4.2	Constructions	Window trusses	
4.6	Covers	Hollow core slabs	The project has shown that hollow core slabs are reusable, despite this not specifically being planned in the design.
4.7	Internal staircase	Steel between the 8th and 9th floors	Can be removed and reinstalled
5.2	Sanitary equipment	Sinks and toilets	The sinks and toilets are generally removable and can be reinstalled
5.3	Heating	Radiators	The radiators are generally removable and can be reinstalled
5.4	Fire hose cabinet	Fire hose cabinet	The fire cabinets are generally removable and can be reinstalled
5.7	Air supply/cooling	Air Diffuser	The air diffuser are generally removable and can be reinstalled
6.2	Electrical installations	Cableways	The cableways are removable and can be reinstalled
6.3	Electrical installations	Wall ducts	Can generally be dismantled and reinstalled
6.4	Electrical installations	Plug sockets, triple	Can generally be dismantled and reinstalled
6.5	Lightning/roof	Misc. fixtures	Can generally be dismantled and reinstalled
7.3.2	Terrace	Railings	Can be removed and reinstalled

Elements in KA13 where reusability is a common solution. The elements are not included in the reuse calculations as they have not been specially treated in the project in order to make reusability feasible and/or they constitute such a small weight percentage in the calculations that they do not have a large enough impact.

8.5 COSTS
8.5.1 Student projects

Three bachelor's degree students at Oslo Met (Katja Jødal, Audun Hansveen and Erland Hall) compiled a picture of the costs for four of the reused elements: steel structures, windows, chilled beams and ceiling panels. Specialist consultants and contractors for various building components provided insight into how we could conduct the assessments. It was specified that this is based on estimated figures and does not include costs for project management, documentation or project planning. The results of the cost analyses are given below the relevant sections.

The cost analyses had varying results: The cost differences between new and used varied from a savings of 66% from reusing chilled beams to a cost increase of 63% from reusing ceiling tiles.

The students discussed different aspects of the results further:

- It can be difficult to compare the price of a new product with a reuse process, as different phases in this process require different inputs in regard to costs. If you are able to buy used building parts in the same way as new ones, such as from a materials bank or a reuse database, it would be easier. The windows purchased from Resirqel included only transport as an expense in addition to the price of the building material. The ceiling tiles, on the other hand, required many more stages that added to the overall cost beyond the price of the tiles.
- Transport and storage can make up a significant proportion of the costs of a construction project. In this respect, there can be a big difference for new and used elements, especially in local reuse, where the building elements do not necessarily need to be transported to temporary storage or require processing. However, if you have to depend on external storage solutions, the costs for transporting used elements can be high.
- Aftertreatment is also an additional expense that may arise, especially for used building materials. For example, some elements require further processing after they're dismantled to attain the quality required to align with regulations and new usage. Steel structures, for example, must be quality-assured through scanning and destructive testing, which then makes up a large proportion of the total costs for using steel. If in the future there are specialists in the field who streamline the processes for capacity testing and redocumentation, the costs in this respect could be reduced.
- The costs for assembly may also be worth comparing. For some elements, such as windows, the cost of installation may be the same. For other elements, the assembly of used elements may be more complicated when compared to using new. An example of this is the ceiling panels in KA13, which were used as sound-absorbing elements beneath the hollow core slabs. They were considered to have the same effect as mineral wool, but the installation time was estimated to be about 65% longer. The fact that alternative solutions have been found by pursuing reuse means that, in some cases, more extensive assembly processes may be required. However, we can see from the cost assessment that, for most elements, the installation time is approximately the same. (Jødal, Hansveen & Hall, Oslo Met bachelor's thesis 2020).

The extra time taken for planning and project management were not included in these calculations.

8.5.2 Other cost assessments
As the student calculations show, the costs connected to reuse have arisen in different phases of the project and for different products. A large cost item not reflected in the student theses is the extra time required for project planning and project management. Its inclusion would have resulted in higher costs than calculated for the elements. The time spent internally on the project was particularly high in regard to the steel, hollow core slabs and brickwork, as these elements required a lot of extra follow-up.

In the OsloMet student thesis, the price of the acquired reused steel came to about NOK 86/kg. It turned out, however, that the cost of the reused steel was somewhat higher: up to 100 NOK/kg. This figure includes searching for reused steel, purchasing, dismantling, scanning/testing, processing, temporary storage, transport and assembly. In addition, extra time was required for the planning (RIB) and project management.

In the table provided below, the results of the student thesis for windows, ceiling panels and chilled beams are compared with the project's calculations of the costs of the steel structures.

	Quantity	Unit price, reused element	Unit price, new element	Price difference
Windows[1]	1588×1488 mm - 16pcs.	Approx. NOK 6,017/pc.	Approx. NOK 14,414/pc.	Approx. 59% savings
	1588×2188 mm - 12pcs.	Approx. NOK 8,336/pc.	Approx. NOK 21,195/pc.	Approx. 61% savings
Ceiling panels[1]	Approx. 3,321 m²	Approx. NOK 228/m²	Approx. NOK 140/m²	Approx. 63% more expensive
Steel structures[2]	Approx. 45,000 kg	Approx. NOK 100/kg	Approx. NOK 67/kg	Approx. 49% more expensive
Chilled beams[1]	138 pcs.	Approx. NOK 1,840/pc.	Approx. NOK 5,405/pc.	Approx. 66% savings

Results from the cost calculations for the windows, ceiling panels, steel structures and chilled beams.

The estimated cost of the hollow core slabs was approx. 5–6 times as much as the price for new hollow core slabs and does not include the extra time required for planning and project management. At the same time, we know that reusing steel, hollow core slabs and bricks has a significant impact on environmental costs, as these are materials that have a high environmental impact during production. These materials also make up a large proportion of the construction waste produced nationally. It is therefore extra important that we "walk the path less travelled" for these elements.

Reuse of other elements incurred less additional time.

It may be interesting to look more closely at the details of the costs of reuse elements, particularly the phases and activities in which the costs arise. When it comes to the methodology to use for this, the costs incurred in the dismantling phase should be added as a cost only to the extent that the dismantling of reuse elements costs more than normal demolition (which must be carried out anyway). The costs of (or possible gain from) avoiding waste treatment should be deducted from the reuse cost. A review of the price differences – and the difference in environmental impact – between used and new elements can serve as a basis for looking at any "low hanging fruit" available when reusing various building materials.

It is hoped nonetheless that this experience will help enable future projects to implement more rational processes. If reuse becomes more industrialised in the future, it will have a positive effect on the costs of reuse. Moreover, if a bigger price tag is put on greenhouse gas emissions, then the reuse of hollow core slabs, for example, could eventually pay itself off, even if they are a more expensive option today.

8.5.3 Support

The project received some funding for additional planning and construction costs through FutureBuilt. The funding originated from the Norwegian Environment Agency's Klimasats programme, which provides support for environmental initiatives. However, the level of funding has not come close to covering all of the additional costs incurred as a result of investing in a full-scale reuse building project.

[1]Conducted by the students at OsloMet (Jødal, Hansveen and Hall, OsloMet bachelor's thesis 2020) [2] Conducted by the reuse team, KA13

In 2019, funding was applied for via Enova under the programme Best Available Technology in Existing Buildings. Predefined measures for energy reduction included additional insulation of the outer roof, the replacement of windows and the conversion of a quantity-regulated heating system. The application did not measure up to the competition, however, and was rejected.

In parallel with the KA13 project, Enova included reuse as a possible measure for ensuring greenhouse gas reduction in construction projects as well as associated concept studies. On this basis, Mad architects applied for funding to prepare a report based on the experience of several other reuse projects. As the objectives of this study partly overlapped with the objectives of the KA13 experience report, we entered into a collaboration on the distribution of effort and hours. Parts of this report are therefore supported through the concept study Recycling – The Conventional Direction, for completion in 2021. Mad's own contribution to the descriptions of ARK themes, as well as its illustrations, have been covered by the Enova report, and the reuse consultant's hours are linked to the summary chapter. These parts of the report are also included as a background/thematic report in the concept study.

The question is whether the support apparatus in use today is strong enough to initiate other reuse projects. Questions were raised at a contact meeting with FutureBuilt, and the preliminary answer to this was a clear no. The extra costs incurred in planning, administration, quality assurance, documentation gathering and construction in reuse projects exceeded normal costings, and such projects are dependent on external funds if reuse and circular solutions are to be scaled up from pilot building projects to general industrial construction projects.

8.5.4 Socioeconomics

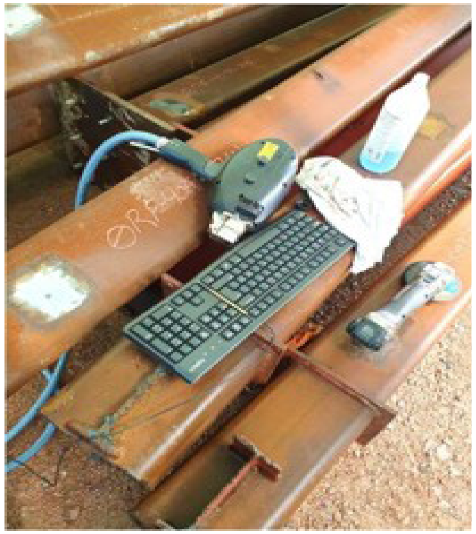
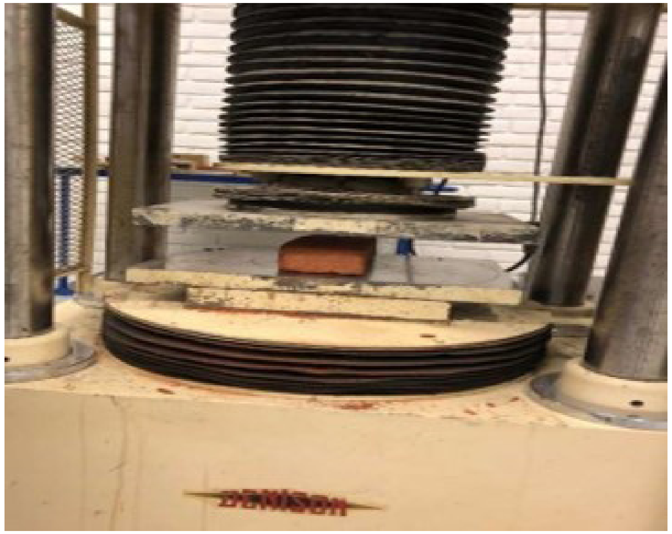
Socioeconomic impact has received little attention in the discourse on circular buildings and cities. In connection with the development of KA14, several principles for a circular economy were developed that are expected to be significant in terms of creating socioeconomic value in the form of, not least, new industries and local workplaces when reused materials are used.

One example of this is the establishment of a new urban floor. According to current practice, granite slabs are often produced in Asia, then transported to Norway. In connection with the development of KA13, however, used façade stone from nearby buildings was used for the new urban floor. Its removal, shipping and modification created new jobs.

Another example is the soil mixture used on the roofs. The soil mixtures available today are often peat-based. The soil mixture used for this project is devoid of energy-intensive leca and environmentally toxic peat, instead containing compost made from slaughterhouse waste. This is waste that has become a resource and contributes to local value creation.

In this project, new services relating to the use and modification of used materials were requested from a number of suppliers. Wooden handrails acquired from Tøyenbadet were used for the amphitheatre staircase, and the old dome ceiling lights from St. Olavsplass 5 were remodelled with a new LED system for use in the reception. These individual projects were not necessarily profitable individually, but the demand for these services could be the prelude to the establishment of new businesses and business models that better align with circular thinking. The environmental benefits of such measures are enormous in themselves, but projects such as KA13 are also expected to have a significant socioeconomic impact by creating local jobs through the reuse of materials. While the socioeconomic impact is not a part of the thesis, the topic should nonetheless be a central focus in future reuse projects.



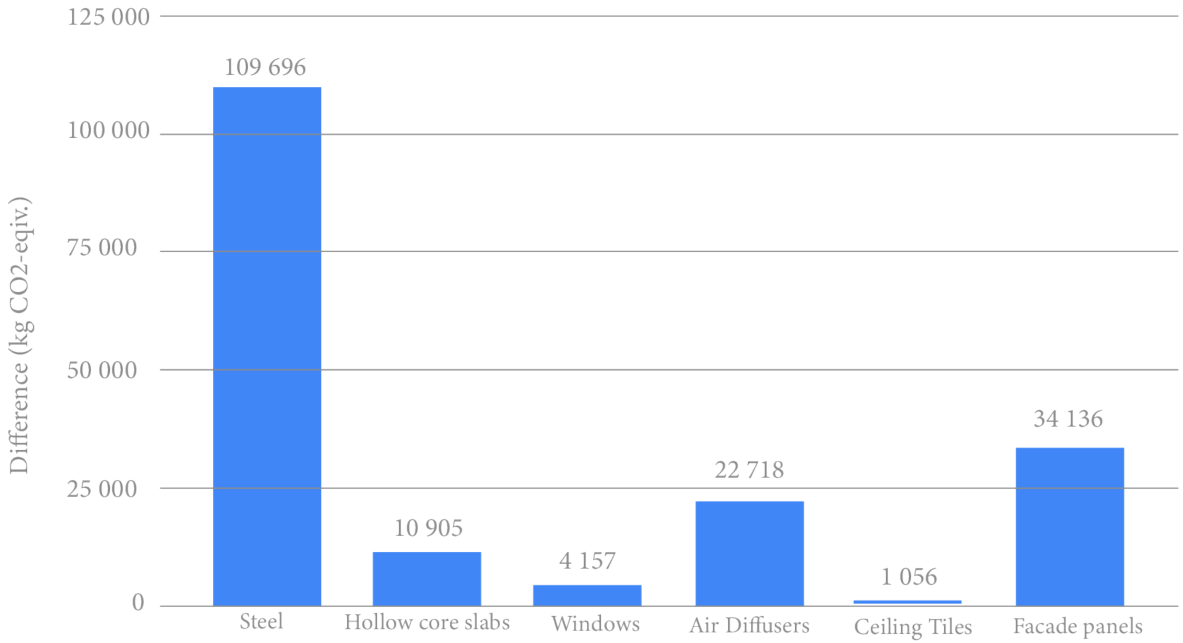





Circular solutions contribute to major environmental benefits and are also expected to have significant socio-economic impact through the creation of local jobs when reusable materials are used.

8.6 ENVIRONMENTAL ASSESSMENTS
8.6.1 Student projects
Two master's degree students at NTNU (Vilde Vår Høydahl and Hanna Walter) – alongside the construction process in 2020 – calculated the environmental impact of six reused elements: steel structures, hollow core slabs, windows, chilled beams, ceiling panels and façade panels. Specialist consultants for various building parts provided insights for the basis of the assessments. The results of the environmental analyses are outlined under each relevant section and in the tables below.

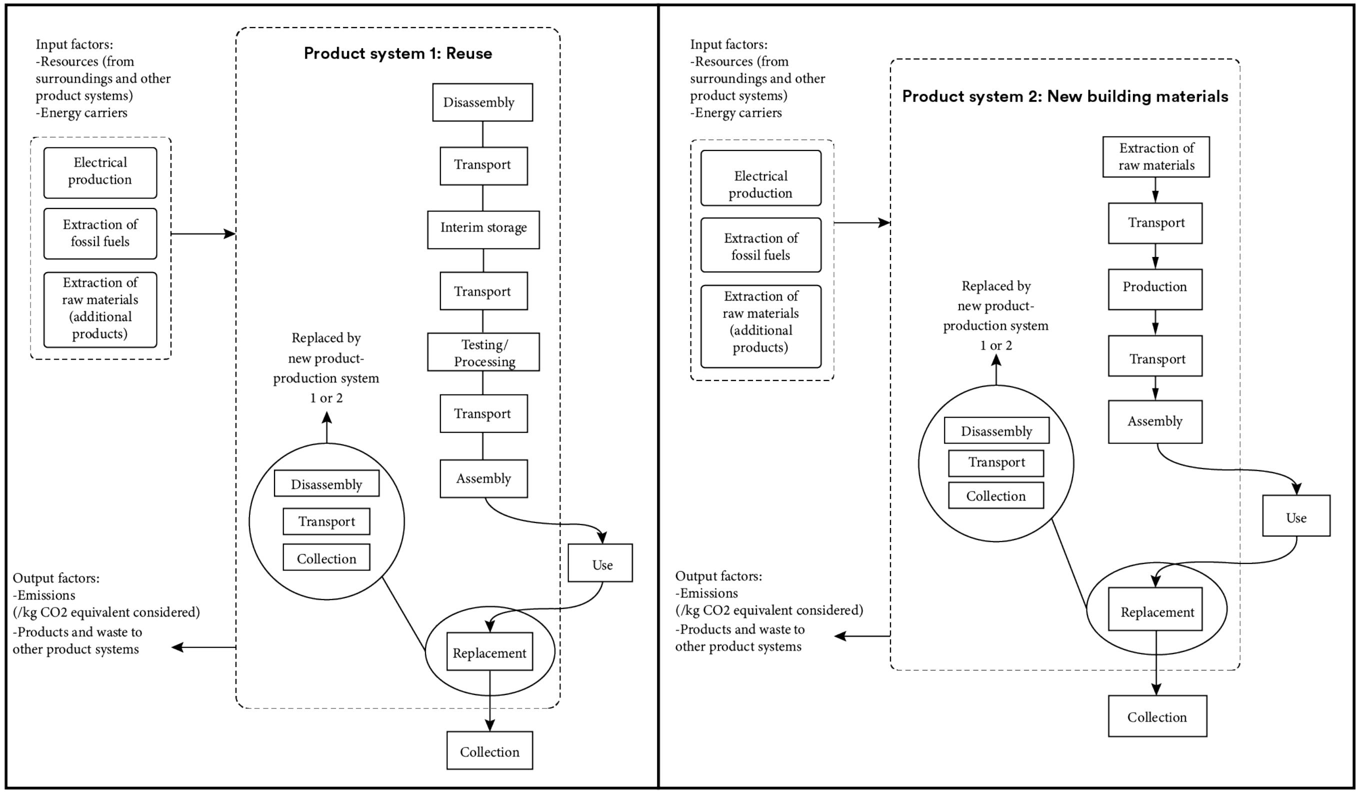
Materialgroup	Emissions per unit reuse [kg CO_2-eiqiv/unit]	Emissions per unit new [kg CO_2-eqiv/unit]	Unit	Saving
Steel	0,07	2,5	kg	97%
Hollow core slab	13,9	124,9	tonnes	89%
Windows	13	161,5	pcs	92%
Air Diffusers	8,9	173,4	pcs	95%
Ceiling tiles	0,01	0,65	m²	98%
Facade panels	1,4	50,7	m²	97%

Savings in kg of CO_2 equivalents/unit for the analysed material categories in phases A1–A4. (Høydahl and Walter 2020)



An overview of the emissions savings from the reused products in KA13 when compared to new alternatives, phases A1–A4. (Høydahl and Walter 2020)

The calculations show that all of the elements brought about major savings in climate emissions (89%–98%) in comparison to purchasing new. Considered together, the results show that reused products within these material categories have resulted in a total saving of 186 tonnes of CO_2 equivalents. The system limits for the calculations are shown and commented on below.



Flow chart for analysed product systems. The system limit is marked with a dashed line (Høydahl and Walter 2020).

The greenhouse gas emissions occurred in various phases of the reuse processes. In the thesis, it was decided that the removal of the used elements would be included as part of the environmental impact of reuse, as it is assumed that the elements would have been either removed or otherwise demolished had they not been planned for reuse. Furthermore, transport, temporary storage, testing and processing were also included. For example, it is noted that the heating of warehouses for storing items such as the reused windows and chilled beams contributes a significant level of emissions.

The reduction in greenhouse gas emissions over the 60-year analysis period depends very much on which replacement scenarios the calculations are based on. If we look at the best possible scenario, where all replacements are made with additional recycled products, the project's total savings would be 210 tonnes of CO_2 equivalents. In comparison, if we look at the worst-case scenario, where all reused products are replaced with new products during their lifetime, this corresponds to a savings of 149 tonnes of CO_2 equivalents. If we consider only the manufacture of materials (phases A1–A3) and transport to the construction site (A4), the total savings are estimated to be around 186 tonnes of CO_2 equivalents, meaning somewhere in between.

The windows are an example of a solution that ended up being quite different due to the use of reused products. Given the higher U-value of the reused windows compared to new windows, extra insulation was used in the wall. The environmental impact of the extra insulation was taken into account for the used windows.

The solutions chosen in KA13 are not necessarily generalisable. The students note that it is conceivable that what is considered possible and appropriate for reuse today may change in the years to come. However, the more specific examples we have of calculations for the environmental effect of reuse, the greater the foundation we are likely to have for discussion of the environmental effect overall. (Høydahl and Walter, NTNU master's thesis 2020)

8.6.2 Methodology for environmental analysis in regard to reuse
Environmental analysis of reuse is a relatively new field and the methodology is not well established. Therefore, the methodology for reuse analysis has been a subject of discussion throughout the course of the project and has also involved FutureBuilt and other external consultants outside of the project.

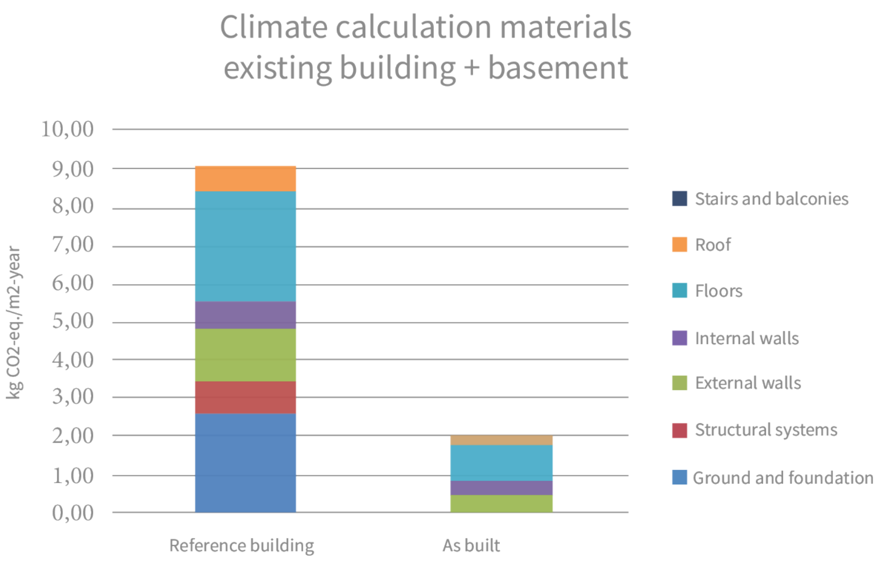
The system limits used in the student theses do not fully correspond to the limits used in other areas, such as environmental product declarations (EPDs). Removal and transport of an element in accordance with waste treatment is considered in the EPD as part of the waste phase of the product. Dismantling for reuse of an element will therefore be relevant to include in a reuse process only if it has been dismantled differently than it would have been for a normal demolition process. The extent to which dismantling for reuse is different than dismantling for demolition will vary depending on the component. For example, windows are usually removed and transported whole from a demolition site, while removing concrete elements requires completely different, and more environmentally burdensome, measures if they are to be reused.

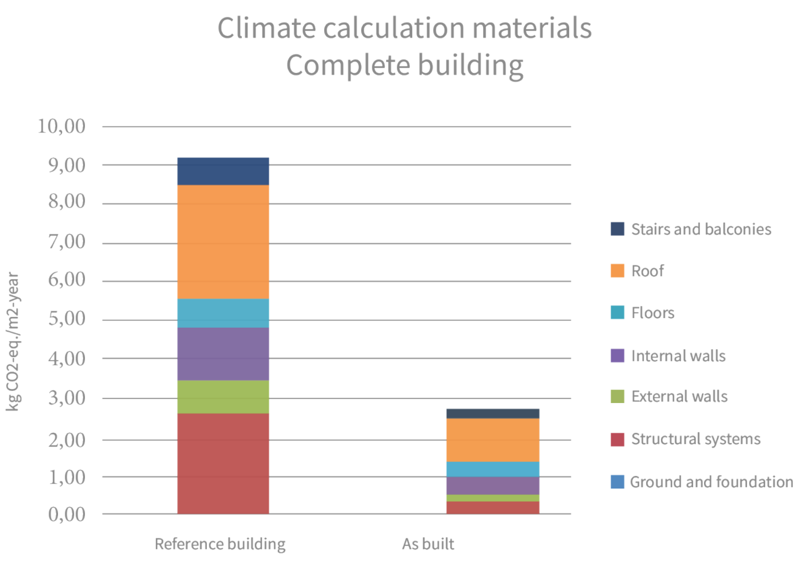
It can be said that the methodology the students have used provides a rather conservative picture of the situation and that they have stayed well within the margins.

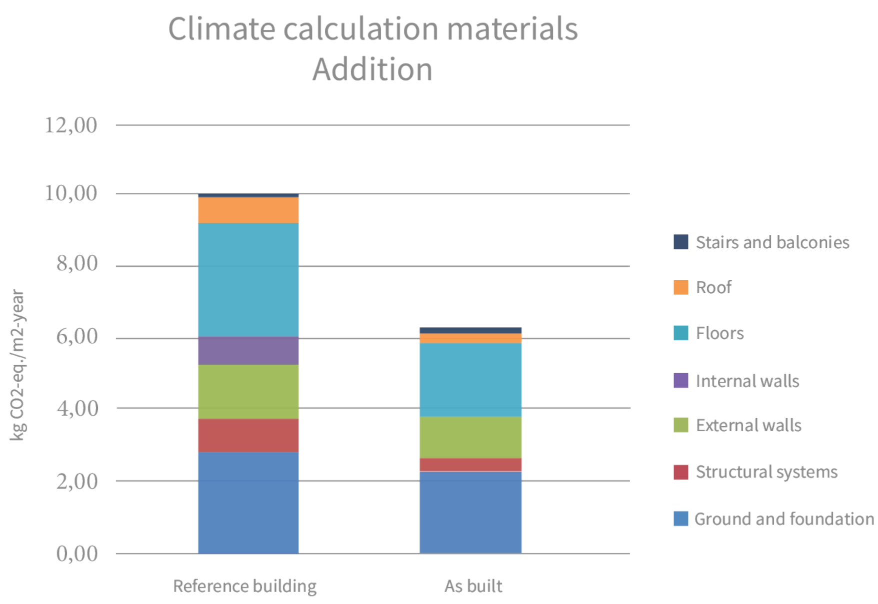
The environmental calculations on reuse require time-consuming data collection on the processes in the various phases. Based on the results of the student theses and previous studies relating to environmental assessments of reuse (e.g. Nordic Built Component Reuse, 2016), simplifications of the methodology were made in collaboration with FutureBuilt for use in other reuse elements of this project. Instead of calculating the emissions in connection with the removal, transport, storage, etc. of each individual element, a given percentage of the emissions relating to these processes was generally assumed. This percentage was set rather conservatively at 80% of the emissions for a new product. Compared with the results from the student thesis, where savings in climate emissions varied between 89% and 98%, this allowed a good margin for deviations.

8.6.3 FutureBuilt greenhouse gas accounting
Asplan Viak prepared the greenhouse gas accounting for the entire KA13 project in accordance with FutureBuilt's criteria, including the emissions caused by energy, material use and transport. The project is compared to a reference building with the same area as KA14 but built new using conventional materials. The calculations show that a reduction of greenhouse gas emissions of 70% was achieved for the building as a whole, meaning both the renovated part and the new build. The main cause of the reduction in greenhouse gas emissions was the preservation of the existing building structure and the load-bearing systems. There is also a high degree of reuse in the new building, which results in a reduction of greenhouse gas emissions.

[1] *Nordic Built Component Reuse (2016): https://www.asplanviak.no/prosjekt/10203/*



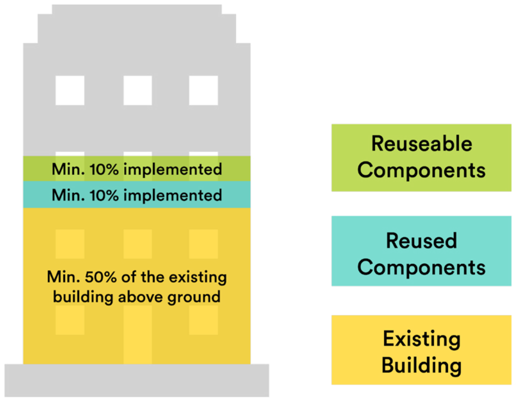




Distribution of greenhouse gas emissions per building component: Reference building compared to the existing building+ basement and compared to a new build.

For the existing building+basement, a reduction of greenhouse gas emissions of 78% was achieved compared to the reference building, and for the new building a reduction in emissions of 36% was achieved. For the existing building, much of the building's structure was preserved, which provides major reductions for the load-bearing systems, external walls, decking and roofs. The existing foundations were also preserved, apart from the ground floor flooring that was included in the decking. This means that the existing building has particularly low greenhouse gas emissions compared to the reference building.

For the new build, the load-bearing steel structure makes significant use of recycled materials. Reused hollow core slabs and façade panels were also used, which contributes to this reduction.



Rehabilitation

Source: FutureBuilt's criteria for circular buildings, v. 2.0, 16/03/2020.

The building's floor plan means that there is little need for internal walls, which is what makes this aspect deviate the most from the reference building.

Technical installations and fixtures are not considered as part of the use of materials in accordance with FutureBuilt's methodology for greenhouse gas accounting. Reuse of these building components in KA13 has therefore not been included. For other results, and for an appendix with a complete list of the reused elements included in the greenhouse calculations, please refer to the separate report.

8.6.4 FutureBuilt's criteria set for circular buildings – reuse calculation
In its criteria set for circular buildings, v. 2.0, FutureBuilt set out the following quantitative requirements for reuse and reusability.

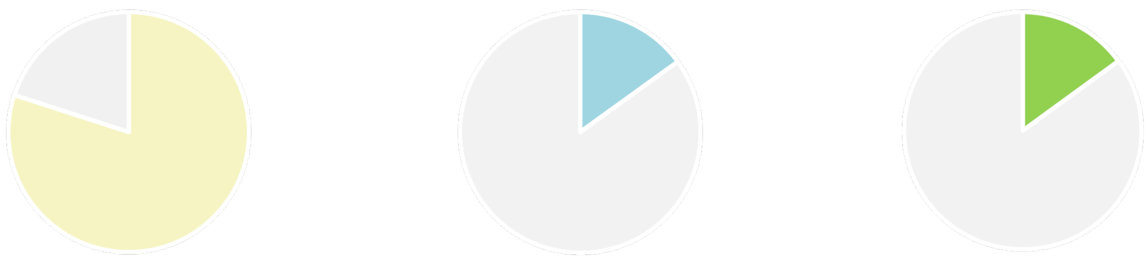
Since Kristian Augusts gate 13 is a renovation project in which it was decided to retain as much of the existing construction as possible, the requirements for local reuse (50%) were met without issue. Local reuse amounts to approx. 80% of the project's total weight. The building's total weight is estimated on the basis of a combination of loads that were used in connection with the dimensioning of foundational and load-bearing systems, and calculations based on the quantities and specific weights of various materials. For a new build, other methods for calculating weight may be more appropriate, e.g. specific calculations that can calculate the weight in addition to the costs.

Here, the project's estimate of the weight percentage achieved through local reuse, reuse from acquisition and reusability is presented.

Local reuse, approx. 80 weight

Reuse acquired, approx. 15 weight percent of element

Reusability, approx. 15 weight percent of element



In regard to reuse acquired from "donor buildings", the proportion amounts to approx. 15% in weight of elements added to the project. The figure is equivalent to the proportion of reusability of additional materials. There is some overlap between what was reused and what is reusable. For example, the brick wall was built from recycled stone and using lime mortar, which makes the wall reusable in the next round. As a weight percentage of the building's total weight, the share of reuse and reusability comes in at approx. 3%. The construction elements that make up most of the weight of the reuse and reusable elements are the steel structures, the brick wall and the external cladding. There is a strong correlation between greenhouse gas reductions and weight, such that a reuse calculation based on weight could facilitate reuse and thus bring about significant savings in greenhouse gas emissions.

Elements such as sanitary equipment, technology and surface materials are not counted in the reuse calculation. These are, however, elements with a high replacement rate that have the potential for reuse instead of being used and disposed of according to the current mentality around them. In order to motivate people to reuse elements that provide less pay-off in terms of their weight percentage, FutureBuilt has specified a minimum number of components, in accordance with the building parts table (2 digit level), which must be reused from acquisition and also reusable. The requirement is set at 5 and 10 for renovation and new builds respectively.

	Requirements for reuse from acquisition	Reuse from acquisition	Requirements for quantities of reusable pcs.	Reusable
Building part, 2 digit level	5 pcs.	23 Load-bearing system 23 Outer walls 24 Inner walls 25 Decking 26 Roof 27 Permanent fixtures 28 Stairs and balconies 31 Sanitary 32 Heating 33 Fire extinguishing 36 Air treatment 37 Air cooling 43 Distribution	5 pcs.W	22 Load-bearing system 23 Outer walls 24 Inner Walls 25 Decking 26 Roof 28 Stairs and balconies