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The Urban Lab of Europe !

The Super Circular Estate project Journal N° 3

Project led by the ***Municipality of Kerkrade***

CIRCULAR ECONOMY

European Union
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The Super Circular Estate project

The **Super Circular Estate** project will test new circular economy processes aimed at 100% reusing, repairing and recycling of the materials acquired from the demolition of an outdated social housing building. The project will experiment with and evaluate innovative reuse techniques for decomposing a high-rise tunnel formwork concrete building in Kerkrade. The demolition materials will be used to build 4 pilot housing units with 5 different reuse/recycle techniques to be compared in order to assess their viability and replicability. Besides the project will experiment with innovative techniques for water reuse in a social housing context by testing closed water cycle. Social tenants will be strongly involved in the co-design, operation and monitoring of new collaborative economy services/ facilities (aiming at reducing the need for vehicles, tools, spaces etc.) to support the transition towards a sharing, reuse and repair community model.

Partnership

- Municipality of Kerkrade
- Brunssum municipality
- Landgraaf municipality
- Stadsregio Parkstad Limburg
- VolkerWessels Construction
- Real Estate Development South and Dusseldorp Infra
- Water Board Company Limburg
- Limburg Drinking Water Company
- IBA Parkstad B.V
- Zuyd University of Applied Sciences
- HeemWonen
- Association of Demolition Contractors (VERAS)

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1. Executive summary

Construction industry is the biggest consumer of natural resources and producer of CO2 emissions and waste. According to the department of Dutch ministry for infrastructure and environment Rjkswaterstaat 2017, construction industry in the Netherlands is responsible for 50% of total use of natural resources, 40% of total energy use, 40% of total waste production, 35% of total CO2 emissions (Rjkswaterstaat 2017). TU Delft report in 2018 indicated that when analysing all construction activities, use of raw material itself is responsible for 67% of CO2 emissions compared to activities on the construction site 16% and transport 17%.

UN report warns that consumption of raw materials in construction has tripled in last few decades. In a linear "take – make – waste" economy of today, such growth results into diminishing of natural resources, increase of pollution, waste, CO2 emissions and degradation of living conditions on the planet. Shift from linear use of raw materials to a circular "Take – Make – Remake" economy has been recognised as a key to a resilient future by the EU, aiming to reach zero CO2 emissions by 2050.

As the world is increasingly debating the details of the Paris agreement and UN resolutions, daily life of many has already been disrupted by climate change. While countries are negotiating climate deals, need for immediate action is recognised as the only way further.

UIA project Super Circular Estate in Kerkrade (The Netherlands) is one of much needed light-houses today that bring light on a new circular carbon neutral construction world, by acting and showcasing circular deconstruction and construction technologies, products, and tools needed for new circular generation of buildings. SCE project implements construction approach which relays on mining of materials from the existing building stock in place of real miens, and creating a new homes with re-sourced products and materials.

While embracing such innovative approach Super Circular Estate consortium members have faced numerous challenges on a way, from change in design and engineering culture to deconstruction, refurbishment and construction methods of construction not seen before. Major challenges were related to issues as legislation, technique, value perception and mindset (discussed in more detail in journal 2 and zoom in 1) (UIA 2019) https://www.youtube.com/watch?v=azLRMLTlOMw; https://www.uia-initiative.eu/en/news/super-circular-estate-journal-2-next-steps.

Nevertheless, after more than a year of experiments, significant steps have been made and results achieved, illustrating the potential and challenges of circular building construction today. The SCE consortium is already finalising the construction phase of the three new houses made of reused materials (90%) and engaging former inhabitants in social revitalisation and further development of the social facilities and the neighbourhood.

As this UIA Project in Kerkrade investigates the whole pallet of effects that built environment and building construction have on society, economy and the planet, it also enables us to identify important steppingstones for circular building of the future.

This Expert Journal focusses on the new advancements of this unique circular project and elaborates

- construction phase of three Super Circular Estate houses reusing 90% of materials from the donor block next door
- further development of reversible building technology that will enable recovery and reuse of building elements and blokes in future buildings,
- environmental and economic impacts of implemented building technologies
- social engagement and impact of Super Circular Estate Project

2. Testing circular construction techniques during construction of Super Circular Estate houses

The **Super Circular Estate** project consortium has been testing new circular economy processes during construction of three **Super Circular Estate** houses. The construction process aimed at 90% reusing, remanufacturing and recycling of the materials re-sourced from the demolition of an outdated social housing building next door. In order to work towards this goal, the project experimented with new unique deconstruction technique for deconstructing a 10-story high-rise tunnel formwork concrete building in Kerkrade. Three new houses are under construction testing three innovative circular building techniques (direct reuse, remanufacturing and recycling) in order to assess their viability and replicability.

Construction of three Super Circular Estate Houses (Type A, B and C) started in spring of 2019 using re-sourced materials from a neighbouring donor high-rise flat building built in 60's. (Figure 1) A total of 1.380.000 ton of main building materials (wood, concert, ceramics, steel, glass, coper, missionary, plastic, natural stone, aluminium, insulation material) have been harvested form the existing "donor" building recovering 2.330.000 GJ of embodied energy and 287.000 CO2 (ton) embodied in building materials. *(M.Ritzen at all. 2019)*

Figure 1: Construction of three UIA SCE houses in the row, first Type C, Type B and Type A

Figure 2: Type A left house, Type B middle house, Type C right house

The aim of the construction of three new houses was to construct them using at least 75% of reused materials that are re-sourced from the donor building. House Type A has 74m2 and is a two-bedroom house (Figure 2 left). During construction the following circular techniques have been tested:

- Foundation has been made out of circular concreate (aggregate and cement for the concrete which have been acquired by crashing the existing concreate structure, only 7% of new cement has been added during production of concrete for the foundation) (Figure 5)
- main loadbearing structure has been directly reused from the existing building by cutting 3D concrete module from the existing structure, (Figure 3)
- partitioning walls have been directly reused from the exiting building as well as
- wooden frames for doors, finally
- façade has been constructed out of modules using crashed concrete pieces form the existing building (Figure 4)

House Type B is also a two-bedroom house of 74m2. (Figure 2 middle) During construction, the following circular techniques have been tested:

- Foundation has been made out of circular concreate (aggregate and cement for the concrete which have been acquired by crashing the existing concrete structure, only 7% of new cement has been added during production of concrete for the foundation) (Figure 5)
- main loadbearing structure has been directly reused from the existing building by cutting 3D concrete module from the existing structure, (Figure 3)
- partitioning walls have been directly reused from the existing building
- Insulation has been reused form the existing building
- Facade has been made of reused brick modules, which have been cut out from the existing building(Figure 4)

House Type (C) is a one-bedroom house and has 54 m2. (Figure 2 right) During construction, the following circular techniques have been tested:

- Foundation has been made out of circular concreate (aggregate and cement for the concrete which have been acquired by crashing the existing concreate structure, only 7% of new cement has been added during production of concrete for the foundation) (Figure 5)
- main loadbearing structure has been made of circular concreate as foundation
- Facade has been made of circular concreate as foundation (Figure 5)

Three key circular techniques (direct reuse, reuse by remanufacturing and recycling) tested during implementation of SCE project are illustrated in figures 3,4 and 5 below.

DIRECT REUSE

LOAD BEARING STRUCTURE OF HOUSE TYPE A AND B

Figure 3: Recovery of 3D reinforced concrete units from outdated high-rise social housing building built in 60's and placement of 3D units on the foundation of super circular estate houses type A and type B

REUSE BY REMANUFATURING

INSULATION FASADE HOUSE DOOR FRAME, SEPARATION WALLS

Figure 4: Main building materials recovered from the high-rise social housing building from 60's and reused by remanufacturing

REUSE BY RECYCLING

HARVESTED AGGREGATE FOR THE FOUNDATION OF THREE HOUSES

Figure 5: Aggregate for the foundation of three super circular estate houses has been reused from a donor building in the neighbourhood which has been demolished using conventional demolition techniques. Foundation of houses type A, B and C has been made with 100% reused aggregate.

3. Environmental impact of Super Circular Estate House construction

University of Applied Sciences Zuyd has been monitoring the construction of SCE houses and produced report on savings achieved in material, CO2 emissions and energy adding also carbon costs as external cost of construction.

House Type A has been used as a reference house for the calculation of environmental impact of SCE project. (Figure 6) According to the detailed assessment of materials used in House type A total of 20.500 ton of main building materials have been built into the House (table 1).

Material	Quantity (ton)	Embodied Energy (GJ)	Embodied CO2 (ton)	Shadowcosts (€)
Aluminium	2.60E-02	4.03E+00	2.14E-01	5.36E+00
Bricks	3.93E+00	1.18E+01	9.44E-01	2.36E+01
Ceramique	1.04E-01	1.97E+00	1.09E-01	2.74E+00
Concrete	1.96E+02	1.73E+02	2.59E+01	6.47E+02
Copper	3.25E-02	1.37E+00	8.46E-02	2.12E+00
Glass	3.38E-01	5.07E+00	2.91E-01	7.27E+00
Insulation	3.44E-01	1.36E+01	5.85E-01	1.46E+01
Paint	5.52E-02	3.25E+00	1.40E-01	3.50E+00
Plaster	6.24E-02	1.12E-01	8.11E-03	2.03E-01
Plastic	3.77E-01	3.10E+01	1.23E+00	3.09E+01
Rubber	9.84E-01	5.02E+01	3.74E-01	9.34E+00
Steel	1.24E+00	2.27E+01	1.78E+00	4.44E+01
Stone	5.00E-03	1.00E-02	5.80E-04	1.45E-02
Timber	1.23E+00	1.70E+01	1.45E+01	3.62E+02
Total	**2.05E+02**	**3.35E+02**	**4.62E+01**	**1.15E+03**

Table 1: Overview of materials and their embedded energy and embodied CO2 built into House Type A, including shadow costs based on 25€/ton CO2 (M.Ritzen at all. 2019)

Out of 20.500 ton of building materials that have been built into house Type A, 90% has been harvested from the donner building. This is equivalent to saving of 4.621 ton CO2 and 33.500 GJ embodied energy in materials.

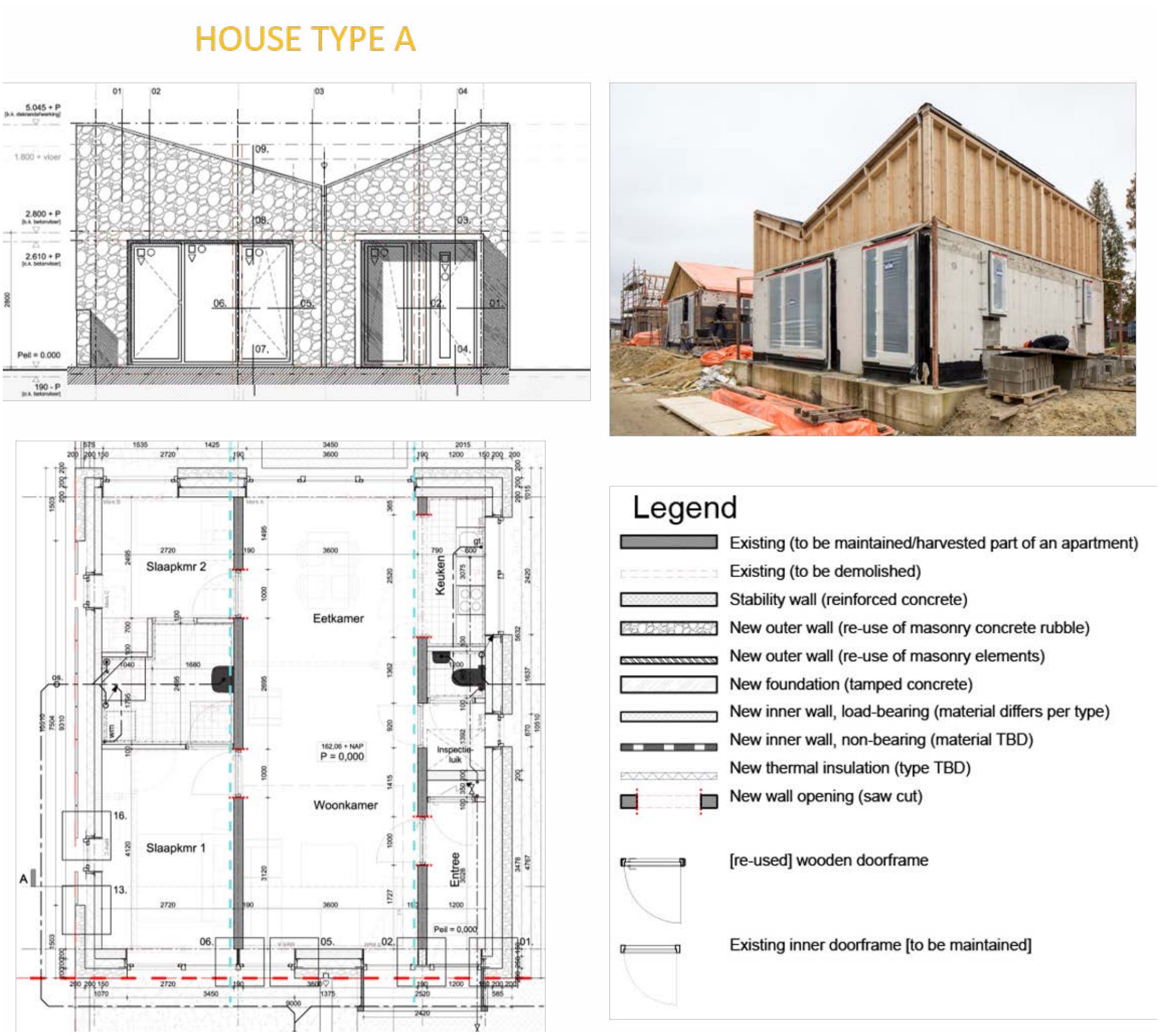

Figure 6: House Type A designed by Bart Creugers from SeC Architecten and constructed by construction company JongenBouw 2019

Main loadbearing structure of Houses Type A, B have been harvested directly as a 3D concrete unit from the donor building. This has been the most costly operation within the project. Recovery of 3D reinforced concrete units from the high-rise flat involved extensive preparation work such as reinforcing apartments around the unit before taking the unit out of the building, reinforcing the unit itself, cutting concrete floors with a diamante saw. The preparations taken on the day itself were following: Set up crane of 750 tons, Set up crane of 500 tons, Set up crane of 100 tons, Last sawing tasks, Preparation of foundation, Prepare lifting construction, Attaching lifting construction to the units, Low-loader onsite parking (Figure 7).

This process represents direct reuse of materials from one building into another by slight reparation (Figure 3).However, as the existing building was designed for linear economy with one end of life option, demolition and downcycling, its materials were not designed for recovery and reuse of parts of the structure. Efforts that needed to be taken in order to deconstruct one flat form a 10-story building were immense and are reflected in the financial feasibility study done by Jeroen Zaad from University of Applied Sciences Zuyd. Results of this study will be elaborated in next chapter.

4. Financial feasibility of circular techniques tested

Super Circular Estate project tested circularity potential of high-rise social housing structure built in 60's and illustrated the effects of circular building approach considering this building typology and material composition. SCE consotrium has done impact analyses of three major reuse techniques on environmental and investment costing. In order to identify the financial feasibility of project student Jeroen Zaad from University of Applied Science Zuyd has developed a calculation method in collaboration with Contractor JongenBouw and deconstruction company Dusseldorp. Since most of deconstruction and remanufacturing techniques have being tested for the first time during the construction itself, it was not possible to asses financial feasibility of the project in advance.

The construction process itself is an important learning point of this UIA project. In order to be able to asses financial feasibility of construction, additional data had to be collected during the construction process such as:

1. Man-hours needed to recover and apply the building product or material and average cost per hour.
2. Additional material needed on top of recovered material in order to create final product for new buildings and market costs of new materials
3. Equipment costs, tools and machinery needed to recover and install recovered/ remanufactured materials and market costs for the use of tools and machinery
4. Information with respect to the existing materials. When using own reused materials, the materials themselves are taken as a grant from the donor building. But in this case, the costs necessary to obtain and edit the materials before they can be used are included in the cost of the material.

In order to compare construction costs of SCE project with conventional construction, a construction of recently built social house with similar typology and material composition has been taken as a reference project.

Methodology that assess financial feasibility of SCE construction considering environmental impact as well, has been developed by student J.J.M. Zaad from Zuyd University of Applied science.

Financial assessment of SCE is a result of mapping parameters determining construction costs (internal costs) and environmental impact of construction (external costs) as listed below.

The environmental impact consists of costs related to:

- Embodied energy saved
- CO2 emissions saved
- Residual value- future value of materials

The cost of a project (internal cost) consists of the following components:

- Man-hours
- Material
- Equipment

(J.J.M. Zaad 2019)

4.1 Data collection for cost determination

Indicators of construction costs (internal circular building costs) are man-hours, equipment and material. In order to calculate how many man-hours are needed to realize specific technique, the construction process has been analyzed with the use of construction-task-roadmap of deconstruction and construction indicating necessary steps. The time associated with the steps in the roadmap are created through calculation standards or field research at the construction site by University of Applied Sciences Zuyd (Figure 7).

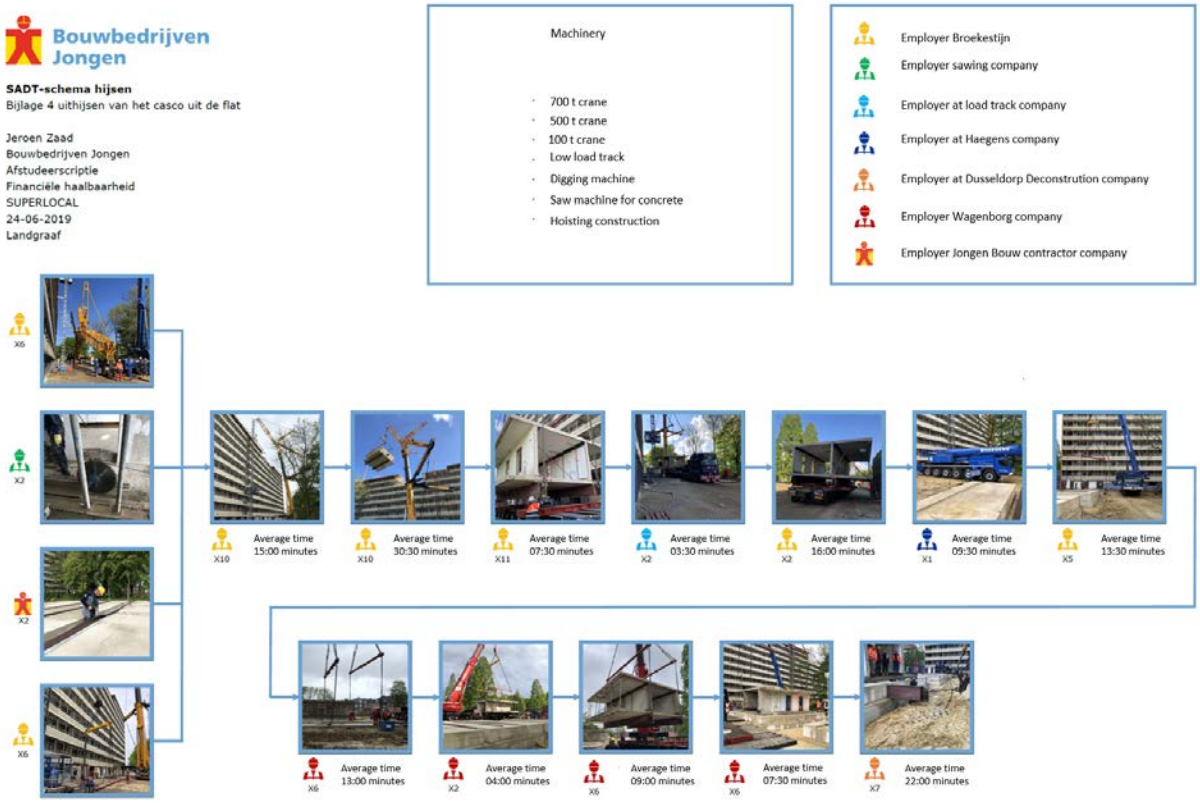

Figure 7: Execution and implementation roadmap (direct reuse of concrete modules) used to asses required man-hours, equipment and material per deconstruction process and construction technique (J.J.M. Zaad 2019)

In order to carry out the process, equipment is also needed. This could be small hand tools, but this can also be the rental of a crane. The costs for additional materials have also been mapped. This is done by calculating the amount of additional material required. Prices are then searched or requested for at permanent suppliers of Bouwbedrijven Jongen.

Indicators of external circular building costs are costs associated with CO_2 emission (Dutch price is set at € 0.025 per kg CO_2 (Finanzen, 2019)), energy embodied in materials equivalent to the cost of energy needed to produce material and residual value.

Residual value is the amount that a product will generate when applied again in the new project in a future.

Three ways to generate residual value from existing buildings have been tested in SCE project.

Reuse: the materials or products are reused 1:1 by means of minor reparations. This means that materials are fully functional and can be directly reused.

Remanufacturing: the products or materials are disassembled into separate parts. These are then re-used to create a new product. This means that product does not have a value as a product but can retain some value at element level.

Recycling: In the case of recycling, the products or materials are again used as raw materials. When upcycling, these raw materials are used for an equivalent or even better product. When downcycling, the raw materials are used with a lesser value than it had before.

Based on the above definitions University for Applied Science Zuyd in collaboration with contractor JongenBouw and deconstruction company Dusseldorp has attached value percentage to the three circular processes.

1. Re-use between 76 % and 100 %
2. Remanufacture between 51 % and 75 %
3. Recycle
   3a. Upcycle between 26 % and 50 %
   3b. Downcycle between 0 % and 25 %

The market price of the products is then searched or requested. This market price is multiplied by the assumed percentage specified above. After the costs of deconstructing the product have been deducted, the amount left is the residual value.

4.2 Cost comparisons

As a part of monitoring and measuring of SCE impacts cost calculations have been made of different insulation, concrete and facade techniques applied in the SCE project. Cost calculations took into account internal (construction cost) and external (environmental costs) as defined in chapter 4.1.1. Bought costs put together represent integral costs of Circular Building.

4.2.A Construction and Environmental costs of three insulation techniques

After analyses of six possible solution for the insulation of three SCE houses, the SCE consortium has decided to apply following insulation solution on three houses:

Type A – Stone wool insulation

Type B – Reused insulation from the existing flat building

Type C – Isovlas

Reference house PlusLivin, which is used to compare SCE costs with costs of conventional construction, used Glass Wool.

The table below illustrates cost indicators of circular building and their prices for placing the insulation on SCE houses.(Figure 8) The cost indicators are man-hours, the material and equipment costs, as well as the costs incurred for the environmental impact such as cost of CO2 emissions, residual value and embodied energy. The minus sign in table stands for benefits, this means that the money is saved. This is usually the case when material can be used multiple times with minor effort.

Figure 8: Tested insulation technologies used for financial feasibility

Prices per component	Stone wool insulation	Reused insulation from the flat	Isovlas	Glass Wool of PlusLiving
Man-hours	€ 1.286,22	€ 2,999.99	€ 271.20	€ 876.12
Material	€ 2,041.85	€ 804,00	€ 1,047.93	€ 1.650,40
Materiel	€ 157.30	€ 257.30	€ 49,20	€99.20
Subtotal cost	**€ 3,485.37**	**€4,034.55**	**€ 1,368.33**	**€ 2,625.72**
CO2 emissions	€ 24,73	€ 0,00	€ 13,23	€8.51
Residual value	€ - 426,25	€ - 1.160,00	€ - 141,59	€ 0,00
Embodied Energy	€1,011.32	€ 30,09	€ 785.45	€ 451.25
Subtotal Environmental cost	**€ 609,80**	**€ - 1.129,91**	**€657.09**	**€459.76**
Price				
Total price	€ 4,095.17	€ 2,904.6	€2,025.42	€ 3,099.99
Total price / m2	**€27.38**	**€19.42**	**€ 32,28**	**€ 40,07**

Table 2: Financials feasibility of insulation techniques (J.J.M. Zaad 2019)

Based on the m2 price per insulation technique, it can be concluded that reuse of the existing insulation material in House type B is environmentally and ultimately financially more beneficial than any other insulation. The reason for this lays in benefits related to the environmental costs as zero CO2 tax, low energy cost and high residual value. Although recovery of insulation material is labor intensive and material itself is therefore very expensive, external costs (environmental costs) are much lower resulting also in much higher environmental benefits.

4.2.B Construction and Environmental costs of concrete techniques

Within SCE project three techniques to reuse the concrete from the existing flat building were tested. The first technique is about reusing current structure as 3D module from the flat building. One complete apartment was lifted out of the flat and used as a loadbearing structure for new houses. The second technique is circular concrete made of the concrete debris coming from the existing flat. In order to make a new concreate a minimum amount of water, cement and plasticizing agent has been added (18% of added, 82% reused). The third technique is specially designed concrete block “Briks” for dry assembly (designed by Pieter Scheer, Dusseldorp). With “Briks” blokes a wall can be assembled without using glue or cement. The fourth technique is the use of prefabricated concrete applied in reference building PlusWonen. (Figure 9)

Figure 9: Tested loadbearing technologies used for financial feasibility (J.J.M. Zaad 2019)

Prices per component	Reused unit from the flat	Circular concrete	Briks	Prefabricated Concrete PlusLiving
Manhours	€ 14,791.38	€ 8,064,67	€ 8,067,33	€ 1.440,00
Material	€ 19,999.99	€ 12,678.01	€ 3,719,40	€ 8.039,20
Materiel	€ 99,000.00	€ 13,857.73	€ 18,155.44	€1.355.00
Subtotal cost	**€101,632.91**	**€ 34.600.41**	**€29,942,17**	**€ 10,834,20**
CO2 emissions	€256.48	€ 86.89	€19.86	€ 236.84
Residual value	€ - 2,495,74	€ - 730,54	€ - 630.36	€ 0,00
Embodied Energy	€ 4,138.17	€ 1,199.99	€313.56	€ 3,000.00
Subtotal Environmental Costs	**€ 1,898.91**	**€ 484.94**	**€ - 296,94**	**€ 4.094,70**
Price				
Total price	**€ 103,531.82**	**€35,085.35**	**€29,645,23**	**€ 14,928.90**
Total price per m³	**€ 2,607.99**	**€ 883.76**	**€ 2,687.69**	**€ 878.17**

Table 3: Financials feasibility of concrete techniques (J.J.M. Zaad 2019)

M3 prices in the table indicate that circular concrete has future potential, Briks blokes have been developed only as a first prototype. The price of Briks is a bit misleading here since the table indicates price per m3 while one concrete wall can be made with much less concrete when using Briks modules due to their hollow geometry. Furthermore, price of “Briks” blokes can be reduced drastically by future optimisation of the technique. Homeware financial feasibility of direct reuse of 3D concrete structure that has been cut out of the flat building will be a great challenge due to very costly equipment needed.

4.2.C Construction and Environmental costs of façade techniques

A total of three different exterior facades are tested within the SCE project. The first exterior façade is made of crashed concrete pieces and will be applied in house type A. Type B House will have a facade made partly of blokes of missionary that have been cut out the of existing buildings. The exterior façade of type C house is made of circular concrete as described in the paragraph above. Reference PlusWonen house has regular masonry facade wall. (Figure 10)

Figure 10: Tested facade technologies used for financial feasibility (J.J.M. Zaad 2019)

Prices per component	Crashed concrete	Reused masonry	Circular concrete	Masonry PlusLiving
Manhours	€ 12,746.70	€ 12,888.92	€ 2,843.92	€ 7,194.80
Material	€ 3,634.35	€ 73,211,02	€ 9,047.12	€ 3,994.97
Materiel	€1.165.00	€ 1.141,00	€ 12,435.98	€ 691.00
Subtotal cost	**€ 17,546.05**	**€ 87,240.35**	**€24,327,02**	**€ 11,880.77**
CO_2 emissions	€66.29	€8.16	€66.87	€163.16
Residual value	€ - 753,47	€ - 3.294,55	€ - 1.475,14	€ 0,00
Embodied Energy	€ 1,146.64	€ 260,60	€ 805.37	€ 5,211.98
Subtotal Environmental Cost	**€459.46**	**€ - 3.025,79**	**€ - 602,90**	**€5,375.14**
Total price	€18,005.51	€ 84,214.56	€23,724.12	€ 17,255.91
Total price / m2	**€127.13**	**€ 594.61**	**€167.51**	**€ 121.84**

Table 4: Financials feasibility of façade techniques (J.J.M. Zaad 2019)

Based on m2 prises of façade techniques crashed concrete modules and circular concrete do have future potential and their production can be optimised. Reused masonry modules turned out to be very expensive primarily due to the expensive cutting technique that need to be applied. Potential future improvement can be made in optimisation of the size of modules and cutting technology.

5. Social circularity

Besides material reuse and technical circulate, the SCE project looks at social aspects of circular economy as well and work on social cohesion and social circularity within the SCE neighbourhood. Former and existing tenants are involved in the co-design, and monitoring of new services to support the transition towards a sharing, reuse and repair community model. One of the objectives of SCE project is to reinforce liveability, social cohesion and continuity in the neighbourhoods by structured communication with former inhabitants and encouraging their return to the neighbourhood. With that in mind, housing cooperation HeemWoonen organises regular meetings with inhabitants and informs them about the ambition, progress of the project and the planning.

Figure 11: Reunion of former inhabitants HEEMWonen 2019

On 8 May 2019, housing corporation HEEMwonen organised a reunion with the former residents and informed them about the planning of SCE project and follow up projects (Figure 11). Housing cooperation invited all former inhabitants to register and fill in the form declaring whether they would be interested to move back into one of the circular building houses. 220 former inhabitants were invited to the reunion and 48 have attended the reunion on 08 of May 2019. At the end of the day, 11 former inhabitants showed interest in moving back to their old neighborhood and 2 declarations of interest were received later on. (Figure 12)

Next opportunity to communicate with former inhabitants will be organised during the official opening of the three Super Circular Estate Houses in 2020. Inhabitants will have a chance to see and feel the space and materials of three circular houses and communicate their view and perceptions with housing cooperation.

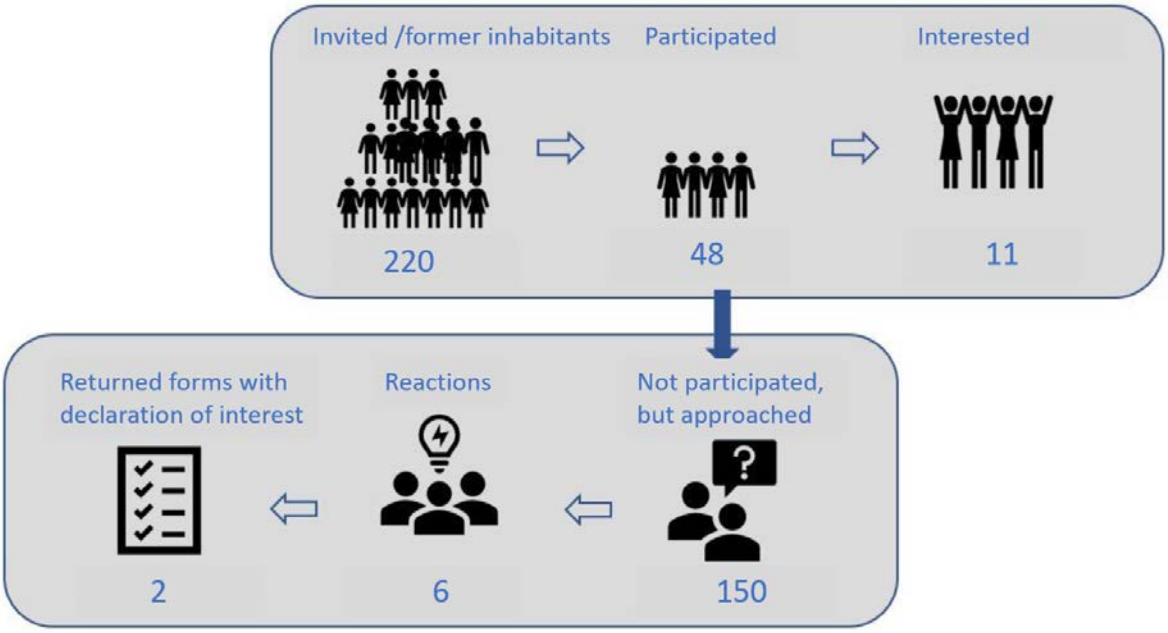

Figure 12: Summary of response of former inhabitants and declarations of interests to move back after completion of SCE and follow up projects. (HEEMWonen 2019)

6. Lessons Learned and future challenges

In order to reach the goal, set up by the Super Circular Estate consortium and contribute to a sustainable, low carbon, resource efficient economy by creating high-quality and affordable housing based on breakthrough innovative material, the consortium has faced many challenges on a way.

Key takeaways:

- Uncertainty with respect to the process of deconstruction, time and effort needed to refurbish/remanufacture components cause delays. More accurate assessment of the quality and process is needed beforehand in order to increase efficiency in time and reduce costs.
- Major obstacle for effective deconstruction of the building and its parts lays in the way the building has been constructed in the first place. Materials and building products were not assembled with the aim to recover and reuse them after initial use life. One of the key lessons learned is that it is crucial to build new circular buildings with recovery and reuse in mind.
- Besides testing deconstruction, remanufacturing and recycling techniques during SCE project a new circular product has been designed and developed. Bricks module is designed to be assembled and disassembled without using heavy equipment nor cement and glue. Its hollow geometry enables enormous savings in material while the geometry of product adages enables complete dry assembly and disassembly technique to be applied. This new product is tackling the core of future circular building technology. The module itself is made of recycling aggregate from the existing building. It needs further optimisation, but its rationalisation can reduce its product costs and increase its reuse potential in future buildings.
- Circular concrete has also been one of the future proof techniques that have been tested within the Super Circular Estate project. Financial feasibility study indicates that this technique has brought economic and environmental benefits already. This technique has already earned number of spin off projects in the Netherlands.
- Based on the techniques that have been tested within the project so far, it can be concluded that standardisation of deconstruction and construction processes, luck of deconstruction protocols as well as understanding of the reuse potential of materials and residual value beforehand, are main bottlenecks for the effective reuse of the existing materials in construction today.
- Regular communication with inhabitants results into a positive engagement of existing and former inhabitants into the process of transformation of a neighbourhood and contributes to social cohesion, positive image of the neighbourhood and return of its inhabitants.

CHALLENGES	LEVEL	OBSERVATIONS
Leadership for implementation	Low	SCE project continues to have a strong coherent leadership. Leadership of SCE process is about continually stimulating partners to be innovative and to investigate options which are beyond the work as usual. This has resulted into relatively smooth process and completion of objectives so far. Project of such scope and ambition will always experience delays. Delays within SCE project have been handled by timely identification of potential delays and regular communication with the partners involved with deliverables that might be postponed. Regular communication helped leadership to understand the context and circumstances causing delay and whether delays are of internal or external nature and will impact other deliverables. Based on that, a joint solution has been carefully tailored with the consortium in a way that would avoid negative impacts on the final results.
Public procurement	Low	Important procurement issues have been addressed in earlier project phases.
Integrated cross-departmental working	Low	There is a strong commitment and understanding within organisation across different departments within urban authority. This has resulted into relatively smooth deconstruction and construction of the three houses. SCE consortium benefited from strong support of the building permit department and all related deportments involved with safety, security and environmental issues of the project. They were jointly working on finding a practical solution for innovations, often reaching outside of their own department or even municipality and raising the question even up to the level of national government. Those were cases as for example using gallery floors as a pavement or using existing construction units as elements for new housing, both being in contradiction with the existing regulations.
Adopting a participative approach	Low	High levels of participation evident across stakeholder groups. For this project to succeed, strong participation and engagement of both public and private partners in joint building team has been proven to be very effective and stimulating for all partners involved. This resulted in a number of new initiatives by private partners as development of a new technology as well as joint public/private initiative such as preparation of market for selling of materials form SCE project. Consortium has also put more effort during the last six months in involving inhabitants in decision making around the development of shared facility and future development of the neighbourhood.

Monitoring and evaluation	Low	Monitoring of financial feasibility and environmental impacts of tested deconstruction and construction techniques has been completed successfully. The results of the monitoring will be used for the elaboration of scaling up opportunities of different techniques. Monitoring of social acceptance will be finalised after the opening and proof testing of the tree SCE houses in 2020.
Communicating with target beneficiaries	Low	The progress and activities of the project have been promoted extensively on the social media, websites, newspaper. The focus has also been on communication with existing and former inhabitants and reunion. This has resulted into an active group of existing inhabitants, which are involved with development of social / shared space and communication of results to their neighbours. Besides, number of former inhabitants have declared interest of returning back once the circular buildings are finalized. Out of 220 invited inhabitants 48 participated and 11 showed interest in moving back. This has been seen as a good result considering that all 229 former inhabitants had to move to other neighbourhoods and apartments (couple of years ago) and have already settled in their new homes and neighbourhoods. Nevertheless, consortium is organising a big public event in conjunction with the official opening of the three houses. This will be a new opportunity to communicate the results of the UIA project but also to communicate the planning of construction of new houses. Well organized promotion of the project has brought the recognition of the project on national and international level positive image of the project.
Upscaling	Medium	Implementation of different circular deconstruction and construction techniques and financial feasibility of SCE houses provided good indication of potential scaleup opportunities. Construction company JongenBouw is already working on scaling up circular concrete technique and deconstruction company Duseldorp in developing the circular Briks module further for the new applications. Housing Corporation HeemWonnen is preparing construction of other 15 circular homes as a follow up on SCE project. More detailed analyses of short term and long-term strategies for scaling up testing techniques will be elaborated in 2020.

7. Conclusion and next steps

SCE consortium has tested and measured the environmental and economic impact of nine different circular construction techniques developed during construction of three SCE houses. Nine circular building techniques have been applied on three building functions: insulating, loadbearing and enclosing. For each of the mentioned building functions, one of circular methods of construction different reuse and recycling scenario have been tested from a donor building, such as: (1) direct reuse, (2) remanufacturing or (3) upcycling. Their economic and environmental impacts have been compared with conventional methods of construction in order to get first insides into the future potential and financial feasibility of innovative solution.

Next journal will focus on more in-depth analyses of future potential of tested circular construction techniques and their possible field of implementation and scaling up.

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Urban Innovative Actions (UIA) is an Initiative of the European Union that provides urban areas throughout Europe with resources to test new and unproven solutions to address urban challenges. Based on article 8 of ERDF, the Initiative has a total ERDF budget of EUR 372 million for 2014-2020.
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