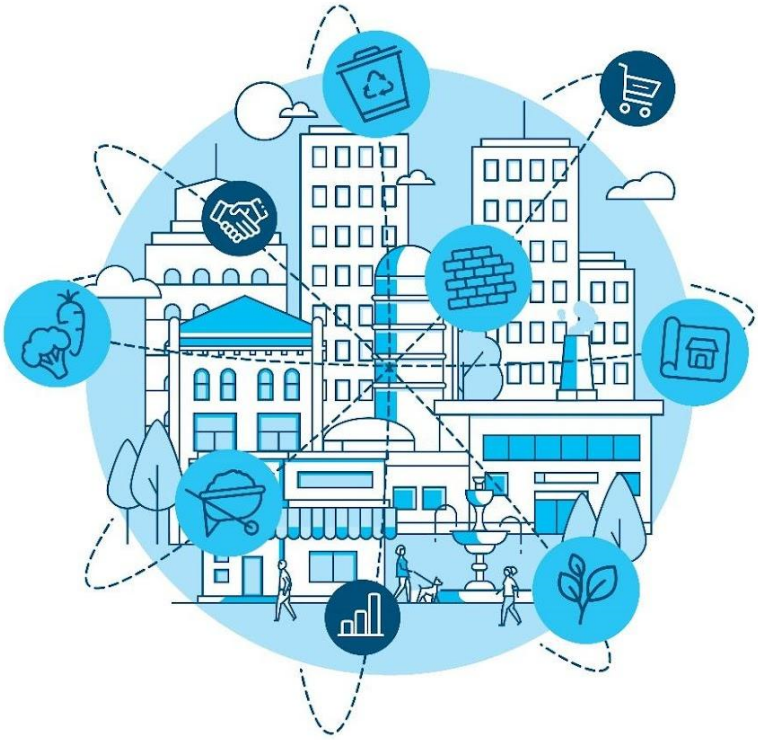
CIRCULAR CDW in Apeldoorn

Demonstration Report

Municipality of Apeldoorn



Version	1.2
WP	2
Deliverable	D2.6 CDW: Demonstration Report for Apeldoorn
Date	July 21th, 2023
Dissemination level	Public
Deliverable lead	Municipality of Apeldoorn
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Abstract	From 2019 till 2023 the Municipality of Apeldoorn and Saxion UAS had within the Horizon 2020 CityLoops project the opportunity to experiment in renovating a residential road as circular as possible. Our efforts, experiences and results in changing people, techniques and processes from a social, economic and ecological perspective are brought together in this demonstration report.
Keywords	circular, road renovation, demonstration, municipality, research
License	

Contents

List of abbreviations

3DBag	Three dimensional model ‘Basisregistratie Adressen en Gebouwen’ (Key Register Addresses and Buildings)
AP04	AccreditatieProgramma voor keuring van partijen grond, bouwstoffen en korrelvormige afvalstoffen (Accreditation Program for soil, construction materials and granular shaped waste)
BOM	Bill of Materials
BSS	BetonStraatSteen (Concrete Paving Stone)
CDW	Construction and Demolition Waste
CE	Circular Economy
CO_2	Carbon dioxide emissions
CO_{2e}	Carbon dioxide equivalent emissions
D-CENT	Decentralized Citizens Engagement Technologies
EME	Excess Materials Exchange
EPSG	European Petroleum Survey Group
EWC	European Waste Catalogue
GBI	Gemeentelijk Beheer Informatiesysteem (municipal asset management system)
GIS	Geographic Information System
GPS	Global Positioning System
KPI	Key Performance Indicators
LoD	Level of Detail
MKI	MilieuKosten Indicator (Environmental Costs Indicator)
MLM	Material Loops Matrix
PBL	PlanBureau voor de Leefomgeving (Netherlands Environmental Assessment Agency)
PLM	Partner Loops Matrix
RAW	Rationalisatie en Automatisering Grond-, Water- en Wegenbouw (Dutch specifications framework for civil engineering projects)
SaaS	Software as a Service
SAST	Saxion research group ‘Sustainable Areas and Soil Transitions’
SLM	Strategy Loops Matrix
UAS	University of Applied Sciences

1. Executive summary

1.1 Introduction

During the last four years, the Municipality of Apeldoorn, located quite centrally in the Netherlands, was able through the H2020 CityLoops project to take part in a circular transition process. This process took place in close collaboration with European partners, both municipalities and other organisations. In this circular transition process the focus was on closing the loops for both organic waste, as well as construction and demolition waste (CDW). In this report, we share the experiences and results regarding CDW. All Apeldoorn's CDW demonstration actions took place in close collaboration with Saxion, a Dutch university of applied sciences. The demonstration actions were all related to a residential road renovation project at Griffiersveld (see Figures 1.1 and 1.2 for the before and after situation).

***Figure 1.1**. An impression of the residential road Griffiersveld before renovation.*

***Figure 1.2.** Parking space after renovating Griffiersveld where old concrete pavers were reused*

As road renovations are common practice in many municipalities, the tools developed and lessons learned in this specific case will allow copying and scaling up in other projects. In our analysis, we build on theories of transition management. Specific attention is paid to the way Apeldoorn builds its internal and external coalitions, as this has proven to be to be difficult and essential. The demonstration actions of the Municipality of Apeldoorn concerning and concentrating in Griffiersveld involved three perspectives:

- societal perspective: a co-design process to align stakeholders and a participation trajectory with residents;
- technical perspective: developing material depots, adopting material passports, collecting road data and visualizing data;
- economic perspective: developing a CO_2 transport indicator, business models and online matching platforms.

All resulted in a particular physical appearance of the renovated residential road, accompanied by digital models and many lessons learned in line with the intentions of the CityLoops Optimized Implementation Plan (OIP) of May 3th, 2021 (Lubberhuizen and Entrop, 2021).

1.2 New approaches and instruments

In the H2020 CityLoops project the municipality adopted multiple new approaches and applied different new instruments, as is explained in this demonstration report. Information about these experiences is laid down in five separate factsheets, conference papers, student reports, study reports and in this demonstration report. Annex A provides an overview of the output related to the demonstration project in the Municipality of Apeldoorn.

A *first new approach* for the municipality was to align stakeholders in a co-design process with a focus on closing material loops. Traditionally, these residential road renovation design processes are done internally. By letting external stakeholders participate early in the design process, in a so called process journey facilitated by Koos Service Design, we noticed an increased awareness and knowledge amongst the different stakeholders on roles, tasks and perspectives. By bringing these stakeholders together in one group, awareness was increased on the cross-connections in the project. Ideas to improve circularity were generated and many were implemented (see Section 4.1.1). *A second new approach*, one to acquire knowledge about material qualities and quantities, involved automated scanning. Traditionally, a non-automated visual inspection was conducted by an inspector walking around on site. Various new scanning equipment and procedures were used to automatically collect data on the status of road materials in Griffiersveld. It was experienced that it requires quite some steps to store this automatically retrieved data in the asset management software of the municipality (see Section 4.3). After the project was executed also a camera equipped drone navigating on basis of GPS set points was used to scan the materials in place. A *third new approach* was to make circularity part of the procurement process. A small financial incentive was provided, improving the change for a contractor to get the renovation project, when circularity was taken into account. In one A4 page the contractors were allowed to set out their own ideas to close material loops and to reduce the environmental impact of the project (see Annex D). During the project, the contractor helped in collecting data on distances driven enabling Saxion and the Municipality of Apeldoorn to assess CO_2 emissions (see Section 4.4 and 4.6). A *fourth new approach* is the implementation of physical and virtual material depots. Just like in many municipalities in the Netherlands, a soil and sand site are already available for many decades, but new physical material depots with different used products for Apeldoorn's public space were opened. These are at the disposal of contractors working for the municipalities and her own departments. Virtual relates to miscellaneous online material platforms, sites and applications. The Municipality of Apeldoorn now works with the matching tool DuSpot to match the used material supply and demand (see Section 4.2 and 4.5).

When the new preliminary circular road designs were available, the municipality started to inform residents using a, fifth, new approach. Due to covid regulations, it was not possible to get the residents involved more actively in an earlier stage of the project or in the process journey. By organising an event called 'sustainable doing day' for the residents and providing them information through letters, a brochure and a poster presentation, it is expected that the residents of Griffiersveld were more engaged with the circular aspect of the reconstruction of the road. The local social housing association, energy coaches and the contractor were participating in the event (see Section 4.1.2).

1.3 Results

The result of the circular demonstration project is physically clearly present. The ambition was to renovate a street or section of at least 3000 m^2. In total a paved surface of 4.785 m^2 was renovated, without taking the surface of the kerb stones into account. For the road's foundation much sand stayed onsite, instead of bringing in debris from elsewhere, and 500 m^2 of onsite concrete pavers were reused in this residential road renovation project. The road Griffiersveld was renovated with 49 tonnes less CO_2 equivalent emissions than normally would be the case. Old concrete pavers, concrete tile slabs and some kerb stones were reused within the municipality and only two containers left the site with concrete waste materials to be recycled to aggregates for new concrete mixes.

H2020 CityLoops brought us an increased knowledge and awareness within the municipal organisation of Apeldoorn, by means of circularity now being part of design and procurement processes. The municipality is now facilitating multiple material depots, using asset management software as a project passport, and has adopted an online matching application.

External to the municipal organization, multiple residents and companies now have experienced that closing material loops is clearly a new focal point. Taking circularity into account offers new opportunities to reduce your environmental impact, to reduce costs or to increase turnover. The Municipality of Apeldoorn and Saxion UAS organised multiple events and participated in local, national and international events to actively disseminate the derived experiences and insights.

On the other hand, also some obstacles were experienced during the demonstration project. We were not able to turn the decision to apply a new brown concrete paver because of the requirements set by the welfare committee. If they agreed we could had reduced the project's environmental impact by 174 tonnes of CO_2 equivalent emissions. This new paver chosen for aesthetic reasons by the urban planner to replace for approximately 90% the old worn out pavers did not encompass any recycled concrete aggregates; only virgin materials were used. Furthermore, used concrete products are generally low valued, while their handling and transport are quite labour intensive and costly. Old usable concrete pavers and curb stones needed to be provided to local agricultural organisations for free or else downcycling by means of crushing it into a concrete aggregate would be the only option.

1.4 Lessons learned

Within CityLoops, the Municipality of Apeldoorn introduced the residential area Griffiersveld, as a casus to test tools and to come to circular road renovation. Trying not to fall into repetition, a few important lessons are shared in this section.

Have a structure in place for (automatically collected) project and material data
The Municipality of Apeldoorn has by means of her asset management system, a structure in place to store relevant quantitively and qualitative information on road materials for a specific road or road section. It is this data that makes up the project passport for Griffiersveld after automated data collection had taken place. It could speed up the circular transition, if other (municipal) organisations know that such an existing system can be used to facilitate them in the transition; it might not be necessary to develop completely new information systems.

Road scans can provide additional insights in the status of road materials and 3D-GIS-data can be used to assess the volumes of material to be moved, indicating the workload and simplifying the planning process. However, developments are still needed to interpret data and to further automate data storage.

Short lines between principal and a committed contractor
In the procurement process, the municipality, as a principal, clearly asked for circular ideas and measures. The bidding contractors were willing to make an effort to explain what vision they have regarding the renovation process, time management and circularity in the renovation of Griffiersveld. The winning contractor offered in total nine measures to improve circularity (see Annex D). For example keep the sand which lay under the pavement, because the quality is still good for the use of the street; use the bricks: crush them and use them for water collection. By actively implementing three out of nine measures the environmental impact was significantly reduced. Three measures were not adopted due to the extra costs. One measure regarding a online material matching tool was implemented by the end of the project. One measure out ruled another one and about one measure communication was lacking. When a project is being executed, it is important that the principal stays in close contact with the contractor to make sure that all measures are being implemented. The sunny side in this project was that by applying two measures very successfully, namely the reuse of concrete paving stones nearby and the reuse of sand as a foundation, two other measures were hard to implement.

During the execution of the renovation, it was experienced that the main contractor was able to recognize various practical possibilities within its network to reuse materials instead of considering them as waste. For example the bricks could be reused for a local farmer. These possibilities were recognized at short distances from the project location and were arranged within a short time. It was estimated that more than 90% of all 3.785 m^2 concrete pavers have been reduced within the municipal boundaries. The lesson learned here is to as a principal be open to the practical ideas of the contractor and maybe even other organisations in the field.

Know what's in store and what can be put in store to others

The online marketplace and experiences with Excess Materials Exchange (EME) were focusing on this demonstration project. When it was noticed that the online matching tool DuSpot has some advantages compared to these two, the matching tool became available to enable material loops in municipal projects to be closed. The material depots of the municipality are also spots in DuSpot, so that one can see what's currently in store.

1.5 Scalability and replicability

Many of the materials used in the construction industry will not quickly or easily regrow. The last thing we want is the project Griffiersveld to be a first and last demonstration project of how to close material loops in the built environment. For this reason many of the CityLoops experiences in the Municipality of Apeldoorn were disseminated in Dutch locally and nationally and in English internationally (see Figure 1.3 and 1.4 for two examples of meetings and see Annex A for a list of knowledge dissemination products). Knowledge dissemination took place by means of events, presentations, a brochure, posters and papers. LinkedIn also proved to be a valuable platform to share our insights and experiences. A number of international scientific conferences were visited and conference papers were published with open access.

Figure 1.3. *A circular network meeting organised by the Municipality of Apeldoorn on October 6, 2022.*

Figure 1.4. *The CDW study visit to Griffiersveld with the CityLoops consortium on October 11, 2022*

The Municipality of Apeldoorn and Saxion UAS also were in contact with other European cities. Saxion architectural engineering students even visited CityLoops-partner Bodø to participate in a design challenge to reuse airport facilities. One particular Spanish municipality Valles Occidental was assigned as a twin to Apeldoorn. In September 2023 Apeldoorn will visit Valles Occidental and will organise several workshops.

2. City context

Apeldoorn is the city of 'the Veluwe'; a forest-rich ridge of hills that is considered as the Netherlands finest area of natural scenic beauty. Its surface of 339.96 km^2 accommodates 165,611 inhabitants; the 11th city of the Netherlands. The inhabitants make up 77,970 households, that use on average 1,200 m^3 of natural gas and 2,830 kWh of electricity. Apeldoorn holds 15,310 companies offering 104,000 employees a job. The democratic structure is comparable to other municipalities in the Netherlands.

A board of one mayor and five aldermen executes the policy guidelines set by the local council, which holds 39 seats. Within the municipal organization a board of directors, consisting of one municipal secretary and four theme directors, manages around 1,300 civil servants. The strategy of Apeldoorn has been laid down in a vision called 'Woest aantrekkelijk Apeldoorn'. It mentions the following challenges (Apeldoorn, 2021):

- An expected increase to a total of 180.000 inhabitants for which an additional 12.500 houses are needed;
- An increase of the business parks by 80 ha;
- An increase of spatial green and blue areas (not mentioned how much), paired with an increase of biodiversity and a decrease of nitrogen emissions;
- An increase of shared and sustainable mobility;
- A decrease of areas devoted to intensive farming

In the Netherlands municipalities are by law responsible for the collection of waste of civilians, but the actual waste collection, separation, recycling and incineration activities are often carried out by privately owned companies. The government often operates as a principal. Private companies need to take care of their own waste, which is collected by private companies they contracted. Very little is known about how much waste goes from these companies to the waste companies. What is known, is shown in Table 2.1. The total of unseparated waste is 87,5 kg per inhabitant and separated waste is 349 kg. A target of 80% waste separation is set by the municipality. In 2022, a value of 75% was met. The municipality's policy is to reduce waste and to increase the level of separation by conducting awareness and sense of urgency campaigns. A project like CityLoops contributes to the realisation and that you need to use materials wisely by reducing your need for virgin materials, reusing products, using bio-materials and recycling waste materials.

Kg per inhabitant	2022	2021
Inhabitants	165,586	164,770
Unseparated		
Residual waste	66.8	62.1
Bulky waste	24.6	24.8
Separated		
Garden, vegetables & fruit waste	131.9	155.1
Paper & cardboard	50.8	56.3
Packaging glass	23.5	25.0
Plastic, metal & drink cartons	41.8	50.5
Textile and clothes	4.8	4.8
Diapers	5.2	4.8
Electric waste	5.4	5.6
Organic waste	5.2	5.9
Others	38.2	41.0

Table 2.1. *Waste figures in Apeldoorn (Circulus, 2023).*

In this report we focus not on household waste, but on sand, construction and demolition waste. The construction industry is known for its huge environmental impact. Within the CityLoops consortium Metabolism of Cities was able to collect data on how much materials are stored in Apeldoorn's built-up environment (Metabolism of Cities, 2023a). In the neighbourhood De Maten, where our demonstration project area Griffiersveld is located, houses contain easily 60 to 90 tonnes of materials each. The total amount of materials (in tonnes) stored within the building stock is shown in Figure 2.1. However, the built environment consists of more objects than buildings alone. The demonstration project in Apeldoorn considers the renovation of a residential road mainly consisting of concrete pavers.

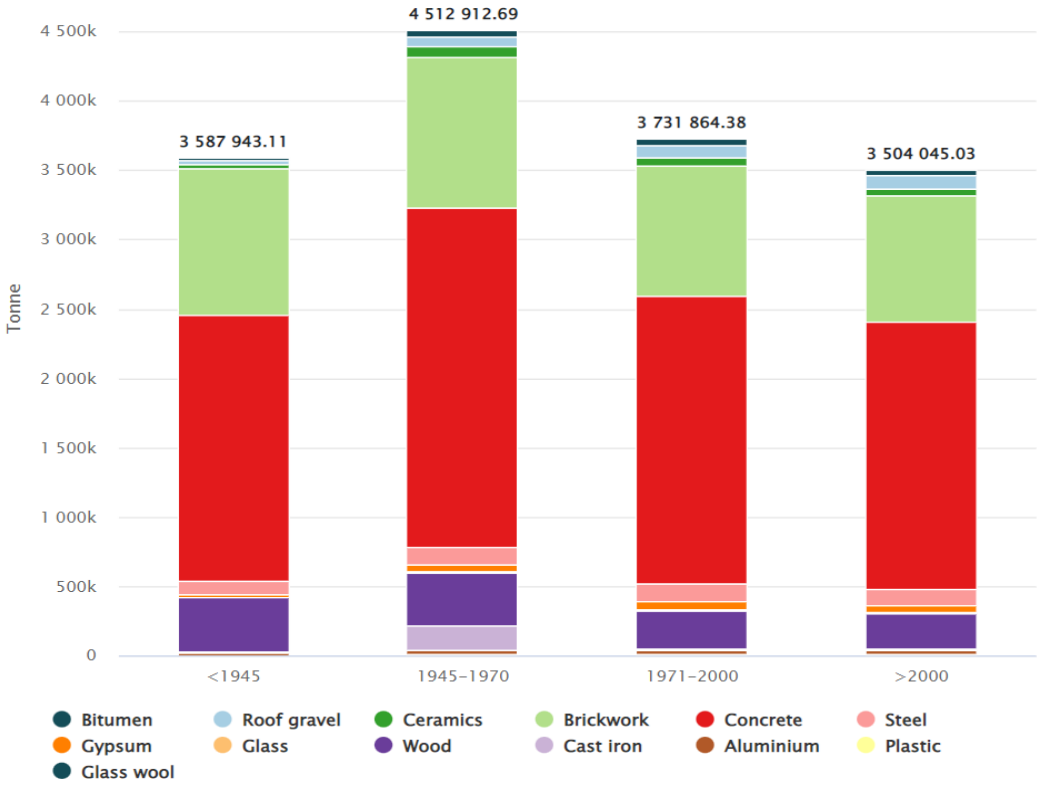


Figure 2.1. *Overview of materials stored in the building stock of Apeldoorn (Metabolism of Cities, 2023b).*

3. Implementation

In Apeldoorn the CityLoops Demonstration project concentrates on the challenge to renovate as circular as possible a paved road named Griffiersveld, as well as the public space directly surrounding this road. Constructed in 1976, this road is located in a residential area called De Maten. The budget for the future contractor to team up in the last phase of the design process was set at € 50,000 and for executing the renovation € 500,000 was set aside. Before renovation, the winding road Griffiersveld (see Figure 3.1) consisted of concrete pavers and concrete paving slabs covering a surface of approximately 4,785 m^2 (see Table 3.1 and Figure 3.2 for an impression).

Table 3.1. *Overview of materials coming available and needed in Griffiersveld.*

Products	Coming available from Griffiersveld	Needed to renovate Griffiersveld
Concrete kerb stone 100 mm x 200 mm	585 m	625 m
Concrete kerb stone 120 mm x 250 mm		75 m
Concrete lawn border 120 mm x 250 mm	805 m	760 m
Grey concrete paver	3185 m^2	
Anthracite concrete paver	535 m^2	
Brown concrete paver		3560 m^2
Grey/anthracite double paver	65 m^2	65 m^2
Black/basalt double paver		190 m^2
Concrete paving slab 30 cm x 30 cm	1000 m^2	75 m^2
Brown concrete paver for parking space		370 m^2
Reused grey concrete paver for parking space		500 m^2

Figure 3.1. *The particular residential area with its winding road Griffiersveld.*

Figure 3.2. *Impression of the local situation at Griffiersveld in the Municipality of Apeldoorn before renovation.*

Policy at the Municipality of Apeldoorn is that the current status of her roads is recorded in an asset management software system. Once every two years, a visual inspection takes place on site. The results of these inspections are recorded within the asset management system.

After a fixed number of years, as well as on the basis of a bad result at an inspection or due to complaints from users, maintenance and renovation activities are being planned. Griffiersveld qualified for a renovation trajectory.

The renovation project aims to improve well-being of residents, safety to users and overall aesthetics. To renovate the road as circular as possible by closing its material loop, it was necessary to prepare internally the municipal organisation and externally involved (commercial) organisations and residents for what was coming. This meant that not only communication processes started, but also research and development processes. It was necessary to learn more about and experience first-hand the material depots, road materials, road material data collection, storage and visualization, emissions, business models and trading used materials. Therefore, this particular case comes along with different perspectives and multiple implementation activities, as will be further explained in the next sections.

The preparations to renovate the residential road Griffiersveld in 2022 started already in 2019, when the first notification was provided by the asset management software of the Municipality of Apeldoorn. This notification is simply given due to the age of the road and its maintenance history. Being the CDW demonstration project of H2020 CityLoops in Apeldoorn, a trajectory started in which extra attention was paid to circularity through a collaboration between internal departments and external experts. Although every road section was inspected once every two years and a digital twin of these road sections is available in the asset management software, Griffiersveld was subject to two extra scanning trajectories to collect more detailed information on the road materials used (see for more information on these scans: Entrop, 2022a and Entrop, 2022b). This information was helpful to come to a project passport addressing the quantities and qualities of road materials.

The road was composed of concrete pavers and concrete paving slabs (30 cm x 30 cm). To keep things in place, concrete curb stones were applied. In Annex B, a detailed drawing can be found showing all the paving materials with their quantities that needed to be taken out. In tendering the contractor reuse and recycling options were already mentioned by the principle; the Municipality of Apeldoorn. In this situation, it is important to mention that there is for the municipality, being the principal, only one contractor. In their contractual agreement, one and the same contractor digs up the road, alters the stormwater facilities, does the logistics, and also paves the road. When it comes to buildings, quite often the demolition trajectory is done separately from the site preparations and the actual building activities.

When the contract was prepared and signed, the opportunity existed to work out the plans for selective demolition for this road project in more detail, as Figure 3.3 suggests (Malk and Lauritzen, 2021). Considering that in this renovation project the waste material groups concrete, bricks, tiles and ceramics (EWC Code 1701) and soil, stones and dredging soil (EWC Code 1705) are mainly involved, the demolition is possibly not as complicated as for some buildings. Nevertheless, selective demolition did need and also received the necessary attention in this project. Typical handling processes for the first material group are crushing and recycling, and for the second material group reuse of clean soil, cleansing and recovery of soil containing hazardous substances. From an aesthetic point of view, it was not acceptable to the urban planners to leave the old concrete pavers, concrete paving slabs and curb stones in place. However the Municipality of Apeldoorn and cthe ontractor did come to actions that

increased the reuse of products on and off-site. The CDW management will be set out for the two main material groups present on site, namely sand and concrete materials.

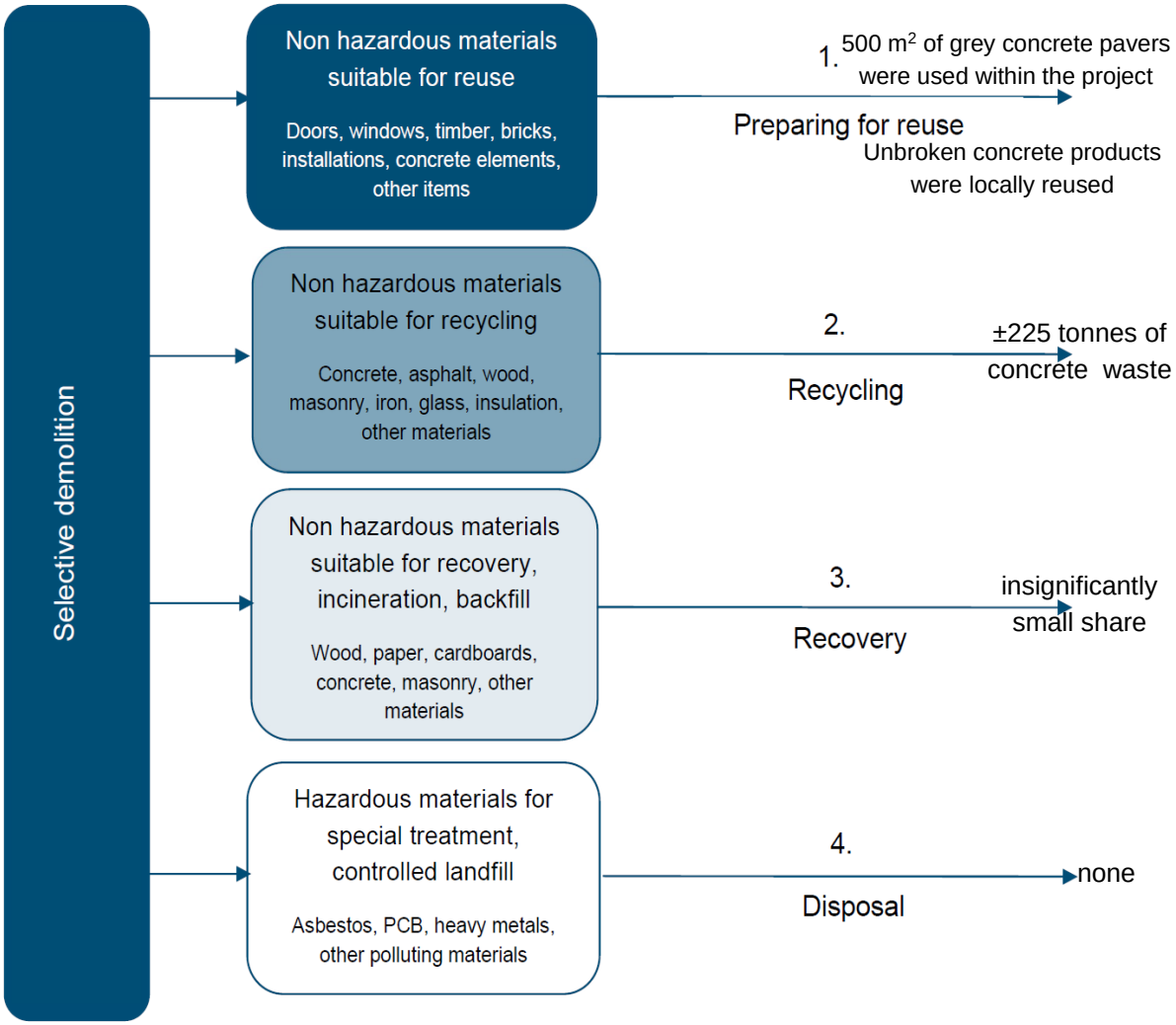


Figure 3.3. *Framework for decision-making on materials & waste management (Malk and Lauritzen, 2021, p. 21). with the values for the renovation project Griffiersveld.*

Closing the material group sand

Already for many years, the Municipality of Apeldoorn is managing surpluses and shortages of sand and soil by means of a depot. Although the initial idea was to replace the sand beneath the concrete pavers with a nowadays more common and stronger foundation of rubble, this idea was reconsidered by the principal and contractor. The heaviest form of transport in the street will probably consist of the garbage truck, passing once each week and for which this foundation of rubble is not necessarily needed. This significantly reduced the need of removing sand and supplying rubble, reducing the environmental impact and financial costs a lot.

Closing the material group concrete

Although many of the current concrete road products in Griffiersveld are already being used for more than forty years, the quality of at least a part of the pavers can be assessed as good. Therefore, the inner part of individual parking spaces will be paved reusing the old anthracite

concrete pavers (see Figure 3.4). The total surface is expected to sum up to around 500 m^2, being 10% of the total paved surface in the project.

Although the anthracite concrete pavers are being directly reused in the project, the old grey concrete pavers will leave Griffiersveld to be reused at farms in the direct surrounding area. The farmers will reuse the pavers as floors of their silage facility to store cattle feed.

Some of the grey 30 cm by 30 cm concrete paving slabs are broken, but those that aren't will be used as ballast in flat roof photovoltaic systems. In this way, these used products even help in the energy transition. In the past the photovoltaic systems provider bought new concrete or stone products to use as ballast to keep the systems on flat roofs with high wind speeds.

Figure 3.4. *Used anthracite concrete pavers waiting on site to be reused in the parking spots.*

Broken concrete pavers, paving slabs, curb stones and parts of the old stormwater system will be collected in containers. These containers will be transported to a crushing facility of a third party nearby. Given the small amount of concrete waste and that the road is in a residential area, a mobile crusher on site was not economically and environmentally acceptable.

Demonstration activities to close material loops

To be able to execute the Griffiersveld renovation process as circular as possible, the CityLoops demonstration project in Apeldoorn encompassed multiple activities to make sustainability and in particular circularity a priority for stakeholders involved in planning, reshaping and experiencing the built environment. Related to Elkington's triple bottom line "people, planet and profit" (1999), these activities can be more or less categorized as social, technical or economic:

- Social: a process journey with stakeholders took place (Section 4.1.1), a participation program with residents was developed (Section 4.1.2) and a contractor with circular ambitions took care of executing the project accordingly (Section 4.4);

- Technical: material depots were studied, designed and developed (Section 4.2.1) project passports were studied, road data was collected and stored (Section 4.3.1) and was visualized in 3D (Section 4.3.2);
- Economic: online marketplaces were studied and one of them is used (Section 4.5), a CO_2 indicator was adapted to assess the impact of material transport (Section 4.6.1) and circular business models were explored (Section 4.6.2).

4. Findings & lessons learned

Throughout the overarching demonstration action, different sub actions have been conducted to get insights, to develop tools and to learn from the circular journey the Municipality of Apeldoorn adopted when reconstructing Griffiersveld. Below (Table 4.1) the instruments and experiences are presented by means of the following the provided “grouping” structure with the accompanied expected outcomes formulated in the monitoring and evaluation framework. This chapter provides per sub action a short introduction, the lessons learned and how this relates to the expected outcome and the impact achieved[1].

Table 4.1. *Expected outcomes of the H2020 CityLoops project in Apeldoorn.*

	Grouping	Sub actions	Expected outcomes
4.1	Stakeholder/citizens involvement	Internal stakeholder process journey	Increased knowledge and awareness raising within municipal organisations
		Participation program	Citizens in Griffiersveld are engaged in the circular economy by means of raised awareness
4.2	Handling / Physical material banks	Developing material depots	Improved innovative products and services in CE practices within municipal organisations
4.3	Gathering and digitalising data for reuse or recycling / material passports	Collecting and storing data for project passports	Quality assurance certification system for reuse of material fractions has been established within the asset management system Municipal Basic Instrument (in Dutch: GBI)
		Visualizing project data	
4.5	Tendering and procurement/procurement handbook	Circular procurement	By the end of the project, procurement of circular products related to Griffiersveld have increased by 10% in volume, due to awareness raising activities within the Municipality of Apeldoorn
4.6	Online Marketplace	Online matching platform	Improved innovative products and services in CE practices within municipal organisations
4.7	Organizational Changes / planning and decision making	CO_2 calculator	Reduced CO_2 emissions from reduced transport and through reusing and recycling material (≥ 3,000 m^2 road), compared to conventional street development projects
		Exploring circular business models	

[1] Please note for some of the expected outcomes final results, data collection is still ongoing

4.1 Stakeholder/citizens involvement

4.1.1 Internal stakeholders process journey

The Municipality of Apeldoorn wondered how to align the stakeholders in its public infrastructural projects to come to a circular and, at the same time, executable project. To this end, a literature study and experiment were conducted. The experiment consisted of a co-design process aiming for the renovation of a residential road constructed in the late seventies. Because of their expertise in methods of service design and guiding a team of stakeholders through the co-design process, advisors of Koos Service Design facilitated the process to come to this process journey, including the organisation of multiple interactive co-design sessions.

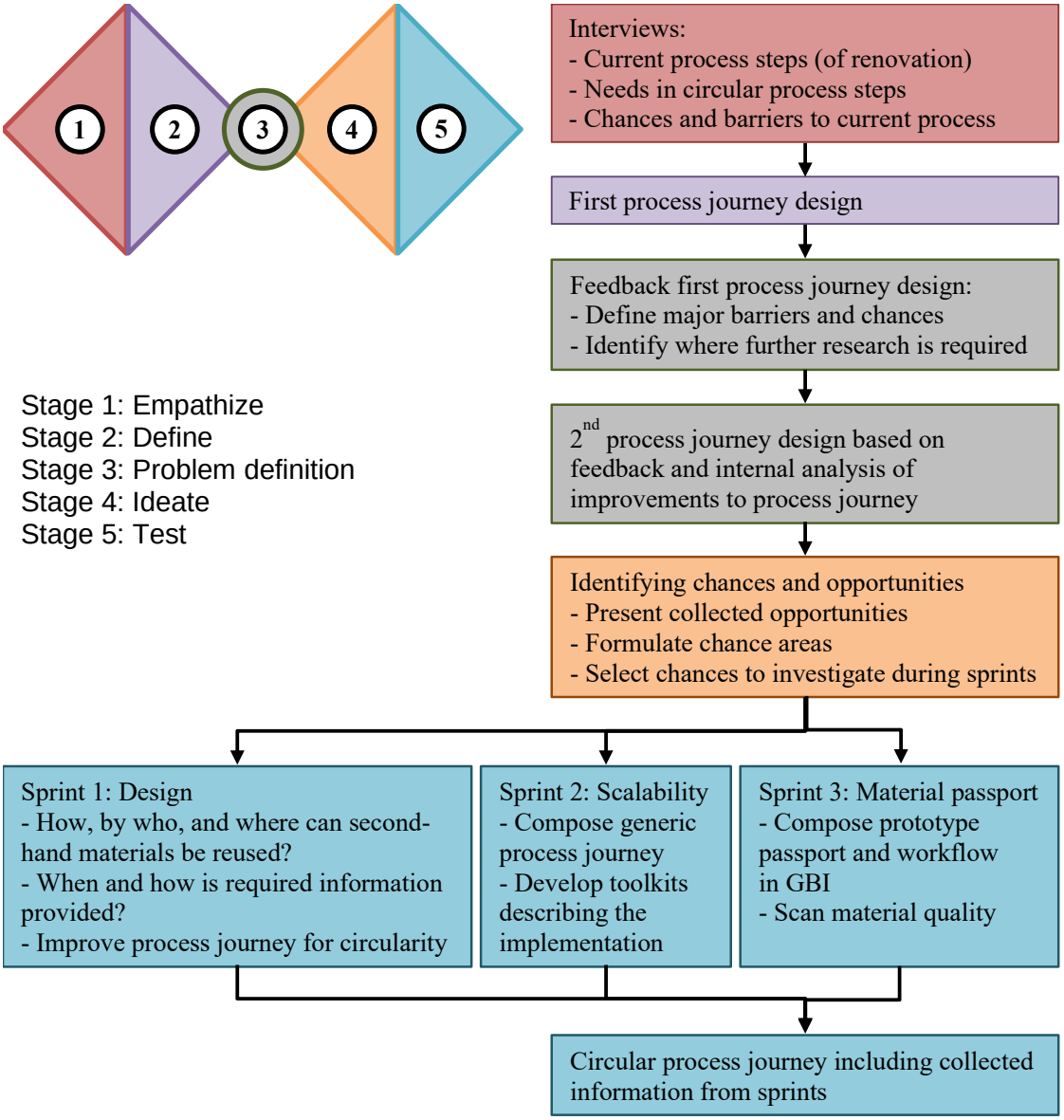


Figure 4.1. *Overview of the complete service design trajectory resulting in a circular process journey by the early stakeholders involved in Griffiersveld (Entrop, Hagen and Van Leeuwen, 2022).*

When conducting road renovation, multiple departments within the municipal organization and different external organizations need to collaborate. To them, circular material usage was introduced as a new specific sustainable objective, while traditional constraints, like time and costs, remained. It was visualized in a process journey, showing who is expected to meet which collaborative milestones and when (see Figure 4.1). For more information please take notice of the paper on this topic of Entrop, Hagen and Van Leeuwen (2022).

STAKEHOLDER CONSULTATION PROCEDURE: THE CO-DESIGN PROCESS

Together with the external process facilitator, Koos Service Design, the steps to come to a circular process journey were executed. When preparing a circular construction project, multiple actors and stakeholders are involved. However, difficulties (like time schedules, availability of stakeholders) can be experienced in aligning these actors and stakeholders to come to an executable project, because of the different objectives actors and stakeholders might have in mind. A co-design process, based on the method of service design, was used to develop a process journey. This process journey is an overview of the involved actors per process phase. To collaboratively complete deliverables, it shows the roles and tasks each actor is expected to fulfil. As such, the process journey can form a manual instruction to accomplish the desired project circularly.

Lessons learned

The process journey is generic and applicable for design-driven projects in other cities worldwide. However, within CityLoops it has not yet been tested by any other municipality than Apeldoorn. When following the roadmap, which is comparable to Figure 4.1 but with the involved actors and stakeholders in place, the output will be a circular process journey. This output adds to the possibility to compare cities nationally and across countries. Design thinking forms the basis when going through the service design process. It may take time to develop and apply this way of thinking. “Service design does not have distinct expertise in the circular economy by itself. Its tools inspire and enable an intrinsic transition to design a new system collaboratively.” (Koos Service Design, 2022, p.43).

To make use of the tool successfully, the developers recommend having an open mind to opportunities to include organizations with knowledge of and experience in developing material passports and closing materials loops. Please, do not stay away from those who currently are not yet part of construction processes. Furthermore, it is important to involve stakeholders throughout the co-design process to make them at least partially owners of the process and to increase their sense of responsibility. In this way, stakeholders can share their insights within their organization and spread this way of working and thinking.

Although coming to circular material usage in road renovation projects highly motivated contractors to execute the process that is needed, it is not, due to European public tendering rules, an easy task to just invite contractors to participate in the co-design process. “Most of the transformations need to happen in the market, not in the municipality itself.” (Koos Service Design, 2022, p. 44).

Tool Factsheet “Stakeholder consultation procedure: the co-design process”

Conference paper https://iopscience.iop.org/article/10.1088/1755-1315/1078/1/012119

Facilitator Koos Service Design https://www.koosservicedesign.com/

Impact

Expected outcome: Increased knowledge and awareness raising within municipal organisation

Indicator	Base line result	Intermediate result	Final result
21: New planning / tools for improved circularity	Zero	Together with Koos Design a process journey was developed. Design thinking process and workshops were held between sept 2021 - feb 2022. Every six weeks a meet up, to develop the design thinking template.	By participating in the process journey we noticed an increased awareness and knowledge amongst the different stakeholders on roles, tasks and perspectives. By bringing all stakeholders together in one group, awareness was increased on the cross-connections in the project.
Outcome review In the Municipality of Apeldoorn, this tool was used to map collaboration across actors in multiple phases of a road renovation project. In the process journey, actors were involved with a profound knowledge of road quality and road materials. The expected outcome of increased knowledge and awareness raising within the municipal organisation was achieved.			

4.1.2 Participation program

To design its communication plans, the Municipality of Apeldoorn makes use of the so called participation ladder. Although originally developed by Arnstein, an extended version as offered by Pröpper (2009) is adopted. Experienced communication experts, employed by the municipality, design and deploy participation trajectories by advising project leaders and policy officers. They help in communication processes, but don't participate in the actual execution of projects. In some projects this is being experienced by the project leaders and policy officers as a shortcoming. To get residents and other stakeholders actively involved, one needs a clear understanding of the context.

Although one might consider the renovation of a road as a relatively simple process, still residents need to be informed through newsletters and meetings. The area under consideration is a neighbourhood to its residents; it is not a number of square meters asphalt in a highway nobody relates to or adores. The residents need to be offered an opportunity to interact in the design process and need to be prepared regarding what will happen during execution. Especially, when for most residents and many civil servants a new concept is introduced, which circularity was to them.

Thoughts had already been given to how the municipality could interact with the residents in Griffiersveld and how to offer a newsletter to residents, when the COVID-19 virus locked down the Netherlands in March 2020. The Municipality of Apeldoorn used for example a self-made online environment to collect input from residents living in the residential area around Gilles Pieter Duuringlaan (see Figure 4.2 and 4.3). The input collected online was used to redesign this road. For Griffiersveld still a survey was developed by students from Saxion to collect information among residents about their thoughts for the renovation plans. This survey of Ten Brinke, et al. (2021) can be found in Annex E.

Figure 4.2. *During Corona the Municipality of Apeldoorn used a self-made online environment to collect input from residents, when it comes to redesigning and renovating public residential areas, like here in the G.P. Duuringlaan (website by courtesy of Elbert de Hon).*

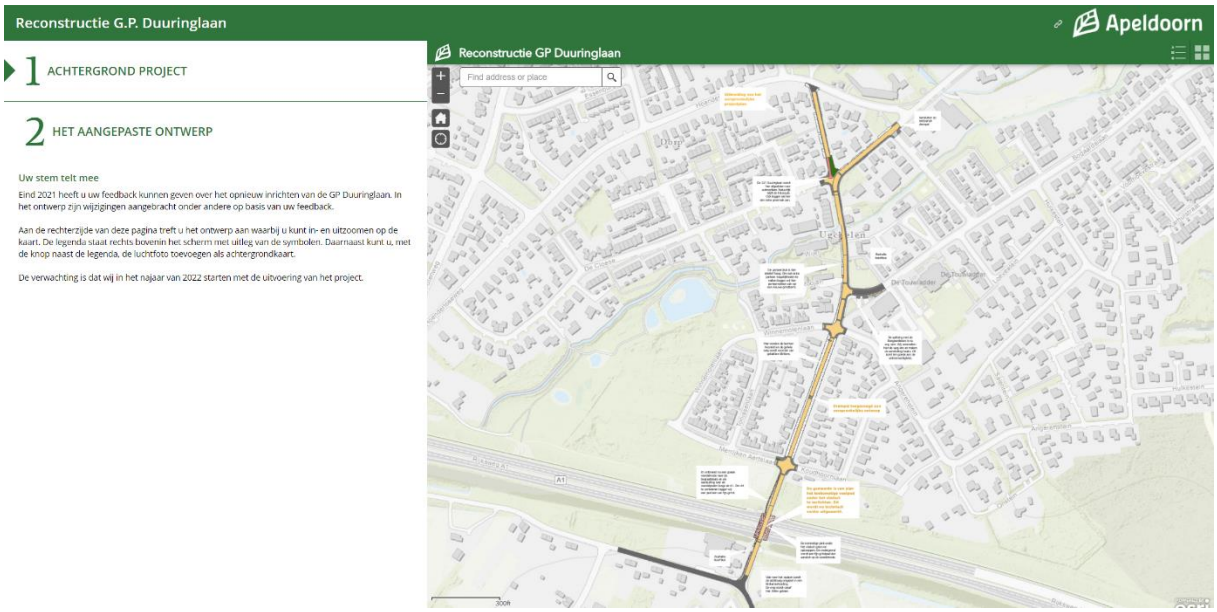


Figure 4.3. *During Corona the Municipality of Apeldoorn used a self-made online environment to collect input from residents, when it comes to redesigning and renovating public residential areas, like here in the G.P. Duuringlaan (website by courtesy of Elbert de Hon).*

Based on experiences of other Dutch municipalities and based on research, the municipality decided to use a digital platform. The European D-CENT (Decentralized Citizens Engagement Technologies) research project ran from 2013 to 2016. The D-CENT project brought together civil servants of municipalities, that in recent years played a role in transforming democracy and decision-making processes using digital tools. With the input of these innovators, a new generation of shareable, local and privacy-aware tools for direct and deliberative democracy were developed. In Madrid, Reykjavik, Helsinki, and Barcelona a number of participation tools

was extensively tested. Digital tools were made available for organizations and governments via the GitHub sharing platform (https://dcentproject.eu/, visited on February 22th, 2023).

Using the insights from the D-CENT project, the Municipality of Apeldoorn had the intention to purchase a license for OpenStad, an online digital platform that can interact adaptively with its users (please have a look at https://openstad.org/, visited on February 22th, 2023). The idea was to use this tool for interactive design processes with the residents in Griffiersveld. The current state of the road and the new designs can be shown in the platform, people can react to it and with the help of smart techniques, the reactions and comments can be given in real time.

At the Municipality of Apeldoorn, an official was appointed for OpenStad who was going to make himself familiar with the platform. The person in question internalized himself to get started with it. However, the question rose to what extent the residents in the particular neighbourhood are digitally skilled to be able to work with this tool. A small survey was distributed among the residents both digitally and paper-based. The outcome was on the one hand unpleasant and on the other hand very enlightening. Only a few people completed the survey digitally, most paper based. The survey showed that many residents are digitally illiterate and prefer to communicate directly and not via a digital platform with the municipality.

As a result, we organized a Sustainable Activity Day in the neighbourhood on the 25th of May 2022 (see Figure 4.4 and 4.5). On this day we reviewed several themes. Of course the circular ambition in renovating the road was an important topic (the developed poster and brochure can be found in Annex C), but also other sustainable topics such as: improve storm water infiltration, saving energy in homes, reusing products, reducing and separating waste, etc.

Figure 4.4. *Impression of the Sustainability Activity Day in Griffiersveld.*

Figure 4.5. *Discussing the plans for renovating Griffiersveld with the residents at the Sustainability Activity Day.*

In terms of the different topics, we:

- made people aware of what they can do in the field of waste separation;
- gave people the opportunity to give up pavement in exchange for soil and plants in the context of climate change;
- put people in contact with energy coaches, so that they could get an explanation about what they can do in the context of energy saving and renewable energy sources;
- made people aware of what circularity is by explaining the plans and by inviting the contractor, who was going to carry out the reconstruction. In this way, the contractor was already able to work on his relationship management with the residents.

Impact

- Expected outcome: Citizens in Griffiersveld are engaged in the circular economy by means of raised awareness

Indicator	Baseline result	Intermediate result	Final result
5. CE - related knowledge building campaigns	Zero, citizen engagement method was not used before	Though the different events and communication methods; sustainable doing day, and the survey to 134 inhabitants, development of brochures awareness is raised.	Due to the different methods of engagements and participation, the citizens of Griffiersveld were more engaged with the circular aspect of the reconstruction of the road. At several occasions during casual conversations on the street when the citizens of the neighborhood were passing by. They outlined in the conversations held with the constructor, the researchers of Saxion and the staff of the municipality that there was a circular element to their road construction. The constructor indicated that this was more than usual. Which we believe had to do with the additional information provided during the doing day event, the brochures handed out and the survey conducted.
Outcome review: There has been a positive intervention towards citizen in Griffiersveld. Although the municipality had to deviate from the original plan dude to COVID-regulations, we were able to have face-to face meetings during the doing day, to get inform citizens on the circularity element of their road renovation. One of the main learnings throughout the process is that before choosing a participation tool/method, to first conduct research on the characteristics of the citizens. In this case, the digital platform showed to be a mismatch as the digital platform asked a certain level of digital skills, which did not match with the skills the citizens in this particular neighborhood in general have.			

4.2 Handling/Physical material banks

4.2.1 Developing material depots

For many years the Municipality of Apeldoorn already has been experiencing the advantages of deploying a soil and sand site along the Terwoldseweg to temporarily store multiple qualities and different quantities of soil and sand. This site operates as a depot, where the quality of soil and sand also is assessed. These experiences were laid down in a research report (please have a look at Entrop, 2021). The soil and sand depot in Apeldoorn fulfills its role with verve (see Figure 4.6 and 4.7). It offers temporarily space for soil and sand in times that supply and demand are not well aligned. The added value of the soil and sand depot can be found in the space it has to offer to store and to combine batches, to facilitate the inspection of batches of soil, building materials and granular waste –by means of the so called AP04 accreditation (is a kind of examination in the quality of sand) inspection procedures (SIKB, 2023)– and the immediate availability of this important resource. There are in general not extra services being offered.

Figure 4.6. *Sand stored at the soil and sand depot of the Municipality of Apeldoorn (by courtesy of Robert Rouwenhorst).*

Figure 4.7. *Sand site of Apeldoorn as can be viewed from south to north at Google Maps (by courtesy of Aerodata International Surveys).*

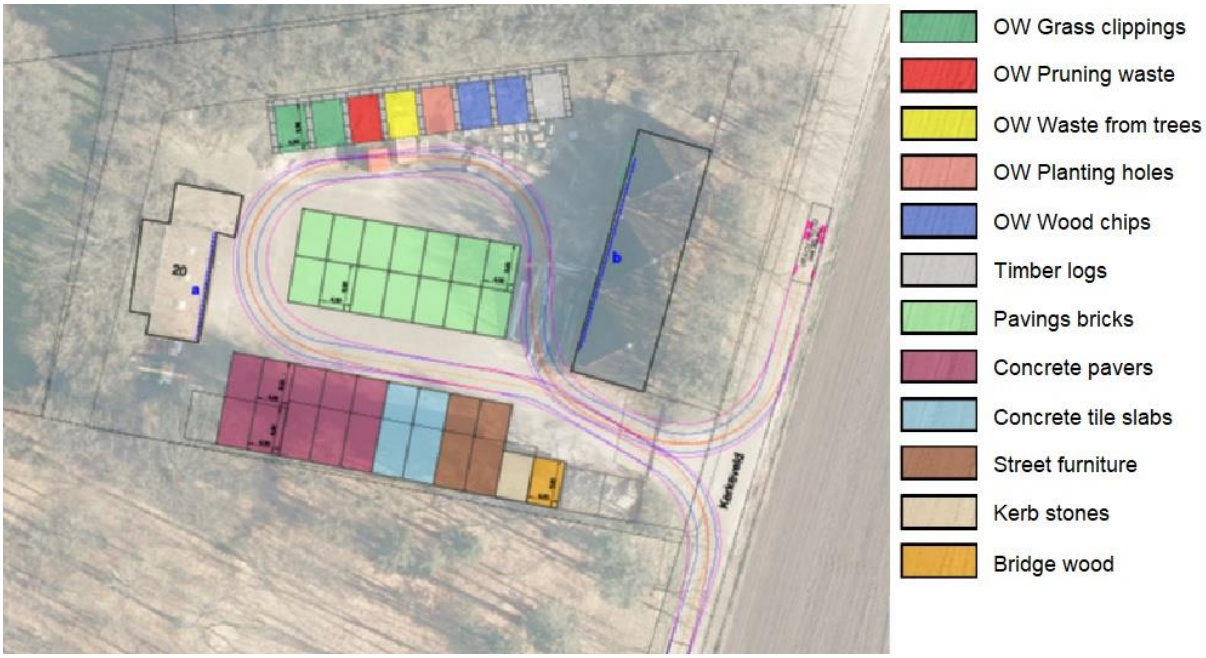
The study showed that it is already rather complex to properly record the quantity and quality of soil and sand (Entrop, 2021). Currently most civil engineering works and buildings are mainly being composed of linear end-to-life components, products and materials. This should alarm us about the efforts needed to be undertaken, when it comes to investigating and administrating the historical background, former usage and current state of all other circular resources needed in construction. These processes will be time-consuming, prone to errors and costly. Logistic systems necessary to have all components, products and materials in place at the site in time are complex. Being a local depot, a soil and sand depot is able to operate as a node in the logistic system of the soil and sand market where supply and demand can converge. However, there will be a need for a new kind of depot for a circular construction industry in a new sort of logistic system. A system that is supported by automated sensors and a proper digital infrastructure linked to databases.

Since the start of CityLoops, Apeldoorn was expressing her ambition to also store other materials needed in her public civil constructions. Internally, a feasibility study (Kaal, 2020)

was conducted to learn more about the basic requirements for a material depot at Kerkeveld (see Figure 4.8 and 4.9). This location has a total surface of 5,458 m^2; slightly larger than an American football field and smaller than a soccer field. Effectively, this site can offer 2,750 m^2 to store materials outside, while it was assessed that approximately 1,600 m^2 was needed. They laid eyes on three locations for a second depot. Licenses were being obtained and zoning plans were brought in line with the new designated usage. At the same time, students of Saxion University of Applied Sciences were designing possible site layouts for the depot at the Laan van Zodiak in Apeldoorn (see Figure 4.10, Poutianen et al., 2020).

Figure 4.8. *The actual start of the material depot at Kerkeveld (photo by courtesy of Ryan Kaal).*

Figure 4.9. *Different sections of the material depot at Kerkeveld will be storing specific kinds of materials*



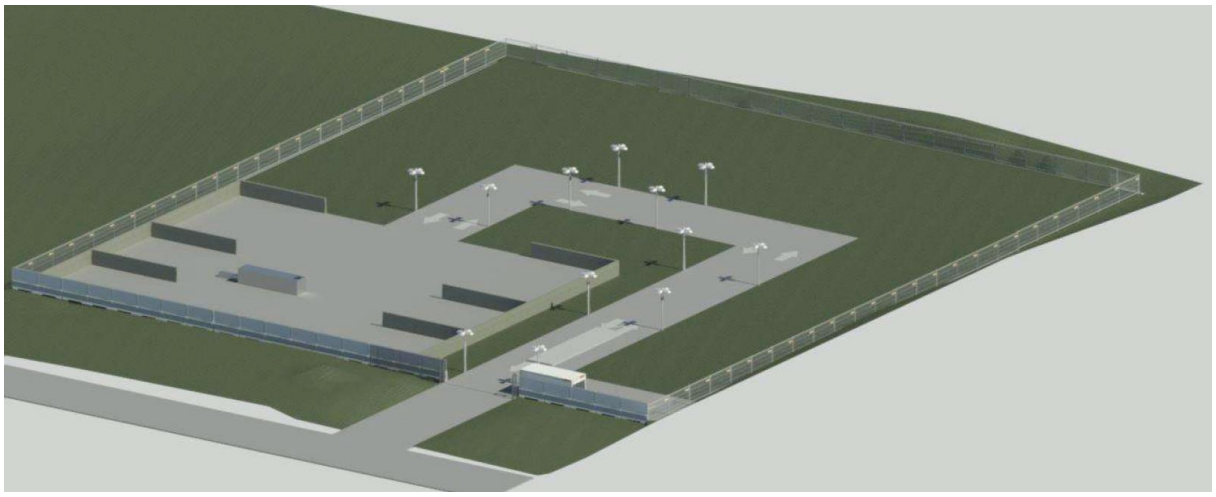


Figure 4.10. *3D design for a possible depot at the Laan van Zodiak in Apeldoorn (Poutiainen, et al., 2020)*

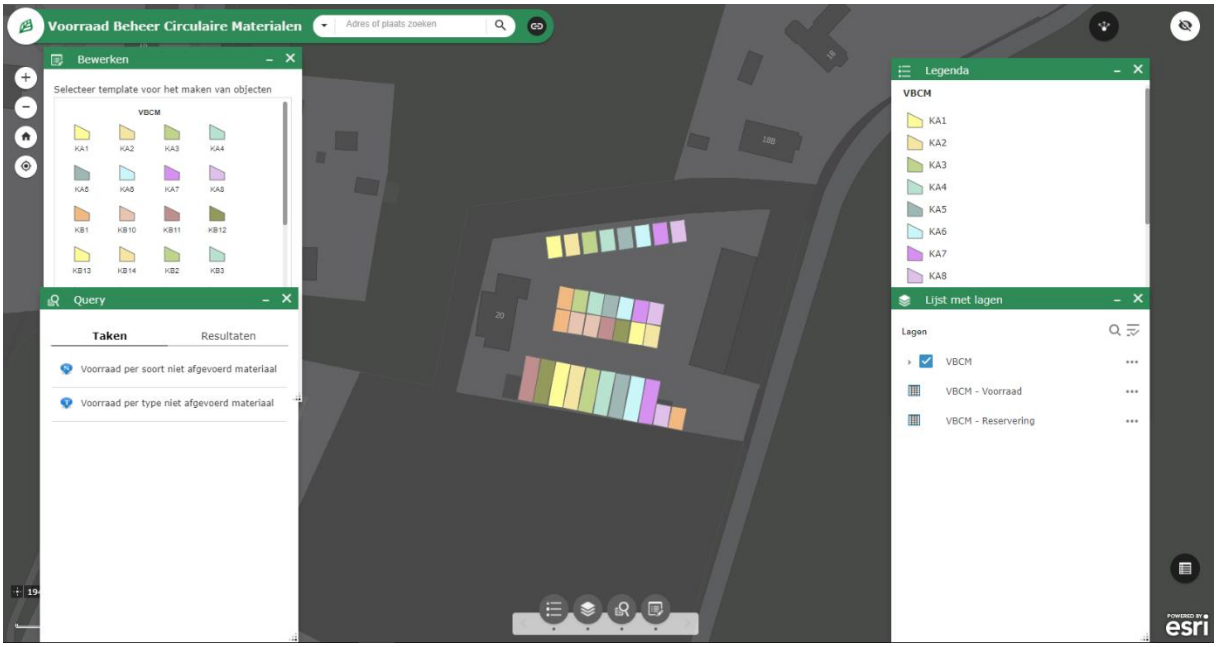


Figure 4.11. *Screenshot of the database managing the material streams at the Kerkeveld depot.*

The efforts of the municipality resulted in the opening of a material depot at Kerkeveld. At this depot products, like pavers and concrete products, are being stored that are planned to be reused within one year. Due to the depots limited size, broken or to be broken materials that can be reused in the production of new concrete are not stored at this site. Figure 4.11 shows a screenshot of the materials stored in the depot. With the arrival of the online matching tool DuSpot, this database became redundant. In 2022, a second material depot opened at Laan van Zodiac (see Figure 4.12 and 4.13). This second material depot is also familiar to the contractor working at Griffiersveld. Often materials are brought to and taken from this depot by this contractor.

Figure 4.12. *Materials stored at the Laan van Zodiac depot of the Municipality of Apeldoorn (by courtesy of Bram Entrop).*

Figure 4.13. *Materials stored at the Laan van Zodiac depot of the Municipality of Apeldoorn (by courtesy of Bram Entrop).*

Impact

- Expected outcome: Improved innovative products and services in CE practices within municipal organisations

Indicator	Baseline result	Intermediate result	Final result
3. New tools for better mapping of resources and their location: Qualitative description	Zero. New tool analysed according to its functionality and usefulness. Measuring tool in use internal	1 Material-depot were developed Kerkeveld and is in use. The second Material-depot Laan van Zodiac is planned The municipality works with a digital platform based on warehousing principle, allocate and store material in the physical depot at both.	3 Material banks realised and running. (1) soil and sand site along the Terwoldseweg (2) Material Depot Kerkeveld and (3) Material Depot Laan van Zodiac. The pilots with DuSpot resulted in a full roll out and implementation of DuSpot, making the database (warehousing principle) redundant.
Outcome review The number of physical material banks increased from 1 to 3 in the lifetime of this project, and the contractor reconstructing Griffiersveld made use of the 3rd one throughout the implementation phase. Further it became apparent that the database in use by the municipality became redundant with the use of DuSpot. As next to the additional options, Duspot provided an overlap with the existing functionalities of the current database.			

4.3 Gathering and digitalising data for reuse or recycling/material passports

4.3.1 Collecting and storing data for project passports

The basic principle of a circular economy is to close material loops and so retain the highest utility, quality and value of products, components and materials as possible. An important question to be answered for Apeldoorn was how to qualify and quantify material flows. Material and project passports seem to be part of the solution to improve insights and sharing information on quantities and qualities of materials used in construction projects. A literature study on material passports was conducted. This study provided a top five of requirements for a material passport, namely (Goselink, 2021):

1. it needs to include a bill of materials (BOM) with quantities, material composition, and location (GIS) of the materials on site;
2. inspection and maintenance history of the materials on site needs to be recorded in the passport;
3. it includes technical lifetime expectancy of materials on site, so information on production date, manufacturer's, contractor's and or the municipality's lifetime expectancy adjusted with information from the field;
4. renovation or 'end-of-life' options of the materials are addressed;
5. the setup of the material passport complies with a uniform system and clear definitions.

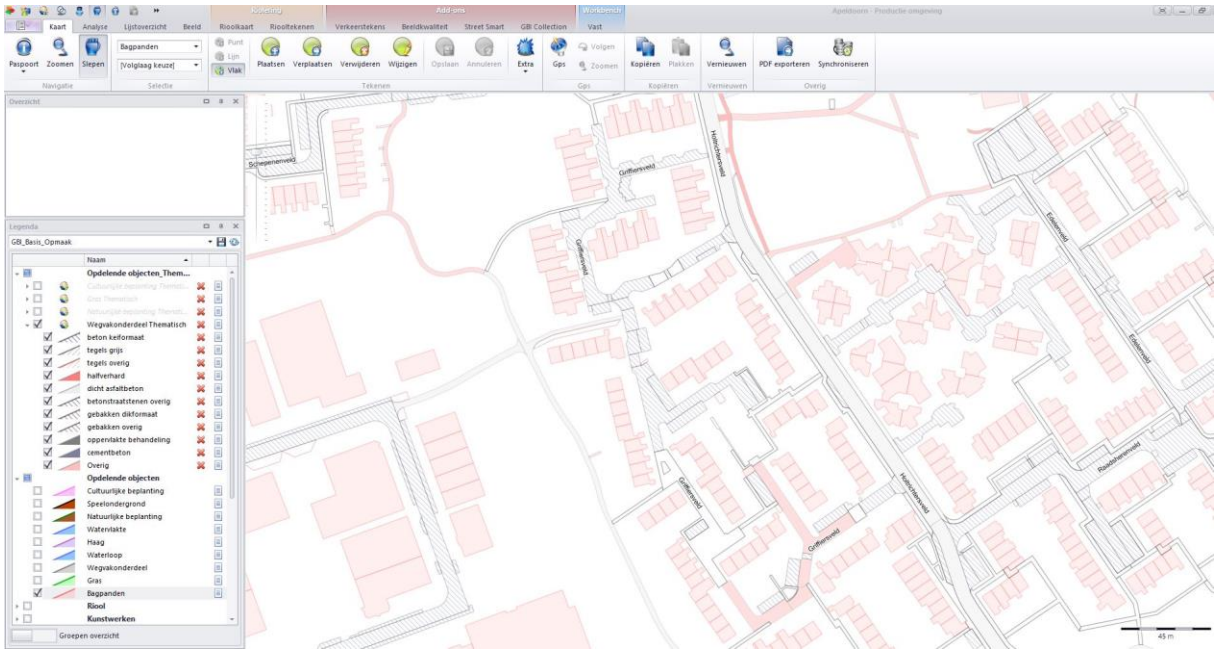


Figure 4.14. *screenshot of the GBI asset management system showing Griffiersveld in Apeldoorn.*

Furthermore, current project management software as used by the municipality was taken into account, in order to share a framework for organising and collecting road construction data (see Figure 4.14). This software exists to help the municipality manage and maintain their

public works. Apeldoorn adopted a GIS-based Gemeentelijk Beheer Informatiesysteem (GBI – Municipal Management Information System) of AnteaGroup to store data relating to the management and maintenance of public works. According to three of the interviewees, a visual inspection takes place to make sure the roads are clean, whole and safe, approximately once every two years. Inspections like these make it possible to check if the municipality's information in GBI still corresponds with the actual situation. When aesthetics, usability and/or safety fall short in real life, an intervention will be planned. An intervention might consist of relatively simple repairs up to a complete renovation of the road and surrounding public space.

An MS Excel file extracted from the GBI-system shows that the Municipality of Apeldoorn distinguishes up to 53 different characteristics for each road section. These characteristics include the road's identity, location, typology, inspection date, year of origin, maintenance year, appearance, safety level, width, surface and perimeter of the particular road section. A significant number of these 53 characteristics are particularly useful when focusing on the quality of asphalt roads, but are less relevant to roads consisting of concrete pavers or paving slabs. Furthermore, it is striking to see that many cells addressing the qualitative characteristics of road sections are empty, due to missing data. Available data helps assess the quality of a road section by means of pavement unevenness, grout width, appearance and safety. Quantities by means of the total number of pavers or paving slabs, their original sizes and original product mass are currently not provided. The main actors involved are not addressed either, so it might not be an easy task to learn more about the product's manufacturer, the road's contractor, contracted repairmen, inspector or principal (Entrop, 2022a).

Figure 4.15. *Two different companies with different sets of sensors conducted the road scans at Griffiersveld.*

Figure 4.16. *Applied pavement materials (red = concrete pavers, green = concrete paving slabs).*

Various scanning equipment and procedures were employed onsite in an experiment in collecting actual road data to be added in the GBI asset management database (see Figure

4.15). This resulted in a large amount of different data files that have been interpreted and incorporated into the existing database structure of the municipality. For one impression of how the collected data was interpreted see Figure 4.16. For more information please have a look at the conference paper on this topic of Entrop (2022).

MATERIAL PASSPORTS; COLLECTING AND STORING DATA IN CDW PROJECTS

The Municipality of Apeldoorn developed and tested a workflow in which quantity and quality characteristics were linked to the asset management system through a process, in which material characteristics were automatically assessed.

Lessons learned

The Municipality of Apeldoorn has by means of her asset management system, GBI (Gemeentelijk Beheer Informatiesysteem), a structure (up to 200 characteristics) in place to store much wanted quantitively and qualitative information on road materials to come to project passports. Road scans can provide additional insights in the status of road materials, but developments are still needed to interpret the data and automate data storage.

Tool Factsheet "Material Passports; collecting and storing data in CDW projects"

Facilitators Antea Group with their GIS-based asset management software GBI. InfraFocus and De Wegenscanners facilitated the scanning of the road Griffiersveld.

Research reports Goselink, R., 2021. *Circular approach for neighbourhood renovation; construction material passports and databanks.* CityLoops.

Entrop, B., 2022a. *Collecting and storing data in a circular road renovation process*. H2020 CityLoops, Saxion UAS, Enschede, The Netherlands.

Conference paper Entrop, B., 2022b. 1131 The Road to Circularity: a Framework for and Experiences in Collecting Road Data in a Circular Renovation Process. *Acta Polytechnica CTU Proceedings, 38.* Retrieved from https://ojs.cvut.cz/ojs/index.php/APP/article/view/8329

Impact

Expected outcome: Quality assurance certification system for reuse of material fractions has been established (GBI)

Indicator	Baseline result	Intermediate result	Final result
21. New material passports: Qualitative description	Zero	Various scanning equipment and procedures were employed onsite in an experiment in collecting actual road data to be added in the GBI asset management database	It became apparent that although the various scanning equipment and procedures enhanced the quantity and quality of data on the status of road materials. However, it requires quite some steps still to store it into the GBI system, such as custom made additions, to be able to interpretate data and automatically storage the data.

Outcome review

Material passport is essentially a database including GIS (location) to store information about a material that is relevant for its future reuse. Material obtained from the demolition work in Griffiersveld is stored in an enhanced version of Apeldoorn's existing material databank, which uses GBI software. GBI software (GIS currently in use by Apeldoorn) is two-dimensional. Need to find out how to combine it to become three-dimensional. Is it possible to develop products to measure the quality and get the information you need. Report - how to connect the scanning data to GBI. The tool factsheet "Collecting and storing data for material passports" was updated April 2022.

The Municipality of Apeldoorn decided not to develop a universal material passport for all existing situations. It is simply not achievable by means of time and costs. For future projects the ex-ante and ex post situation regarding material present, will be assessed to give form to material passports.

4.3.2 Visualizing project data

The work done regarding how to visualize project data is explained in two sections. A first section explains how to visualize the neighbourhood and road as a 3D GIS. The second section explains how to assess road quality and to lay it down with the help of a colour scheme in this created 3D environment.

Visualising the road and material use in 3D GIS

To make the process of circular road renovation more transparent and decision-making more data-driven a 3D visualisation tool has been developed. A rough prototype was developed by students from Saxion. The students have experimented with making a 3D model in Revit (https://www.autodesk.eu/products/revit) and while this is perfect software for creating 3D models for buildings, it is not suitable to visualise larger areas. Furthermore, it lacks the possibility to colour elements with attributes. The students have moved to GIS using QGIS (https://www.qgis.org). They combined the 2D-data from the asset management software GBI with the 3D data from 3D BAG (Peters et al., 2022) creating visualisations based on the *ScoringQualityRoad.xlsx* tool (see Figure 4.17).

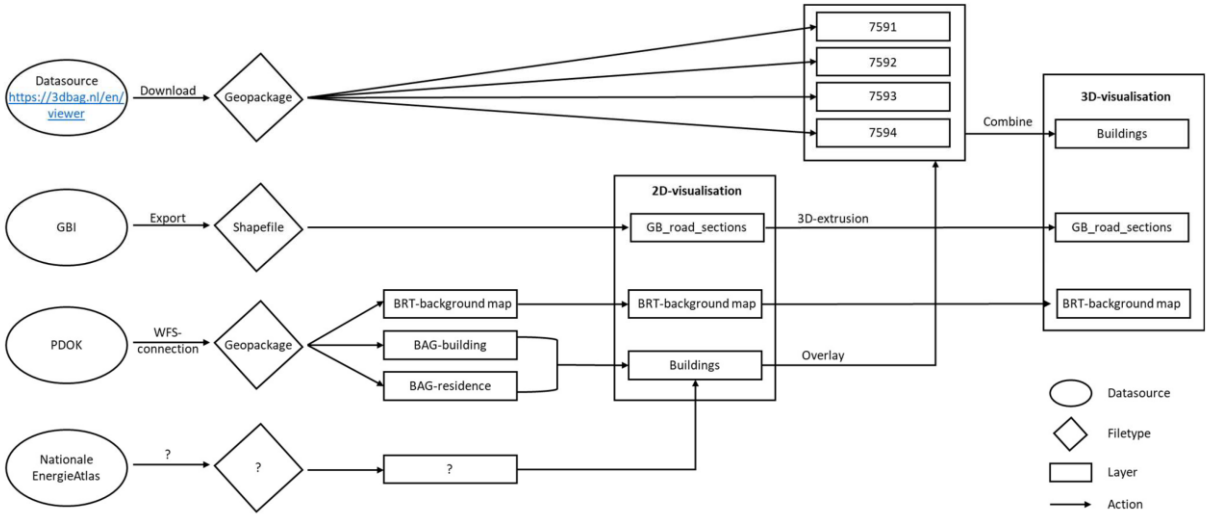


Figure 4.17. *Dataflow scheme for a 3D model of Griffiersveld developed by students (Van den Boog, et al., 2022).*

A reproducible tool has been developed by Ronald Visser of the research group SAST from Saxion UAS using open software, namely R (R Core Team, 2022), QGIS (https://www.qgis.org), PostgreSQL (https://www.postgresql.org/), and PostGIS (https://www.postgis.net/). Various libraries were needed in R (Wickham et al., 2019, 2022). The tool is shared under the Creative Commons License on Zenodo/GitHub (Visser, 2023). Two visualisations were developed, one using partly hard coded virtual data and one using data acquired by scanning the subsurface.

The 3D visualisation is GIS-based and for the buildings the 3DBag (Peters et al., 2022) is used (https://3dbag.nl/en/viewer). This open data can be downloaded in different Levels of Detail (LoD). For the visualisation the most detailed version has been used and cropped to Griffiersveld in GIS. The first tool uses the polygon-layer with roads from the topographic map of the Netherlands (https://www.pdok.nl/introductie/-/article/basisregistratie-topografie-brt-topnl). There polygons have been reprojected to EPSG 7415 from 28992. The main script

(Mapping_3D_top10.R) firstly moves the roads to the Z-coordinates in line with the underside of the 3D-buildings. The road layers are extruded based on the thickness and placed on top of each other, resulting in a 3D visualisation of roads and houses. This visualisation uses road layers of about 20 cm to make them more visible. A line is drawn in GIS to show the possibility of visualising pipes and drains in 3D-GIS (see Figure 4.18).

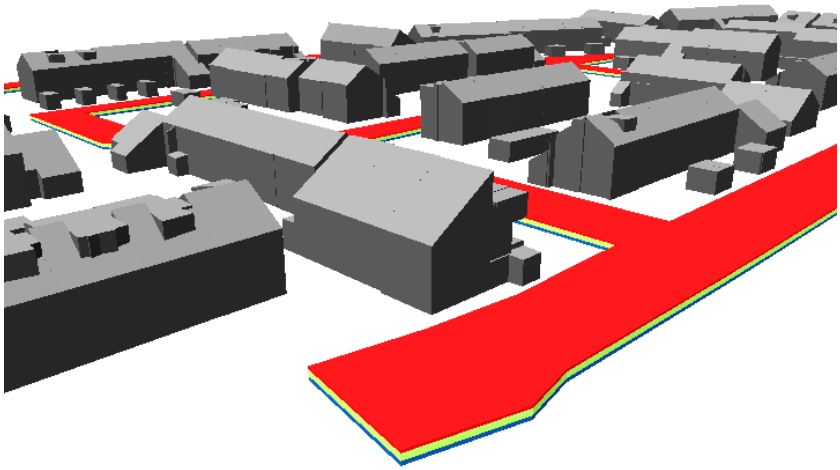


Figure 4.18. *Visualisation of Griffiersveld in 3D based on 3D BAG and using virtual thickness of the road layers (Buildings: © 3D BAG by TUDelft3d, Road: Top10NL, Kadaster).*

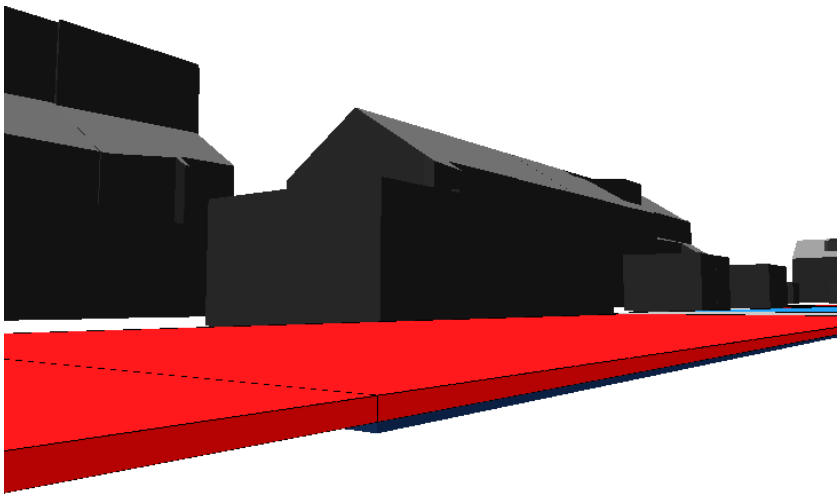


Figure 4.19. *Visualisation of Griffiersveld in 3D based on 3D BAG and using scanned thickness of the road layers (Data road layers: wegenscanners.nl, Buildings: © 3D BAG by TUDelft3d, Road: GBI (AnteaGroup)).*

The second tool is almost similar to the first one, but is based on data obtained by scans of the subsurface using a gamma-spectrometer (as conducted by https://dewegenscanners.nl). These scans resulted in data on the thickness of various layers of the road, e.g. the pavement and a layer below the pavement in Griffiersveld. The various types of pavement used in the study area each lead to a particular thickness. The scans confirmed the data stored in GBI. Therefore, if the data on pavement types is not available, scanning might be considered as a suitable method. These thicknesses were than used to create 3D-visualisations of the roads in the subsoil. In this particular case, the layers were often less than 10 cm, leading to thin layers, especially compared to the size of the houses (see Figure 4.19).

ROADS SUBSURFACE IN 3-DIMENSIONS (RSI3D)
The 3D tool has been developed by Ronald Visser based on earlier work by several students, namely: Jordi van den Boog, Joost van Duijn, Latisha Talapessij, Nick Huusken, Wouter Jansen. This tool makes it possible to visualise the various road layers in 3D. This method helps the user to gain insights in the construction of the road. The 3D model makes it possible to calculate the volumes of material, enabling easy planning of removal, transport, storage and (re-)constructing the road.
Lessons learned The use of open source software and the availability of the code online makes the tool easily replicable and also scalable to other situations. The scanning of road surfaces is useful to assess the various layers of material in the soil, since the results are comparable to the documented thicknesses of the layers The 3D-GIS-data can be used to assess the volumes of material to be moved, indicating the workload and simplifying the planning process
Tool factsheet "Visualising the residual lifespan of road constructions in a 3D model" **Tool File** Visser, R.M., 2023. Roads Subsurface in 3 Dimensions (RSI3D) (v1.0.0). Zenodo. https://doi.org/10.5281/zenodo.7554736 **Student research report** Brinke, R.J. ten, Hal, T.J.L. van, Jong, P.G.J. de, Lintelo, G.H.J. te, Podt, G.B., Revenberg, M., Ros, B., and Thijert, B., 2021. Designing and realizing circular urban road renovation. 3S-project. Saxion UAS

Visualising the quality of the pavement

Road pavement needs to be maintained. To assess the quality of the material of the road pavement a visual inspection tool has been developed by Saxion together with students. The basis of this tool is a simple colour scheme using red, orange and green. Green stands for aesthetic high-quality reuse (can be reused by the municipality itself). Orange stands for non-aesthetic high-quality reuse. This means that the pavers are of good quality for reuse, but not of the quality required by the local authority. Red indicates broken pavers or non-reusable pavers. These can only be reused by recycling. The quality of the pavement can be assessed based on three aspects with different criteria:

- Erosion of the top layer
- Fracture
- Crumbling

The erosion can be described on three levels with the following criteria:

- None: the top layer is clearly visible and is not worn out;
- Light/medium: crushed stone and gravel in the concrete elements come through the top layer;
- Heavy: the original top layer is no longer visible and the entire top of the element consists of stone chippings.

The fracture can be described on two levels with the following criteria:

- None: the concrete element is not fractured;
- Heavy: the concrete element is fractured in two or more pieces.

The crumbling can be described on two levels with the following criteria:

- None: the concrete element is not crumbling;
- Light/medium: the gravel or crushed stone are slightly chipping of;
- Heavy: the gravel or crushed stone in the component are chipping of heavily.

This can be assessed for each road segment using a systematic assessment form, which was developed in Excel (see table below). Each road segment can be assessed and the results can be stored in GIS-data-formats (e.g. shape-file, geopackage or a spatial database). Since this is stored as attribute data of a spatial layer of polygons, it is easy to visualise the quality of the roads and also quantitatively assess the quality of larger region.

ROAD QUALITY VISUALISATION SCHEME

To objectively assess and visualise the quality of road pavement, a tool has been developed using the colours of a traffic light. By scoring each aspect based on the criteria shown in the most left column a final score is given for a road section. Scoring is based on numeric values, with 0 used for good quality, 1 for moderate degradation and 2 for heavy degradation. The different aspects (erosion, fracture, crumbling) are treated equally. These aspects are summed as a final score. The quality is fine if the total score is below 3 (green). A total score of 3 or 4 is considered moderate degradation, and above 4 the pavement is heavily degraded.

	None	Light/medium	Heavy	Scoring
Erosion of the Top layer	Top layer is clearly visible	The crushed stone comes through the top layer	The top layer is no longer visible. The entire top of the element consists of stone chippings	1
Fracture	The stone is not fractured		The element is fractured in two or more pieces	2
Crumbling	The chippings in the element are not crumbling	The rock chippings in the tooth are slightly chipping	The rock chippings in the component are chipping heavily	2
				5
This tool can be used to assess and score the visual quality of the road pavement.				
Column F is used for scoring, with the scale based on the aspects: none = 0, light/medium = 1 and heavy = 2				

This research (Van den Boog, et al, 2022) was conducted in a preliminary stage by the following students, namely: Jordi van den Boog, Joost van Duijn, Latisha Talapessij, Nick Huusken, Wouter Jansen. Researcher Ronald Visser continued in this field and suggested the method and tool as discussed.

Lessons learned

The tool is easy to use, because of the implementation in a spreadsheet. In this particular case Excel was used, but LibreOffice Calc can also be used.

The tool is relatively fool proof: in the sense, that the criteria are easy to understand and to learn. It can be applied by people from many different backgrounds, as long as they understand English. The opportunity also exists to translate the terms in any other language.

Tool factsheet “Visualising the residual lifespan of road constructions in a 3D model”

Tool File ScoringQualityRoad.xlsx and ScoringQualityRoad.ods

Student research report Brinke, R.J. ten, Hal, T.J.L. van, Jong, P.G.J. de, Lintelo, G.H.J. te, Podt, G.B., Revenberg, M., Ros, B., and Thijert, B., 2021. Designing and realizing circular urban road renovation. 3S-project. Saxion UAS

4.4 Tendering and procurement

4.4.1 Circular procurement

As explained earlier in this report most of the CDW activities were concentrated around the residential road renovation project of Griffiersveld in Apeldoorn. Already quite quickly after the start of the H2020 CityLoops project, this renovation project was spotted as a potential candidate for the much needed demonstration actions. Only one main research sub-project had started prior to the definitive case selection, namely that one in which the sand and soil site of the municipality was being studied. It turned out that all phases of initiating, designing, preparing and executing the Griffiersveld renovation project nicely fit between start and finish of the CityLoops project, as is shown in Figure 4.20. On site, actual construction activities took place between July 2022 and December 2022. In nine phases of approximately two weeks each, the hindrance for residents regarding accessible was tried to reduce to a minimum. However, due to shortages of personnel some delay did take place, resulting in little activity for a few weeks during the project.

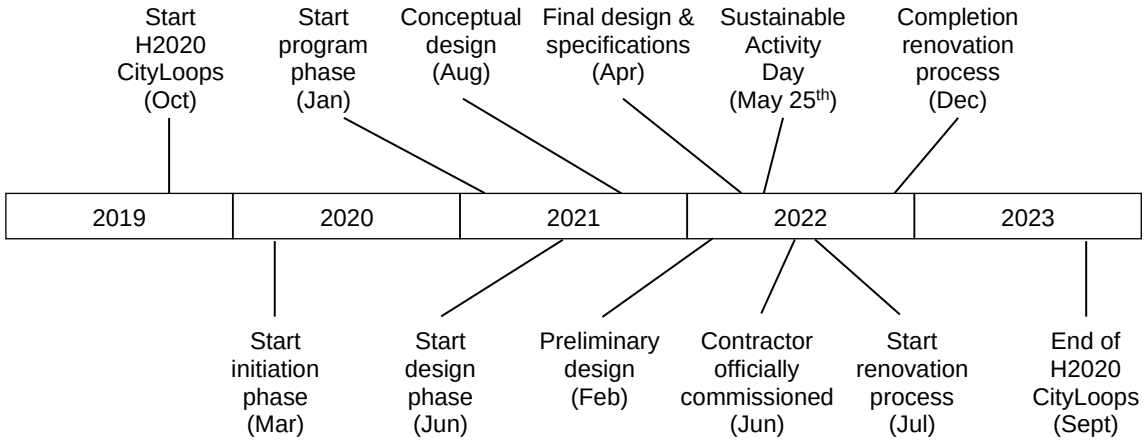


Figure 4.20. *Time line for the renovation project of the residential road Griffiersveld.*

This project represents a situation that is very recognizable for many municipalities in the world on an annual, monthly, or even weekly basis, namely the renovation of a paved residential road. Constructed in the late seventies, it is a street that is paved with concrete pavers and small 30 cm by 30 cm concrete slabs. When planning, designing, and executing a road renovation project, multiple departments within the municipal organization, as well as different external organizations, need to collaborate. To the stakeholders involved in this project, circular material usage was introduced as a new specific sustainable objective. However, traditional constraints like time and costs still exist to come to a new renovated residential road. Therefore, circular objectives were introduced and discussed through a set of interventions.

Challenges regarding contractual agreements

Before setting out how procurement took place in this project, it is important to mention the contractual agreement the Municipality of Apeldoorn has with a supplier of concrete products. This agreement is laid down in a framework contract, which is a document that outlines the terms and conditions for an ongoing business relationship between material supplier of

concrete surface elements ‘De Hamer’ and the Municipality of Apeldoorn. When it comes to public open space construction projects, any contractor working for the municipality will be confronted with the sand the municipality has available at their soil and sand site and the agreement the municipality has with this material supplier De Hamer.

An interview with a financial expert of the Municipality of Apeldoorn on the 20th December 2021, learned us that the contract was concluded in 2019 and would run until the end of 2021. Although there is some debate on the effectiveness of the contract and which elements should be altered how, it is was extended till May 2023. In January 2023 it was carefully mentioned that the agreement might be terminated after this due date and that new projects will comply with a basic overruling set of specifications, partially developed with the help of platforms https://bouwcircurlair.nl and https://moederbestek.nl.

One important article in the current agreement that aims to close material loops at least to a certain extent, is formulated, as follows: *The tenderer agrees with the following and confirms that his tender complies with it.*

In connection with the desire for circularity, the minimum requirement in above-ground concrete products for secondary aggregate is 15% (volume percent). The circularity requirement does not apply to the requested concrete street paver coloured through and through.

The secondary aggregate used in concrete must have a CE marking based on EN 12620. The aggregate must also meet other existing quality requirements for use in concrete as described in BRL2506-1, BRL 2507 or BRL 2502.

The municipality does not demand a higher percentage because this is not recommended due to insufficient availability of suitable secondary aggregates on the one hand and possible negative consequences for sustainability on the other.

A nationwide exemplary set of specifications provides a product sheet on concrete paving stones (BSS) and the 15% is also mentioned therein. This has been available since 20-09-2016. The circularity requirement in Article 1.1.2 in the contract does specifically not apply to a concrete paving stone (in Dutch: betonstraatsteen or BSS for short) coloured through-and-through, as the designer and project leader envisaged in the case of Griffiersveld. The circularity requirement means that otherwise 15% secondary aggregate is used. A higher percentage is not required because there is too little material to use as secondary aggregate and on the other hand because of alleged negative consequences for sustainability in the sense of the technical lifetime of the concrete paving stone. The mentioned Environmental Costs Indicator (in Dutch: Milieu Kosten Indicator or MKI for short) of 25 euro/m^3 has been changed in various product certificates since the agreement of 1 October 2021 to 23 euro/m^3, which is a lower and therefore even more environmentally friendly value.

However, enforcement of the minimum 15% requirement must take place. This is a challenge on paper and in practice. A recent past project in the Municipality of Apeldoorn did not show the desired results. Although online information can be found that the redevelopment of the park-like neighborhood 'De Parken' in Apeldoorn is the very first civil engineering project in the Netherlands to be designed and executed in a circular manner, there was not enough secondary material available in that project. At the time, the control of the aforementioned minimum 15% volume percentage was not to be actively pursued, due to a shortage of aggregates coming from breaking used construction products.

Circularity in the demonstration project

On the 14th of February 2022 at Saxion in Apeldoorn a workshop was provided by Rijkswaterstaat, the Netherlands executive agency of the Ministry of Infrastructure and Water Management, dedicated to promote safety, mobility and the quality of life. In this workshop information and guidelines were provided and thoughts were discussed enabling civil servants of the Municipality of Apeldoorn to improve the inclusion of circularity in their procurement activities. The guideline 'procurement in eight steps' (Van Oppen, Croon and Bijl de Vroe, 2018) was addressed and explained. For the particular case of Griffiersveld, the result of this workshop was for the principal and project leader to put more effort in coming to a team already including a contractor to guarantee constructability of the project, and efficient and effective material use and reuse in the project.

One week later, on the 21st of February, a tender guideline with instructions for interested contractors to renovate Griffiersveld came publicly available. Financial and time constraints were given in this guideline. In this guideline the Municipality of Apeldoorn asked, among others, the contractors to come up with ideas to improve circularity. The better the vision on the process, time management and circularity were, the lower the costs of the project would be assessed by the principal, with a maximum of € 7.500 per topic.

In April 2022 it became clear that the contractor, had prepared three concise documents as his plan of action. As requested in the guideline, one document was about the vision of the contractor, a second one on time management and the third one was about circularity. This third document was translated in English and can be found in Annex D. The contractor suggested to apply six measures to improve the level of circularity and offered for additional payments three extra options, which could be considered for adoption by the principal.

- Measure 1: to organize a circularity session with multiple participants;
- Measure 2: to work out a reuse inventory for Griffiersveld;
- Measure 3: to apply released materials from this project to other projects using DuSpot;
- Measure 4: to break released concrete products into rubble for foundations;
- Measure 5: to repave the street completely on a foundation of sand;
- Measure 6: to directly reuse sand in other projects without transporting it to the soil and sand site first;
- Option 1: to reuse trees elsewhere in the municipality
- Option 2: to palletize used concrete paving stones for reuse
- Option 3: to set up a material passport for the project.

Measure 1 about organizing an internal session on circularity, was implemented on the 25th of April, when the principal, the project leader and the H2020 CityLoops demonstration manager of the Municipality of Apeldoorn, together with the director and project leader of Pannekoek GWW and a researcher of Saxion UAS sat down to discuss how circular this project could be executed.

Measure 2 was covered by the Municipality of Apeldoorn by means of providing drawings specifying which materials where available where in what quantities, as can be found in Annex B. Section 4.3 provides insights in how data was collected and stored. Therefore, the contractor did not need to implement this measure anymore.

In regards to Measure 3 the contractor communicated the availability of materials through DuSpot; an online matching tool for construction materials. However, at the beginning of the

renovation project no interest was shown by those within the municipality who manage construction projects and, therefore, could be affiliated to this matching tool. By the end of the renovation project, one did see the opportunities DuSpot has to offer. The matching tool was implemented for new projects to come. However, at that time 500 m^2 of grey concrete pavers already had been reused and most materials had already been given away mainly to agricultural organizations within the municipality. The concrete paving slabs of 30 cm by 30 cm were offered to a company selling photovoltaic systems, where they can be used as ballast for flat roof systems. The contractor made it possible that much of the old concrete products were to be reused. In the end only 225 ton, instead of 1150 ton, ended up to be crushed to concrete granulate.

A total permeable surface of 1120 m^2 was realized to make it possible that storm water can infiltrate the subsoil and will not end up anymore in the waste water treatment plant. Although storm water infiltration was facilitated, no values regarding traced volumes or weights of 0/4 or 4/40 fractions as addressed in Measure 4 were communicated.

Measure 5 was applied significantly reduced the number of sand and rubble loads from and to the project site.

Because only little sand was needed, due to Measure 5, Measure 6 was not actively implemented; sand transport went through the soil and sand site of the Municipality of Apeldoorn. Besides the willingness of the contractor to collaborate with the Municipality of Apeldoorn on the topic of circularity and the CityLoops project, the three options that had been offered with some extra costs, were not implemented.

CIRCULAR PROCUREMENT

In the procurement trajectory, contractors interested in the project were not only given financial and time constraints in a guideline, but were also challenged to work out their vision on the process, time management and circularity. The better the vision on the process, time management and circularity were, the lower the costs of the project would be assessed by the principal, with a maximum of € 7.500 per topic.

Lessons learned

Three contractors made an effort to clearly explain what vision they have regarding the renovation process, time management and circularity in the renovation of Griffiersveld. The winning contractor offered in total six measures and three options to improve circularity. By actively implementing three out of six measures the environmental impact was significantly reduced. When the project is being executed, it is important that the principal stays in close contact with the contractor to make sure that all measures are being implemented. The sunny side in this project was that by applying two measures very successfully, namely the reuse of concrete paving stones nearby and the reuse of sand as a foundation, two other measures were hard to implement.

Book Oppen, C. van, Croon, G., Bijl de Vroe, D., 2018. *Circular procurement in 8 steps.*

Guideline Jones, M., 2021. *CityLoops WP2 Circular Procurement: D2.4 Construction/demolition procurement guidelines.* Rijkswaterstaat.

Impact

In renovating Griffiersveld 500 m^2 of grey concrete pavers and approximately 300 tonnes of sand were reused within the project, 225 tonnes of debris came available consisting of old concrete curb stones, old broken concrete paving slabs and stones, and leftovers by means of cut new concrete paving stones. This debris will be crushed and will be reused in the foundation of new projects. In

total, an estimated 925 tonnes of materials were being reused within the project itself or in its proximity.

Expected outcome: By the end of the project, procurement of circular products related to Griffiersveld have increased by 10% in volume, due to awareness raising activities within the Municipality of Apeldoorn.

Indicator	Baseline result	Intermediate result	Final result
12. Circularity requirements in procurement beyond existing levels	Zero	To ensure to optimize all circular solutions, the procurement process was organised differently. Usage was made of a so-called Bouw team. The bouw team is a partnership in which the contractor is involved in the design phase of the construction project. In this way the construction team together with the contractor can think through all circular options to implement during the execution of the construction process.	The final result of this process is that the road renovation of Griffiersveld has conducted in a circular way. Traditional construction procurements do not by default entail circular aspects. This is completely depending on the person in charge. This has to do with the bouwteam method which was implemented, through the bouwteam method the offer of the constructor provided circular basic principles and optional additions for the municipality. From the evaluation session it became apparent that although auditions were offered, none of the additions were implemented and only the basic principles were implemented
16. Procurements making use of stakeholder dialogue to strengthen circularity: Qualitative description	Zero	8 steps guideline for circular procurement. RWS has organised a webinar for Apeldoorn internal stakeholders and an in-person workshop for internal stakeholders. Organise a market dialogue of construction companies. Procurement team consolidated; project started. Publication of the Tender for 'Design & Engineering'. Procurement process is implemented.	In the evaluation session on the procurement process, it became apparent that several of the eight steps guideline on circular procurement (Van Oppen, Croon, and Bijl de Vroe, 2018) have been followed, none the less not all. Reasons for this was partly due to timing of the instrument in relation to the Bouw team discussions. Nevertheless during the evaluation workshop held, the internal stakeholder of the Municipality of Apeldoorn did underline the importance of the steps in relation to the procurement workshop, and are also eager to work with this more in the coming years.

4.5 Online marketplace

The urge exists to develop and use tools that enable us to operate road materials retaining their highest utility, quality and value. Here we share our experiences in using online marketplaces to close material loops. These matching tools assist those offering used materials -or an unanticipated surplus of materials- are linked to those in need of materials. Results will be shared regarding the experiences of Apeldoorn in three ways 1) setting up a

completely new digital marketplace, 2) collaborating with an existing digital marketplace in an early phase, and 3) partnering up with an online matching tool for future projects.

In a circular economy it is still possible, just like in a linear economy, that materials, products and components change hands. Although some circular movements focus on letting the right of usage prevail above ownership, online matching platforms are by many seen as a useful instrument to let ownership change from one person or organisation to another, while maintaining high user value. When it comes to trading used materials, products and components, the website http://www.marktplaats.nl, established in 1999, is one of the best-visited websites in the Netherlands; namely 8 million unique visitors each month out of a population of 17.8 million. All kinds of small and large consumer products, but also professional trades and even building materials are offered on this website. However, as a municipality or company in the construction industry, it is not easy to upload your used materials, products or components completely and quickly. It takes quite some effort to correctly express their quantity and quality.

The Municipality of Apeldoorn looked for opportunities to let her road materials experience the best next usage possible by collaborating with existing trading platforms and by giving a try with a newly designed website. Students of Saxion UAS designed a website with specific categories of materials, products and components useful to the construction industry (ten Brinke et al., 2021). Furthermore, a new function to date availability was introduced. This date addresses when a certain building material, product or component might come available and can be harvested on-site. However, setting up a completely new site means that you will start at zero regarding visitors and, therefore, potential buyers. It will take time and money to attract visitors to your new website (see Figures 4.21 and 4.22).

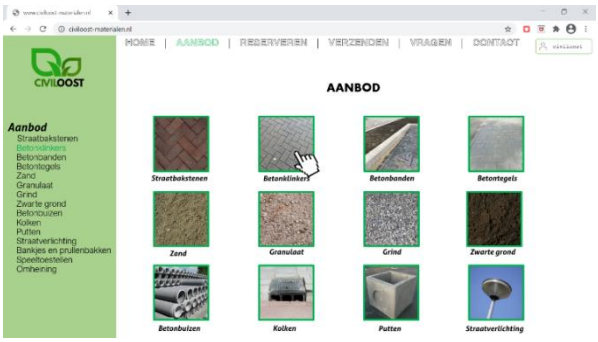


Figure 4.21. *An impression of the online marketplace for public space materials and products as designed by the students (ten Brinke et al., 2021)*

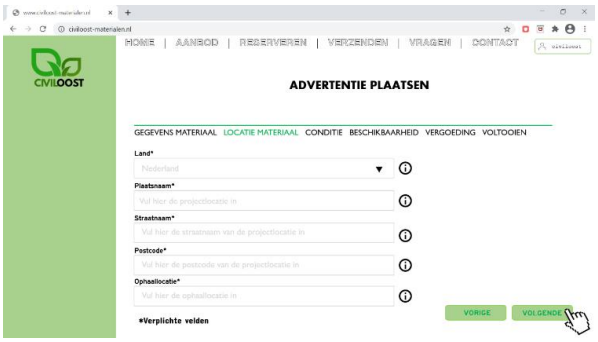


Figure 4.22. *An impression of how a product can be uploaded at the designed online marketplace (ten Brinke et al., 2021)*

To cope with the problem of the number of users, the Municipality of Apeldoorn tried to collaborate with the more established online matching platform Excess Materials Exchange (EME). This technology company has the ambition to find new high-value options for materials or (waste) products by showing their financial and ecological value. By means of four instruments 1. Resource passports, 2. Tracking and tracing, 3. Valuation and 4. Matchmaking (https://excessmaterialsexchange.com), the used materials available in Apeldoorn could have been linked to new users. However, after a first inventory of the environmental impact of some of the old materials in Griffiersveld by EME, the company lost interest and the collaboration came to hold.

The third trajectory that started and is sealed by an agreement, is the collaboration between the Municipality of Apeldoorn and DuSpot. DuSpot is also an online matching tool and it specifically focuses on matching materials in civil construction projects (see Figure 4.23). Materials coming available in different stages of a building project are offered in a user-friendly, organized and comprehensible way. This is being achieved by making use of the standardized way specifications for civil construction projects are organised (https://duspot.nl). As its name implies DuSpot enable a user to make a building project or depot online visible as a spot where products and materials are offered and needed for certain users (see Figure 4.24 and 4.25). The user can select who will be able to see this spot. By this means DuSpot is used to facilitate the reuse of materials needed and coming available in Apeldoorn's construction projects in public space. To facilitate circular material loops DuSpot also shows the inventories of the material depots Apeldoorn is operating.

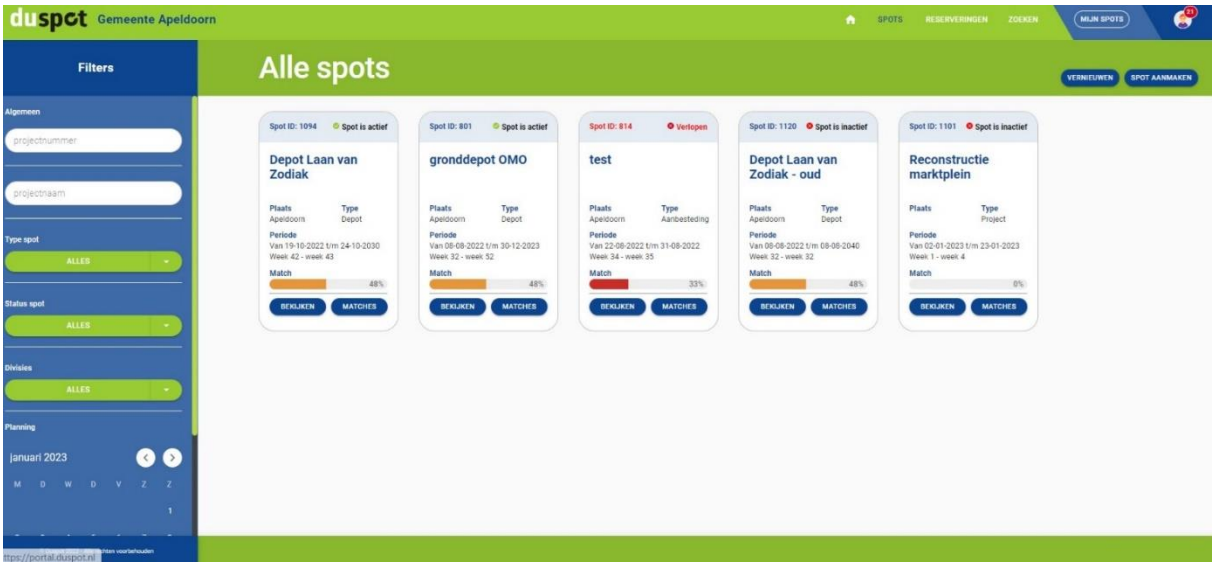


Figure 4.23. *An impression of how a set of spots in the Municipality of Apeldoorn look like in DuSpot (courtesy of Mart Mensink)*

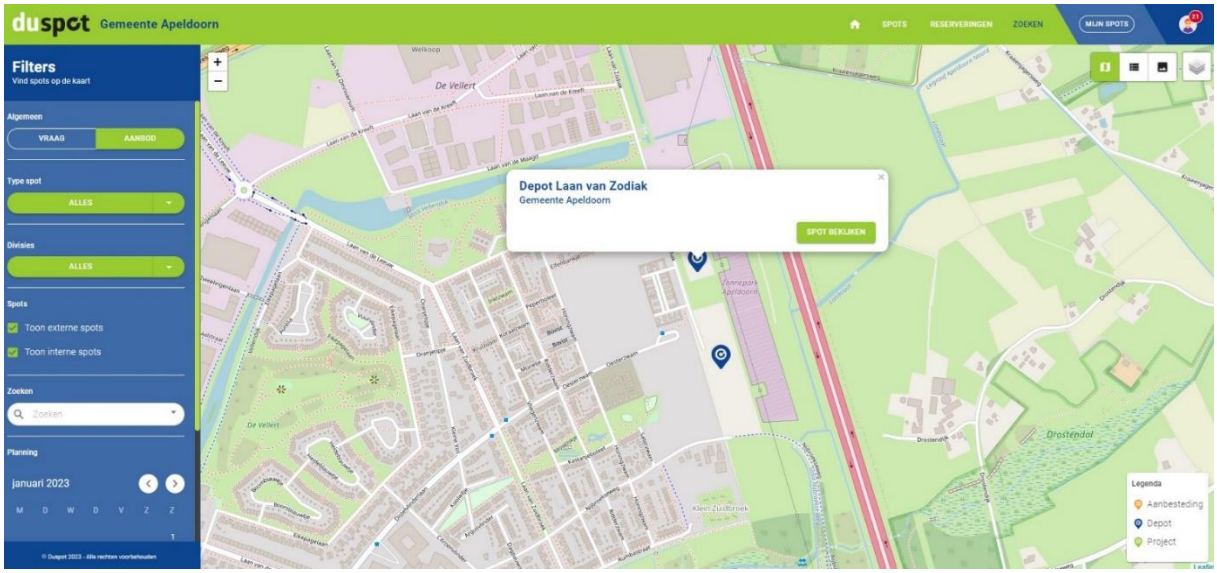


Figure 4.24. *The location of the material depot at the Laan van Zodiac as shown in DuSpot (courtesy of Mart Mensink)*

By analysing these three demonstration actions, it was found that the rates of effectiveness and efficiency by which the main service was offered, hence the matching process, strongly differ. Differences can be found in input, throughput and output. Handling costs of the products offered are a traditional point of concern. The ease with which one can upload the specifications of materials onto the platform is being tackled in different ways. Insights in the environmental costs and benefits of reusing materials are not yet provided by every platform.

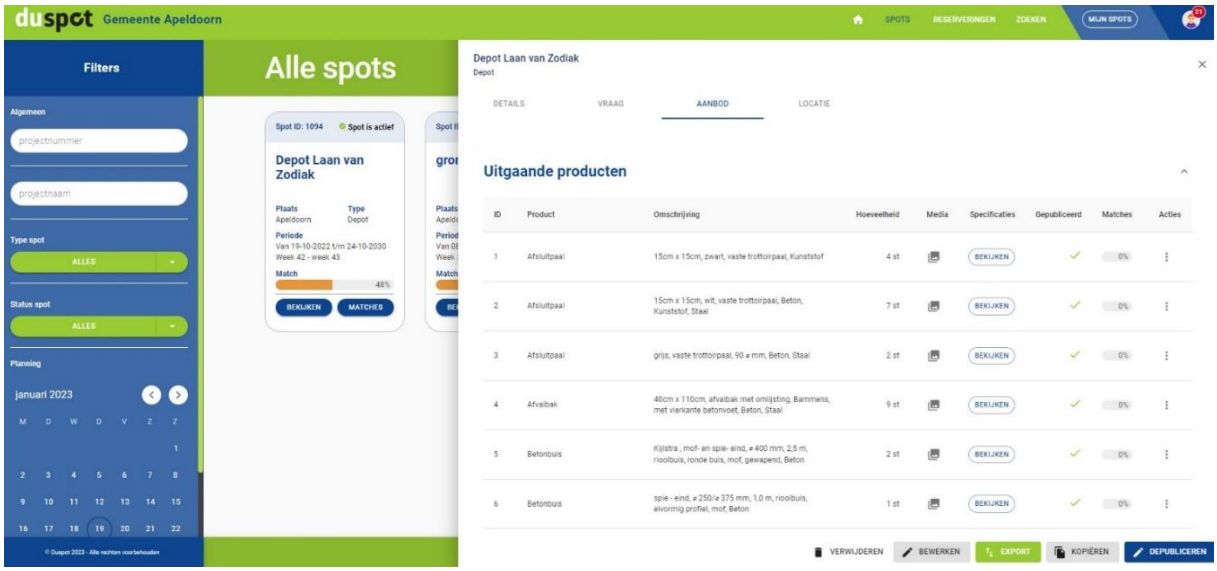


Figure 4.25. *Some of the products and materials that are offered at the depot at the Laan van Zodiac as shown in DuSpot (courtesy of Mart Mensink)*

ONLINE MATCHING TOOL DUSPOT

DuSpot is an online matching tool e.g. for governments, contractors, and engineering offices. It is hosted centrally as Software as a Service (SaaS). When a spot is a building project for example, the data-input shown in the database consists of project specifications aligned according to the Netherlands commonly used 'Rationalisatie en Automatisering Grond-, Water- en Wegenbouw' (RAW)-system, which encompasses juridical, administrative and technical requirements. When a spot is representing any kind of location, the inventory of this location depot will be shown (so for example the spot is a road, the information provided will detail out the type of material at that location) One can select who is able to see what is offered or needed at a certain spot An organisation using DuSpot pays an annual fee for the number of users, that have access to and will be using DuSpot.

Lessons learned

Within CityLoops, the Municipality of Apeldoorn introduced the residential area Griffiersveld, part of the relatively large neighbourhood De Maten, as a casus to test tools and to come to circular road renovation. The online marketplace and experiences with EME presented in this tool factsheet were focusing on this demonstration project. When it was noticed that DuSpot has some advantages compared to these two, a trial period not limited to Griffiersveld was started, which ended in December 2022. After that, the matching tool is now widely available to enable material loops in municipal projects to be closed. The material depots of the municipality also became available as spots in DuSpot. The decision for DuSpot derived from an analysis of four systems, to access the best fit in relation to the requirements of Municipality of Apeldoorn. As DuSpot provided this, there was no need to investigate developing our own marketplace/platform. Besides that, we never develop IT by ourselves.

Tool factsheet "Matching platforms for construction materials"
Company website of DuSpot, https://www.duspot.nl/

Impact
Expected outcome: Improved innovative products and services in CE practices within municipal organisations

Indicator	Baseline result	Intermediate result	Final result
Indicator 30. New digital material databank / market place: qualitative description	Zero	Pilot was run and experiences were obtained with EME . Trail with DuSpot started with a scope beyond Griffiersveld	DuSpot now widely available within the municipality and the material depots became available as spots in this matching tool.

Outcome review
Through the purchase of DuSpot, the municipal has not only obtained improved innovative products and services, but also enhanced it CE practices. This because the two material spots became available as spots on DuSpot.

4.6 Organizational changes / planning and decision making

4.6.1 Developing a CO_2 indicator

Within the CityLoops project, Kellermann (2021) developed a tool to calculate the CO_2 emissions of earth-moving lorries. This tool is adapted to a Dutch version by including specific transport emissions with a focus on the transport of concrete (products), soil, and asphalt. By allowing the user to enter specific lorry and route characteristics, we expect this tool to be able to provide more accurate insights into the CO_2 emitted due to transport. Furthermore, also emissions of other forms of transport were regarded, for example that of a tractor with a tipper, an excavator and a crane (see Figure 4.26 and 4.27).

Figure 4.26. *Tractor with tipper and in the back an excavator at Griffiersveld in July 2022 (by courtesy of Bram Entrop).*

Figure 4.27. *A crane transporting kerb stones at Griffiersveld in September 2022 (by courtesy of Lisanne Hagen).*

This Dutch version was used to calculate the CO_2 emissions during the transport of materials that have been supplied and taken away by lorries during the renovation project of Griffiersveld in the Municipality of Apeldoorn. To calculate these transport emissions, the CO_2 transport calculator requires the input as presented in Table 4.2. The parties working on the renovation project provided insights and data for this input.

Table 4.2. *Instrument's input parameters (Hagen and Entrop, forthcoming).*

Input parameter	Unit
Loading capacity of the lorry	tons
Unloaded weight of the lorry	tons
Total distance of the route	km
Highway distance of the route	km
Amount of materials	tons

In case the lorry characteristics would have been unknown, it was still possible to choose a certain lorry type in the developed tool. In that case, the calculated CO_2 emissions will be less accurate. However, the ratio between routes will be similar, and thereby the lowest CO_2 emitted route can still be selected. The “total distance” and the “highway distance” of multiple routes

need to be entered in the CO_2 transport calculator to compare different routes. With this feature, the tool can be especially useful in the preparation phase, before executing a project, to decide what route is favoured to emit the least CO_2.

The CO_2 transport calculator uses Dutch emission factors expressed in kg CO_2/km for road transport with a weight higher than 20 tons. Since the weight of a material-transporting lorry easily exceeds 20 tons, the main factor in calculating the CO_2 transport emissions in this calculator is the distance driven by the lorry. Emission factors expressed in kg CO_2/t·km would be better. When knowing the emission factors of other countries expressed in kg CO_2/km, these can replace the Dutch values to use the calculator for that country. For emission factors expressed in kg CO_2/t·km, the instrument is still usable but might need some small adjustments in relation to the total mass of vehicle and the goods together.

DUTCH CO_2 TRANSPORT CALCULATOR

Material loops should be closed to minimize waste and the extraction of raw materials. This means that materials in the end-of-life phase of a construction should be reused or recycled in other (construction) projects. However, transporting these materials will emit CO_2. The Dutch CO_2 transport calculator is designed by Saxion UAS based on the CO_2 calculator of Kellermann (2021). This Dutch version calculates the CO_2 emission, based on Dutch emission factors, for transporting concrete (products), soil, or asphalt via a certain route. With this instrument, it was possible to calculate the CO_2 emission of the routes driven by lorries to supply and take away materials from the renovation project Griffiersveld. It is possible to calculate the emissions before the execution phase and thereby choose the route with the lowest CO_2 emission.

Lessons learned

The main contractor of the renovation project Griffiersveld has a contract with the Municipality of Apeldoorn, stating that information about their driven routes needs to be shared. Therefore, the transport distances, routes, transported material, and transported weights could be collected to calculate the CO_2 emissions per route. During the execution of the renovation, it is experienced that the main contractor was able to recognize various practical possibilities within its network to reuse materials instead of considering them as waste. These possibilities were recognized at short distances from the project location and were arranged within a short time.

Tool Factsheet "CO_2 transport calculator for Dutch demolition and construction sites" (this calculator is based on the CityLoops calculator of Kellerman, K (2022)
Paper Lisanne Hagen en Bram Entrop are preparing a paper on how the Dutch CO_2 transport calculator was developed and applied to Griffiersveld. Data was collected during renovation.
Tool Kellermann, K. (2022). CO2 calculator for soil transport version 1-51 [Excel tool]. CityLoops.

Impact

Expected outcome: Reduced CO_2 emissions from reduced transport and through reusing and recycling material (≥3,000 m^2 road), compared to conventional street development projects

Indicator	Baseline result	Intermediate result	Final result
87. Annual CO_2 emissions per unit of GDP	Zero	An adapted version of the CO_2 calculator developed by the CityLoops Danish partners has been adapted to include typical Dutch emissions data.	CO_2 calculator has been developed. The parameters have been defined and the instrument was adapted towards Dutch (road), machinery, types of lorry etc. The results are still under review and the paper to be published.

Outcome review

The CO_2 calculator was used in the demonstration action Griffiersveld. This to test and validate the calculator in comparison to the model of Klaus Kellerman.

4.6.2 Exploring circular business models

This part of the demonstration project will be described in two sections. A first section will discuss how Tartarin (2021) researched what business model could be best applied for the Municipality of Apeldoorn for the recycling of its roads in the broader context of handling of construction and demolition waste. The second section will focus on investment decisions regarding the materials within the project Griffiersveld for which a calculation model was developed by Jacques Bazen of Saxion UAS.

Circular business models by a triple layered canvas

In the context of a circular economy, the business model encompasses three types of values: economic, environmental and social. The main research question was: "Which business model and framework are best applicable for the recycling of roads in Apeldoorn? To what extent can the circular economy be embedded in the choices of the business model? What goals and strategies are relevant and suitable to make the business model work?"

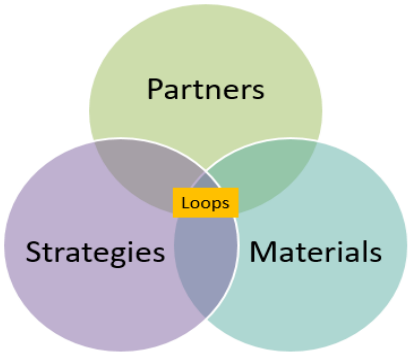


Figure 4.28. *Triangle to close material loops*

Based on research by Tartarin (2021) the setup of a framework and tooling relying on a three parts structure can help close the material loops. The framework is made of the 1) partners (e.g. investors, collaborations partners, suppliers and others), the 2) materials available in a given project and the 3) strategies to close the loops in the short, medium and longer term (see Figure 4.28).

The framework and tooling outlined below have been validated through triangulation during the external test, as conducted by Tartarin (2021). The individual and group feedback sessions have led to improvements of the proposed set up, the results are outlined below using the essential components to an effective circular economy as suggested by the Netherlands Environmental Assessment Agency (PBL) in its latest bi-annual report on circular economy (PBL, 2021).

Coordination of the materials is needed for an efficient management of the volume of materials from different projects. According to Homan (2019), *"the components of an organisation such as a municipality (units, divisions, clusters) functions de facto with relative autonomy and can operate independently from forms of central rules, strategies, objectives and such like".* For the material coordination a complete overview is needed from an organizational viewpoint.

Therefore, a CE officer should be appointed to oversee and manage all materials in order to increase efficiency and control of the material streams. This centralised management is needed as multiple projects in an overall vision and strategy are being rolled out. A situation that can be compared with successful smart cities incorporating a wide range of smart applications and where digitalization is key. Their success in terms of efficiency and management is widely recognised in the responsibility of a single individual, namely a digital IT architect. In Helsinki, second best Smart city in the world (according to Brussels Smart City, 2020) the project Forum Virium operates very successfully using this set up (Pardo-Bosch, Cervera, and Ysa, 2019; Hämäläinen, 2020).

The results of the conducted literature study and interviews by Tartarin (2021) show that the social value aspect of handling and treatment of CDW should play a major role in decision making in terms of identification of social value and embedding in a sustainable business model. Results also show that the economic aspects cannot be properly evaluated and analysed due to the multitude of projects being undertaken from different departments and different individuals with different perspectives. The need for an “open playing field” is critical for the efficiency and the transparency of the projects.

Over time materials collected will be efficiently handled and managed in multiple projects of the municipality with possibly different project leaders/managers in charge. The overview of what materials are available and the decision making process about where these materials will go will also prevent possible cannibalisation of resources by project managers who need the materials. The suggested CE officer will be critical in making sure a fair and relevant dissemination of the materials is done.

As the council gives a clear goal for the ultimate objective(s) to reach in the handling of CDW, e.g. CO_2 emissions reduction (environmental value) and cheaper materials for construction of affordable housing (social value). It is possible to set up KPI’s for each project. These KPI’s would be the common denominators for the entire municipality. Material loops based on a tripartite effort. Although the subject of closing material loops is very complex, the suggested view from the combination set offers a simple way to tackle the issue by means of the following framework for handling CDW for the Municipality of Apeldoorn (see Figure 4.29):

1. Council level: introduce/establish a clear vision, mission and objectives for the handling and treatment of CDW linked to one or more of the (economic, environmental, social) values.
2. Internal organization level: use the triple layered business model canvas as an internal tool to go beyond the pure economic output and maximize other (environmental, social) values.
3. Project Management level: set up and running of a materials related project needs to work towards the strategic objectives set up by the council. KPI’s will enable to evaluate performances and relation to these objectives.

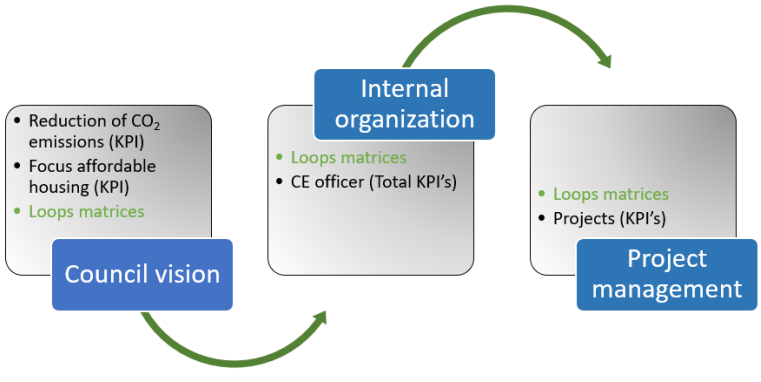


Figure 4.29. *Framework for handling CDW using an example vision*

The suggested tooling to help closing the loops is called the Loops matrix set made up of three matrices; the Material Loops Matrix (MLM), the Partner Loops Matrix (PLM) and the Strategy Loops Matrix(SLM) (see Figure 4.30):

Step 1: Fill in the Material Loops Matrix (MLM) by linking circularity options (R's) to the identified materials in the project.
Step 2: Fill in the Partner Loops Matrix (PLM) by linking circularity options (R's) to the identified partners which can offer solutions.
Step 3: Link the results of the MLM and PLM to decide on the Strategy Loops Matrix (SLM) for all identified materials.

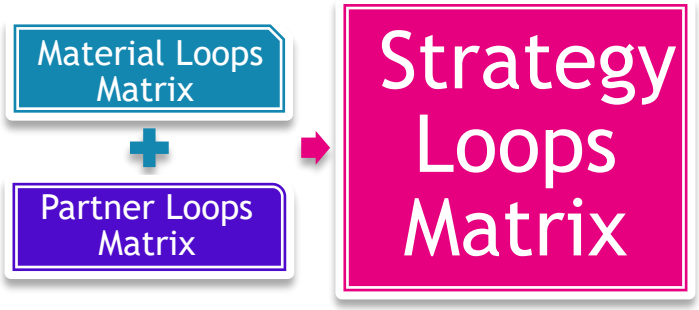


Figure 4.30. *Relation between three Loops Matrices*

The strategies will ultimately lead to the fulfilment of one or more of the CE perspectives (economic, environmental, social). The strategies in this context can be seen as a plan but also as a process using Mintzberg's theories on strategies (Mintzberg, Ahlstrand, and Lampel 1998). The framework and tooling offer a blueprint or design for closing the material loops in processes as well as an operational timeline to achieve this as a plan.

This systematic (framework and tooling) is clearly supported by the just published 2021 Dutch report on the circular economy in The Netherlands. Amongst the conclusions of this comprehensive study are that in order to reach the ambition to be circular by 2050 there is need for an intensification of policies and a wider vision supporting the objectives and activities engaged. Further, there must be clear and measurable objectives. It is further concluded that the government should support relevant innovation through for instance public procurement for circular products and engage the responsibility of the producers Government, market players and other instances must create 'transition teams' in a combine government/private sector combination (Planbureau voor de Leefomgeving, 2021).

In the development of a new business model, the values of the relevant materials can be investigated from an economic, environmental and social perspective. The municipality should actively involve inhabitants and industry partners in the decision making process. Municipality employee workforce involved in these projects need to have a comprehensive and collegial infrastructure and communications line to enable them to be working as one unit.

The municipality's council can benefit from having clear objectives and long-term ambition described in a policy document about CDW. Evaluation tools such as the proposed framework and set of matrices (material loops matrix, partner loops matrix, strategy loops matrix) might be useful to embed these efforts in the municipality's organisation and operations. A new insight was offered by moving away from the pure technical ability of a specific material to be re-used or recycled. It is suggested that closing material loops is highly dependent on the local situation as far as which type of material is concerned, wishes of the municipality and inhabitants of that city. Therefore, although the suggested framework and tooling can be up-scaled to other cities in Europe, the results and decisions taken might vary per material depending on the local context.

TRIPLE LAYERED CIRCULAR BUSINESS MODEL

A framework and tooling have been developed as a result of a research project. The following steps offer a strategic and operational way to close material loops:

1. Use the developed Triple Layered Business Model Canvas filled in from now on to monitor the situation and build upon it.
2. Suggest that the council establishes at least one clear objective to work towards from a strategic viewpoint (i.e. reduction of CO**2** emissions to meet the green deal law)
3. Use the developed Material loops matrix (MLM) in relation to specific materials to be recovered for Griffiersveld.
2. Use the developed Partner Loops Matrix (PLM) in relation to the specific role and possible impact each partner involved in the recycling of the roads in Griffiersveld could have. Engage in a discussion with these partners.
3. Once both MLM and PLM have been filled in, fill in the Strategy Loops Matrix (SLM) and linked to the council objective work on different loops closing materials scenarios (ad 2)
4. Align the activities of the material depot with the chosen strategies as operational tool and incorporate if relevant the material passport concept.
5. Based on the evaluation of the strategies and discussions with the council, draft a proposition policy document highlighting a short, medium and long term CDW strategy.
6. Introduce the concept of the framework and tooling to employees involved with circular economy related projects. Train them to use the framework and tooling and implement the system for all new projects.
7. Appoint a dedicated CE officer responsible for all CE related activities, who used the developed framework 0and tooling. Make all projects coordinators report to that person who directly reports to the council.

Lessons learned

We have to consider that a municipality is not the same as a business organisation. Reconstructions of roads are never an interesting business to invest in. It is the social responsibility of a municipality to keep the neighbourhood accessible for all inhabitants. Last week (July 2023) it was the Municipality of Leeuwarden (up north in The Netherlands) who made the decision to depreciate real estate to make visible what the real residual value of a building is. It is the first municipality in the Netherlands. Hopefully more will follow, because then we really can add value to a circular transition. If we can or will do also into infrastructure we will see economic, social and environmental what the end of lifetime value will be. Still this is not the situation in the demonstration in CityLoops in Apeldoorn we have to consider that we know the costs/benefits are. And that's the situation right now.

More than thirty respondents have clear ideas about how to cope with certain materials, when it comes to road renovation projects in Apeldoorn. By completing the MLM, it became apparent they have the ambition to reduce, reuse, recycle and recover materials. Furthermore, the PLM shows that three partners (Cemtex, Jansen BV, and Adac) are in place regarding reducing, re-using, recycling, recovering and even reconverting road construction materials. With these ambitions and partners in place, an eco-efficiency strategy, use optimalization strategy and community building strategy seem to fit the Municipality of Apeldoorn best and complete the SLM.

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Presentation Tartarin, T., 2021. *Developing a circular business model; framing and tooling*. Presented at the WP2 Cross Consortium meeting of February 10, 2021. Saxion UAS

Calculation model to come to material choice

The cost and emission comparison model provides insights in the actual financial costs and emissions in CO_2 equivalents of the material choice for road renovations. The model provides an overview of costs and emissions for 100% virgin materials, as well as for 100% reused circular materials. The cost and emission comparison model also provides insight in the costs and emissions based on the amount of reusable material, which are currently in stock in the material depot(s) of the municipality. Both greenhouse gas emissions of the materials itself as the transportation from the source of the materials to the project have been taken into consideration.

Based on the description of the previous paragraphs in this section, a set of decision factors has been added to the model to make it applicable in practice. These decision factors are based on financial, social and environmental aspects of the proposed solution. Each of these aspects has a weighing factor in the model. It is up to the local politicians to put a value for each weighing factor, as this is a political decision. The model itself can calculate both the financial and emission characteristics of each decision, but not the social aspects i.e. the acceptability of a proposed solution by the local community. The social acceptability of each solution (for example based on discussions with the residents of the neighbourhood, have to be added manually in the decision model). With the decision model, the consequences for greenhouse gas emissions can be calculated for decisions made throughout the project. This has been done for a number of project decisions in the Griffiersveld project, the details of which are discussed in Section 4.4.1 of this demonstration report.

- When 100% virgin materials are being used in the project and everything would have been replaced (both the street and the underlying sand), the greenhouse gas emissions of all used materials and their transport are calculated to be 286 CO_2 equivalent tonnes;
- The decision to reuse the sand under the street, by simply leaving it there, has led to a reduction of the greenhouse gas emissions with approximately 25 tonnes of CO_2 equivalents (8.7% of the total material and transport emissions); In the calculation model, the resulting emission of 261 tonnes of CO_2 equivalents has been used as the reference amount for the project. In the calculation model can be seen that a relatively small amount of sand was still needed to be added, even though the bulk of the available sand remained in place.
- The decision to reuse a certain type of concrete pavers (for parking places) reduced the greenhouse gas emissions with approximately 24 tonnes CO_2 equivalents (8.4% of the total material and transport emissions);
- Using reused pavers for the entire street instead of new ‘virgin’ pavers could have reduced the greenhouse gas emissions with an extra approximately 174 tonnes of CO_2 equivalents (60.8% of the total material and transport emissions).

This means that with reusing available materials, a total reduction of 78% of greenhouse gas emissions on materials and their transport to the project could potentially be realized. In case of the Griffiersveld project the decision was made to use a very specific type of street paver, which was not available in reused form. Therefore, the reduction in the Griffiersveld project in terms of materials and transport resulted to 49 tonnes CO_2 equivalents, or 17% of the greenhouse gas emissions.

APELDOORN CALCULATION MODEL

The instrument developed is a calculation model for comparison of virgin and circular materials. In practice, making a decision on the type of materials used is a complex issue, as different factors must be taken into account (on environmental, social and financial issues). And even then: available quantities of circular materials must be taken into account as well as the transportation distances, to enable a correct comparison with virgin materials.

Lessons learned

This model can be applied to judge the consequences of decisions related to the usage of virgin and circular materials in terms of carbon emissions and financial implications, taking into account the availability of circular materials. The model can be expanded very easily by adding more lines to calculate more needed materials, also in more complex projects than the Griffiersveld project. The model has given the Municipality of Apeldoorn insight in the consequences (in terms of finances and emissions) of their decisions to reuse the available sand under the pavement, but also to order new virgin type pavers instead of reusing available circular ones.

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Annex A: Overview output

Factsheets

Factsheet 1: CO_2 transport calculator for Dutch demolition and construction sites
Factsheet 2: Material Passports; collecting and storing data in CDW projects
Factsheet 3: Stakeholder consultation procedure: the co-design process
Factsheet 4: Visualising the residual lifespan of road constructions in a 3D model
Factsheet 5: Matching platforms for construction materials

Documents

Entrop, A.G., Hagen, L., and Leeuwen, J.P. van, 2022. Aligning actors in a road renovation project by a co-design process: the road to circularity? *IOP Conf. Ser.: Earth Environ. Sci.* 1078 012119

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Other output

Infographic "*Project Circulair Bouwen Gemeente Apeldoorn*" developed by Jarno Leussink, Kevin Kleverwal and Tim Semmekrot.

Poster "*H2020 CityLoops Griffiersveld Apeldoorn; De circulaire transitie in een gemeentelijke organisatie*" developed by Bram Entrop and Lisanne Hagen

Poster "*Circulair Bouwen; hoe doen we dat in Griffiersveld?*" developed by Bram Entrop, Lisanne Hagen and Inge Smolders

Brochure “*Circulair Bouwen; hoe doen we dat in Griffiersveld?*” developed by Bram Entrop, Lisanne Hagen and Inge Smolders

Poster “*H2020 CityLoops: Griffiersveld - Apeldoorn; Negen deelprojecten voor een circulaire gemeente*” developed by Bram Entrop and Lisanne Hagen

Annex B: Drawings Griffiersveld

A road renovation process goes through different stages; an initiative was taken, multiple designs were made and were considered, plans for execution were developed and the actual situation is being checked and registered in the asset management software. In all these stages drawings are being made and often also altered. In this section multiple drawings are being shared to offer the reader an impression of what considerations were given to Griffiersveld.

Figure B.1: Drawing showing what the new Griffiersveld should look like.

Figure B.2: Drawing showing which elements need to be taken out of the road and might come available for reuse.

Figure B.3: A revision drawing that shows in green the actual location of the storm water infiltration system under beneath the road after renovation took place.

Annex C: Informing residents

In this annex you can find a poster (Figure C.1) and brochure (Figures C.2 and C.3) that were developed by Saxion UAS and the Municipality of Apeldoorn for the residents of Griffiersveld. The poster tries to visualize which materials are considered how in Griffiersveld. The brochure explains in a concise way what circularity and closing material loops are all about and how this will be achieved in renovating their street. It also provides the general applicable 10R system to close material loops.

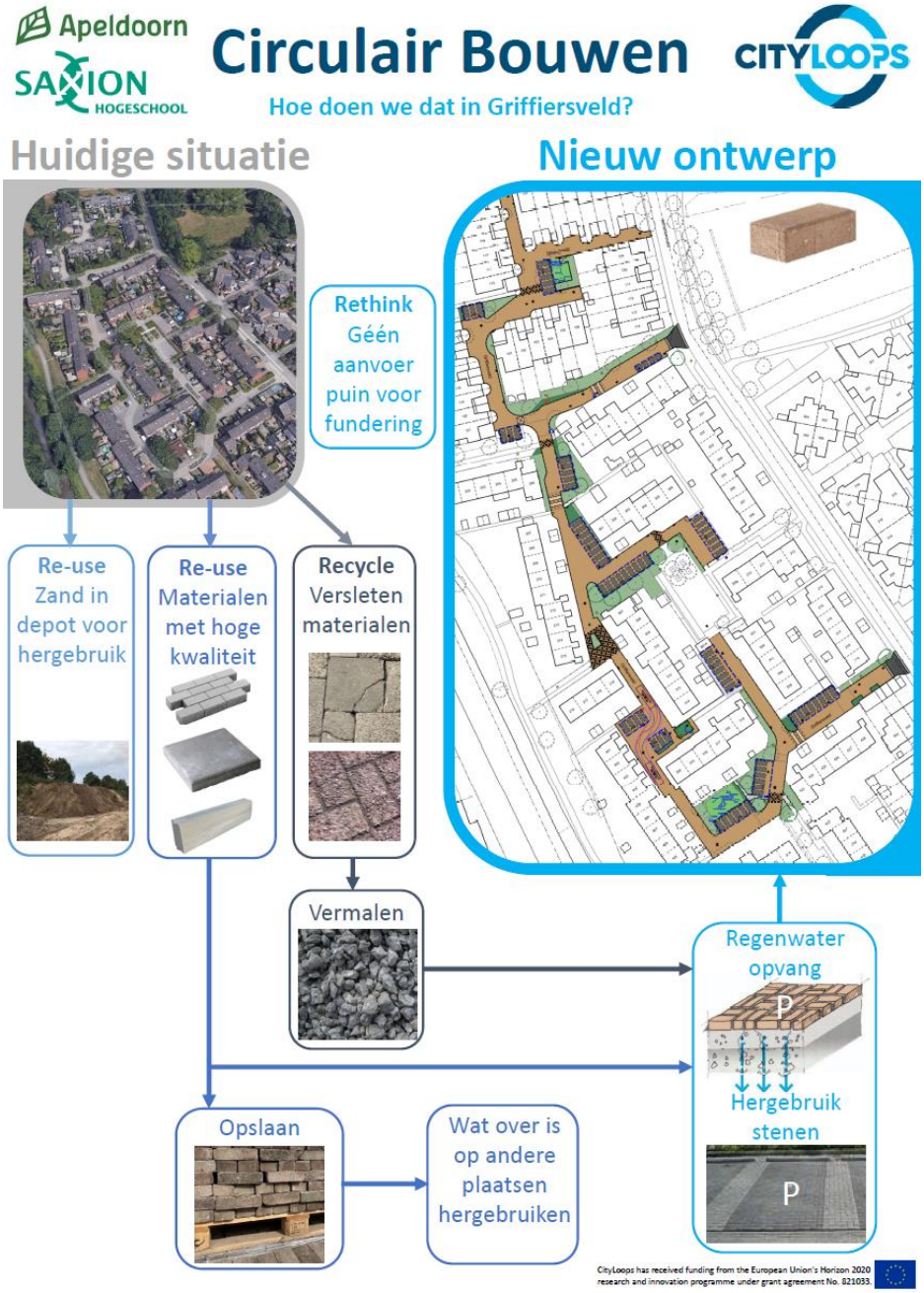

Figure C.1: The poster that was presented to the residents on the sustainable action day.

Circulair Bouwen

Hoe doen we dat in Griffiersveld?

Het CityLoops project
CityLoops is een groot Europees project, waarin zeven gemeenten uit zes verschillende landen samenwerken aan het sluiten van materiaal-kringlopen, zodat waardevolle materialen niet worden verspild. Dit doen ze zowel voor biologisch materiaal (denk bijvoorbeeld aan gemaaid gras of gevallen bladeren), als voor bouw- en sloopafval. Samen met u en verschillende bedrijven werken de gemeente Apeldoorn en hogeschool Saxion eraan om dit in Griffiersveld voor elkaar te krijgen.

Wat is circulair bouwen?
Voor de bouw is van veel grondstoffen maar een beperkte voorraad aanwezig, daarom moeten we hier zuinig mee omgaan. In een circulaire economie bestaat er -net als in de natuur- geen afval, omdat materialen steeds opnieuw worden gebruikt. Dit wordt ook wel het sluiten van materiaalkringlopen genoemd. Omdat Nederland de ambitie heeft om in 2050 volledig circulair te zijn, moet ook de bouwsector circulair gaan bouwen.

Het 10R model
Het 10R model bestaat uit tien lagen die beschrijven hoe er circulair kan worden gebouwd. Deze tien lagen staan hiernaast beschreven. De meest circulaire toepassing is laag 1 en het minst circulair is laag 10. Het beste is dus om een maatregel in een zo hoog mogelijke laag toe te passen.
Het verbranden van materiaal zonder energie terug te winnen of het storten van materiaal in de natuur of op een vuilnisbelt vallen niet onder één van deze tien stappen en horen dus niet thuis in een circulaire economie.

1. **Rethink** (heroverwegen) is het begin van circulair denken en doen door een andere manier van denken en organiseren aan te leren;
2. **Redesign** (herontwerpen) door het ontwerp zodanig aan te passen dat het product een langere levensduur heeft, makkelijk te demonteren is en bestaat uit duurzame materialen die opnieuw gebruikt kunnen worden;
3. **Reduce** (verminderen) gaat om het verminderen van het verbruik van grondstoffen tijdens de productie;
4. **Reuse** betekent hergebruiken van een volledig product, in dezelfde functie;
5. **Repair** (repareren). Het is beter om goed onderhoud en reparatie uit te voeren dan spullen weg te gooien en nieuwe te kopen;
6. **Refurbish** (opknappen). Producten of bouwdelen worden hersteld of vernieuwd door ze op te knappen;
7. **Remanufacture** (reviseren). Het gaat er hierbij om dat nieuwe producten worden gemaakt van oude producten of onderdelen hiervan;
8. **Repurpose** betekent het hergebruiken van producten met een ander doel;
9. **Recycle** is een brede term die we gebruiken voor de verwerking en het hergebruik van materialen;
10. **Recover** is het terugwinnen van energie uit materialen.

Figure B.2: Front page and two inner pages (when A4 is folded) of the brochure for the residents.

Wilt u meer weten over het CityLoops project?
Kijk dan op apeldoorn.nl/cityloops

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

Circulair materiaalgebruik in Griffiersveld
In het vernieuwen van de bestrating in Griffiersveld worden drie van de tien levels van het 10R model toegepast, namelijk: Rethink, Reuse en Recycle.

Rethink (Heroverwegen)
De belangrijkste manier om circulair te bouwen is door zo min mogelijk materialen te gebruiken en te produceren. Dit kan worden gedaan door in de ontwerpfase te heroverwegen (rethink) of een bepaald materiaal wel echt nodig is.
In eerste instantie zou bij Griffiersveld een puinlaag als fundering onder de wegen worden toegepast. Deze zwaardere vorm van funderen is niet nodig in deze wijk, omdat er naar verwachting niet veel zware voertuigen (op de vuilniswagen na) over de weg zullen gaan rijden. Er is daarom besloten om de huidige zandlaag onder de wegen opnieuw als fundering te gebruiken. Dit type fundering is voldoende in deze wijk en daardoor hoeft er geen tot weinig zand te worden afgegraven en te worden afgevoerd. We voorkomen hiermee het aanvoeren van 750 m^3 puin.

Reuse (Hergebruiken)
Wanneer het materiaalgebruik in de vorige stap tot een minimum is beperkt, is het belangrijk om de productie van nieuwe materialen te verlagen. Dit wordt gedaan door bestaande producten te hergebruiken (reuse).
Bij Griffiersveld wordt daarom een deel van de huidige materialen, die nog voldoen aan de kwaliteitseisen, hergebruikt in het nieuwe ontwerp. Dit is 535 m^2 aan betonstraatstenen die worden gebruikt voor de nieuwe parkeerplaatsen. Andere bruikbare betonstraatstenen, betontegels en betonnen opsluitbanden, die niet in het nieuwe ontwerp van Griffiersveld passen, worden op een online marktplaats speciaal voor bouwmaterialen geplaatst. Op deze manier kan een deel van de uit Griffiersveld komende materialen worden hergebruikt in andere projecten.

Recycle
Wanneer materialen niet kunnen worden hergebruikt, omdat bijvoorbeeld de kwaliteit niet meer goed genoeg is, worden de materialen gerecycled.
Het gaat hier om de betonnen materialen die worden vermalen. Door grof gemalen betonpuin onder de parkeerplaatsen toe te passen, kan regenwater makkelijker in de grond trekken. Hierdoor blijft het grondwaterniveau beter op peil en komt er minder schoon regenwater in het riool terecht, waardoor er minder water onnodig gezuiverd hoeft te worden. De kans op water-overlast wordt ook verminderd. Wanneer het betonpuin fijner wordt gemalen, kan het worden gebruikt als één van de ingrediënten in de productie van nieuw beton.

Figure C.3: Back page and two inner pages (when A4 is folded) of the brochure for the residents.

Annex D: Procurement

This annex shows how the contractor responded to the request of the Municipality of Apeldoorn to encompass one page of information about how circularity will be taken into when executing the renovation of Griffiersveld. Together with an overall vision on the process, a narrative on time management and the cost specifications the appropriate contractor was selected.

Section 1 Measures that contribute to circularity

The current design offers possibilities in the field of circularity on several aspects. The following measures are directly applicable within the target budget.

Measure 1: Organize circularity session: immediately after the project start-up (PSU), we organize a circularity session, to which we invite employees from CityLoops in addition to the permanent project team. The session will basically consist of brainstorming ideas about circularity and how this can be implemented specifically in this project, but also in future similar projects. Experience from the work 'Circular Waste Water Treatment Plant (WWTP) Terwolde' (on behalf of Water Board ‘Vallei en Veluwe’), where we have also applied this, teaches us that such a session is very valuable for the integration of circularity within a project.

Financial consequence: none, is included in the construction team costs.

Risks: none, is purely a brainstorming session. Outcomes that are applicable are incorporated in the elaboration of the design.

Measure 2: Reuse inventory: during the construction team phase, we draw up a reuse inventory. Here we provide insight into which materials that need to be removed are suitable for reuse. This gives a complete overview of the type, quantity and condition of these materials.

Financial consequence: none, is included in the construction team costs.

Risks: none, is purely an inventory. Outcomes that are applicable are incorporated in the design elaboration.

Measure 3: Apply released materials to another work: the contractor is affiliated with DuSpot. This is an online platform intended for trading materials that are released during reconstruction work, for example. We place the materials that are released during the demolition work on this platform, so that other parties (governments, contractors, private individuals and/or gardeners) can reuse these materials one on one within their project.

Financial consequence: by trading the released materials on DuSpot, they will generate money and no dumping costs have to be charged. In the construction team phase, the expected yield is included in the detailed budgets to be drawn up by us.

Risks: none, released materials are transported according to regular working methods.

Measure 4: Breaking released stones into concrete rubble with a size of 4 to 40 mm to be used in water-storing foundations: If it appears that the released pavements are (partly) of insufficient quality for reuse, we propose to break them (outside the work area) into concrete rubble 4/40 , so that we can use this one on one for the water-storing foundations to be installed. We use the fine fraction 0/4 that remains, just like the sand released from the existing foundation (after we have sieved it), as a paving layer. In order to have concrete rubble 4/40 immediately at the start of work, we propose to collect material from other works in Apeldoorn (including the Schoutenveld work) during the construction team phase and then break it up.

Financial consequence: (partially) no new concrete rubble / new street layer has to be supplied and the paved surfaces that are released do not have to be removed. On the other hand, breaking the exposed pavement does entail additional costs. However, it is expected that this measure will yield more than it costs. The financial benefits are included in the detailed budgets to be drawn up by us during the construction team phase.

Risks: nuisance to local residents due to the use of a rubble crusher. Control measure: During the construction team phase, we look together with you for a suitable location in the vicinity for the rubble crusher. At this location, material can already be collected from other works in Apeldoorn during the construction team phase, so that material is available immediately upon execution

Measure 5: Paving completely founded on sand: experience from the nearby project 'Revitalisation Schoutenveld' teaches us that the current street layer is founded on sand. For this reason, we propose to base the paving entirely on sand. We are currently applying this to various works. Foundation on sand is general policy at the municipality of Nunspeet, as well as among some other municipalities.

Financial consequence: foundation on sand means less supply and removal of material, which directly results in cost reduction.

Risks: subsidence/rutting of paving. Because the current foundation has been there for years, it is so well compacted and the fact that no sewer is replaced, no subsidence / rutting of paving is to be expected when we apply this. It is also not expected that the traffic load will increase in the neighbourhood in the coming years. If it turns out in the construction team phase that a rubble foundation is desired/necessary, we can still optimize by using 150 mm rubble instead of 250mm.

Measure 6: Reuse released sand from existing foundation: The reuse of released sand is nothing new in the infrastructure. However, this can be done more efficiently by taking it directly to the place of reuse without placing it in a depot in the meantime to carry out the necessary inspections. We do this by carrying out an AP04 inspection in-situ. Given the location and our experiences from the area, we do not expect any deviating results here. We can reuse the released sand 1 on 1 in one of our or perhaps one of your current projects. Due to the efficient reuse, this results in a significant CO_2 reduction in view of the reduction of transports.

Financial consequence: less transport means a reduction in costs.

Risks: the AP04 inspection results could indicate that non-applicable (polluted) soil is present, resulting in project delay. Control measure: experience from a comparable project 'Revitalisation Schoutenveld' and given the location of the residential area indicate, that this kind of result is not to be expected.

Section 2 Circular opportunities not included in the target budget

Option 1: Reuse trees elsewhere in the municipality: we see opportunities to transport trees that have to be removed elsewhere to this work and to replant them here. During the construction team phase, we want to make an inventory of this together with the principal.

Option 2: Palletizing stones for reuse: to make reuse within other projects more attractive, we can palletize the paving materials that are released. Palletizing stones is more expensive (and takes more time) than breaking up, transporting and dumping elsewhere. If necessary, we can use the buffers included in the time planning for this.

Option 3: Set up materials passport: we would like to draw up a material passport for this work in consultation with you. In this we jointly determine which materials (existing / new) are located where in the completed construction. We work this out in an integral 3D model. The passport contains information about the quality, origin and location of materials and provides insight into the material, circular and financial (residual) value of products. We see this material passport as a pilot for you as principal. If you like the set-up, you can further apply this concept within all infrastructure projects, so that you can provide digital insight into your infrastructure step-by-step and can easily see where which materials are located where and how they can be reused (in the context of the circular economy). This is a project-transcending opportunity and does not affect the lead time of implementation of this project.

Annex E: Survey residents

In this annex a survey can be found, that was developed for the residents of Griffiersveld. Although it was not actually used, we can imagine that the format and the questions might be helpful to other municipalities planning to renovate street.

Geachte inwoner van Griffiersveld,

Voor u ligt een vragenlijst ten behoeve van een buurtonderzoek onder de bewoners van Griffiersveld in opdracht van de gemeente Apeldoorn. Het onderzoek wordt uitgevoerd door acht studenten van de Hogeschool Saxion.

Het doel van het onderzoek is om de wijk (de straat en de voorzieningen) in de toekomst circulair her in te richten. Circulair inrichten betekent slim nadenken over (her)gebruik van materialen en producten bij het opnieuw inrichten van de wijk. Het circulair inrichten van de wijk is een belangrijk thema, aangezien de grondstoffen op deze aarde steeds schaarser worden en het beter voor het milieu is.

Met deze vragenlijst hoopt CivilOost meer te weten te komen wat u en uw medebewoners belangrijk vinden in de straat en wat u graag verbeterd wilt zien in de toekomst. We vinden het erg belangrijk dat de wensen vanuit de buurt mee worden genomen in het ontwerp aangezien u en uw buren de uiteindelijke gebruikers van Griffiersveld zijn.

Het invullen van de vragenlijst duurt ongeveer tien minuten. Het invullen van deze vragenlijst is natuurlijk vrijwillig, maar zeer welkom om het straatbeeld aan uw wensen te kunnen aanpassen. Uw ingevulde vragenlijst behandelen we vertrouwelijk en anoniem.

Alvast hartelijk bedankt voor uw medewerking!

Persoonlijke gegevens

Kunt u hieronder aankruisen wat voor uw persoonlijke situatie van toepassing is?

1. Wat is uw geslacht?

- Man
- Vrouw
- Neutraal

2. Wat is uw leeftijd?

- 16 – 25 jaar
- 25 – 30 jaar
- 31 – 40 jaar
- 41 – 50 jaar
- 51 – 65 jaar
- 66 – 75 jaar
- 76 – 85 jaar
- 86 jaar en ouder

3. Wat voor een soort huis heeft u?

- Koopwoning
- Huurwoning

4. Hoe is uw huishouden samengesteld?

- Alleenstaand zonder (thuiswonende) kinderen
- Alleenstaand met thuiswonende kinderen
- Echtpaar zonder (thuiswonende) kinderen
- Echtpaar met thuiswonende kinderen
- Ongehuwd samenwonend zonder (thuiswonende) kinderen
- Ongehuwd samenwonend met thuiswonende kinderen

4b. Indien van toepassing, wat is de leeftijd van uw thuiswonende kind(eren)?

5. Hoe lang woont u al in Griffiersveld?

- Minder dan 1 jaar
- Tussen de 1 en 2 jaar
- Tussen de 2 en 5 jaar
- Tussen de 5 en 20 jaar
- 20 jaar of langer

6. Kunt u hieronder aangeven in welk gebied u woont? U heeft keuze uit vier gebieden: A, B, C of D. In de legenda staan de desbetreffende adressen per gebied.

Gebied:

Griffiersveld

Gebied A: Holtrichtersveld 101 t/m 114, Griffiersveld 101 t/m 121 (35 adressen)

Gebied B: Griffiersveld 1 t/m 8, 201 t/m 105, 207 t/m 215 en 302 t/m 306 (26 adressen)

Gebied C: Holtrichtersveld 209 t/m 213, Griffiersveld 216 t/m 219, 307 t/m 320, 401 t/m 409, 501 t/m 509 (41 adressen)

Gebied D: Holtrichtersveld 501 t/m 503, Griffiersveld 410 t/m 428 (21 adressen)

Huidige situatie

De volgende vragen gaan over de huidige situatie in de straat Griffiersveld. Kunt u hieronder beschrijven wat u van de huidige situatie vindt?

7. Wat vindt u positief aan de huidige situatie van Griffiersveld? Denk hierbij bijvoorbeeld aan verlichting, regenwaterafvoer, groenvoorziening, verkeersveiligheid, overzichtelijkheid, parkeren, speelvoorzieningen, hondenpoepgelegenheden en afval op straat.

8. Wat vindt u negatief aan de huidige situatie van Griffiersveld? Denk hierbij bijvoorbeeld aan verlichting, regenwaterafvoer, groenvoorziening, verkeersveiligheid, overzichtelijkheid, parkeren, speelvoorzieningen, hondenpoepgelegenheden en afval op straat.

Kunt u hieronder aankruisen of u het de onderstaande stellingen helemaal oneens, oneens, neutraal, eens of helemaal eens bent?

9. Op dit moment bevinden zich genoeg groenvoorzieningen in de straat, zoals: bomen, groenperkjes, struiken en grasveldjes.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

10. Op dit moment worden er genoeg maatregelen getroffen om de snelheid van auto's te verlagen.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

11. Op dit moment zijn er genoeg parkeerplekken in de straat Griffiersveld?

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

12. De parkeerplaatsen bevinden zich kort op loopafstand van mijn huis.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

13. De parkeerplaatsen zijn groot genoeg voor mijn auto.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

14. Griffiersveld is een schone straat.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

15. Griffiersveld is bij hevige regenval een goed begaanbare straat.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

16. De straat is voldoende verlicht.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

17. Er zijn voldoende speelgelegenheden in de straat.

- Helemaal oneens
- Oneens
- Neutraal
- Eens
- Helemaal eens

Toekomstbeeld

De volgende vragen gaan over het toekomstbeeld van de straat.

18. Welke score geeft u aan de volgende uitdrukkingen? U kunt kiezen uit een score van 1 t/m 5. Hoe hoger het getal hoe meer waarde u hier aan geeft.

	1	2	3	4	5
Er moeten meer bomen geplaatst worden in de straat	O	O	O	O	O
In mijn straat moeten meer groenperkjes en struiken worden aangebracht.	O	O	O	O	O
In mijn straat moet rustig rijden afgedwongen worden door drempels of versmallingen.	O	O	O	O	O
In mijn straat moet autorijden comfortabel zijn.	O	O	O	O	O
Er moeten meer parkeerplekken vrijkomen in de straat.	O	O	O	O	O
De parkeerplekken moeten langer en breder worden.	O	O	O	O	O
Mijn straat moet milieubewust ingericht worden.	O	O	O	O	O
Het gebruik van gerecyclede materialen vind ik belangrijk bij de herinrichting.	O	O	O	O	O

Communicatie

De volgende vragen gaan over de communicatie richting de bewoners in de toekomst. Op dit moment zijn fysieke contacten niet mogelijk door het coronavirus.

19. Op welke manier ziet u graag dat er gecommuniceerd wordt? Meerdere antwoorden zijn mogelijk.

- Via e-mailadres, namelijk …….
- Via de post.
- Via een website.
- Tijdens buurtavonden.
- Via Social Media, bijvoorbeeld Facebook/ WhatsApp/ Twitter/ LinkedIn
- Anders, namelijk……..

Opmerkingen/ aanvullingen

Heeft u nog opmerkingen of aanvullingen naar aanleiding van deze enquête of wilt u over een bepaald onderdeel nog wat uitgebreider uw mening kwijt? Vul het dan hieronder in.

Einde van de vragenlijst

Bedankt voor uw medewerking aan het buurtonderzoek.

CITYLOOPS

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

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

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

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

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