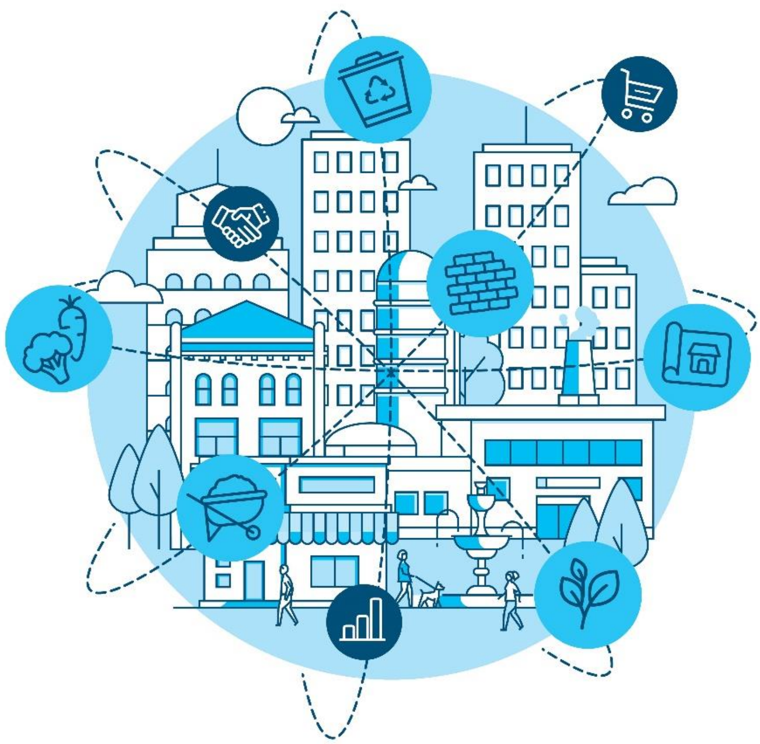
Data and material passports in Apeldoorn

Extract from the Demonstration Report

Apeldoorn, The Netherlands



Contents

This text describes Apeldoorn's experience gathering and digitalising data for reuse or recycling and for material passports. The sections come from Apeldoorn's CityLoops demonstration report available here.

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 or contractor'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.

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.

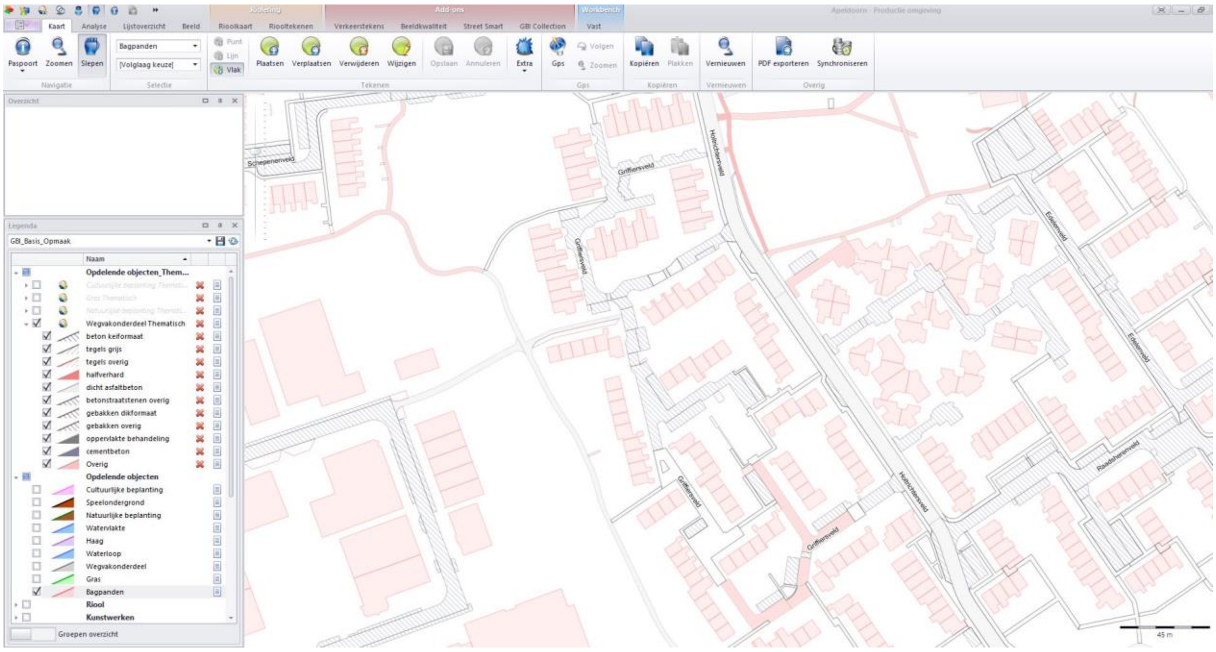


Figure 4.14. screenshot of the GBI asset management system showing Griffiersveld in Apeldoorn.

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.

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.

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).

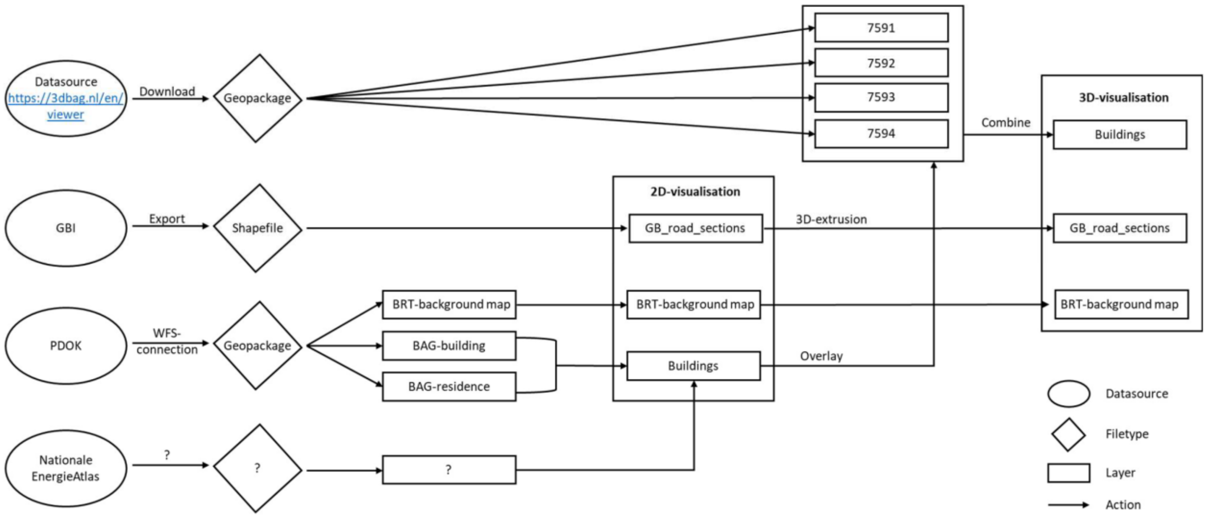


Figure 4.17. *Dataflow scheme for a 3D model of Griffiersveld developed by students (Van den Boog, et al., 2022).*

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).

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).

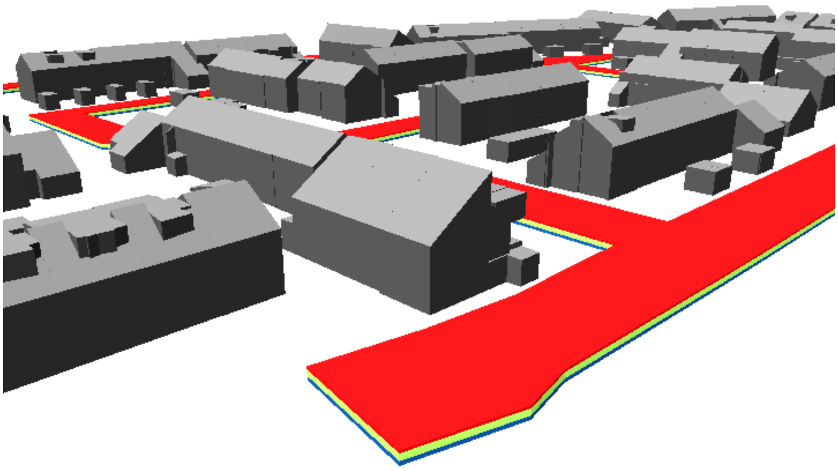
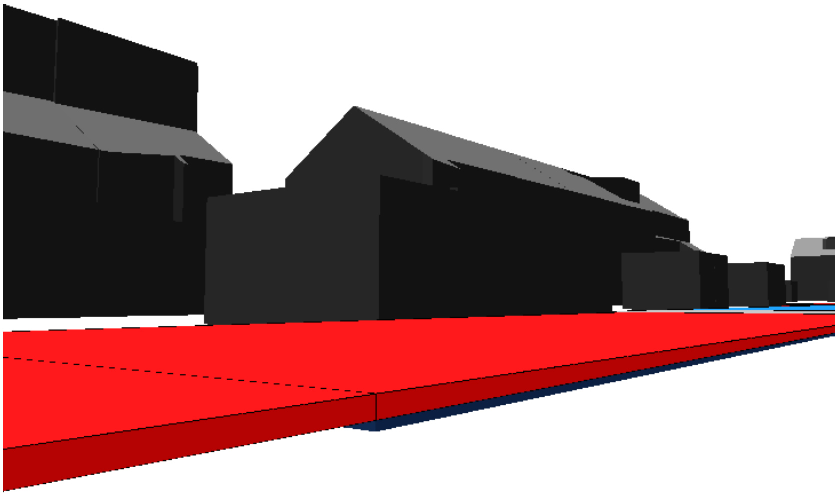


Figure 4.18. *Visualisation of Griffiersveld in 3D based on 3D BAG and using virtual thickness of the road layers (Buildings: © 3D BAG by TUDelft3d, Road: Top10NL, Kadaster).*

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)).



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 chippings in the concrete element are not crumbling;
- Light/medium: the rock chippings in the teeth are slightly chipping;
- Heavy: the rock chippings in the component are chipping heavily.

This can be assessed for each road segment using an 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.

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CITYLOOPS

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

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

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

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

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