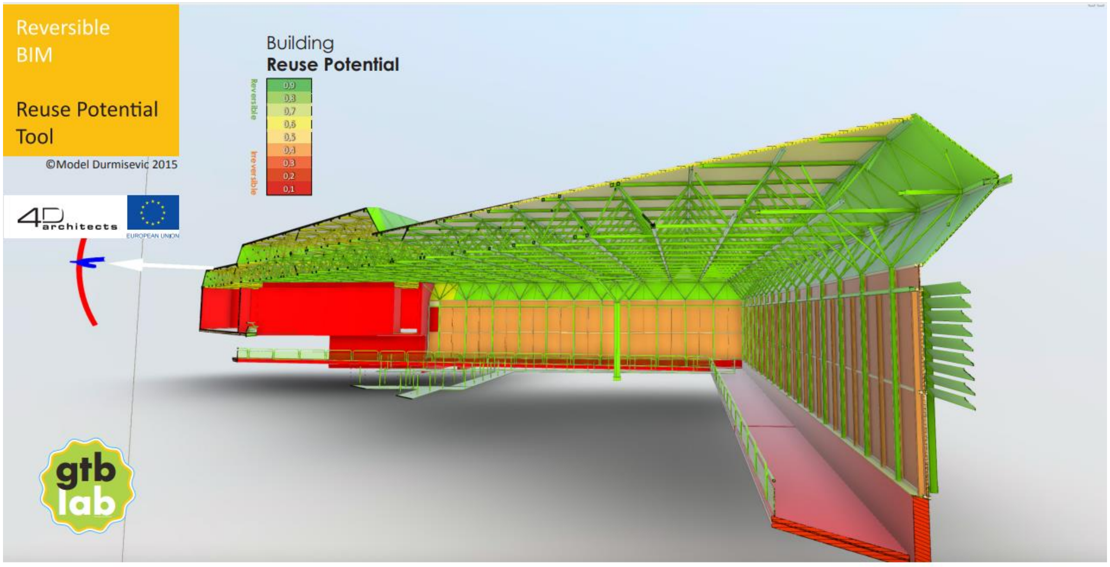
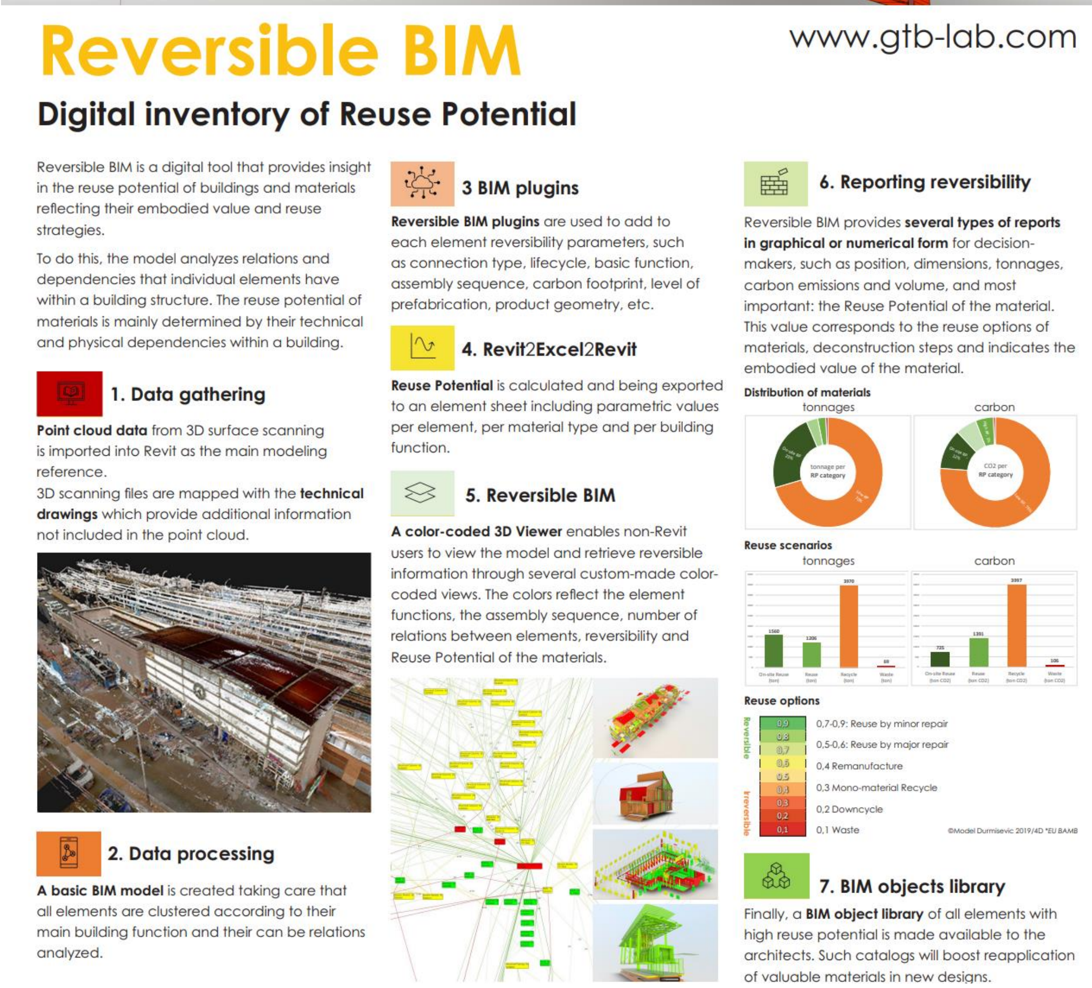
©Reversible BIM (RBIM)

Reversible BIM module developed by E. Durmisevic 2018 is one of the four modules that are integrated on the Digital Deconstruction platform to support decision making regarding reuse and deconstruction strategies. Reversible BIM© module enables a digital assessment of the technical reversibility of buildings and recovery options of building components and materials by assessment of technical and physical dependences between building parts based on the model (Durmisevic, 2006).





Reversible BIM module is a BIM software module developed by E. Durmisevic (Durmisevic 2009 and 2019) that, based on captured cloud points (from 3D scanning) and with use of a Revit plugin for digital reversibility assessment, enables the reconstruction of the digital models of existing buildings covering spatial dimensions, relationships, quantities and reversibility properties of building and its components. ReversibleBIM© has 7 major steps and 16 sub-steps covering the process for data gathering (archives research and point cloud files), the creation of the reversible BIM, running RBIM plug-ins for Reuse potential calculation, 3D visualisation with colour coding (i.e., colours representing reuse potential score) and the access to RBIM© deconstruction in a new construction project. Reversible BIM is viewed in 3D viewer (see Figure above).

Reversible BIM supports the process of designing, constructing and operating a building (i) with the reversibility principles defined by Durmisevic and (ii) with reuse of computer-generated object orientated information in mind. It is identified as a value maintaining and re-creating process through the multiple lifecycles of a building and its parts (Durmisevic, 2019).

Reversibility module calculation takes into account hierarchical dependence of building elements/material within a building configuration, number of relations between building elements, assembly/disassembly sequences of individual building elements/materials, specification of a base element of an assembly, level of prefabrication, geometry of element/product edge, type of connections, Life Cycle Coordination and remaining technical life. Conventional BIM does not support analyses of above specified indicators of reversibility and reuse potential because the key reversibility related data, hierarchical dependency of building elements, number of relations and type of connections cannot be extracted from a conventional BIM Model. In order to upgrade conventional BIM towards Reversible BIM above, mentioned key data representing indicators of reversibility and reuse potential have been integrated into Revit by adding plugins. This has created a smooth transition from linear BIM towards circular /Reversible BIM.

RBIM© outputs provide information on

building level: embodied tonnages of materials per building per material, embodied CO2 in the building, average reuse potential of building parts and materials, potential savings of CO2, tonnages of waste and raw material based on the method of construction and reversibility of the applied method of construction and recoverability of its products and materials.

Part level: embodied tonnages of materials per building per part category, embodied CO2 per part category, reuse potential of building part category and associated reuse options, potential saving of materials, potential savings of CO2, tonnages of waste and raw material based on the reuse options that part category. Potential financial savings based on reuse option that material has.

Material level: embodied tonnages of materials per material, embodied CO2 per material, reuse potential of material and associated reuse options, potential saving of materials, potential savings of CO2, saving of tonnages of waste and saving of tonnages of raw material based on the reuse options that material has.

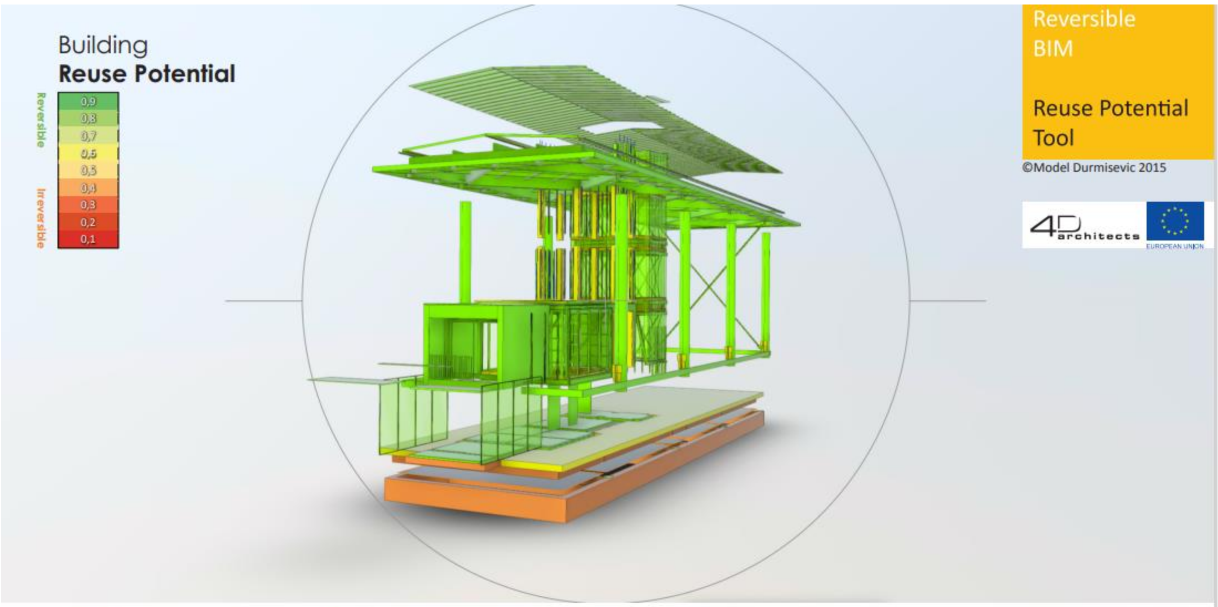
Reversible BIM© has two integral features:

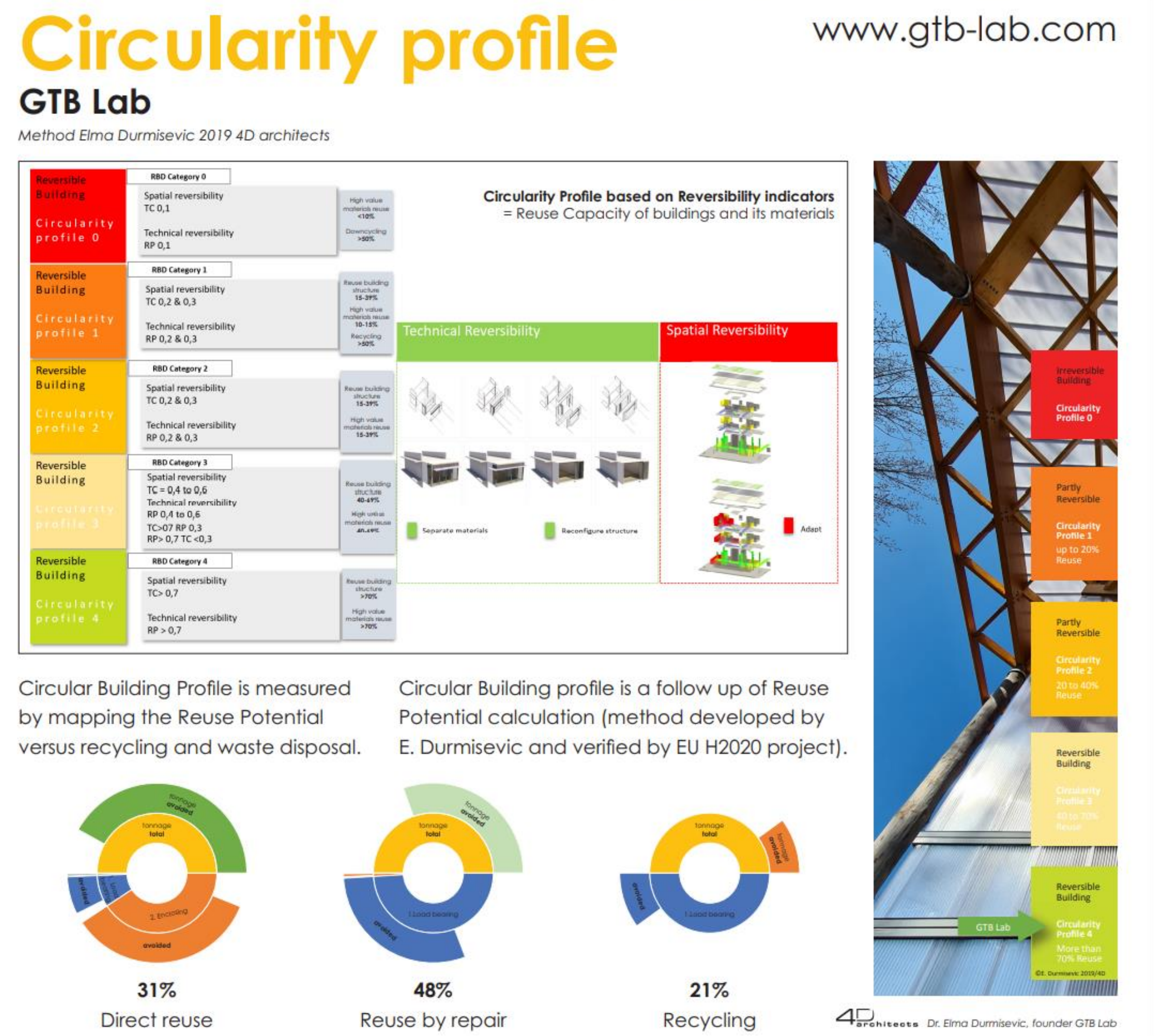
1. **Digital Parametric representation of Building** with information about geometry, position, function, relations and connections between building elements. Digital representation of Building uses the Reversible BIM template which is structured in a way that enables assessment of reversibility (i.e., disassembly and reuse potential) of building products. Reversible BIM translates 3D point-cloud files form 3D scanning into a standardised geometry and properties which is used for assessment of the material composition of a building, embodied tonnages and embodied CO2 within a building and digital reversibility of the building systems, components, elements and materials as indicators of potential material, waste and CO2 savings.

2. **Digital Reversibility Assessment (DRA**) provides assessment of reversibility/Reuse potential using the model of (Durmisevic, 2019) developed to assess how easy building products and materials can be recovered without damaging surrounding parts or the part itself. It also identifies reuse options of individual systems, components, elements and material. The model measures effort and time needed to recover an element from the building as well as the level of damage that occurs during the disassembly process (to the element itself and surrounding

elements). This Reversibility assessment is being carried out on three levels of the building's technical composition (i.e., building, system and component level) (Durmisevic 2019, 2020)

Based on Digital Reversibility Calculation a score indicates the Reuse Potential of each element in a building. Reuse Potential (RP) score (ranges between 0,1 worst and 0,9 best) sorts all building elements into three categories: (i) irreversible buildings (building elements/materials with low Reuse Potential, materials are in a degrading loop towards recycling and down cycling), (ii) partly reversible buildings (partial Reuse Potential, materials can be remanufactured or reused after major repair) and (iii) reversible buildings (buildings whose materials can be directly reused or after minor repair or reconfiguration). As the model measures the effort and time, the model also considers the number of disassembly steps and operations needed to recover an element forming a solid base for the environmental and economic assessment of reuse options. Above defined three categories of reversible/circular buildings form the base for the specification of circularity profiles of a building. Five Circularity Profiles, in figure below, indicate the percentage of direct reuse, reparation, remanufacturing, recycling or waste. If up to 80% of materials of a building can only be recycled, the building would have Circularity profile 1. If between 20 and 40% of materials can be reused, the building would have circularity profile 2. If more than 70% of material can be reuse the building would have Circularity profile 4 (see figure below).

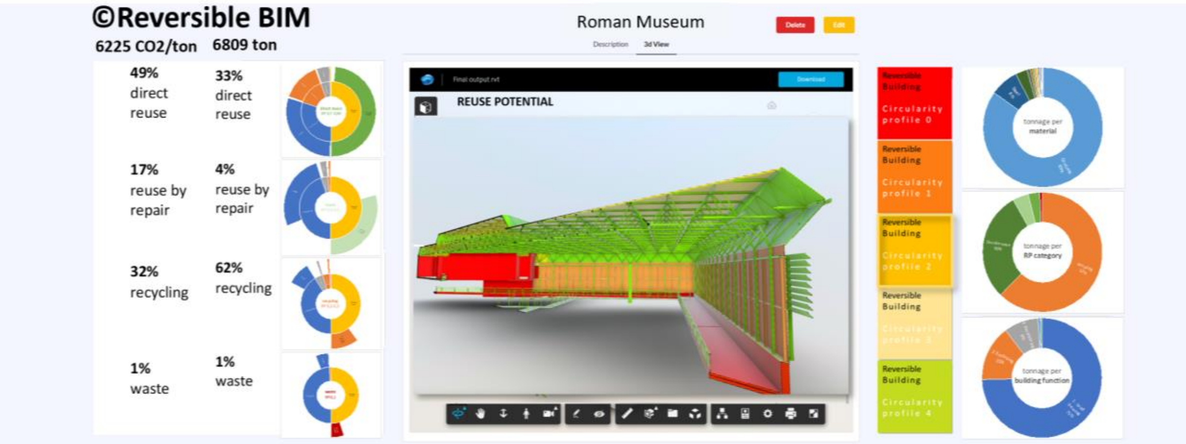




Digital Deconstruction Platform is BIM based platform which relies on information form RBIM regarding the material composition, geometry, quantities, reuse potential of materials and potential CO2 and material savings. RBIM is directly linked with 3D scanning as it uses point cloud files for the generation of RBIM. Once Material

@Reversible BIM (RBIM) E. Durmisevic, 4D architectes 2019 with high reuse potential are identified by RBIM a material passports is created with use of third DDC module and link with the potential sales platform using block chain technology.

Pilot Roman Museum in Heerlen



Roman Museum in Heerlen is GTB Lab run pilot in collaboration with the municipality of Heerlen.

After Digital inventory of the existing building using RBIM methodology and tool a circularity profile of the building has been created with specification of materials which had potential for reuse.

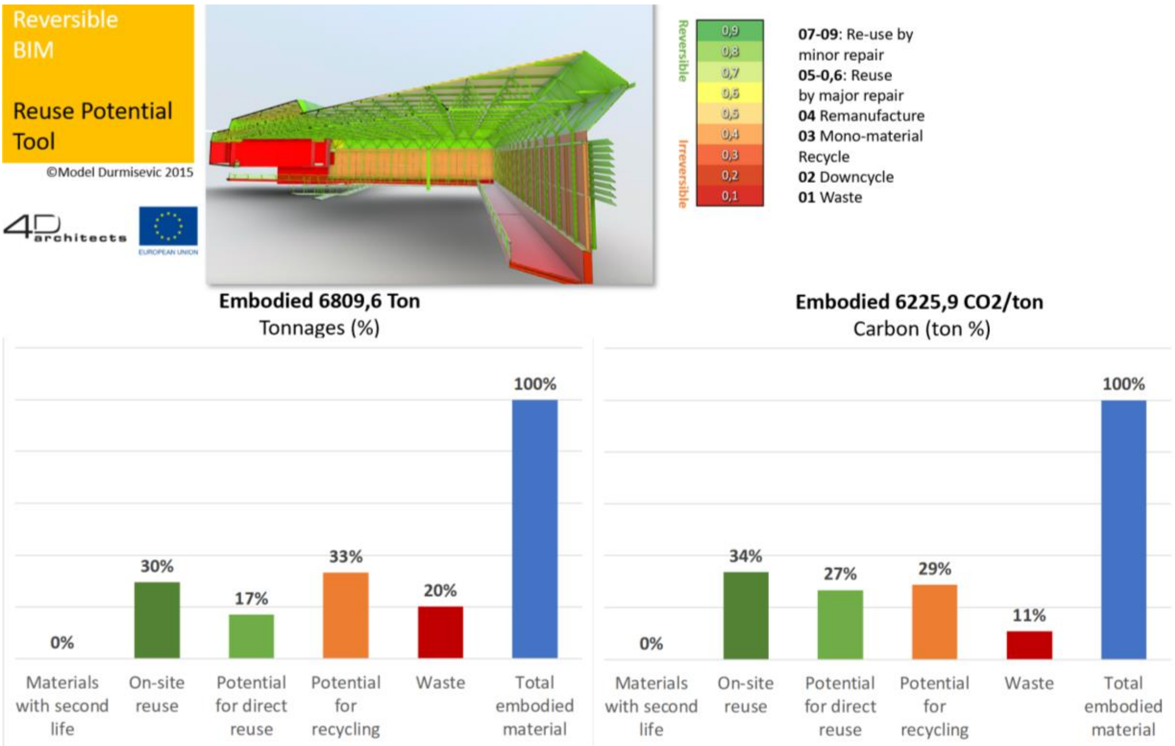
This inventory has been used by the municipality of Heerlen in defining the tender for partial deconstruction of roman museum. Municipality of Heerlen did insertion of **REUSE POTENTIAL in tender specifications.**

Tenders are assessed on multiple quality criteria. For each quality criterion, the assessment committee indicates how much added value can be achieved on this particular quality criterion.

The extent to which the reuse of materials is achievable is used as a quality criterion following reuse potential index. (see table below)

Nr.	Definition	Re-use potential	Score
1	Reuse within the project (on-site)	099	100
2	Reuse within other project(s)	05-09	70
3	Recycle	02-04	40
4	Waste	01	10

is coordinating


Reversible BIM
Reuse Potential Tool
©Model Durmisevic 2015
4D architects
EUROPEAN UNION
Reversible
Irreversible
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
07-09: Re-use by minor repair
05-0,6: Reuse by major repair
04 Remanufacture
03 Mono-material Recycle
02 Downcycle
01 Waste
Embodied 6809,6 Ton
Tonnages (%)
0%
30%
17%
33%
20%
100%
Materials with second life
On-site reuse
Potential for direct reuse
Potential for recycling
Waste
Total embodied material
Embodied 6225,9 CO2/ton
Carbon (ton %)
0%
34%
27%
29%
11%
100%
Materials with second life
On-site reuse
Potential for direct reuse
Potential for recycling
Waste
Total embodied material