METABOLIC

City of Amsterdam

Copper8

Building with recycled building materials

The circular tool box

Content

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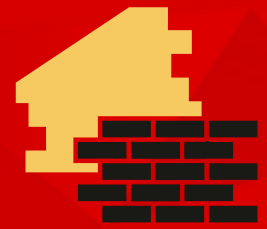


- → understand the importance of building with recycled materials.
- → know how to apply the 10 Rs principles to the reuse of materials.
- → understand how building with recycled materials affects the design process.

Summary

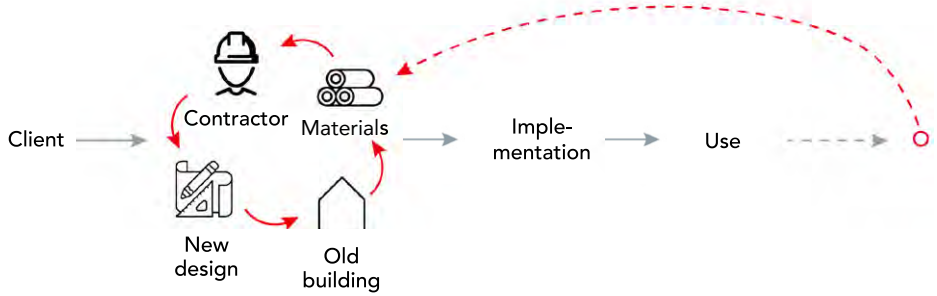
Using reused materials is an important element of circular construction, an approach to the construction of new buildings and public spaces that incorporates reused products and building materials. The goal is to maximize the high-value reuse of materials, and the 10 R model described here serves as a practical tool for how to best preserve their value (see Figure 2).

It is crucial that any circular construction process begins with the design and implementation process. For example, there must be a shift to supply-driven design, which means the supply of existing materials that are becoming available influences a building's design. The contractor therefore should be involved earlier. Because materials sometimes have to be purchased during the design process, organizing the logistics and temporary storage for these materials is another important factor. In practice, there are many possibilities, but it requires involvement during the design and implementation process, as elaborated upon in this Circular Design Process Paper.

Figure 1: Change in the construction process when building with recycled materials

Building process with new materials

Building process with reused materials



Recommendations

- Base designs (or part of them) on the range of available building materials, instead of designing first and searching for the building materials later.
- As a client, be aware that part of the construction cost may have to be used as early as the design phase in order to secure the supply of materials becoming available.
- As a client and contractor, make a joint effort to organize temporary storage for materials, so they can be stored in climate-controlled surroundings.
- Begin the search for available building materials that can be reused on time, together with the design team and the contractor.
- Involve the building contractor as early as the design phase, with or without an integrated contract. After all, that individual is tasked with building using reused materials.
- Enter into clear agreements about guarantees and risk allocation. Be prepared to carry part of these risks as a client whenever setting circular objectives.

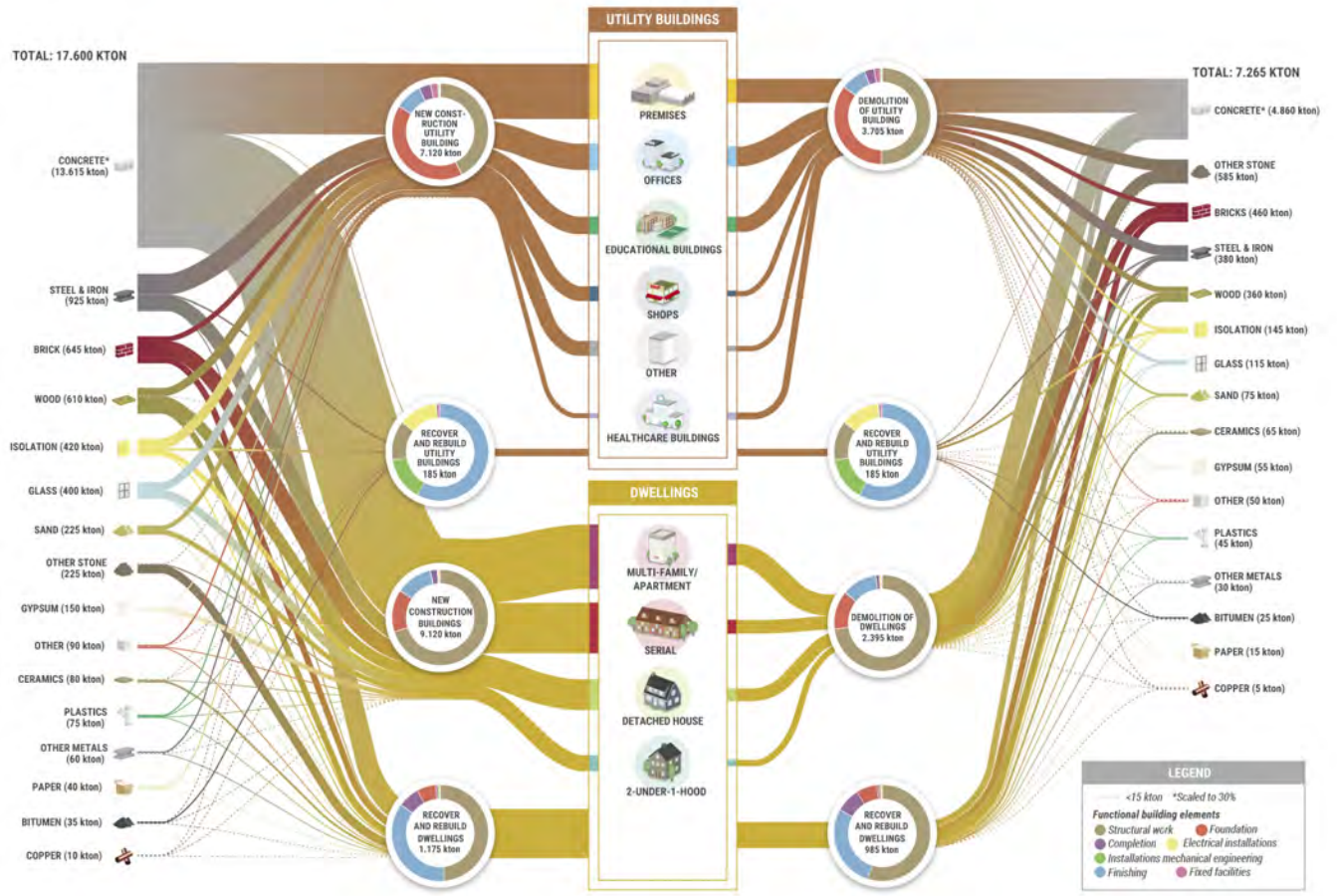
Substantive deepening

The importance of reused products and materials

The high-value reuse of products and materials is vital to a circular construction economy. Consider all the buildings with unusable materials that have "gone to waste", while we need a large amount of new material for future building plans. At the same time, there is not enough reused material available to meet demands for construction of new buildings. Where the annual demand for material is more than 17,000 kt, the annual supply of available materials is more than 7,000 kt (see Figure 2).

Because of this shortage, reusing existing building materials must be coupled with promoting future high-value reuse, by designing new buildings circularly (as described in the Circular Design Paper) and using bio-based materials (an example of which can be seen in this Timber Construction Paper). To ensure that parts can be reused in the future, the detachability of connections and fasteners between building elements and components is key.

Figure 2: Inventory of material flows in construction (Eib, Metabolic & SGS Search)[1]



High-value reuse with the 10 Rs

The objective of circular construction is to minimize waste and the amount of raw materials used. To fully benefit from the value and potential of recycled materials, reuse as many products deemed as high-value as possible to ensure they can be reused even more often in the future, whether or not in a low-quality form. A higher-value form of reuse often requires less energy and environmental impact to make reuse possible. One example is the high-value reuse of a wooden beam. It retains more value when reused again as a beam, as opposed to the same wooden beam being finely ground into wood wool for insulation.

The 10R hierarchy outlines the principles and forms of high-quality reuse (see Figure 3), with the goal being the reuse of a product or material as high-value as possible in the 10R principles. To which "R" a situation applies is not the same for every product, depending on things such as the technical quality of the product or material and a building's aesthetic requirements.

Factors and implications during the design and implementation process

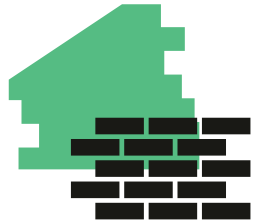
Not only is the reuse of products or materials different from a technical point of view; it also requires a different design and implementation process. There are a number of important factors that when met, will ensure the use of recycled products and materials.

A mindset shift to supply-driven design

It is important to shift the design team's mindset from demand-driven to supply-driven design. When a project is first laid out to certain specifications, the probability of the range of materials becoming available corresponding exactly to the specification is very small, let alone these materials having the correct dimensions and properties. In order to increase the probability of using available materials, it is necessary for a design team to base designs on the existing supply of available materials. It is then up to the creativity of the design teams to actually use as much of that supply as possible.

Figure 3: R-ladder as a practical tool for high-quality reuse (PBL, 2018).[2]

Goal	Strategy	Explanation
Use and create product in a smarter way	R0 *Refuse*	Making product obsolete by renouncing its function, or delivering it with a radically different product
	R1 *Rethink*	Intensify product use (e.g. by sharing products or multifunctional products)
	R2 *Reduce*	More efficient manufacturing of product through fewer raw materials and materials in the product
Extending the life of product and parts	R3 *Reuse*	Hergebruik van afgedankt, nog goed product in dezelfde functie door een andere gebruiker
	R4 *Repair*	Reuse of discarded, still good product in the same function by another user
	R5 *Refurbish*	Refurbishment and maintenance of broken product for use in its old function
	R6 *Remanufacture*	Onderdelen van afgedankt product gebruiken in nieuw product met dezelfde functie
	R7 *Repurpose*	Use parts of end-of-life product in new product with the same function
Useful application of materials	R8 *Recycle*	Processing materials to the same (high) or lower (low-grade) quality
	R9 *Recover*	Incineration of materials with energy recovery



Designing doors

In a demand-driven design, the design team determines the dimensions of the doors first. Suppose all doors must be 93 x 234 cm in this case. But when a contractor is then asked to use recycled products, the chance of finding doors meeting these specific dimensions will be small, because existing doors will come in other sizes. In the supply-driven design mindset, the design team first looks for existing doors that are becoming available. Suppose the team finds an array of doors measuring 88 x 231.5 cm, 78 x 211 cm, and the intended 93 x 234 cm. Based on that supply, the design team can include all these dimensions in the design. As a result, the entire supply can be reused, instead of only a portion being used in the demand-driven approach.

Involving the building contractor earlier

When the building contractor is involved earlier in the design process, this facilitates the technical feasibility of reusing products and materials. Involvement will therefore not be based on specifications (after all, there are none yet), but rather on other quality criteria. Alternatively, select an architect and contractor as part of an integrated tender (design and build) in which they submit a joint bid, so the contractor can use his or her expertise much earlier to contribute ideas during the design phase.

Earlier release of the construction budget

Designing based on the supply of materials often necessitates the immediate purchase of available material. Such materials are often available only temporarily, because suppliers do not have the space or do not want to run the risk of storing them for long periods of time without the security of buyer interest. This is why it is important that clients free up part of the construction budget as early as the design phase, to fund the purchase of such materials.

This, in turn, has an impact on a client's risk-bearing capital. As a result, the purchase of materials when the design is still yet to be completed requires clear agreements about risk allocation within the design team.

Organizing temporary storage

When materials are purchased earlier in the process, logistics and temporary storage must be organized earlier in the process as well. To maintain the quality of the materials that will be reused, it is important that they are stored in a climate-controlled environment, at least one that is dry and frost-free. In practice this means the client and the contractor must jointly assess their options, possibly in combination with sheltered workshops.

Different handling of guarantees

Finally, both clients and contractors must adjust guarantees accordingly. The specifications often require a standard warranty period from a building contractor or supplier, depending on the type of product. However, it is more difficult to provide the same guarantees for recycled products or materials, because the quality of products is not always clear.

Risks do not necessarily have to be covered and reduced by means of guarantees from the building contractor, but they can also be covered by performance agreements, for example.

Guarantees

When building CIrcl in Amsterdam, ABN AMRO, the client, wanted BAM, the contractor, to issue a guarantee on the life of the hinges and locks. However, BAM found it difficult to quantify these, because it involved reused hinges and locks. ABN AMRO and BAM discussed this and identified the bank's needs regarding a guarantee, in this case, properly functioning hinges and locks for a certain period of time. Ultimately, BAM delivered a small reserve batch of reused hinges and locks to ABN AMRO, which is stored in Circle. BAM met the needs of ABN Amro this way, without any guarantees being issued.

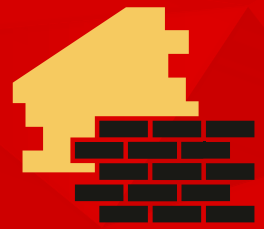
Case study 1

Vondeltuin

The municipality of Amsterdam had clera circular goals during the renovation of Vondeltuin, a restaurant and terrace in Vondelpark. The design and implementation of Vondeltuin used many recycled materials,. and that choice greatly reduced the environmental impact of its construction.

These recycled materials came partly from Amsterdam and partly from demolition projects in the region:

- The **piles** are made of wood from the Belgian Ardennes. For each pile, a new tree is re-planted in the forest.
- The **foundation** of the building is Freement and largely consists of recycled raw materials, resulting in about 50% lower CO_2 emissions.
- The **floor beams** are recycled wooden beams from an old Dekamarkt supermarket.
- The **insulation** consists of iCell insultaion material, made from old newspapers.
- The **plinth** is made of natural stone sleepers: these are old curbstones, which had been stored in Amstelpark indefinitely.
- The **roofing** consists of shingles made of old water cypress trees from Amsterdam, which have been sawn to size by Stadshout.
- The **frames** are made of recycled hardwood, supplied by New Horizon.
- The **fuse boxes**, the switchgear, and sockets were sourced from the former KPMG building.

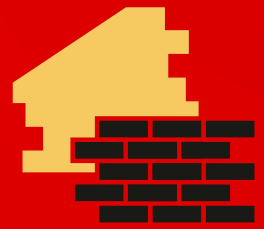


Case study 2

Superlocal homes

The housing association HEEMwonen, contractor Jongen Bouwpartners, and demolition company Dusseldorp worked on three habitable circular test homes of 40 and 74 m² in Kerkrade. The reuse of materials was central to these circular test homes; more than 90% of the products and materials were reused from a demolished high-rise flat. Experiments were carried out with a different reuse method for each of the three types of homes:

- **Concrete look:** One house is actually an apartment lifted from the old block of flats, supplemented with recycled concrete brick blocks. The external wall is made of masonry concrete blocks, which became available during the demolition of the flat. The window frames and roof structure are made of wood from the flat and have been insulated with bio-based material. The homes are powered by means of energetically innovative solar panels.
- **Masonry:** This house was also a complete apartment lifted out of the block of flats. And in this instance, too, the frame has been supplemented with recycled concrete brick blocks. Walls and flooring from the flat have been reused. The external wall of the house is made of recycled masonry stones from the block of flats. The window frames and roof structure are made of recycled wood sourced from the block of flats.
- **Recycled concrete:** The external walls and load-bearing internal walls of this third house are cast from recycled concrete made on-site. The roof is removable and finished with local slate. On the inside, the roof has been finished with old interior doors from the block of flats.



More information

The following publications offer more background on circular design:

- **Greenpaper Circulair Ontwerpen (Cirkelstad): a paper describing the circular design process' main principles and the collaboration it requires.**
- **Inspiratieboek circulaire producten en diensten (Transitieteam Circulaire Bouweconomie): inspiring examples of construction and civil and hydraulic engineering.**
- **Materiaalstromen, milieu-impact en energieverbruik in de woning- en utiliteitsbouw (Eib, Metabolic & SGS Search): a publication with insights into the current state of affairs regarding circulairty in residential and non-residential construction.**
- **Circulaire materialen in de bouw: juridische feiten en fabels (AT Osborne): insight into the legal possibilities of requiring recycled building materials.**

Footnotes

1. Eib,Metabolic&SGSSearch(2020)Materialflows,environmentalimpactandenergyconsumption inresidentialandnon-residentialconstruction
2. Netherlands Environmental Assessment Agency (2018) Mapping out the circular economy