THE APPLICATION POTENTIAL OF RECLAIMED MATERIALS IN ARCHITECTURAL DESIGN

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ABSTRACT

In recent years, attention is risen about the linear way the building sector consumes resources. The aim is to develop the sector in a circular system that is profiting from its own stock. However, steps according to knowledge on the design process and implementation of reclaimed components need to be taken. This research assesses the different types of building components available in office buildings originating from 1980-2000 in Amstel III. Viability, environmental benefits and cost effectiveness are important factors to consider defining a components potential for reuse. By considering these factors for the components available in the skin and interior of Amstel III's office buildings, a decision can be made about their potential for harvesting and way of implementation in new designs, which might for Amstel III be the start of a sustainable redevelopment.

KEYWORDS: *urban mining, reuse, circular building, construction and demolition waste, component reuse, construction process, reclaimed components*

I. INTRODUCTION

Construction and demolition activities are widely known as one of the most important sources of waste (Koutamanis, Van Reijn & Van Bueren, 2018). Overall, the Dutch building sector is consuming 50% of raw materials, is responsible for 50% of the energy consumption and 35% of the CO2 emission (MIE, 2016). The way the sector uses materials and resources seems wasteful; raw materials are mined, used for certain amount of time and become waste after. To transform the linear way of building in a circular system Urban Mining (UM) can be used as a tool. UM is the process of reclaiming components and elements from any kind of anthropogenic stocks, including buildings, infrastructure, industries, products (Cossu & Williams (2015). UM has recently become a widespread concept that is implied on different systems and sources of harvesting. In this paper is referred to the harvesting of components instead of materials. Reuse of individual components extracted from the demolition of one project in a new building is commonly known as *element* or *component reuse*. Structural components, such as beams, columns or non-structural components, such as cladding panels, bricks or staircases, are taken from one project and used in another. The potential of reusing components from older buildings into a new structure lowers the addition of new materials and preserves much of the value of the components. Reusing components in its original shape also minimizes the impact of reprocessing that is often required when materials are recycled, where materials are fed back into the manufacturing process (Gorgolewski, 2008). From an environmental and economic point of view, component reuse is usually more beneficial than a recycling process.

Amstel III, located in the southeast of Amsterdam, will develop in the next 20 years from a monotone office district into a mixed-use residential area by the addition of 15.000 dwellings (Gemeente Amsterdam Zuidoost, 2018). To do so, several office buildings, of which some have been empty for years, must give place to new structures. Currently, 26 office buildings[1] are planned for deconstruction or transformation (Dekker et al. 2018). Based on data from Metabolic this will result in more than 220.000 tons[2] of building material come to waste if not considered for reuse. Where heritage buildings often are considered for reuse because of their cultural value, here the focus is more on the embodied energy within the buildings which are not older than 40 years and are often intensively renovated within the last ten years.

This paper will focus on what the process of UM and component reuse can mean for the material consumption during the redevelopment of Amstel III. In the area, offices, mostly dating from 1980-2000 and often vacant or in temporal use, are considered for demolition or transformation. This results in the following research question: *How can reclaimed building components from office buildings dating from 1980-2000 be implemented in architectural design?*

The following sub-questions will serve as a means to answer the posed thematic research question and will also be the guideline throughout this paper:

- *Which materials and building components are typically present in office buildings dating from 1980-2000 located in Amstel III, Amsterdam?*
- *What are the specifications of reclaimed components and their materials?*
- *What factors could influence the usability of building components?*
- *What are the possible implementations for useable reclaimed building components?*

II. METHOD

The components of office buildings in Amstel III are as well quantitatively as qualitatively analysed to understand their potential for new design implementations. Therefore, the research consists of several steps: creating a component inventory, ascertain factors that influence the process of reuse and constructing a value assessment and proposing design applications.

Firstly, it is important to understand the scope of materials the area consists of and what kind and number of components come available through the demolishment or transformation of office buildings. This component inventory is established through data analysis of key figures on materials, visual observation of the exterior and plan analysis. Based on the exterior appearance of the office buildings a categorisation in four types is made: glass, masonry, natural stone and timber panels. Of each category, a building is research in more depth to provide additional key figures about the skin and interior finishing[3]. Based on the established key figures, corrected by site observation, an estimation of the available components in the office buildings is constructed.

Following on the acquired data, a qualitative based analysis is performed. Application for reuse of components requires knowledge on the physical characteristics and performance of the materials itself, but also of actors that influence the reuse potential of the component (Vandkunsten Architects & Manelius, 2017). For each component, their value is determined by considering their viability, environmental benefits and costs. Based on this assessment components can be ranked by their potential for reuse.

Lastly, the components are evaluated on their application potential. A *decision chart* is designed as a tool to determine whether a component can be reused in its original function or one should look for new types of applications. Through case studies design implementations of these components in their authentic as well new use are illustrated.

[1] One is yet transformed and two are deconstructed, March 2019 (appendix A).
[2] For complete data on available materials, see appendix B.
[3] Hoogoorddreef 60, Hogehilweg 13, Hullenbergweg 1 & Hessenbergweg 109, Amsterdam (appendix C)

III. INVENTORY BUILDING COMPONENTS AMSTEL III

The buildings in Amstel III are mainly constructed in the period after 1980 and are built with the similar goal to supply functional office buildings, resulting in an office typology that is seen more often in The Netherlands. Within the area, a resemblance in exterior is recognisable; materials as well shape, size and composition are repeated over the office buildings. Multiple times, building designs are almost identically duplicated.

3.1 Available building materials

A rough estimation of twelve materials available in the buildings considered for transformation or demolition, is made based on key figures from Metabolic (table 1) This gives a quick overview of where the emphasis is in demolition waste.

	Ton/m2 BVO	Mass (ton)	Volume (m3)
Polystyrenes	0,003	361	9.025
Concrete	1,354	168544	70.226
Bricks, stone, ceramics	0,084	10456	418
Glass	0,006	744	298
Aluminium	0,007	874	317
Gypsum	0,035	4354	2.721
Steel	0,014	1744	224
Copper	0,000	12	1,35
Wood	0,018	2241	3.201
Plastics	0,001	123	102
Bitumen	0,007	871	829

Table. 1: materials originating from 26 office buildings in Amstel III
(data from Metabolic, 2018: appendix B)

Concrete is in volume and weight the heaviest and bulkiest available material. A large partition of this concrete is processed in structural columns, beams and floors, which are mostly poured in situ. In case the concrete is prefabricated it is joined in situ. In this research, concrete won't be analysed as a component, since the inventory and value assessment will focus on elements available in the skin and interior. The application potential of concrete will be exemplified in the last chapter.

Further analysis of skin and interior components relates to a minor part of the materials indicated by Metabolic. Besides the named sixteen types of components, there are many additional components that can be considered.

3.2 Available building components and their specifications

The typological division of the offices is based on the façade materialisation and distinguishes: glass, masonry, stone and timber panels[4]. From each category one office is analysed for its exterior components (façade cladding, windows and doors) and important interior finishing (interior walls, suspended ceilings, doors, lifts, toilets, luminaries and radiators), of which can be assumed that they are likely to be present in all office buildings dating from 1980 and on[5]. The knowledge from the analysed offices is converted to key figures and is thereafter projected on the other offices in relation to floor surface (BVO)[6]. A correction is made for the windows and glass surface of the offices when the calculations differ significantly from the visual observation. The inventoried exterior and interior components are summarized in the image on the next page (fig. 1).

[4] More information on categorization and inventory of the case studies can be found in appendix C
[5] Based on the authors general knowledge, visual examination on site and investigation of images.
[6] The complete inventory can be found in appendix D

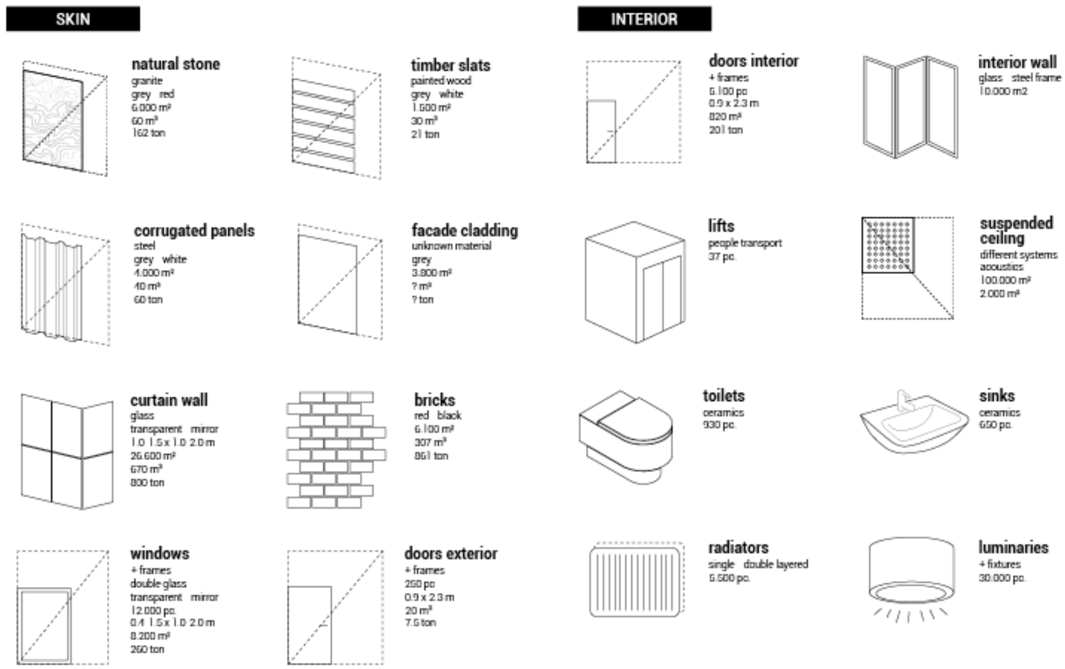

Fig. 1: inventory building components Amstel III

The Amstel III offices consist of 54.000 m2 façade which are mainly glass façades based on a curtain wall system. Often this glass has a mirroring foil in it that makes the glass look brown or blue. Second most used façade materials are natural stone (granite) panels and masonry. In lower quantities timber panels and steel panels as corrugated wall systems are covering the offices and accompanying buildings. Windows are highly available and often have either aluminium or plastic frames. The number of doors is relatively low due to the large floor spaces of the offices compared to entrances. For all components counts that the materials are available in a range of colours and in a variety of sizes. The skin of the buildings are relatively simple architectural designs and the measurement of panels are quite straight forward. Hence exceptions are only made for functional purposes.

As regards the interior, the following components are looked into: interior wall elements for temporarily means, suspended ceilings including framework as well as acoustic panels, interior doors, elevators, toilets, luminaries and fixtures, and different types of radiators. Noticeable is the high numbers of interior walls available. These panels have great acoustic qualities since it must provide privacy in conversations and presentations. For this reason, the transparent walls are made of layered glass and the opaque partitions from acoustic or layered materials. Knowledge about the precise materials and measurements is not available. Since, several office buildings have been recently renovated many interior walls are relatively new. Some walls have an industrial steel look and other consist of large glass panels. Also, the large amounts of suspended ceilings are characteristic for office buildings. Because of the many office buildings considered, radiators, toilets, luminaries and doors are available in high quantities. However, little is known about the specifications of these components and they will probably differ from one office building to the other, which contrast will be especially high between renovated offices and original interiors.

IV. FACTORS AFFECTING USABILITY RECLAIMED COMPONENTS

The reuse of individual components is affected by a variety of actors which each have their own scope of influence on the production process or the material itself. Multiple literary studies describe opportunities and threats for the reuse of components (Addis, 2006; Guy & Esherick, 2006; Gorgolewski, & Morettin, 2009; Hobbs & Adams, 2017). Stated as large threats of reuse are costs, time and the fact that buildings in modern society are not typically designed to be deconstructed (Guy & Esherick, 2006). Here, a summary of the most important factors that determine the potential for a component to be reused are given. While some of the actors below can be measured in clear numerical measures (notably costs), others can only be measured in very vague terms and may verge on subjective choices.

4.1 Viability

From a practical point of view, it is important to estimate the viability of components for further reuse. The viability includes realistic and physical criterion (Addis, 2006); how easy it is to find the items, how much effort will be required and how interesting components are for future buyers and users. The viability can be dissected in the following characteristics: *availability*, *ease of detachment*, *ease of refurbishment* and *reuse potential*. Through evaluating these characteristics, a first assessment can be made whether it would be feasible to harvest certain components for reuse purposes.

The availability relates to the quantity and quality of the material. When it is possible to harvest materials in larger quantities from one and the same site this impacts the logistical ease and financial benefit. Therefore, harvesting more of one component type from one building or planning to harvest materials from several buildings in the same time span, will improve the design process and cater to the demand for reusing components (Addis, 2006; Slager & Jansen, 2018).

The same information is relevant for the deconstruction process. It is more logistically efficient to harvest and reuse on the same site or by the same developer, since this reduces identification, sourcing and planning problems (Gorgolewski & Morettin, 2009). The deconstruction process is also influenced by whether the surrounding area is yet ready for the urban mining process; transport requires sufficient roads and due to the building process materials and components must be stored, meaning an area should become available for storage. The ease of the whole process is affected by the building systems and technologies used, and the availability of relevant documentation and information (Gorgolewski, 2008). The way materials can be harvested can influence the quality of the materials and the accompanied construction costs. For example, metals are relatively easy to separate in demolition process through collection with electro-magnetic methods. Therefore, typically 90% is reclaimed (Addis, 2006). Other materials or components are more difficult since it must be done by visual examination and harvested by hand. Yet, there are technologies developed to separate bricks by using colour-recognition (Addis, 2006). Additionally, harvesting of only non-structural components greatly reduces the worker safety and equipment considerations and increases the cost-effectiveness of deconstruction (Guy & Esherick, 2006).

The ease of refurbishment and a component's reuse potential is in close relation with each other. Refurbishment is relating to the effort that needs to be taken to make the components ready to be reused in new design. Where the reuse potential relates to the (multiple) possible ways a component can be used. In many cases, when the ease of refurbishment is higher also the potential ways of reuse increases.

4.2 Environmental impact

The current ideology of reusing materials and components is among others based on the envisioned benefits for the environment. Reuse of materials lowers the use of raw materials, saves energy and precludes materials to end up as waste and landfill. The effect materials and the manufacturing processes of components have on the environment can be assessed through different procedures. Life Cycle Analyis evaluates the environmental burdens associated with a product, process and activity (Addis, 2006). This method, however, is difficult in use, since the results are entirely dependent on the precise material descriptions and production processed used and transport distances. This method can be very accurate, but is not helpful in making an estimation. A less comprehensive assessment of the environmental impact of a component is its embodied energy. Embodied energy is the energy invested in creating the materials and components and includes the manufacturing, transport to and assembling on site as well maintaining them throughout the life of the building. This method is easier in calculation and is stated in familiar units. The reuse of components with the highest embodied energy will have the greatest potential energy savings impact. Hence, the ecological gain of reusing might be greater of materials where the production process has a large CO_2 emission than for materials based on renewable materials (Te Dorsthorst et al., 2002). Based on this vision, reuse of metals, plastics, bricks and generally high value processed components have priority (Gorgolewski & Morettin, 2009).

A different way of looking at reuse is not to regard the individual component, but to study components on a larger scale; what their effects are on the environment when they would not be reused, but would end up in recycling bins or as landfill. To make a difference in the amount of materials ending up in recycling bins, power plants and landfill it is interesting to consider the components for its availability in weight and volume.

Whether reuse is the best answer in the perspective of environmental gains, can be questioned when weighting reclaimed components against the advantages of using new products and conventional techniques and methods, which may be more energy resource efficient (Kernan, 2002; Te Dorsthorst et al., 2002). This is particularly the case with reclaimed mechanical and electrical equipment (Kerman, 2002). Additionally, reclaimed components might need energy consuming adaptations or long distance transport, which both add to the embodied energy significantly.

Lastly, value of a component can also be based on its material composition. The way we currently use natural resources makes them run out. When considering the depletion of resources and the rareness of individual materials, a new focus on reuse can be found.

4.3 Costs

Value of products and materials can be an opportunity or a barrier. The opportunity to reduce construction costs is a benefit of using reclaimed materials and can result in significant saving (Kerman 2002). Deconstruction may cost 30-50% less than straight demolition due to lower machinery and disposal costs (Gorgolewski, 2008). However, the difficulty is associated with the acquiring of the right elements in sufficient quantities throughout the design process; time needed to locate and purchase components is critical in cost saving (Kerman, 2002). When components are not immediate reused, the market value should also be considered before storage to estimate its potential for resale in architecture salvage marketplace (Addis, 2006). In case of products and materials with a low market value, the incentive to reuse versus the cost of careful removal can be low or negative (Hobbs & Adams, 2017). In this situation, harvesting is not financially feasible.

As noted before, the way components are attached to a building determines the ease of dismantling, which is highly influencing the demolition time and therefore the demolition costs (Gorgolewski & Morettin, 2009). Reused components can be more expensive if there is a need for multiple handling and refabrication (Gorgolewski, 2008).

The distribution phase after harvesting is marked by transportation and storage which might rise the costs. In previous case studies by Gorgolewski (2009), storage space and time was not highlighted as a problem, nor linked with additional costs. In dense cities, however, space is expensive and storage might become problematic. Long transport distances logically increase costs, but certain materials or additional benefits could be worth it. In general, it is as well from an environmental as cost effective perspective best to reuse close to original location (Gorgolewski & Morettin, 2009).

4.4 Value assessment components Amstel III

The potential for reuse of available components origin from the offices in Amstel III, is determined by a value assessment build on the previous named characteristics (appendix F). The simplified conclusion of this assessment is presented in table 2. To construct a general objective about the components in the area the exceptions on the component's material characteristics and size are not included in the assessment.

		viability				environment		costs	
		Availability	Ease of detachment	Ease of refurbishment	Reuse potential	Embodied energy	Volominous impact	Market value	Production costs
skin	Stone cladding	green	orange	orange	red	orange	green	green	orange
	Corrugated cladding	green	orange	orange	red	green	orange	green	orange
	Timber cladding	orange	orange	orange	red	red	red	green	orange
	Curtain walls	green	orange	orange	orange	green	green	green	red
	Bricks	green	red	orange	orange	red	green	red	red
	Windows	green	green	orange	green	green	orange	green	red
	Doors exterior	orange	green	orange	green	red	red	green	green
interior	Doors interior	green	green	orange	green		red	green	green
	Lifts	green	green	orange	orange		red	green	orange
	Toilets	green	green	orange	orange	red		green	green
	Sinks	green	green	orange	orange			green	green
	Suspended ceilings	green	green	green	green		red	red	green
	Luminaries	green	green	green	green			orange	green
	Interior wall panels	green	green	green	green		red	orange	green
	Radiators	green	green	orange	orange			orange	green

Table 2: value assessment components offices Amstel III
(green - positive; orange – intermediate; red – negative)

A distinction between interior and skin components is visible in their ease of harvesting. The origin lays in the way the components have been attached to the building; often interior items aren't fixed in a way that can't be undone, since this type of components don't have to resist rain or temperature differences. In the case of office buildings, interior finishing is meant to be easily assembled and taken apart, since the renting companies want to easily adapt the space to their preferences. The ease of detachment and refurbishment is a high value for the reusability of the components.

Façade cladding is more difficult to disassemble due to the fastening systems. Individual bricks can only be reused from older buildings of which the (lime) mortar can be easily resolved from the brick (Kerman, 2002). Recent masonry constructions are based on cementitious mortar, which cause the brick to break earlier than the mortar (Durmisevic & Binnemars, 2014). Therefore, modern masonry must be cut in panels to be reused. Easier to detach façade systems are corrugated and timber panels, since they are often screwed to the framework. Stone panels are often fixed to a framework which can also be disconnected. When the stone panels are fixed with mortar as well, it becomes as difficult as brick to detach undamaged. Overall, the façade cladding is highly available and consists of interesting materials that have potentially several reuse implementations.

From an environmental point of view the façade cladding, curtain wall systems, windows and (glass) interior wall panels are most interesting for their high embodied energy and large available volumes. However, these items are also more difficult to detach and adjust to new designs resulting in higher production costs which makes it less financially feasible.

V. APPLICATION OF RECLAIMED COMPONENTS

The general objective about implementation of reclaimed building components in architecture is that several stakeholders in the design process are unskilled and lack design knowledge on the topic; they are simply unfamiliar with incorporating used parts in the projects they are working on (Van Hinte, Peeren & Jongert, 2007). As well designers and architects as developers as the constructors are unaware of what can be done exactly and how to act on it. When this frightens one or more parties within the process full commitment is not achieved. Especially the commitment is essential in such an experimental way of working (Addis, 2006).

Designing with reused components is significantly different that designing with recycled components. Where recycled components have been tested in reproduction and hence come with known specifications and performances, knowledge on these topics is missing for reclaimed components. Not until the moment a deconstruction or harvest company has taken the components from the site and inventoried them, and sometimes not even until the designers themselves have seen the components, knowledge about measurements and performances is not available. This asks for a completely different design process that allows for more flexible design and adaptive specifications (Gorgolewski, 2008); Size ranges, rather than fixed dimensions, should be specified initially (Kernan, 2002). Superuse Studios introduced a so-called Dynamisch Definitief Ontwerp (DDO) as a phase in the design process, which means that where normally the specific materials are decided upon, in a DDO the shape is not fixed. Measurements and material types can be adapted throughout the process when more is known about the specific components. In such a design process, it is extra important the strongly communicate with the contractor.

This chapter, will focus on the considerations, challenges and possibilities of a design team. It will answer on the component's potential for design implementations. A *decision chart* is designed as a tool to determine whether a component can be reused in its original function or one should look for new types of applications (appendix F). This chart is based on the principle of the Delft ladder, which indicates that the preferred way of handling components is to maintain them and therewith prolong their lifecycle (Te Dorsthorst et al, 2000). If maintaining in identical manner is not possible, refurbishing and remanufacturing is the next best option. Case studies on reference projects (appendix G) help to illustrate the reuse potential for the components based on its qualities. Important to be aware of is the interaction between design and the availability of existing materials (Van Hinte et al, 2007).

5.1 Façade cladding

The way of disassembly is crucial for the reuse potential of façade elements; it determines the quality of the products afterwards and, mostly, the deconstruction costs may rise significantly. The masonry buildings in Amstel III are constructed with mortar that can't be removed, which means the brick facades have to be cut into smaller blocks to be reused. This has been done by Lendager Group in their project Resource Rows, where the brick was cut out in modules, processed and stacked up to create new walls. Phooey Architects also cut panels from a building that was previous on the plot of Cubo House and combined it together with other reclaimed cladding components. In their design process, they used the Cubomania technique, a surrealistic way of making collages from square cut images (Phooey Architects, 2019). Other materials are often in panels which could be either screwed (easy detachment) or glued (hard detachment) to a structural system.

The rate of refurbishment of the panels (light or heavy machinery) and the reuse of the attachment systems influence the construction costs. All types of façade cladding are not bound to complete water tightness or thermal regulations, since it only concerns the outer shell. Water tightness and thermal boundaries can be solved with additional products.

The aesthetic character together with the quality product rises the potential of façade elements. From the inventoried cladding systems, the natural stone panels together with corrugated panels are highly interesting, because of their respectively exotic appearance and easy adaptation. Both also have a high embodied energy due to previous transport distances and production processes, which can be an additional argument to invest extra costs in reusing these components. Functionally, both have water tight qualities and have therefore also additional implementation options such as floor tiles or interior wall cladding of kitchen and sanitary areas.

Corrugated panels have the specific quality that it is easily shaped in new sizes. Often, corrugated panels start to rust around their weakest points, which makes it easier to estimate the quality through visual examination. Rusty aesthetics can also provide an additional identity to the material. Dwell Development is using metal panels from old barns as façade and balustrades which gives the design a colourful appearance. American company Dakota Tin even advertises with the rate of rustiness of the material in their panels made from corrugated sheets, which they apply in a non-conventional way as suspended ceilings.

5.2 Glass elements: curtain walls, windows, transparent interior panels

Regulations considering thermal performance are essential for the reuse of exterior glass components. Over the years, building regulations have improved in such a way that the performance of glass windows and curtain walls dating from the 80's-00's is not good enough to be reused in a thermal shell. Therefore, the glass needs to be refurbished into two layers and frameworks need to be replaced to meet the sufficient U-value. To reuse the windows and curtain walls without such kind of heavy refurbishment, glass elements can only be applied in secondary skin or interior applications. The same applies to the former interior system walls. Different from the window and curtain wall systems, the interior walls are often designed in a modular system that is easier to the disassemble and construct again than the elements used in the façade.

Several reference projects use reclaimed windows, but more than once the glass itself was altered. In the Europa Building, by Phillipe Samyn, the wooden frames are collected from different European countries and reused as a curtain wall. The glass itself, however, was replaced by tempered glass (Wright, 2017). Also, the windows in Villa Welpeloo, by Superuse Studios, were reused, but the glass was adjusted to fit the improved thermal regulations (Knudsen, 2010). Application of glass elements without mayor changes is often in a second skin façade. The Afvalbrengstation by Wessel van Geffen Architecten, used reclaimed windows to build the skin of the building, which only needs protection from wind and rain (Wessel van Geffen Architecten, 2017).

Interior class partition walls, probably won't meet thermal insulation classifications, hence it can't be reframed for application in the outer shell. Interior wall systems are acoustical well performing and are often double layered glass, which can be used horizontally; this makes application in roof elements, green houses etc. possible.

5.3 Doors

Doors and their frames are relatively easy to disassemble, but since building regulations have changed in terms of measurements and, in case of exterior doors, insulation values, they cannot always be reused in the same condition. Doors lower than 2,3m and/or smaller than 0,85m can only be reused in transformation and renovation projects. In new architectural design, it must find a new type of use. In the 'Pavilion Circular' doors are reused as façade cladding; here the value of the doors was in the materials origin. Doors in Amstel III are potentially different, since a large part of the doors will be of low quality materials or even hollow from the inside.

5.4 Interior components

For interior components, their value lays in their ease for disassembly and low needs of refurbishment. Although exact knowledge on measurements and product types is missing in this research, this is not a requirement to determine potential design application, since the exact measurement don't determine the architectural design. Toilets and radiators need cleaning and maybe testing, where after they can be reused. It can be considered, whether it environmentally and financially more feasible not to buy newer (more efficient) ones instead. Other components, such as suspended ceilings and luminary fixtures, can almost directly be reused. When the ceiling panels are not suiting to the functional performance in the new design, the panels can be replaced in the modular attachment system.

5.5 Concrete components

Structures from in-situ poured concrete are extremely expensive to repurpose, since excessive use of heavy equipment, engineering resources, on-site manpower and severe safety precautions are needed to disassemble the structure (Vandkunsten, 2017). Although concrete is one of the hardest elements to reuse in new design, it is also by far the biggest and heaviest bulk of deconstruction waste in Amstel III. Over the past decades several studies have been done on this topic and although none have yet been proved to be economically feasible, either due to technical aspects or other interests, there are indications that some of these technologies could become useful in the future. (Icibaci, 2019). A joint study of the Technical University of Berlin and architecture office Conclus in 2007, resulted in a cost saving of 26% though optimal application of building structures and incorporating logistics. Deconstructed elements from German post-war housing blocks, so-called Plattenbau, were reused as load bearing interior walls, exterior walls, and ceilings in a free-standing dwelling. Results showed that environmental benefits were reached and economic viability under strict circumstances was possible (interview with Kowalszcy in Icibaci, 2019). Lack of demand for these kind of products and missing regulations supporting the method, were holding back further development (Asam, 2007 in Icibaci, 2019). Prefabricated components such as staircases are easier to disassemble, since they are often not load bearing. However, in the Netherlands there is a limited market demand for such products (Icibaci, 2019). A different project cut out a floor element to enlarge the interior space and placed the elements back in the interior to maintain structural balance. Here, reuse of concrete was highly visible and was even exposing it as being a sculpture. These case studies indicate that there is a potential in reusing concrete floors and walls by valuing their structural, functional and aesthetic qualities.

CONCLUSION

To conclude on the research question: '*how can reclaimed building components from office buildings dating from 1980-2000 be implemented in architectural design?',* the design implementation of a component very much relies on the value of an individual components and the effort designer as well constructor are willing to invest in harvesting and adapting it to an envisioned design. It has become clear that most important aspects determining the value of reclaimed components, are the *viability*, *environmental benefits* and *cost effectiveness*, which are on their turn influenced by the *availability*, *ease of detachment*, *ease of refurbishment*, *reuse potential*, *embodied energy*, *voluminous impact* in landfill, *market value* compared to new products and *production costs* of the components. To construct a complete value assessment according to these actors, much must be known about the specific qualities of the components, including the previous production process, harvesting method and adaptation measures for future application. These details are often not available in the first phases of a design process. Also, for the offices within Amstel III these specifications are rather unclear. Yet, with little information about the components itself a rough indication can be made based on general knowledge about components and material qualities of these times.

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APPENDIX A - office buildings Amstel III

Hoogoorddreef 62 PLANNED
1988 OFFICE

Hogehilweg 5 & 7 PLANNED
1984 OFFICE

Hogehilweg 13 & 15 PLANNED
1984 OFFICE

Hondsrugweg 50 PLANNED
1900? OFFICE

Hessenbergweg 109 PLANNED
1999 OFFICE

Hessenbergweg 95 PLANNED
2000 OFFICE

Hettenheuvelweg 12 & 14 PLANNED
1988 OFFICE

Hessenbergweg 73 PLANNED
2000 OFFICE

Hessenbergweg 8 PLANNED
1987 OFFICE

Hettenheuvelweg 26 PLANNED
2008 OFFICE

Hettenheuvelweg 18 PLANNED
1987 OFFICE

Hettenheuvelweg 16 PLANNED
1986 OFFICE

Hullenbergweg 1 PLANNED
1988 OFFICE

Karspeldreef 14 & 16 PLANNED
1990 OFFICE

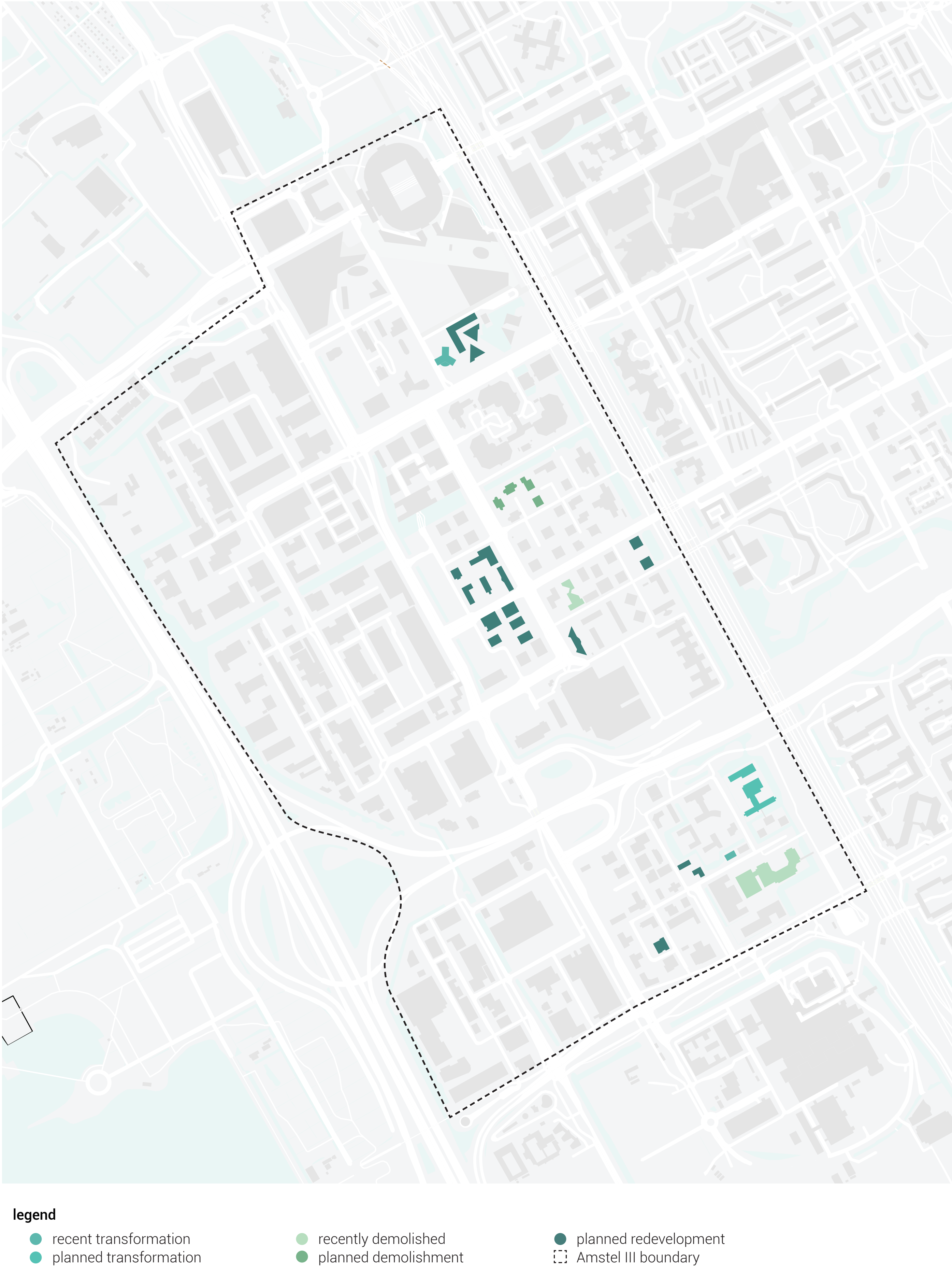
Paalbergweg 2 PLANNED
1978 OFFICE

Paasheuvelweg 24 PLANNED
1991 PUBLIC

Paasheuvelweg 15 PLANNED
1989 OFFICE

Paasheuvelweg 17 PLANNED
1991 OFFICE

Fig 1: map of office buildings planned for redevelopment

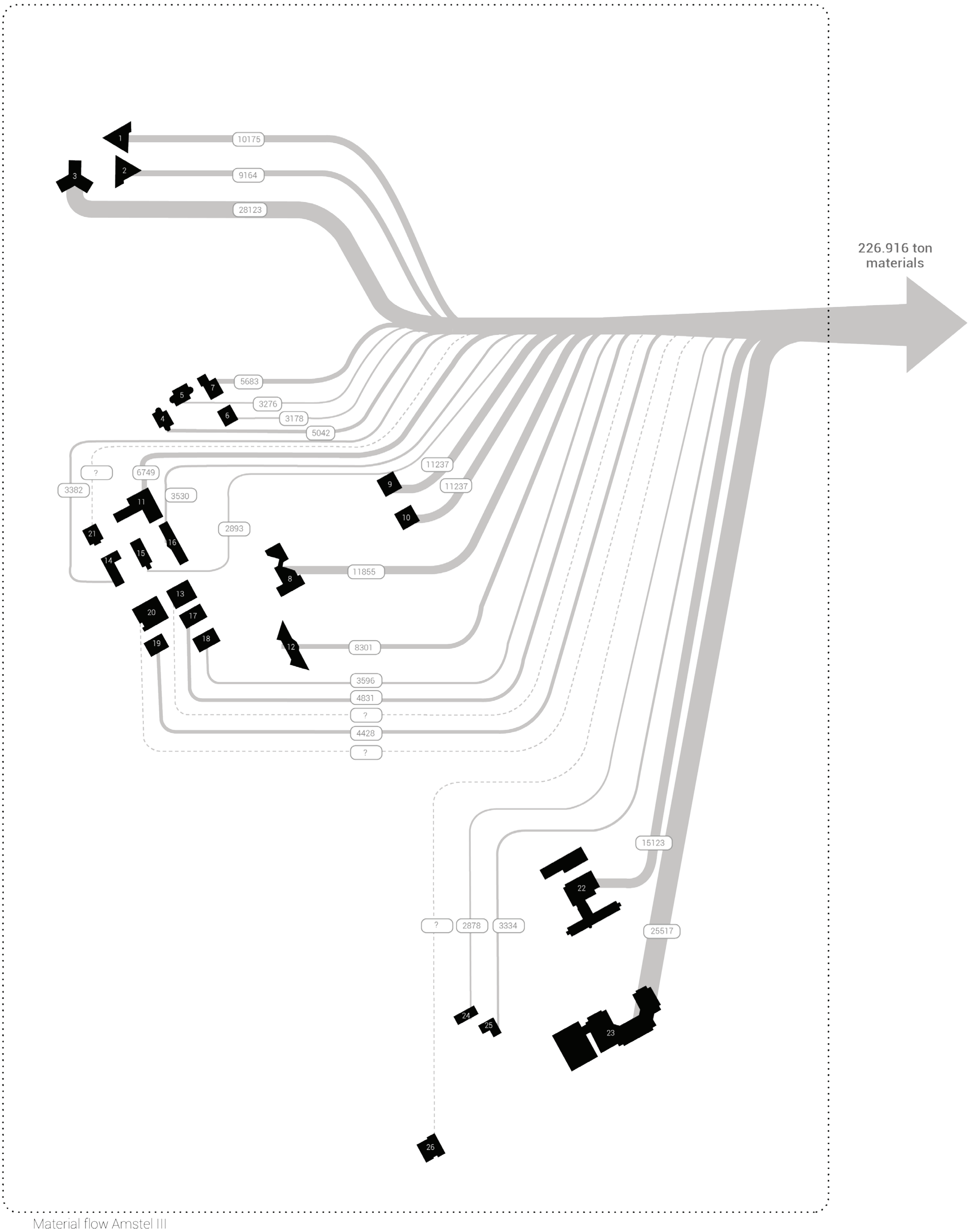


APPENDIX B - materials

Tabel 1: types of material available in office buildings (Metabolic, 2018)

				Expected material stock														
Address	Function	BVO/GFA (m²)	Building Year	Granite	Polystyrene	Sand and g	Concrete (t	Bricks, stone and ceram		Glass (ton)	Aluminium	Cladding (a	Gypsium (t	Steel (ton)	Copper (ton	Wood (ton)	Plastics (to	Bitumen (to
De Corridor 2	Café	761	2001															
Hoogoorddreef 60	Office	6699	*1988*		6,0	2680	9070	563		40	47	10	234	94	1	121	7	47
Hoogoorddreef 62	Office	6034	1988		5,4	2414	8170	507		36	42	9	211	84	1	109	6	42
Haaksbergweg 4	Office	14367	*1992*		12,9	5747	19453	1207		86	101	21	503	201	2	259	14	101
Hogehilweg 5	Office	3320	*1984*		3,0	1328	4495	279		20	23	5	116	46	0	60	3	23
Hogehilweg 7	Office	2157	1984		1,9	863	2921	181		13	15	3	75	30	0	39	2	15
Hogehilweg 15	Office	3743	1984		3,4	1497	5068	314		22	26	5	131	52	0	67	4	26
Hogehilweg 13	Office	2091	1985		1,9	836	2831	176		13	15	3	73	29	0	38	2	15
Hogehilweg 6	Office	2951	*1987*		2,6	1180	3996	248		18	21	4	103	41	0	53	3	21
Hogehilweg 8	Office	5425	1987		4,9	2170	7345	456		33	39	8	190	76	1	98	5	38
Karspeldreef 4	Office	7805	1991		7,0	3122	10568	656		47	55	11	273	109	1	140	8	55
Karspeldreef 14	Office	7398	1990		6,6	2959	10017	621		44	52	11	259	104	1	133	7	52
Hullenbergweg 1	Office	5465	1988		4,9	2186	7400	459		33	39	8	191	77	1	98	5	38
Hondsrugweg 50	Office	4443	1988		4,0	1777	6016	373		27	32	6	156	62	0	80	4	31
Hessenbergweg 109-1	Office	2324	1999		2,1	930	3147	195		14	16	3	81	33	0	42	2	16
Hessenbergweg 95	Office	1905	2000		1,7	762	2579	160		11	13	3	67	27	0	34	2	13
Hessenbergweg 73-83	Office	2556	2000		2,3	1022	3461	215		15	18	4	89	36	0	46	3	18
Hessenbergweg 10	Office	2042	1987		1,8	817	2765	172		12	14	3	71	29	0	37	2	14
Hettenheuvelweg 14	Office	2367	1988		2,1	947	3205	199		14	16	3	83	33	0	43	2	17
Hettenheuvelweg 12	Office	3181	1988		2,9	1272	4307	267		19	22	5	111	45	0	57	3	22
Hettenheuvelweg 8	Office	2457	1987		2,2	983	3327	206		15	18	4	86	34	0	44	2	17
Hettenheuvelweg 4	Office	24024	1987		21,6	9610	32528	2018		144	169	35	841	336	3	432	24	168
Hettenheuvelweg 16	Office	2916	1989		2,6	1166	3948	245		17	20	4	102	41	0	52	3	20
Paalbergweg 3	Office	10016	1978		9,0	4006	13562	841		60	70	14	351	140	1	180	10	70
Paalbergweg 9	Office	16800	1982		15,1	6720	22747	1411		101	119	24	588	235	2	302	17	118
Paasheuvelweg 17	Office	2195	1991		2,0	878	2972	184		13	15	3	77	31	0	40	2	15
Paasheuvelweg 15	Office	1895	1989		1,7	758	2566	159		11	13	3	66	27	0	34	2	13

Fig 1: MFA diagram or material flow (ton) offices Amstel III, based on data from Metabolic



APPENDIX C - case studies office buildings

BRICK


Hessenbergweg 73
2000


Hessenbergweg 109
1999


Paasheuvelweg 24
1991


Hessenbergweg 95
2000


Hettenheuvelweg 26
2008


Paasheuvelweg 17
1991

GLASS


Hoogoorddreef 60
1988


Hoogoorddreef 62
1988


Hogehilweg 5
1984


Hogehilweg 7
1984


Hessenbergweg 8
1987


Hettenheuvelweg 12
1988


Hettenheuvelweg 14
1988

STONE


Hogehilweg 13
1984

Hogehilweg 15
1984


Paasheuvelweg 15
1989


Hondsrugweg 50
1900?


Hettenheuvelweg 18
1987


Hettenheuvelweg 16
1986


Paalbergweg 2
1978

TIMBER


Hullenbergweg 1
1988


Karspeldreef 14
1990


Karspeldreef 16
1990

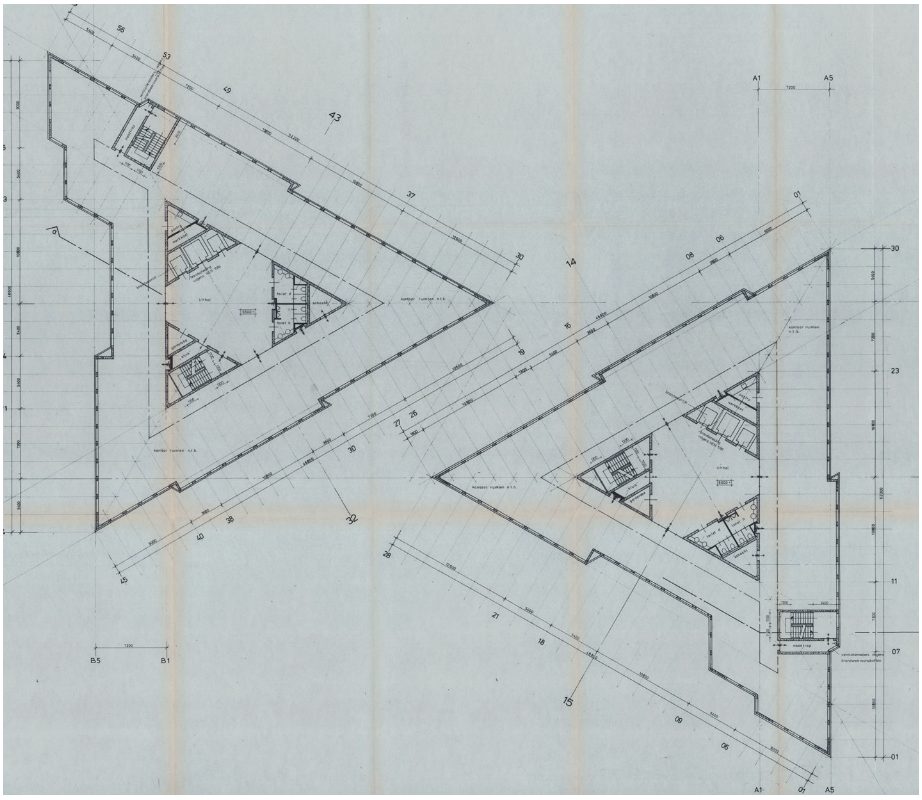
HOOGOORDDREEF 60

BVO 6699 m^2
1988

Hoogoorddreef 60 and 62 are also called respectively Centerpoint I and II. The buildings are located on the border of the office area and the event area with the Arena, Ziggo Dome and AFAS Live. Centerpoint I has 9 floors, was built in 1986 and renovated in 2007. Next to Centerpoint I is the slightly smaller Centerpoint II. The 6-storey building was built in 1988 and failed to renovate in 2009.

https://nsi.nl/location/centerpoint-i-amsterdam-2/

Images:
https://jll.realnext.nl/detail/hf23dtkb-huur-kantoor-hoogoorddreef-60
https://imagesgeorgerex.blogspot.com/2016/06/willis-hq-amsterdam.html



COMPONENTS

structure		? m³	**9070 ton**	
pc.	*x m*	*m3*	concrete	collumn
pc.	*x m*	*m3*	concrete	floor
glass		**5625 m²**	**140 ton**	
2500 pc.	*1.5 x 1.5 m*	*5625 m2*	curtain wall	mirror
curtain wall system		**5625 m²**		
roof	m²	m³		bitumen
facade cladding		**? m²**	**? m³**	**563 ton**
? pc.	*? x ?m*	*? m2*	granite	red
roof	m²	m³		bitumen
doors ext				
lift	*3 pc.*			
toilets	*24 pc*			
sinks	*30 pc*			

concrete	?	m3	1,354 ton	
curtain wall	0,84 m2		0,002 ton	1.5 x 1.5 m
facade panels	?	m2	? ton	? x ? m

HOGEHILWEG 13

BVO 2091 m²
1984

The office buildings is a duo with the building at Hogehilweg 15, which is only two stories higher. The building has recently ben renovated and shows therefore a neat and modern interior.

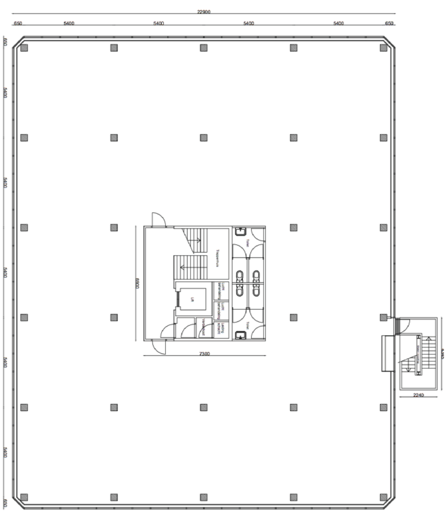
The interior is complemented with mechanical ventilation and cooling, recessed luminaries and every other windows is openable.

The facade is build up of panels from wood (?) and windows which are partly openable. Metal strips are draped vertically over the facade. The entrance is marked by black facade panels.

The calculations for the interior are based on available images and is therefore a rough estimation.

www.fundainbusiness.nl/kantoor/verhuurd/amsterdam/object-85126519-hogehilweg-13/

Images:
www.wehaveanyspace.com
www. flexas.nl



COMPONENTS

structure		**? m³**	**2831 ton**	
pc.	*x m*	*m3*	concrete	collumn
pc.	*x m*	*m3*	concrete	floor
glass		**340 m²**	**8,5 ton**	
252 pc.	*1.0 x 1.2 m*	*300 m2*	double	transparent
20 pc.	*1.0 x 2.0 m*	*40 m2*	double	transparent
window frames		**1180 m**	**340 m²**	alumnium?
facade cladding		**500 m²**	**? ton**	
332 pc.	*1.0 x 1.6 m*	*530 m2*	?	white/grey
roof	m²	m³		bitumen
doors ext	*4 pc.*			
doors int	*36 pc. core*			
lift	*1*			
interior walls		*1530 m*		steel-glass
interior doors		*+- 50?*		steel-glass
toilets		*16 pc.*		ceramics
sinks		*11pc.*		?

concrete	**? m3**	**1,354 ton**	
windows	**0,16 m2**	**0,004 ton**	**0.8-1.0 x 1.2 m**
facade panels	**0,24 m2**	**? ton**	**1.0 x 1.6 m**

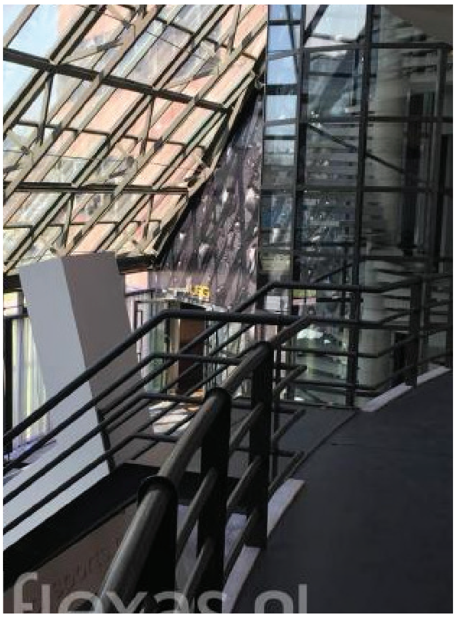
HULLENBERGWEG 1

BVO 5465 m^2
1988

The Hullenbergweg 1 is an office building with a remarkable shape. Its main facade material is granite panels in a standard dimension. On the backside a large atrium arises which is made with a curtain wall system on a steel structure. This in contrast with the rest of the buildings which is based on a concrete structure.

Dekker et al. (2018)

Images:
www.wehaveanyspace.com
www. flexas.nl



COMPONENTS

structure		**1.650 m³**	**4200 ton**	
230 pc.	*3.3 x 0.2 m*	*224 m3*	concrete	collumn
0,22 m	*6324 m2*	*1391 m3*	concrete	floor
glass		**2.300 m²**	**57 ton**	
718 pc.	1.5 x 1.1 m	1292 m2	double	brown mirror
20 pc.	0.7 x 1.1 m	16 m2	double	brown mirror
324 pc.	0.8 x 1.1 m	292 m2	double	brown mirror
24 pc.	0.8 x 0.6 m	12 m2	double	brown mirror
432 pc.	0.8 x 0.9 m	302 m2	double	brown mirror
83 pc.	2.2 x 1.1 m	207 m2	sloped	mirror
34 pc.	1.1 x 1.1 m	44 m2	sloped	mirror
28 pc.	2.6 x 1.1 m	84 m2	sloped	mirror
39 pc.	0.4 x 1.1 m	20 m2	sloped	mirror
window frame		**6.900 m**	**50 m³**	**40 ton**
facade cladding		**1.750 m²**	**52m³**	**459 ton**
1438 pc.	*0.6 x 1.65 m*	*1424 m2*	granite	red
654 pc.	*0.6 x 0.8 m*	*324m2*	granite	red
roof	**1091 m²**	**21 m³**		
0,02 m	*1092 m2*	*21 m3*	bitumen	
doors	*0.9 x 2.3 m*	228 pc.	?	*2,1 m2*
lift	*4 pc.*			

concrete	**0,30 m3**	**0,768 ton**	
windows	**0,42 m2**	**0,010 ton**	**0.4-2.2 x 0.6-1.1 m**
natural stone	**0,32 m2**	**0,083 ton**	**0.6 x 0.8-1.65 m**
doors	**0,04 pc**		**0.9 x 2.3 m**

HESSENBERGWEG 109

BVO 2324 m^2
1999

The office building at the Hessenbergweg is a dual building with the office building on number 73. It contains three layers of office spaces which can be mirrored over the central entrance. The building is currently empty, but still contains suspended ceilings on certain levels and used to contain internal office walls.

The facade of the two wings is made of red brick stone (strips?). The facade of the central hall is made of facade panels which could be steel or PVC kind of material. The exterior has remarkable canopies with steel blinds which mark the main entrances and the emergency exits on the north and south side of the building.

2/3 of the windows is openable.

Images:
www.wehaveanyspace.com
www. flexas.nl

COMPONENTS

structure		**? m^3**	**3147 ton**	
9 pc.	*0.2 x 6 m*	*m3*	steel	collumn
pc.	*x m*	*m3*	concrete	collumn
pc.	*x m*	*m3*	concrete	floor
glass		**200 m^2**	**5 ton**	
162 pc.	*0.8 x 1.2 m*	*145 m2*	double	transparent
36 pc.	*1.0 x 1.2 m*	*43 m2*	double	transparent
window frames			alumnium?	grey
facade cladding			**195 + ? ton**	
1420 m2	brick	red/grey	195 ton	
220 m2	?	grey		
blinds hz.	*x m*	*m2*	steel	blinds
doors ext	*10 pc.*			
doors int	*20 pc.*			
toilets	*17 pc.*			
lift	*2 pc.*			

concrete	? m3	1,354 ton	
windows	0,09 m2	0,002 ton	0.8-1.0 x 1.2 m
facade panels	0,09 m2	? ton	
brick	0,61 m2	0,084 ton	

APPENDIX D - component inventory

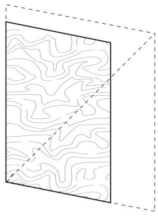
Tabel 1: component inventory per office building

GENERAL		TOTAL	.../m2 BVO	1 Hoogoorddreef 60	2 Hoogoorddreef 62	4 Hogehilweg 5	5 Hogehilweg 7	6 Hogehilweg 13	7 Hogehilweg 15	9 Karspeldreef 14	10 Karspeldreef 16	11 Hondsrugweg 50	12 Hullenbergweg 1
Function				Office	Office	Office	Office	Office	Office	Office	Office	Office	Office
BVO/GFA	(m2)	**124479**		6699	6034	3320	2157	2091	3743	7398	7398	4443	5465
Building year				1988	1988	1984	1984	1985	1984	1990	1990	1988	1988
Building height	(m)			39	28,5	20	17	16,4	23	30,3	30,3	11	16,5
MATERIALS													
Total	(ton)	**190503**		10254	9235	5080	3301	3207	5726	11323	11301	6801	8365
Concrete (ton)	x	**168544**	1,354	9070	8170	4495	2921	2831	5068	10017	10016	6016	7400
Bricks, stone, ceramics (ton)	(ton)	**10456**	0,084	563	507	279	181	176	314	621	622	373	459
Glass (ton)	(ton)	**744**	0,006	40	36	20	13	13	22	44	44	27	33
Gypsum (ton)	(ton)	**4354**	0,035	234	211	116	75	73	131	259	258	156	191
Steel (ton)	(ton)	**1744**	0,014	94	84	46	30	29	52	104	104	62	77
Wood (ton)	(ton)	**2241**	0,018	121	109	60	39	38	67	133	134	80	98
Bitumen (ton)	(ton)	**871**	0,007	47	42	23	15	15	26	52	52	31	38
SKIN	(m2)	**56397**											
Main material				glass	glass	glass	glass	wood white panel,	wood white panel,	granite wall panel	granite wall panel	white steel	natural stone
Panels	Material			granite	granite							white + translucent	granite
27%	(pc.)	**8539**		?	?	-	-	332	595	1500	1500	?	2092
	(m)			?	?	-	-	1.0 x 1.6	1.0 x 1.6	1 x 1	1 x 1	?	0.6 x 0.8 - 1.85
	(m2)	**15389**	0,320	?	?	-	-	531	952	1500	1500	2371	1750
	(m3)	**90**	0,003	?	?	-	-	?	?	15	15	?	17,5
	(ton)	**163**	0,009	?	?	-	-	?	?	40,5	40,5	?	47,3
Bricks	(m2)	**6149**	0,611	-	-	-	-	-	-	-	-	-	-
11%	(m3)	**307**		-	-	-	-	-	-	-	-	-	-
	(ton)	**861**	0,269	-	-	-	-	-	-	-	-	-	-
Curtain wall	(pc.)	**12575**	0,373	2500	2250	1240	805	-	-	-	-	-	1630
47%	(m)			1.5 x 1.5	1.5 x 1.5	1.5 x 1.5	1.5 x 1.5	-	-	-	-	-	0.4 - 2.2 x 0.6 - 1.1
	(m2)	**26656**	0,840	5625	5063	2790	1811	-	-	-	-	-	2170
	(m3)	**0**	?	?	?	?	?	-	-	-	-	-	
	(ton)	**800**	0,006	169	152	84	54	-	-	-	-	-	65,1
Windows (incl. Frames)	(pc.)	**11647**	0,094	-	-	-	-	270	480	700	6700	210	67
15%	(m)			-	-	-	-	1.0 x 1.2 - 2.0	1.0 x 1.2 - 2.0	1.0 x 1.4	1.0 x 1.4	0.8 x 1.6	0.4 - 2.2 x 1.1
	(m2)	**8202**	0,066	-	-	-	-	340	600	980	980	269	100
	(m3)	**?**	?	-	-	-	-	?	?	?	?	?	
	(ton)	**260**	0,002	-	-	-	-	8,5	15	24,5	24,5	6,72	57
Doors exterior	(pc.)	**296**	0,002	16	?	?	?	4	?	23	23	?	13
	(m)												0.9 x 2.3
FINSIHING													
Interior panels	(m)	**91082**	0,732	?				1530	2550				
	(m2)	**9792**	0,079	?				3672	6120				
Suspended ceiling	(m2)	**99583**		5359				1673					4372
Doors interior	(pc.)	**5193**	0,042	279	?	?	?	87	?	?	?	?	228
	(m)	**0**	0,000	?	?	?	?	0.9- 1.6 x 2.3 - 2.6	?	?	?	?	0.9 x 2.3
SERVICES + INTERIOR													
Lifts	(pc)	**35**	0,000	3	4	2	2	1	2	2	2	1	4
	(m3)	**0**	0,000										
Radiators	(pc)	**5467**	0,044	294	265	146	95	92	164	325	325	195	240
	(m3)	**820**	0,007	44	40	22	14	14	25	49	49	29	36
	gelaagd		0,000	?				?					?
Toilets	(pc)	**908**	0,008	24	45	25	16	16	28	56	56	33	41
Sinks	(pc)	**635**	0,014	30	32	17	11	11	20	39	39	23	29
Luminaries	(pc)	**30340**	0,200	1340	1207	664	431	418	749	1480	1480	889	1093

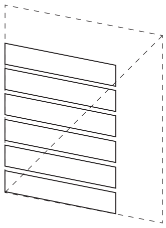
	Hesenbergweg 8	Hessenbergweg 73	Hessenbergweg 95	Hessenbergweg 109	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 2	Paalbergweg 3	Paasheuvelweg 15	Paasheuvelweg 17	Paasheuvelweg 24
	13	14	15	16	17	18	19	20	21	22	24	25	26
GENERAL	Hesenbergweg 8	essenbergweg 73-8	Hessenbergweg 95	ssenbergweg 109-1	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 1	Hettenheuvelweg 2	Paalbergweg 3	Paasheuvelweg 15	Paasheuvelweg 17	Paasheuvelweg 24
Function	Office	Office	Office	Office	Office	Office	Office	Office	Office	Office	Office	Office	Church
BVO/GFA	2042	2556	1905	2324	3181	2367	2916	1936	1578	10016	1895	2195	1848
Building year	1987	2000	2000	1999	1988	1988	1989	1987	2008	1978	1989	1991	1991
Building height	7,3	10,7	14,6	10,8	14,3	14,3	17,4	6,8	7,3	20,9	17	15,6	6,5
MATERIALS													
Total	3126	3912	2914	3557	4868	3623	4461	2963	2415	15330	2899	3359	2829
Concrete (ton)	2765	3461	2579	3147	4307	3205	3948	2621	2137	13562	2566	2972	2502
Bricks, stone, ceramics (ton)	172	215	160	195	267	199	245	163	133	841	159	184	155
Glass (ton)	12	15	11	14	19	14	17	12	9	60	11	13	11
Gypsum (ton)	71	89	67	81	111	83	102	68	55	351	66	77	65
Steel (ton)	29	36	27	33	45	33	41	27	22	140	27	31	26
Wood (ton)	37	46	34	42	57	43	52	35	29	180	34	40	33
Bitumen (ton)	14	18	13	16	22	17	20	14	11	70	13	15	13
SKIN													
Main material	glass	brick: red + grey	(concrete?) brick	brick (red)	glass	glass	natural stone	white steel panels	concrete brick	?	aluminium compos	creme grey brick	grey brick + golfplaa
Panels		plastic?	translucent	grey	-	-	granite	steel				steel	steel
27%	-	?	?	?	-	-	920	?	-	1300	300	?	?
	-			?	-	-	1.0 x 1.4	462	-	1.5 x 1.5	1.0 x 1.6	270	720
	-	240	180	220	-	-	1288	462	-	2925	480	270	720
	-	?	?		-	-	13	?	-	29,25	?	?	?
	-	?	?		-	-	35	?	-	?	?	?	?
Bricks	-	1560	1165	1420	-	-	-	-	615	-	-	1050	339
11%	-	78	58,25	71	-	-	-	-	31	-	-	53	17
	-	218	163	199	-	-	-	-	86	-	-	147	47
Curtain wall	550	-	-		700	650	-	-	-	-	-	-	-
47%	1.0 x 1.0	-	-		0.5 - 0.8 x 0.8 - 2.0	0.5 - 0.8 x 0.8 - 2.0	-	-	-	-	-	-	-
	550	-	-		1859	1726	-	-	-	-	-	-	-
	?	-	-				-	-	-	-	-	-	-
	16,5	-	-		56	52	-	-	-	-	-	-	-
Windows (incl. Frames)	-	220	320	200	-	-	375	200	65	1300	245	200	25
15%	-	0.8 - 1.2 x 1.4	0.4 - 0.8 x 1.4 - 2.0	0.8 - 1.2 x 1.5	-	-	1.0 - 1.4 x 2.0	0.5 x 0.5	0.4 - 1.0 x 0.4 - 1.0	1.5 x 1.5	1.0 - 1.2 x 2.0	1.0 x.1.0	1.0 x 1.0
	-	220	320	200	-	-	600	50	26	2925	367,5	200	25
	-	?	?	?	-	-	?	?	?	?	?	?	?
	-	5,5	8	5	-	-	15	1	1	73	9	5	1
Doors exterior	?	10	9	10	?	?	8	?	6	?	?	?	7
FINSIHING													
Interior panels													
Suspended ceiling				1859									
Doors interior	?	20	?	20	?	?	?	?	?	?	?	?	?
	?		?		?	?	?	?	?	?	?	?	?
SERVICES + INTERIOR													
Lifts	2	2	2	2	1	1	1	0	0			1	0
Radiators	90	112	84	102	140	104	128	85	69	440	83	96	81
	13	17	13	15	21	16	19	13	10	66	12	14	12
Toilets	15	19	14	17	24	18	22	15	12	75	14	16	14
Sinks	11	13	10	12	17	12	15	10	8	53	10	12	10
Luminaries	1207	1207	1207	465	1207	1207	1207	1207	1207	1207	1207	1207	1207

Fig 1: Summarized material inventory for Amstel III based on 26 office buildings

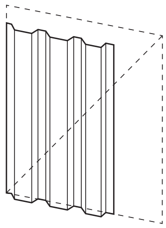
SKIN



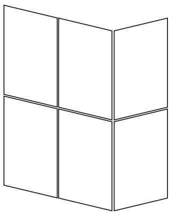
natural stone
granite
grey - red
6.000 m^2
60 m^3
162 ton



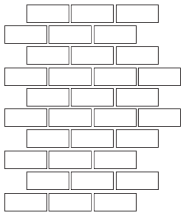
timber slats
painted wood
grey - white
1.500 m^2
30 m^3
21 ton



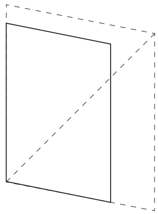
corrugated panels
steel
grey - white
4.000 m^2
40 m^3
60 ton



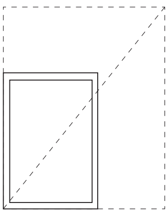
curtain wall
glass
transparent - mirror
1.0-1.5 x 1.0-2.0 m
26.600 m^2
670 m^3
800 ton



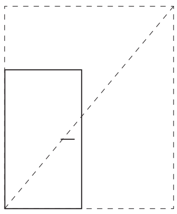
bricks
red - black
6.100 m^2
307 m^3
861 ton



facade cladding
unknown material
grey
3.800 m^2
? m^3
? ton

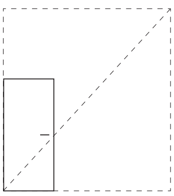


windows
+ frames
double glass
transparent - mirror
12.000 pc.
0.4-1.5 x 1.0-2.0 m
8.200 m^2
260 ton

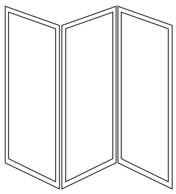


doors exterior
+ frames
250 pc
0.9 x 2.3 m
20 m^3
7.5 ton

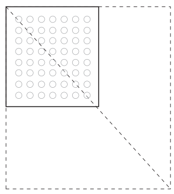
INTERIOR



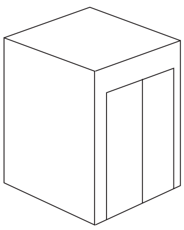
doors interior
+ frames
5.100 pc
0.9 x 2.3 m
820 m^3
201 ton



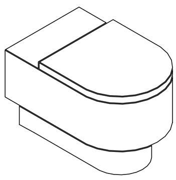
interior wall
glass - steel frame
10.000 m2



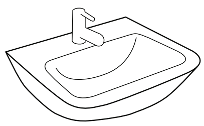
suspended ceiling
different systems
acoustics
100.000 m^2
2.000 m^3



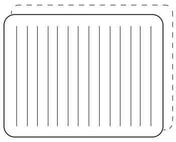
lifts
people transport
37 pc.



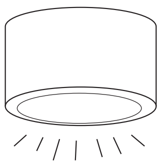
toilets
ceramics
930 pc.



sinks
ceramics
650 pc.

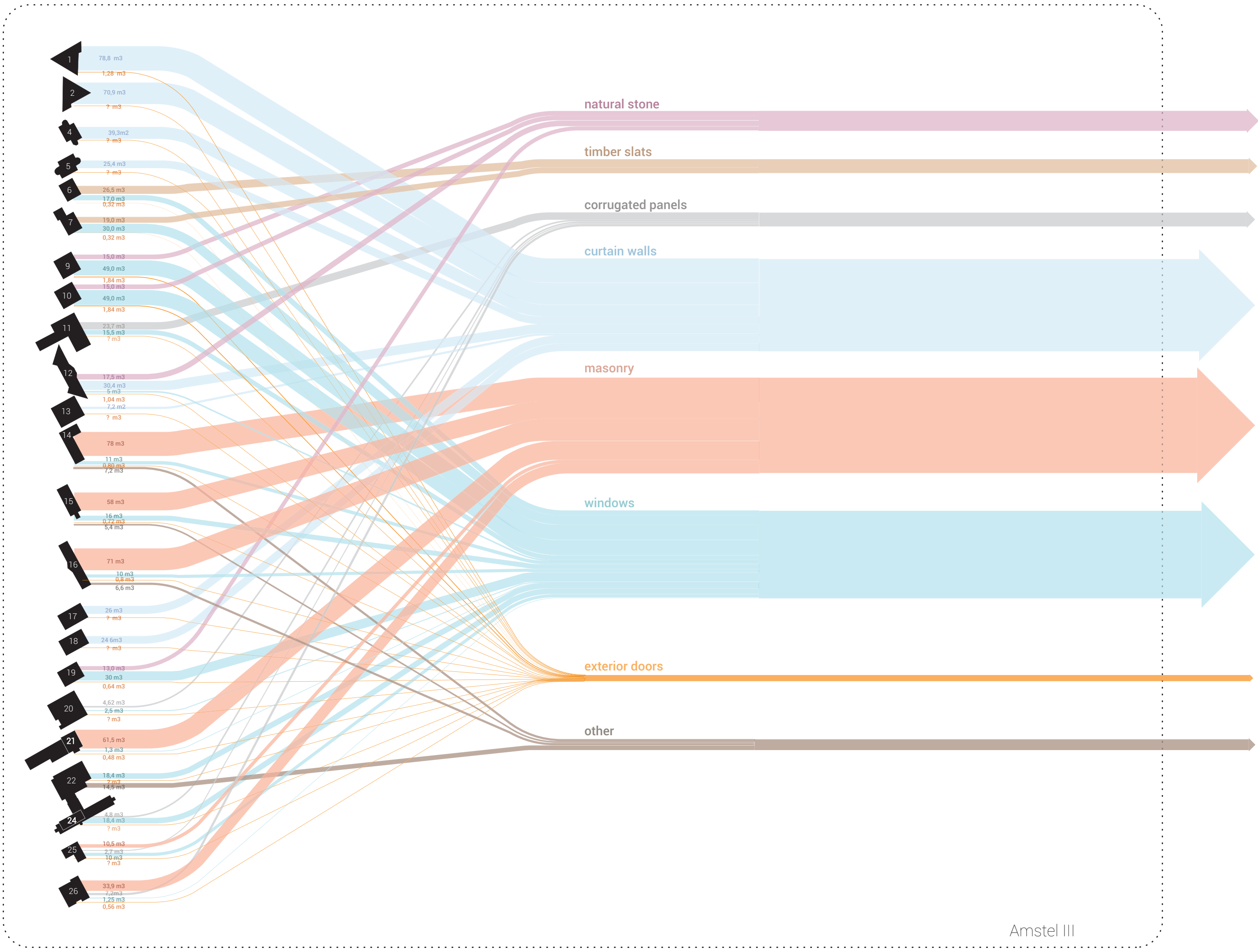


radiators
single - double layered
5.500 pc.



luminaries
+ fixtures
30.000 pc.

Fig 2: MFA diagram of skin components Amstel III in case of linear building system



APPENDIX E - value assesment

Tabel 1: value assesment

		viability				environmental impact		costs	
		Availability	Ease of detachment	Ease of refurbishment	Reuse potential	Embodied energy	Volominous impact	Market value	Production costs
facade systems	**Stone cladding**	60 m3 6.000 m2 163 ton 11% of façades in Amstel III	• Panels modular detachable (clicking or hanging system)	• Can be cut in smaller sizes • Attachment system adjusted to new design • Panels might break	• Same function • Adjusted to floor and interior f inishing • Water tight qualities	• Granite: 11 GJ/ton • 1793 GJ • Transported long distance	• Low		
facade systems	**Corrugated cladding**	40 m3 4.000 m2 60 ton 7% of façades in Amstel III	• Screwed fix	• Easily cut in new shapes and sizes • Easy re attachment using screws	• Same function • Adjusted to interior finishing • Water tight qualities	• Steel 170 GJ/t (Lawson, 1996) • 10.200 GJ • Locally produced	• Low	• High (Vandkunsten & Manelius, 2017)	• Intermediate (Vandkunsten & Manelius, 2017)
facade systems	**Timber cladding**	30 m3 1.500 m2 21 ton 3% of façades in Amstel III	• Screwed fix • Clued on larger panels	• Easily cut in new shapes and sizes • Easy re attachment using screws	• Same function • Adjusted to interior finishing • Interior items	• Timber: 10 GJ/t • 210 GJ • Wood imported	• Low	• High (Vandkunsten & Manelius, 2017)	• Intermediate (Vandkunsten & Manelius, 2017)
facade systems	**Curtain walls** (glazing + system)	670 m3 26.600 m2 800 ton 47% of façades in Amstel III	• Modular system screwed or clicked together • Glass might damage	• Frame sizes hard to adjust • Glass may scatter/break due to storage or manufacturing (needs to be carefully stacked)	• Same function (depending on glass quality) • Separate glass for water tight functions • Layered glass can be horizontally used	• Metals: 150 GJ/t • Glass: 20-30 GJ/t (Addis, 2006; Victoria: Lawson, 1996) • 24.000-32.000 GJ	• High	• High (Vandkunsten & Manelius, 2017)	• High (Vandkunsten & Manelius, 2017)
facade systems	**Bricks**	307 m3 6.100 m2 861 ton 11% of façades in Amstel III	• Mortar can only be unbind when lime mortar (older type of buildings); these mortars are probably cement based	• Difficult to clean from mortar • Larger panels (including mortar) can be cut	• Same function (exterior) • Esthetical interior qualities • Paving	• Brick: 2,5-3,0 GJ/t (Addis, 2006 Lawson, 1996) • 650 GJ • Locally produced	• Intermediate	• Medium (Vandkunsten & Manelius, 2017)	• High (Vandkunsten & Manelius, 2017)
facade systems	**Windows** (glazing + frame)	205 m3 8.200 m2 260 ton 12.000 pc.	• Glass might damage	• Glass may scatter/break due to storage or manufacturing • New size needs new frame • Regulations needs to be considered	• Same function (depending on glass quality) • Lower glass quality: double layered facade • Water tight functions	• Metals: 150 GJ/t • Glass: 20-30 GJ/t (Addis, 2006; Victoria: Lawson, 1996) • 7.800-10.000 GJ	• Intermediate	• High (Vandkunsten & Manelius, 2017)	• High (Vandkunsten & Manelius, 2017)
facade systems	**Doors exterior** (+ frame)	20 m3 7,5 ton 250 pc	• Doors easy to detach • Frame depends on way of fixation	• Depending on material size can be adjusted; enlarging tends to be difficult • Regulations (insulation values and measurement) need to be considered	• Same function (depending on passing regulations • Measuremens insufficient: renovation projects • Interior items • Material reuse		• Low		• Low
interior finishing	**Doors interior** (+ frame)	820 m3 200 ton 5.100 pc	• Doors easy to detach • Frame depends on way of fixation	• Depending on material size can be adjusted; enlarging tends to be difficult • Regulations (measurements) need to be considered	• Same function (depending on passing regulations • Measuremens insufficient: renovation projects • Interior items • Material reuse		• High		• Low
interior finishing	**Lifts**	37 pc.	• Depending on system modular	• Testing and safety measurements needed	• Same function (back to • manufacturer)				• Intermediate
interior finishing	**Toilets**	1000 pc. 30 ton		• Cleaning and testing needed	• Same function	• Ceramics: 3 GJ/t • 90 GJ		• High; influenced by quality and uniqueness (Rotor DC, 2019)	• Low
interior finishing	**Sinks**	650 pc. 13 ton		• Cleaning and testing needed	• Same function	• Ceramics: 3 GJ/t • 90 GJ		• High; influenced by quality and uniqueness (Rotor DC, 2019)	• Low
interior finishing	**Suspended ceilings**	2.000 m3 100.000 m2 Average of 80% of total BVO	• Modular system	• Modular frame system an be reinstalled and simply adjusted to different sizes • Panels can be cut in new sizes	• Same functions • Acoustic qualities	• Low (Guy & Esherick, 2006) • Metal frame: high; 150 GJ/t	• High, but low mass		• Low
interior finishing	**Luminaries** (fixtures)	30.000 pc. many different types	• Easy	• Easy	• Same function • Lighting qualities				• Low
interior finishing	**Interior wall panels**	10.000 m2 6.000 m2 transparent (60%) 4.000 m2 opaque (40%)	• Modular systems	• Easy	• Same functions • Material reuse • Glass reuse in new frames • Interior items		• High		• Low
interior finishing	**Radiators**	5.500 pc. many different types	• Easy	• Cleaning • Performance testing needed	• Same function depending on testing				• Low

APPENDIX F - decision charts component groups

Fig. 1: facade gladding

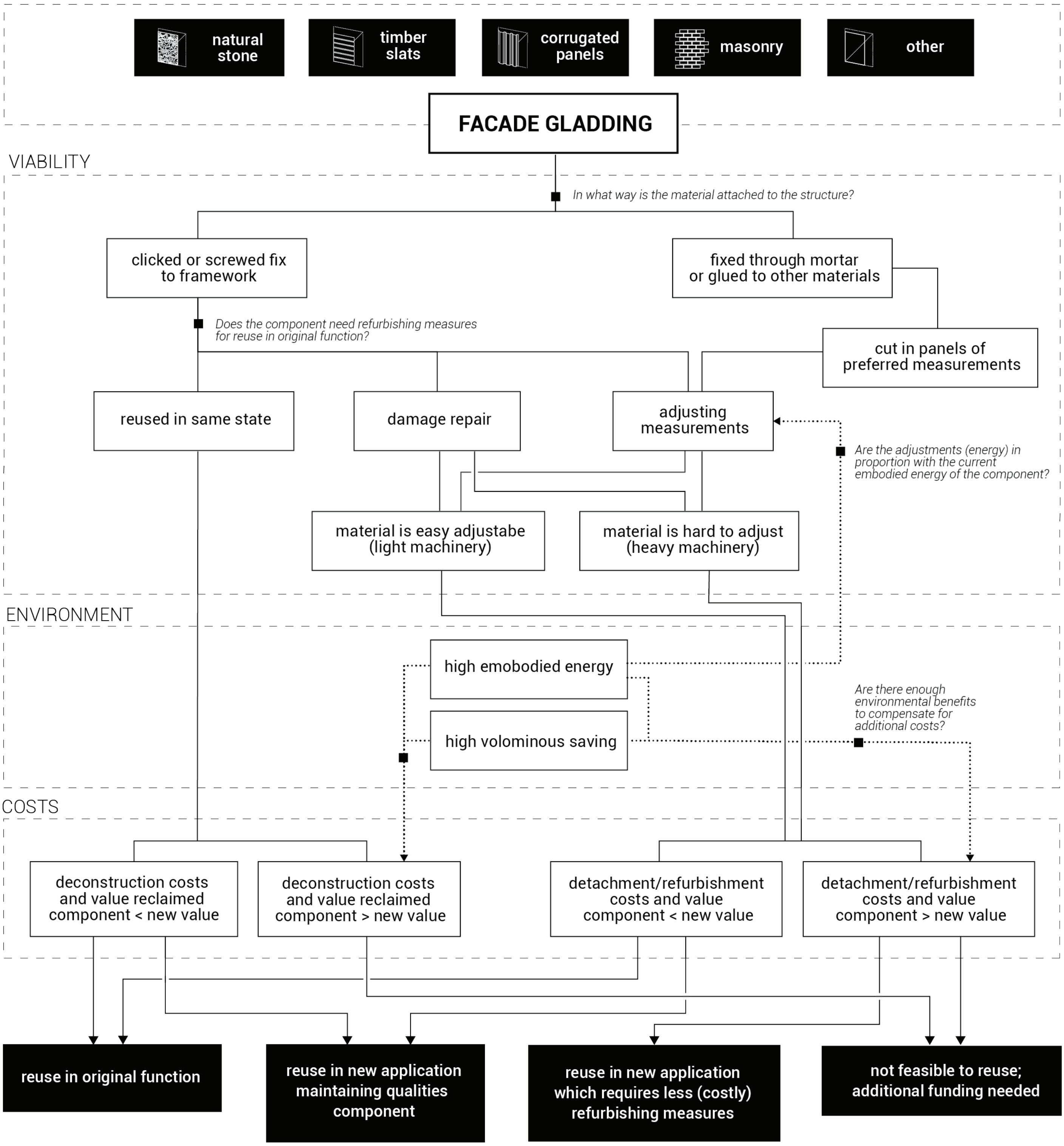


Fig. 2: glass elements

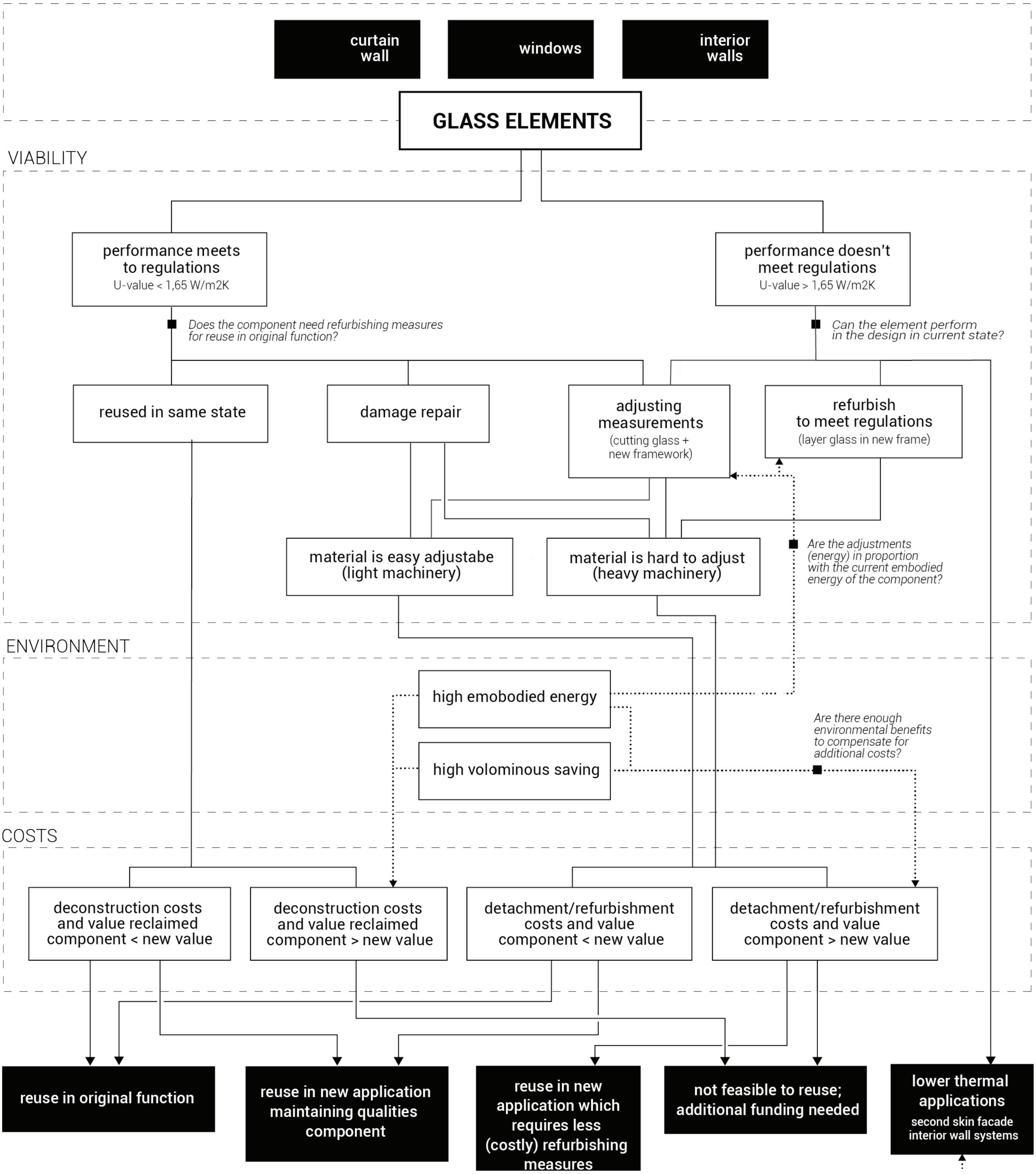
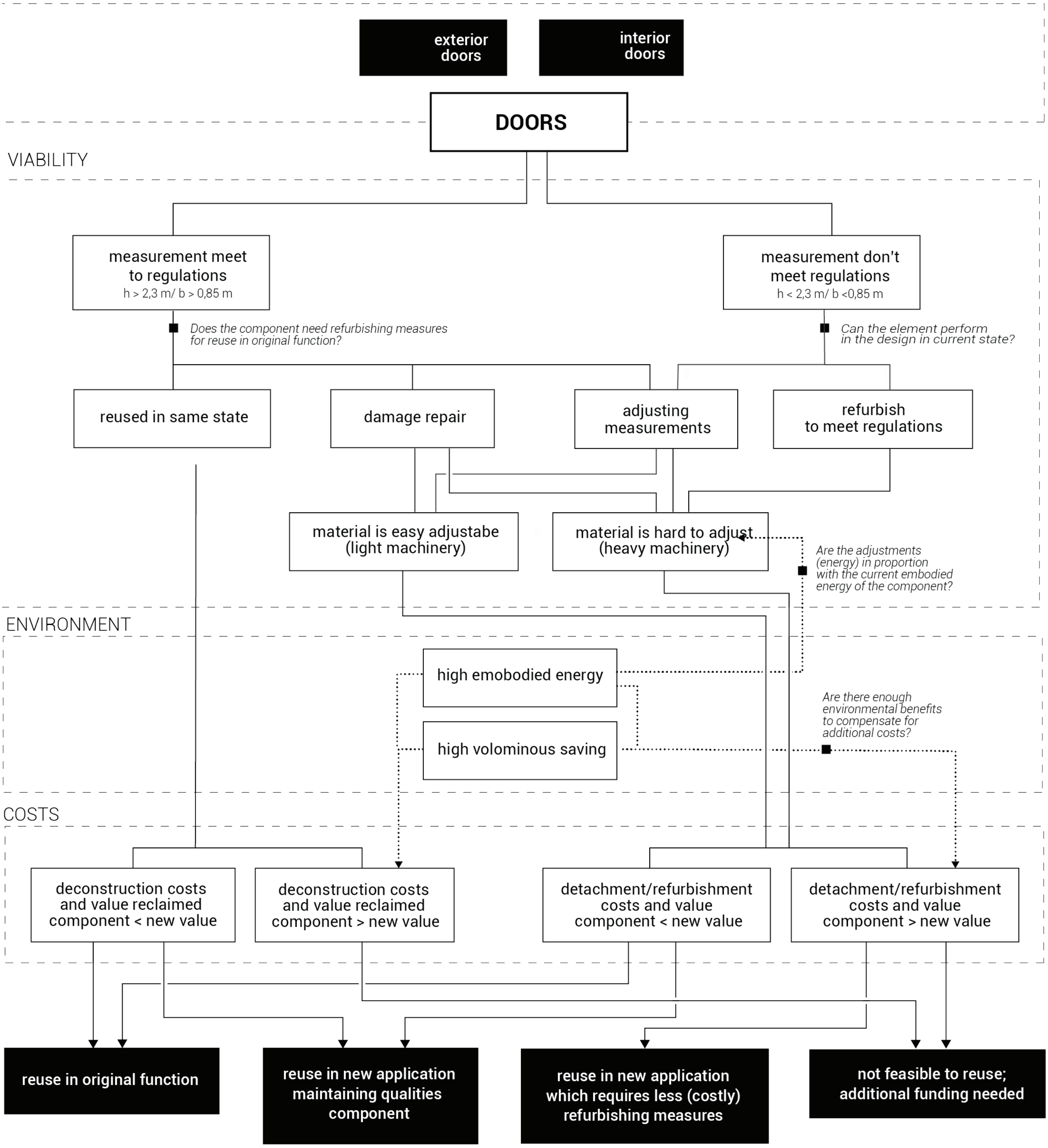


Fig. 3: Doors


exterior doors
interior doors
DOORS
VIABILITY
measurement meet to regulations
h > 2,3 m/ b > 0,85 m
measurement don't meet regulations
h < 2,3 m/ b <0,85 m
Does the component need refurbishing measures for reuse in original function?
Can the element perform in the design in current state?
reused in same state
damage repair
adjusting measurements
refurbish to meet regulations
material is easy adjustabe (light machinery)
material is hard to adjust (heavy machinery)
Are the adjustments (energy) in proportion with the current embodied energy of the component?
ENVIRONMENT
high emobodied energy
high volominous saving
Are there enough environmental benefits to compensate for additional costs?
COSTS
deconstruction costs and value reclaimed component < new value
deconstruction costs and value reclaimed component > new value
detachment/refurbishment costs and value component < new value
detachment/refurbishment costs and value component > new value
reuse in original function
reuse in new application maintaining qualities component
reuse in new application which requires less (costly) refurbishing measures
not feasible to reuse; additional funding needed

APPENDIX G - reference projects application reclaimed components

RESOURCE ROWS

UTILITY

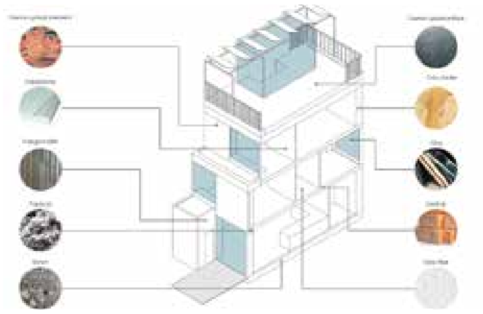
Lendager Arkitekten

2017-2019

The bricks reused in the The Resource Rows are cut out in modules, processed and stacked up to create the new walls in building. This innovative approach makes it possible to reuse masonry more than one lifetime. Lendager ARC and Lendager UP have in collaboration with Carlsberg Byen for the cutting and processing of the masonry. The facade is build up from several deconstructed buildings. Partly the masonry origins from Carlsberg's historical breweries in Copenhagen. Other parts of the masonry come from various old schools and industrial buildings around Denmark.

Additionally, wood from the construction of Copenhagen Metro is reusd in the project. The large amount of wood waste was processed, so the wood appears as beautiful and sustainable materials in the project's facades and interior

https://lendager.com/en/architecture/resource-rows/



CUBO HOUSE

HOUSING

Phooey Architects

2013

Cubo House is a design that is based on a two story house which was before small and dysfunctional proportioned. This building has been demolished and replaced with a more modern design of three stories. Before demolishing parts of the building were harvasted. The front double storey Victorian section has been entirely retained. Many existing features, such as structural and flooring timbers, windows, doors, security grilles and the stair case were salvaged prior to demolition. Slate roof tiles that were harvested from the old roof currently compose the new facades. The old security screens have been assembled to form a dual purpose sun-shading as well a privacy screen over the new rear window.

During the design process a surrealistic collage technique "Cubomania" was applied to re-use and re-invent the demolished building materials.

Embodied energy was minimised by balancing the quantity of demolished materials against the quantity of materials brought in to replace them.This is mostly recognisable in the external brickwork. Additionally, the previous house had limited solar access, which is now compensated with a central light core which delivers natural light and air to the new basement and all adjacent spaces via a window wall made of reclaimed windows of the previous home.

Dwell Development (2016). Columbia City Reclaimed Modern Home. Retrieved from www.dwelldevelopment.com on 10 March 2019

FREE STANDING HOUSES

HOUSING

Dwell Development
2014-2016

Architectural office Dwell Development has designed several offices in Seattle and its surroundings on the principals of green building methods of which the reuse of materials is one of its main design tools. By using **reclaimed, recycled, and local materials,** the design **eliminates the energy use required for new material production, diverts waste from landfills, and reduces fuel emissions in material transport.**

The Reclaimed Modern Home (image above) is the new embodiment of an old farm; the barn wood is incorperated in the roof, while the metal is used for siding and fencing. The pahtway leading to the building is repurposed concrete from the public sidewalk removed during construction. The organic rusty hue coupled with the modern structure of the home creates an instant patina and a compelling addition to the vibrant urban neighborhood.

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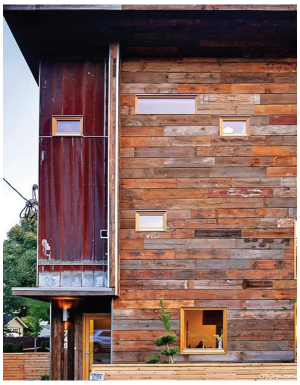
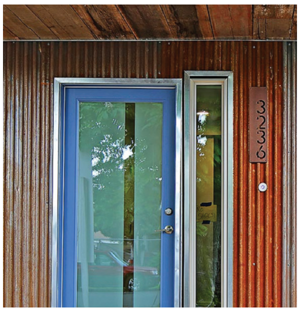
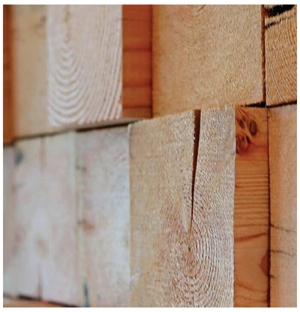
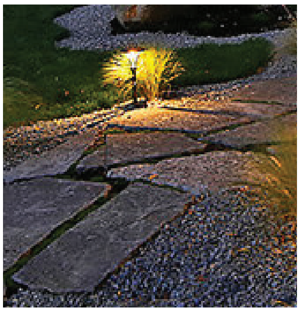
www.dwelldevelopment.com
www.dwelldevelopment.com/portfolio/columbia-city-reclaimed-modern-home









MATERIAL IMPLEMENTATIONS

corrugated metal

old barns → siding
roofing

wood

complete structures → siding
→ floors
→ stairs
→ treads
→ interior details

columns → columns

beams → beams

concrete

structures, flooring, walls → exterior pathways
sliced in pieces or made from components

bricks

walls → exterior pathways
cleaned from mortar

DESIGN LESSONS

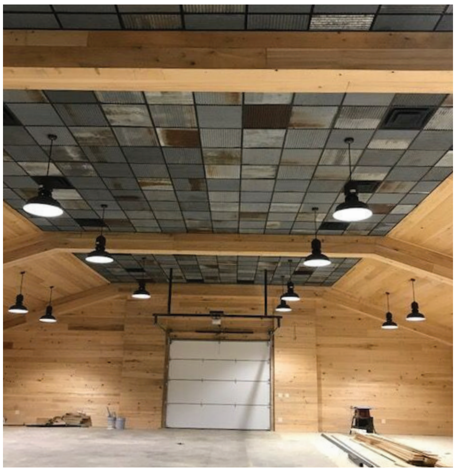
- **wood** has high variety of implementation possibilities
- distinction in reusing for **same function and addaptation** to new purpose
- reuse materials in same **shape**, in **partitions** or transformed into **new shape**

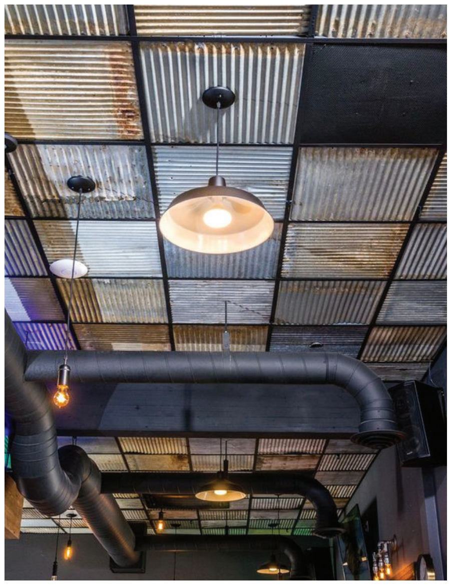
CORRUGATED CEILING

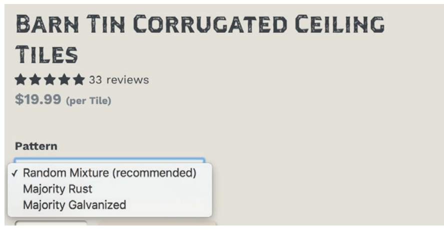
Reclaimed corrugated sheets are cut into smaller pieces which can be used as some kind of suspended ceiling. For this, the system of normal suspended ceilings can be used. The weather-beaten sheets of metal give a nice variation in the pattern and adds more identity to the whole. In combination with light wood the sheets give this raw identity but it still has a modern look to it.

An American webshop sells individual tiles from old barns for $19.99 per tile. Their system makes a distinction between majority rust and majority galvanized.

www.dakotatin.com







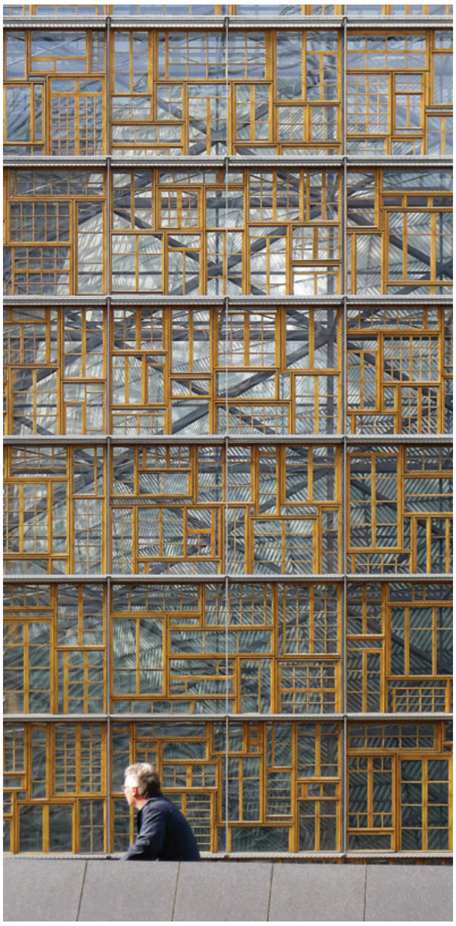
EUROPA BUILDING

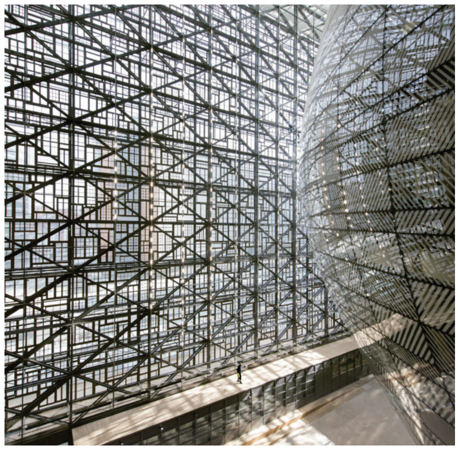
Philippe Samyn

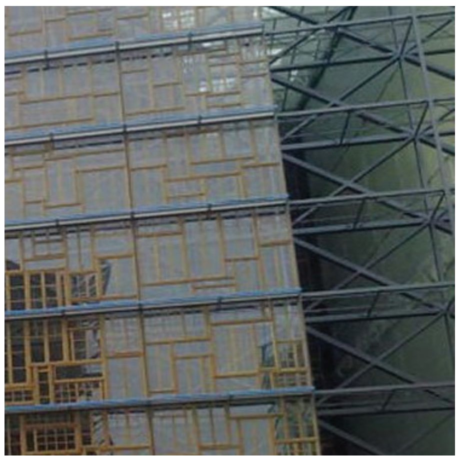
2016

UTILITY

The two exterior façades are made from 3.750 recycled oak windows from the 28 member states of the European Union. The window frames are polished and mounted in a **metal frame**, with **tempered glass** added. The reused windows shape the outer facade of the building. Behind a second layer are more physical demanding functions placed.







AFVALBRENGSTATION DEN HAAG

UTILITY

Wessel van Geffen Architecten / Superuse Studios
2017

The waste disposal station is placed in the inner city and is therefore easy accessible to the using public. The design consists of reused materials itself, so not the form was the starting point for the architect, but the available materials.

Façade material from steel contour plates: an industrial residual material from the automotive industry. This is supplemented by an unsalable sandwich panels, styles of sawn-up, used Azobé sheet piling and rock wool from an industrial hall demolished by the contractor. Only the steel main support structure is new.

The design is constructed by estimation of the materials. The describtion of the reused materials consists of parameters in which the material would be provided and to what supervising committees should consent.

www.dearchitect.nl/projecten/arc17-architectuur-den-haag-afvalbrengstation-wessel-van-geffen-architecten-s-m-superuse-studios
www.wesselvangeffenarchitecten.nl/

MATERIAL IMPLEMENTATIONS

steel

leftover industrial metal → facade panels

stone wool

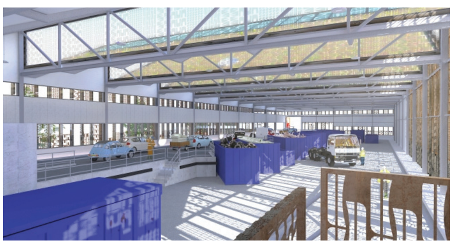
insulation manufacturing hall → insulation office

wood

Azobe sheet piling → facade pillars

DESIGN LESSONS

- **separation traffic flows**: private and freight
- design with **parametric descriptions** to define the unkown supply
- located inside city in residential area



VILLA WELPELOO

2012Architecten

2010

HOUSING

The structure is made from an old textile machine from 1989. Because no guarantee could be given on the steel, the weakest parts were assumed and the steel structure was over-dimensioned to meet all requirements.
Discarded cable reels were the base for the facade material. Material from the sides of the reels cannot be used, but the heartwood is in good condition and without holes. The cable reel slats are mounted vertically in two layers, interrupted by horizontal aluminum water rails. This provides a graphic and lively facade image. The timber of the façade was platatized to make it more sustainable. Polystyrene sheets from a demolished neighboring industrial building were used to insulate the facade and roof. Construction elevator becomes freight elevator. The tractor wall was intended for vertical transport of the paintings between the depot on the first floor and the gallery on the ground floor. Eventually it was decided to install a construction elevator as a goods. Theelevator in the middle of the house after construction. The lift is hidden from view by the raised floor of the kitchen and the three-step stairs leading to the kitchen.

www.architectuur.nl/project/villa-welpeloo-enschede/

PAVILION CIRCULAR

ENCORE HEUREUX

2015

UTILITY

This pavilion made from recycled material in Paris is made of no fewer than 180 doors that have been "saved" from destruction. The architects of ENCORE HEUREUX got the materials for this pavilion everywhere and nowhere: they visited workshops, ruins and contacted suppliers with a large unused stock

Second-hand items were also used for the interior as much as possible. The construction of wooden beams comes from an old retirement home and the wooden furniture comes from the landfill and has been refurbished and painted. The building is illuminated by outdated street lighting..

PLATTENBAU

Conclus

2007

Germany's Plattenbauten, post-war monotonous concrete flats, are increasingly abendoned. Conclus, a Berlin architectural firm is recycling the material single-family homes. The flats were slice it up and turn it into pleasant family homes.

http://www.bldgblog.com/2005/12/plattenbauten
https://www.fastcompany.com/57502/cement-bloc
Icibaci, L. (2019). Re-use of Building Products in The Netherlands: The development of a metabolism based assessment approach. Delft University of Technology. ISBN 978-94-6366-119-5