

Circularity; Refurbishment of an office building

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Abstract

The Netherlands have a high percentage of vacant office buildings. The office area Teleport in the Brettenzone is a mono-functional area with a vacancy rate of 20%. A lot of vacant office buildings are demolished. Buildings contain a lot of valuable materials, which mainly ends on the landfill after demolition. We live in a linear take-make-dispose environment, which results in the depletion of natural resources.

The objective of this graduation project is to make a more liveable area of Teleport by transforming a vacant office building into a building for multiple functions, which attracts all kinds of people during the whole day and acts as a catalyst for the transformation of the whole area. For this, the technical research focuses on the re-use of a vacant office building by closing material cycles, with the reuse of existing materials and the use of additional materials which can be part of a closed cycle.

This paper explains how Cradle to Cradle and circular economy relate to circularity. These concepts are used to determine the material criteria to achieve circularity. Where after the material research is explained in relation to close the material cycle and how buildings can be reused is explained. In the end, a design framework is presented as a guiding tool for designers.

1. Background

The Netherlands have the highest percentage of empty office buildings in Europe, in total over 13% (De Vries, 2013). In the Brettenzone, Amsterdam the vacancy rate is even 20%. The office area in the Brettenzone, Teleport, is a mono-functional area with large offices (Karssing & Scheringa, 2012). After 2008, since the economic crisis, the vacancy of office buildings has increased dramatically (Figure 1). The vacancy has several causes. New buildings appeared faster than office jobs. Next there is a reduction of new businesses caused by the crises. Also less office space is needed because new ways of working lead to (an increase in) flexible workplaces and more people choosing to work at home. Today, the employee has more demands and does not want to work at a mono-functional business area. (Remøy, 2007, p. 215; Van de Rakt, 2010).

In Figure 2 the withdrawal from office building stock to new functions is shown. A lot of the vacant office buildings are demolished. Buildings contain a lot of valuable materials. During the demolition, only a few materials are separated for recycling. Forty percent of the landfills is of the demolition of building(De Lange, 2013, p. 27). We live in a linear take-make-dispose environment. The extraction of building materials, the construction of buildings and in the end the demolition, have serious impact on the quality of the
environment, such as degradation and depletion of natural resources (Bots, Van Bueren, Ten Hevelhoff, & Mayer, 2005, p. 3).

This graduation project addresses two different, but coherent, problems. On the one hand the mono-functionality of the area Teleport. This results in few types of people, a lack of social security after working hours and with the vacancy, the area has become unattractive. On the other hand the current linear approach of take-make-use-dispose, which results in the depletion of natural resources. Therefore, the objective of this graduation project is to make a more liveable area of Teleport by transforming a vacant office building into a building for multiple functions, which attracts all kinds of people during the whole day and acts as a catalyst for the transformation of the whole area. For this, the technical research focuses on the re-use of a vacant office building by closing material cycles, with the reuse of existing materials and the use of additional materials which can be part of a closed cycle.

This gives the research question: How can a vacant office building, be transformed into a multi-functional building, while achieving circularity with the reuse of existing materials and additional materials?

2. Method
The research can be divided into two parts, closed cycles and re-use of a building. We first need to know more about circularity and what the criteria are for the materials and how to design with circularity. Next how to re-use a building and materials in relation to the circularity.

The aim of this paper to guide other designers in the design process of reusing a building.

Literature about Cradle to Cradle and circular economy is used as a starting point in the search how circularity can be achieved. The book Cradle to Cradle (Braungart & McDonough, 2007) is used for some background information about Cradle to Cradle and the papers from the website of the Ellen MacArthur Foundation have given information about circular economy. The papers of Van Dijk (2012) and Kibert, Sendzimir and Guy (2000) describes the differences and similarities between different sustainability concepts.

After having a clear view circularity, the perfect material is described. Whereupon a material research is done by using literature and the computer program CES Edupack 2013 to search for the best material options in the building industry. Some of the materials are described in this paper. The method to find the best materials is described with a small example.

For an in-depth study, only materials in relation to closing cycles will be looked at. The
results of this study are shown in this paper. The other elements of circular economy and Cradle to Cradle are discussed briefly. However, during the design these elements are also very important.

The re-use of buildings and materials is discussed shortly with a literature study. Finally a design framework is made as a guidance how to transform an existing building while achieving closed materials cycles.

3. Results
3.1 Cradle to Cradle & Circular Economy
Before we can answer the research questions related to circularity it is important to know what circularity means. Circularity is about closing cycles. Cradle to Cradle and the circular economy concept have described the aspect of closing cycles clear. This section will describe the equalities and differences between Cradle to Cradle and circular economy shortly, where after the explanation how this will be used.

Circular economy belongs in a wide variety of concepts, principles and strategies related to sustainability and nature, such as Cradle to Cradle, biomimicry, industrial ecology, performance economy and so on. Some of these concepts are almost the same, others covers a different field of sustainability. Some concepts are developed at the same time and others are created from an already existing concept. Therefore, the beginning of these concepts are difficult to date. However, all concepts have a common principle of circularity, closing cycles.

The most well known concept was Cradle to Cradle. Cradle to Cradle is further developed and introduced to the public by Michael Braungart and William McDonough in 2002 with the book Cradle to Cradle: Remaking the way we make things. Cradle to Cradle received a lot of attention in the Netherlands in 2006, after the television documentary Tegenlicht, "Afval is Voezel" (Waste equals Food) (Van Dijk, 2012). Cradle to Cradle focuses on eco-effective instead of eco-efficiency. Eco-efficiency, reduce, reuse and recycle, is a well known motto, which means doing more with less. However, using less, making things less bad, is still bad. Reducing does not mean the end of depletion and destruction, but slowing down the process (Braungart & McDonough, 2007, pp. 65-68). Eco-effective means working on the right products, systems and services (Braungart & McDonough, 2007, p. 95). The goal of Cradle to Cradle is: “a delightfully diverse, safe, healthy and just world with clean air, water, soil and power- economically, equitably, ecologically and elegantly enjoyed” (McDonough, 2005). Cradle to Cradle focuses on the outcome, having a positive impact on life on earth by improving air, water, soil, material quality and biodiversity. The basic principles of Cradle to Cradle are Waste equals food, Celebrate biodiversity, Use renewable energy.

In the 1970s Walter Stahel pointed out the idea of cradle back to cradle already. At that time there was an economic crisis. Therefore, Walter Stahel translated the benefits of closing cycles to positive impacts on business. Whereby he created the circular economy concept. Circular economy is the fundament of Cradle to Cradle (Atsma & Atsma, 2013). Circular economy is further defined by the Ellen MacArthur Foundation. “The Ellen MacArthur Foundation works in education, business innovation and analysis to accelerate the transition to a Circular Economy” (Ellen MacArthur Foundation, 2012).
Circular economy focuses on the process of making, leasing, reuse, redistribute, remanufacturing and recycling materials and products. Circular economy provides a business paradigm with the economic benefits of closing cycles by eliminating waste with complete disassembly and recovery of nutrients (Varney-Wong). This results in a business model which provides the material flows and stocks in a closed cycle. The basic principles of circular economy are Design out waste, Build resilience through diversity, Use energy from renewable sources, Think in systems and Think in cascades (Ellen MacArthur Foundation, 2013, pp. 26-28).

In Table 1 a comparison between the two concepts is made.

As Cradle to Cradle focuses on the outcome, having a positive impact on life on earth, the circular economy focuses more on the process to achieve a positive outcome through business opportunities.

Another difference between the two concepts is the fact that Cradle to Cradle has become a brand. The expression Cradle to Cradle is protected in order to ensure that this will not be misused (Den Held, 2009). Before something can be called Cradle to Cradle it has to be certified by the company.

For this graduation project the emphasis is on the process of achieving circularity. Therefore, the circular economy concept is used mainly. However, this research will not examine the potential economic benefits and possible business models. The principles of the Cradle to Cradle concept are kept in mind for the design project. All Cradle to Cradle aspects are too much to assess for this research. However, the criteria of the material aspects can be of significant value to find the right materials in this research.

### Table 1: Comparison Cradle to Cradle and Circular Economy

<table>
<thead>
<tr>
<th></th>
<th>Cradle to Cradle</th>
<th>Circular Economy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design out waste / waste = food</td>
<td>Closed cycle: Everything is a nutrient for something else Biomedical and technical nutrients</td>
<td>Closed cycle: Nutrients in stock for new products Biomedical and technical nutrients</td>
</tr>
<tr>
<td>Celebrate diversity</td>
<td>Celebrate biodiversity Species, cultural and innovation diversity</td>
<td>Build resilience through diversity in case of external changes: diverse systems with many connections and scales.</td>
</tr>
<tr>
<td>Use renewable sources</td>
<td>Renewable energy from the sun</td>
<td>Energy from the sun and human labour</td>
</tr>
<tr>
<td>Think in systems</td>
<td>-</td>
<td>Emphasize on stocks and flows</td>
</tr>
<tr>
<td>Think in cascades</td>
<td>-</td>
<td>Extract additional value from products and materials by cascading</td>
</tr>
</tbody>
</table>

3.2 Cradle 2 Cradle product certification

Products can be certificated by Cradle by Cradle from the Cradle to Cradle Products Innovation Institute. The certification of Cradle to Cradle products has brought a clear list of criteria to achieve sustainability. The products (and companies) are assessed on 5 different categories: social fairness, material health, material reutilization, renewable energy and water stewardship.
The Cradle to Cradle Products Innovation has a program which guides continual improvement towards products:

- made with materials that are safe for humans and the environment
- designed so all ingredients can be reused safely by nature or industry
- assembled and manufactured with renewable, non polluting energy
- made in ways that protect and enrich water supplies, and
- made in ways that advance social and environmental justice

(Cradle to Cradle Products Innovation Institute, 2011c).

In these categories there are 5 different levels: basic, bronze, silver, gold and platinum. To achieve a silver Cradle to Cradle certificate, the product should achieve at least silver in all categories. It is not directly visible, if a silver certificated product achieved gold or platinum in only some of the categories.

When choosing building materials based on material sustainability the categories material health and material reutilization are very important. The criteria for material reutilization for the Basic certificate is that each generic material in the product is clearly defined as an intended part of a biological or technical cycle. At each higher level, the materials have to have a higher recycling rate. For example, materials have to be at least 35% recyclable for the bronze level (Cradle to Cradle Products Innovation Institute, 2011b).

The criteria for material health is shown in Table 2. From level silver the products contains nothing which can cause cancer, birth defects, genetic damage, or reproductive harm. This means, products with a basic or bronze certificate can still cause harm to people. The criteria for material health contains no criteria for the process of making the product.
Table 2: Material Health Certification Levels (MBDC, 2012)

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>ACHIEVEMENT</th>
</tr>
</thead>
</table>
| BASIC   | • The product is 100% characterized by its generic materials (e.g., aluminum, polyethylene, steel, etc.) and/or product categories and names (e.g., coatings).  
• The appropriate metabolism (i.e., technical nutrient (TN) or biological nutrient (BN)) is identified for the product and its materials and/or chemicals.  
• The product does not contain any Banned List chemicals based on supplier declarations. |
| BRONZE  | • The product is at least 75% assessed (by weight) using ABC-X ratings. Externally Managed Components (EMCs) are considered assessed and contribute to the overall percentage of the product that has been assessed. Products that are entirely BN in nature (e.g., cosmetics, personal care, soaps, detergents, etc.) are 100% assessed.  
• A phase out or optimization strategy has been developed for those materials with an X rating. |
| SILVER  | • The product has been at least 95% assessed (by weight) using ABC-X ratings. Externally Managed Components (EMCs) are considered assessed and contribute to the overall percentage of the product that has been assessed. Products that are entirely BN in nature (e.g., cosmetics, personal care, soaps, detergents, etc.) are 100% assessed.  
• The product contains no substances known or suspected to cause cancer, birth defects, genetic damage, or reproductive harm (CMRs) after the A, B, C, X assessment has been carried out. |
| GOLD    | • The product has been 100% assessed (by weight) using ABC ratings. All EMCs are considered assessed as non-X.  
• The product contains no X assessed materials (optimization strategy is not required).  
• Product meets C2C emissions standards. |
| PLATINUM| • All process chemicals have been assessed and none have been assessed as X.                                                              |

3.3 Closing cycles

Circularity is all about closing cycles, waste equals food, and design out of waste. The Ellen MacArthur Foundation has made a clear overview of closing cycles. In Figure 3 both cycles, the biological and technical cycle, are explained. Biological nutrients are consumed, and returned to the earth after extraction of useful bio-chemicals for example heat fuels and power from biomass. The technical nutrients are used and not consumed. The circular economy provides a system of leasing, using a product instead of consuming and owning by the consumer/user. The technical nutrients are in stock in a product. These nutrients cannot return back to the earth, but are used again in the same product for another user, or remanufactured into another product and so on.
The perfect material is either in the biological sphere or the technical sphere. In case of a hybrid product, the used materials are separable in each cycle. The product will not release or contain toxic gasses during the process and use. Therefore, the products are not unhealthy to work with or to use.

Materials of the technical sphere can be reused perfectly time after time and are therefore demountable. The material can be recycled to something else if it is not suitable or required for the first purpose. During the recycling, nothing is lost, there are no waste products, or the waste products serves as food in another cycle. Materials of the biological sphere are produced without ground depletion. The energy used during production is from renewable sources. Transport energy is from renewable sources. Water used during production is part of a closed cycle. Also there is no water depletion.

### 3.4 Material research

The building industry has a wide range of various materials to choose from. These materials vary in energy use during production, toxic waste or gasses during production and use, recyclability, water use, resource depletion, CO2 emissions and so on. In a perfect building only perfect materials, as described above, are used. However, until these materials are produced, we have to make the best choice of available materials, but how?

As an example I have chosen some materials in the categories construction, insulation, facade cladding and interior finish. The materials were selected by the use of conventional building materials and interesting materials of the Cradle to Cradle competition.

The resources to examine the materials are diverse databases and books. I have used
several databases instead of one, because of some contradictory views of these databases. Databases that are used are: nibe (NIBE, 2013), material database of the program CES Edupack 2013, Greenspec database (Greenspec, 2013), Cradle to Cradle certified product database (Cradle to Cradle Products Innovation Institute, 2011a) and the Cradle to Cradle competition (Cradle to Cradle Products Innovation Institute, 2013).

The first step, to select a suitable material, is to make an inventory of the material properties. Main properties are: toxicity in use and production, reusability / demount ability, recyclability, and biodegradability. Sub properties are: lifespan, energy use in production, transport distance, water use and CO2 emissions. These properties are of less importance in this research because I assume the companies make use of renewable energy for production and transport, have a closed cycle of water, and are CO2 neutral. In Table 3 an example of a material inventory is made of some insulation materials.

The second step is to compare different material solutions, by giving an answer on the question which material is best suitable in a closed cycle approach. If two materials are very similar, the sub properties can provide input for the decision making.

The last step is to determine the design boundaries, required by the material.

Following, some insulation materials are discussed. This clearly reflects the different views of some databases and shows why a sufficient research has to be made before choosing a material.

### Table 3: Example material inventory

<table>
<thead>
<tr>
<th>Material</th>
<th>Toxicity production</th>
<th>Toxicity use</th>
<th>Reuse</th>
<th>Recycle</th>
<th>Biodegradable</th>
<th>Lifespan</th>
<th>Embodied energy (MJ/kg)</th>
<th>Water use</th>
<th>Transport (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheep's wool</td>
<td>Yes (1) / No (4)</td>
<td>+ (healthier) (4)</td>
<td>Yes (2)</td>
<td>Yes (3)</td>
<td>75 (1)</td>
<td>20,9 (2)</td>
<td>1m²=3kg (1)</td>
<td>1,62e⁵ – 1,79e⁵ (3)</td>
<td>300 (1)</td>
</tr>
<tr>
<td>Cellulose fiber</td>
<td>Yes (1)</td>
<td>Yes (Braungart &amp; McDonough, 2007, p. 74)</td>
<td>Yes (2)</td>
<td>Yes (3)</td>
<td>30 (1)</td>
<td>0,94 – 3,3 (2)</td>
<td>1m²=8,4kg (1)</td>
<td>?</td>
<td>300 (1)</td>
</tr>
<tr>
<td>Flax</td>
<td>Yes (1)</td>
<td>?</td>
<td>Yes (2)</td>
<td>Yes (3) / No (2)</td>
<td>40 (1)</td>
<td>39,5 (2)</td>
<td>1m²=3,86kg (1)</td>
<td>2,98e⁵ – 3,29e⁵ (3)</td>
<td>300 (1)</td>
</tr>
<tr>
<td>Straw</td>
<td>No (5)</td>
<td>No (5)</td>
<td>?</td>
<td>No (3)</td>
<td>Yes (3)</td>
<td>0,1 – 0,3 (3)</td>
<td>?</td>
<td>?</td>
<td></td>
</tr>
</tbody>
</table>

1. (NIBE, 2013)
2. (Greenspec, 2013)
3. CES Edupack 2013
4. (Cradle to Cradle Products Innovation Institute, 2013)
5. (Strobouw Nederland, 2013)
Sheep’s wool

Sheep’s wool seems to be a perfect material at first sight. The product was even selected for the Product Innovation Prize of the Cradle to Cradle Products Innovation Institute (Cradle to Cradle Products Innovation Institute, 2013). Sheep’s wool is a natural insulation product, the wool is made of 100% animal fibre keratin, which is a renewable product and is completely biodegradable (Duurzaam thuis, 2013). The wool can absorb and release moisture over one third of its own weight, without adversely affecting the insulation ability (Barton, 2008, p. 215). Wool will make the interior spaces even healthier by absorbing the pollutants in the air. Wool will delay the ignition of surrounding materials in case of a fire, because wool insulation is difficult to burn. When the building is disassembled, the wool insulation can be pulled out easily and be reused, repurposed or recycled (Cradle to Cradle Products Innovation Institute, 2013).

However, at NIBE (Nederlands Instituut voor bouwbiologie en ecologie) the database of building materials classifies sheep’s wool as a very bad insulation option, with high environmental impact. NIBE considers that sheep’s wool is an unacceptable choice (Van Beijnum, Jansen, Naber, & Scholtes, 2013, p. 184). Sheep take up space for grazing. This land use is an environmental impact. But more important, sheep causes acidification and eutrophication. Sheep shit and this is not good for the environment because it contains ammonia and methane (Hoogeveen, 2013b).

Cellulose fibre

Cellulose fibre is made of waste paper, often old newspapers. The paper flakes give a good air seal and therefore insulate well and because of the high density it contains less oxygen for fire (Hoogeveen, 2013a). However, for the durability of cellulose fibre, borax and boric acid are added. The borax and boric acid can cause health problems to the workers during production and processing of the cellulose fibres. The cellulose is not biodegradable. The waste paper contains a certain amount of heavy metals. These metals may not enter in the environment, because this could harm humans and animals over the longer term (NIBE, 2013). The paper was not designed to be reused as an isolation material. “The mere fact that a material is recycled, does not automatically mean it is environmentally friendly, and especially not if it is not specifically designed for recycling” (Braungart & McDonough, 2007, p. 74).

Flax

Flax is made from the flax plant, which grows in Austria and Germany (Barton, 2008, p. 215). Flax is a natural product, but in some flax products the binder agent polyester is used, which is made from petroleum oils. The oil contains substances that are toxic and / or carcinogenic. During production of flax boards, various chemicals, such as borax, is used for the durability, fire resistance, antifungal and binding (NIBE, 2013). Therefore, this product is not biodegradable and cannot be recycled.

Straw

Straw is an agricultural by-product of cereal crops and 100% biological. Straw contains zero toxic gasses. During demolition only reusable or biodegradable products remain (Stroobouw Nederland, 2013). However, straw bales have several design boundaries. Straw bale wall are sensitive for rain. Therefore, a roof overhang is required to protect the walls. During construction, protection against rain and fire should be taken into account. Building with straw bales consumes more space than traditional walls, with a wall width of ca. 55 cm (Stroobouw Nederland, 2013).
3.5 Reuse existing building

Various motivations can lead to the transformation of an existing building. Conventional motivations are archaeological, aesthetic, psychological, functional and economic (Latham, 2000, p. 3). Economic motivation can have different reasons. An important reason for this research is the fact that buildings have valuable energy resources. For example, the origin embodied energy of the construction and used materials are retained, demolition energy is saved and there is less waste released (Birch, 2000, p. 26).

Before a vision can be made for possible and desirable changes in use of the building and to the building, the building has to be analysed. Especially the building technological aspects have to be analysed (Zijlstra, 2007, p. 237). For a successful project, the re-use has to follow a carefully and systematically planned route. Derek Latham has described eight identifiable stages which a re-use project has to go through. The second stage is understanding the building, its condition, exterior movement, stability, examine structure or services and the historic conservation plan (Latham, 2000, p. 55). The process of transformation is more complex than building a new building. The existing building has several building-specific preconditions (Andriessen, 2007, p. 322). Andriessen describes in a shortlist the differences between a transformation and a new building in each phase of the process, attached in appendix A. In this shortlist is shown that there will be only looked at the inventory of the building, the structural conditions and taking measurements of the building (inmeten bestaande situatie). During the definition phase (definitiet fase) there has to be defined what to demolish and what to keep (Andriessen, 2007, p. 323). In non of the phases a material inventory is made. There is no identification if any harmful materials are in the building. Also, there is nothing said about what to do with the waste.

Before renovation or transformation, a feasibility study is recommended. If the building is vacant, try to figure out why the building is vacant. Causes can be building conditions, comfort, function does not meet the supply and demand, location problems, and so on. In an early stage, the tool Herbestemmingswijzer (repurposing guide) (appendix B) can be used in the search for a feasible function. This tool selects and underpins the most appropriate function or functions for an existing building (Michel Hek, 2007, p. 399).

This section is called reuse of buildings, because the transformation of a building with circularity asks for reusing all possible materials of the building. Sustainable re-use requires more knowledge of the building, the used materials. Management is needed of the materials that will be removed of or re-used in the building (Gelfand & Duncan, 2012, p. 146). In Figure 4 the possible destinations of materials are shown. This is in line with designing with closed cycles. However, the first step has to be the material assessment for toxicity in use. If an already used material releases toxic gasses into the building, it has to be removed or it should be ensured that no toxic gases are released into the living environment. New additional materials must be chosen in the same manner as for new buildings. The perfect material which is at least not toxic, but reusable or designed for recycling without down cycling has to be found.
As a result of this research, I have made a design framework as a guide for the transformation of a vacant building, while closing material cycles, where possible. This framework is shown in Figure 5. In my opinion, the normal steps in a design process are only analyse, design and implementation, with some review moments. However, the design, with closed material cycles, needs more steps. The criteria for materials are more strict. There are less materials to choose from in the material databases. These materials will have some boundaries, which should be already taken into account during the design. Think of material sizes, demountable design and so on.

The reuse of a building should start with an accurate analyse of the problems at the location on different scales. What has caused the vacancy of the building? Are there problems in the neighbourhood, which has also affected the building use? After this analyse, possible improvements can be defined.

Reusing a building requires also knowledge about the current situation of the building. For closing material cycles, it is very important to make an inventory of the materials which are in the building. In this inventory, all materials have to be assessed, whether they are safe to use, and the possibilities for reuse or recycling. The harmful materials have to be extracted from the building. For all other materials, a plan has to be made for possible destinations. The designer should aim to reuse as much material as possible in the building itself. However, not all materials are designed for reuse or recycling, yet.
4. Conclusion and Discussion

The objective of this paper has been to guide designers in the design process of reusing a building in relation to closing material cycles. This gave the questions of what circularity implies, how the concepts Cradle to Cradle and circular economy relate to circularity and what the criteria are for materials to achieve circularity. How a material research can be done related to the circularity criteria for materials and how a building can be reused related to circularity.

Cradle to Cradle focuses on the outcome, having a positive impact on life on earth, the circular economy focuses more on the process to achieve a positive outcome through business opportunities. Cradle to Cradle has become a brand. Products can be certified by the Cradle to Cradle Products Innovation Institute. This institute has brought a clear list of criteria to achieve sustainability. The criteria for material health and material reutilization can be used for closing material cycles.

The Ellen MacArthur Foundation of circular economy has made a clear overview of closing cycles. The perfect material will not release or contain toxic gasses during the process and use. The material can be recycled without any waste, or the waste is food in another cycle.

The search for the best materials is very complex caused by the various criteria and differences between material databases. The first step, to select a suitable material, is to make an inventory of the material properties.
The second step is to compare different material solutions. The last step is to determine the design boundaries given by the material.

The reuse of a building in relation to circularity asks for more knowledge about the building. The reuse of a building should start with an accurate analyse of the problems at the location on different scales. For closing material cycles, it is very important to make an inventory of the materials which are in the building. In this inventory, all materials have to be assessed, whether they are safe to use, and the possibilities for reuse or recycling. The designer should aim to reuse as much material as possible in the building itself. However, not all materials are designed for reuse or recycling, yet.

During the research for the best materials, a few difficulties appeared. First, there is not a database with all the best options for designing in closed material cycles. Some material databases and material information contradicted each other, which makes it very difficult to evaluate a material.

To try out the design framework is a work in progress. The design framework will be used during the graduation project. This can be evaluated afterwards.

5. References


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## Appendix A

Table 4: Shortlist of differences between transformation and new building (Andriessen, 2007, p. 323)

<table>
<thead>
<tr>
<th>Initiatiefase</th>
<th>Bouwvoorbereidingsfase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bestaand pand, gebouw of complex</td>
<td>Bestek omschrijft zowel de kwaliteit van het nieuwbouwdeel als van het restauratie en/of transformatiedeel</td>
</tr>
<tr>
<td>Specifieke onderzoeken (asbest, vervuiling, bestemmingsplan, monumentale status) en haalbaarheidsonderzoek</td>
<td>Begroting met relatief grote post transformatiekosten: transformatie in de regel duurder dan nieuwbouw</td>
</tr>
<tr>
<td>Onderzoek naar uitbreidingsmogelijkheden van het gebouw of op het terrein</td>
<td>Post onvoorzien: 5 – 7%</td>
</tr>
<tr>
<td>Financiële uitgangspunten/exploatiemodellen moeilijker op te stellen door onbekende risico’s</td>
<td>Gezien complexiteit en specifieke kennis uitvoerende partijen wordt veelal gewerkt met bouwteams</td>
</tr>
<tr>
<td>Kennis van verschillende bouwstijlen met mogelijkheden en beperkingen noodzakelijk</td>
<td>Keuze bouwmaterialen en bemonstering aanpassen aan bestaande situatie</td>
</tr>
<tr>
<td>Transformatieproces: doorloop tijden brengen risico’s met zich mee</td>
<td>Ontwerpfase</td>
</tr>
<tr>
<td>Bouwkundige opnamen en inventariseren gebouw en bouwdelen noodzakelijk</td>
<td>Architect dient programma van eisen in te passen in bestaande situatie</td>
</tr>
<tr>
<td>Inmeten bestaande situatie noodzakelijk</td>
<td>Opdrachtgever moet bereid zijn flexibel om te gaan met pve en het ruimte-relatieschema</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Definitiefase</th>
<th>Realisatiefase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaststellen monumentale status en (on)mogelijkheden voor aanpassingen voor nieuwe functie(s)</td>
<td>Confrontatie met bestaande kwaliteit en onverwachte tegenvallers</td>
</tr>
<tr>
<td>Overleg overheden over mogelijkheden transformatie</td>
<td>Met name tijdens de sloopfase worden nieuwe zaken “ontdekt”</td>
</tr>
<tr>
<td>Definiëren wat te slopen en wat te handhaven.</td>
<td>Controle en toezicht lastiger aan de hand van ontwerp en bestek</td>
</tr>
<tr>
<td>Inpassen programma van eisen in bestaande situatie</td>
<td>Korte ruwbouwfase, lange afbouwfase</td>
</tr>
<tr>
<td>Selecteren architect met specifieke kennis en affiniteit op het gebied van transformatie</td>
<td></td>
</tr>
<tr>
<td>Selecteren constructeur met kennis en affiniteit op het gebied van oude constructiemethodieken</td>
<td></td>
</tr>
</tbody>
</table>
Figure 6: Werking Herbestemmingswijzer (M. Hek, Kamstra, & Geraedts, 2004, p. 64)