Guide to

Circular Design 2.0

Working agreements for circular construction

Platform CB'23

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Preface

The design phase is the phase of a project when circular ambitions are given tangible shape, as the choices made at that time have a pivotal influence on the final result. But how can we be sure that the right choices are made during that initial phase at the beginning of a new project? Circular design is not expected to become commonplace anytime soon. At the same time, an online search for circular design shows all kinds of strategies for working circularly.

This latter consideration was our starting point when we started mapping circular design in autumn 2020. This was based on the following questions: What design strategies exist and how best to apply them? Which actors are involved in the process and which preconditions make circular design processes easier? This led to us presenting the Circular Design Guide in the summer of 2021.

This is now two years ago. In November last year, we set to work with the responses to the first version and the experiences of the parties who had been working with it. The new guide was then submitted for the consultation round. The responses resulting from this tell us that this subject is very much alive in the sector and that we are on the right track with this new guide.

These efforts have led to this 2.0 version. We have fine-tuned the structure and readability. Of course, we have also come to new insights. We now see preconditions mainly as basic principles for circular design. In addition, we have critically reviewed the design strategies.

All in all, this has led to a more transparent picture of the design strategies. This has resulted in this revised guide, that offers several tips, resources and tools to help circular design become commonplace. That is ultimately the goal we wish to achieve.

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Summary

Circular design starts by having an ambition. An ambition to create a more sustainable building or engineering structure and to follow a more sustainable project process. The design phase is the main point in time when circular ambitions are given shape, as the choices made during this phase have a major influence on the result. That is why we have to ensure that the right choices are made. It is also the reason why everyone involved in the design process should work towards the same goals and the same solutions. It will be clear that proper agreements on this significantly reduce any risks of miscommunication and enable a more effective design process.

This 'Circular Design 2.0' guide is the successor to the 1.0 version of the guide that was published in July 2021. The responses to and experiences with the first guide have been incorporated into this version. The basic principle has not changed in this 2.0 version. We are establishing agreements to make circular design commonplace. These are agreements suitable for the construction and installation sector at large (buildings and civil and hydraulic engineering/infrastructure), further specified for the individual subsectors where relevant. These agreements focus not only on designers, but also on all other roles that can or should contribute to circular designs and their implementation. Of course, these agreements should leave sufficient freedom for designers and must not hamper innovation.

Basic principles

Combining our ambition with general and project-specific preconditions creates basic principles for circular design. Indeed, the basic principles apply to a wider perspective than just the design team's environment. This is because there are important relationships between the basic principles for the initiative phase and the construction phase and direct or indirect factors during the design process, such as legislation, education and urban planning developments.

Technical basic principles determine the implementation of physical and measurable circularity as part of a design process. These technical basic principles often come from such things as guidance documents, models and opportunities databases at the system level.

To ensure progress of the transition towards circular building and enable the necessary acceleration, a review of traditional legal relationships and related responsibilities is a prerequisite.

Legal changes are particularly needed to introduce collaboration where everyone contributes to the team result (agile collaboration). Traditional legal relationships (such as the Dutch UAV conditions, i.e. the Uniform Administrative Conditions for the Execution of Works) leave little or no room for making mistakes on one's own or together and thus for agile working. More recent forms of collaboration, such as the concepts of a *bouwteam* (construction team), *tweefasecontract* (two-phase contract) and Rapid Circular Contracting (RCC), have opened up more possibilities for this new way of dealing with responsibility and liability.

In today's economy, financial basic principles and financial resources are among the most important means to make a start to achieving a goal. Financial resources are estimated with a fairly ample margin at the start of a project, programme, or the initial phase of area development. The exact requirements for the financial resources are honed over time, i.e. the margin on the estimated resources required gradually decreases as the final result comes closer.

Regardless of the design strategy chosen, circular and sustainable work and design are still predominantly in the 'early adaptors' and 'early majority' phases. This means that these markets still need to be brought to maturity. The financial basic principles are also inseparably connected to the ambition.

Value retention is another basic principle. Value retention requires thought to be given to the use, management and the end of the useful life early on in the design cycle. How to best bring about collaboration with a relevant chain and the environment should also be an early consideration.

The pursuit of value creation follows from value retention. However, this will not be possible until we have stopped shifting costs elsewhere (externalising), because then we will have started to place value on a good living environment, to do justice to low-wage countries, climate conservation, and to preserving our own – and only – biosphere that will enable us and the generations after us to live and survive. A concrete example of this is that we assign a value to avoided CO_2 emissions through the European Emissions Trading System (ETS). By including the value of avoided CO_2 emissions or improved environmental performance expressed in the ECI and the MPG, the value created in terms of social added value of the investment can be expressed in a Net Present Value (NPV) calculation or in the scenarios of social cost-benefit analyses (SCBA).

Roles and collaboration

One thing is clear: traditional roles and partnerships in circular design projects are changing. These changes can be profound, but they depend mainly on the ambitions chosen and on how circular goals are pursued. Sustainable construction has led to the design chain being continually elongated and expanded. In a way, circular design has put an end to this tradition and is transforming the process from a linear to a circular one. Rather than elongating the chains, a new playing field has come into being. This is a playing field in which actors relate to each other fundamentally differently.

New roles have emerged, e.g. that of the champion of the circular design process. This champion takes up and continuously monitors the circularity ambition from the first moment that the initiative is taken. To be successful, the different actors have to work together. It is important for this process that parties choose an appropriate form of collaboration. This is why this guide includes the further developed 'Collaboration Wheel for the circular design process' tool.

Information requirements

Circular design projects are characterised by new and changing information needs. Every design strategy has its own information requirements, which includes information requirements during the design phase of the project. Knowledge about those information requirements is essential to ensure a successful circular design process and smooth and successful construction and management phases. An information requirements matrix can be a good tool to identify the information needed by the different actors involved in the process. This matrix shows which party needs what information, from whom and how. Proper completion of this information requirements matrix will also reveal what information is lacking. The matrix can be updated over and over again during the design phases that follow.

Seven design strategies

This guide addresses the following design strategies:

- **Prevention**
  This strategy focuses on avoiding new construction and, if new

construction cannot be prevented, on designing more efficiently and more optimally.

- **Design for quality and maintenance**
  This strategy is about protecting existing value by extending the lifespan of constructions, elements and materials.
- **Design for adaptability**
  Here, we assume that a construction can meet different future scenarios with different needs and requirements.
- **Design for disassembly and reusability**
  This strategy requires the design to enable materials to be easily harvested without any damage during or after use for the highest-quality reuse possible.
- **Design with reused parts of constructions**
  This strategy is about reusing parts of constructions, possibly after they have undergone treatment.
- **Design with secondary raw materials**
  This strategy is about designing with raw materials and materials that have been used previously or with residual flows from another product system.
- **Design with renewable resources**
  The use of renewable resources reduces the use of non-renewable resources and their possible depletion. This strategy thus directly contributes to protecting natural resources.

These seven design strategies describe possible design choices and the means and resources that can be used. The effect of these means and resources should always be considered in relation to the long-term environmental impact. A bespoke strategy is a combination of relevant design strategies put together by a design team at the start of a specific project. This strategy can be adjusted during the successive project phases.

However, it is the construction task that determines which design strategies are applicable, since not all situations are equally well suited to all seven strategies described. Important elements here include the urban planning context and the requirements for the location in question or the civil engineering construction.
To give the design team a good start and choose relevant circular design strategies, it is essential that the opportunities are mapped and a statement is provided on the anticipated end-of-life cycle scenario during the initiative phase of a design process. There are certain points in the design process when the design team has to make choices in order to achieve the strategies. We are introducing the roadmap in this guide as a tool to help design teams. This roadmap is a handy tool for improving one's understanding of the process.

1 Introduction

1.1 Transition to a circular construction economy

The Netherlands is on the brink of transitioning to a circular economy. A circular economy is a way to reduce the global consumption of materials and the associated environmental impact. A circular economy thus contributes to the integral sustainability challenge that we are facing: conserving resources, reducing environmental impact and ensuring value retention. This calls for a change to our current working methods that are still based on a linear economy.

The Dutch government wants the Dutch economy to be fully circular by 2050. These ambitions were expressed in the Dutch national programme 'Nederland Circulair in 2050' (The Netherlands circular in 2050) that was first published in 2016. This programme has been gradually expanded.

The construction and installation sector plays an important role in the transition to a circular economy. The objectives for the Dutch construction sector are set out in the Circular Construction Economy Transition Agenda and the associated Implementation Programme (Transition team Circular Construction Economy 2019).

1.2 Working agreements

The need to achieve a circular construction sector has become clear to many people. However, ideas are still being developed about the exact nature of the transition and the changes it will require. Collating existing ideas and using them to achieve unambiguous agreements is an important step. Such agreements will anchor circular thinking and circular actions in daily construction practice.

Platform CB'23 has committed to achieving such agreements. CB'23 is short for Circular Building in 2023. The platform brings together stakeholders in the construction sector (including clients, designers, suppliers, construction companies, recyclers, policy makers and scientists) to work together and reach generally supported agreements. The agreements from Platform CB'23 are working agreements or guiding principles and are not formal standards (see 2.1).

The efforts of Platform CB'23 have resulted in the following six documents:

- Circular Construction Lexicon (Platform CB'23, 2020a): clear language in the circular construction sector
- Circular Construction Framework (Platform CB'23, 2019a): summary of frameworks in the circular construction sector
- Guide for Measuring Circularity (Platform CB' 23, 2020b): core method for measuring circularity in the construction sector
- Guide to Passports for the construction sector (Platform CB'23, 2020b): information storage and data exchange for a circular construction sector
- Circular Procurement Guide: guiding principles for circular procurement in the construction sector
- Circular Design Guide: working agreements for circular design in the construction sector.

1.3 The how and why of the guide

This guide is about circular design and is an elaboration of the guide that was published in the summer of 2021. The guide has been drawn up by Platform CB'23's Circular design action team ("the action team"). A list of members of the action team can be found at the end of this guide.

Circular ambitions are given tangible shape during the design phase of a project. The choices made at that time have a major influence on the result. But how do we ensure that the right choices are made? And how do we get everyone involved in the design process to share the same goals and work towards the same solutions?

Proper agreements on these points reduce any risks of miscommunication and contribute to an effective design process. The purpose of this guide is to establish those agreements, drawing on existing knowledge and findings on circular design. These agreements:

- are suitable for the construction and installation sector at large (buildings and civil and hydraulic engineering/infrastructure), further specified for the individual subsectors where relevant;
- focus not only on designers, but also on all other roles that can or should contribute to circular designs and their implementation;
- leave sufficient freedom for designers and do not hamper innovation.

1.4 Structure of this guide

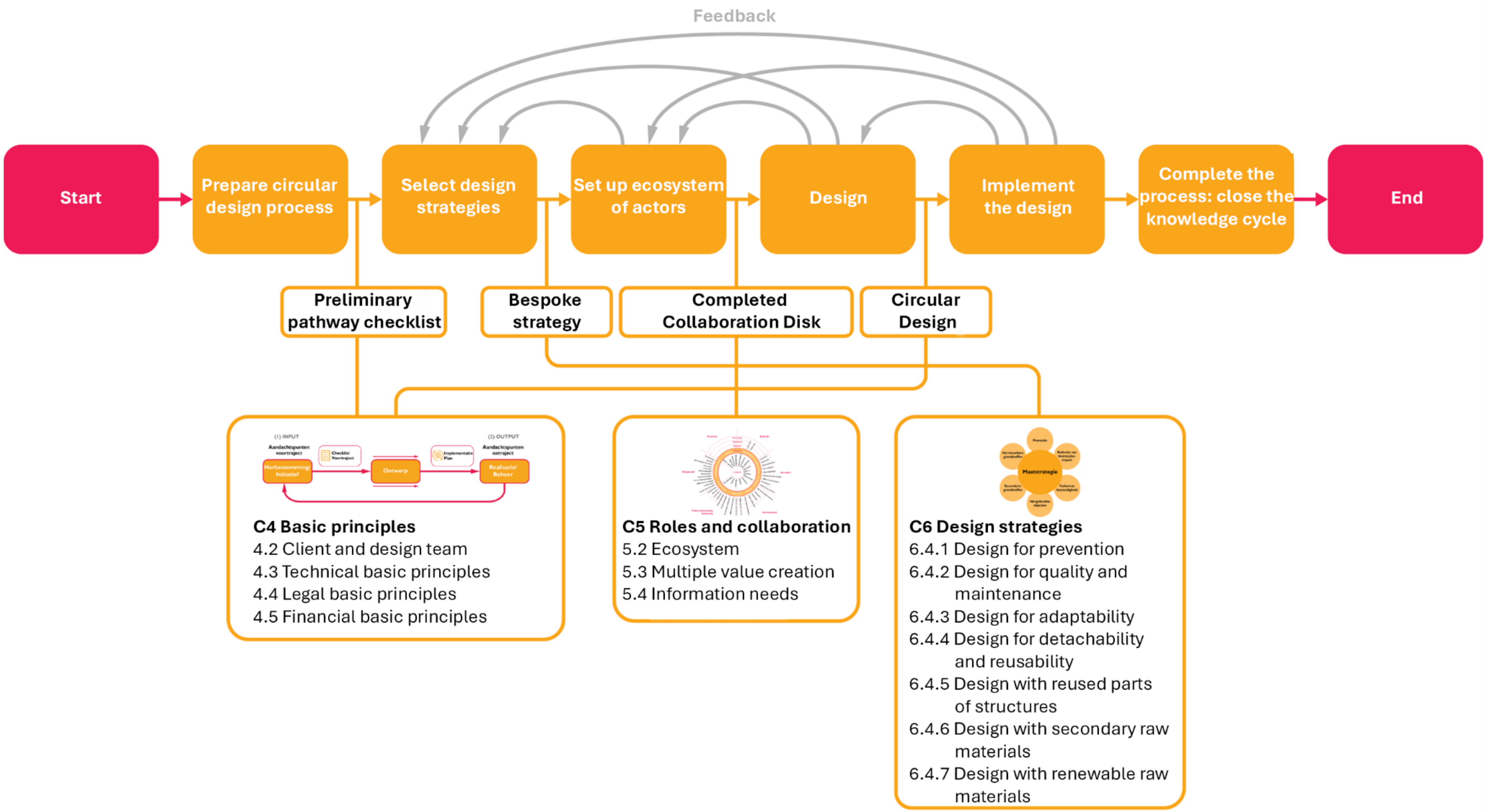


Figure 1 – The interrelationships between the chapters in this guide

During the design process, the design team also makes decisions that are decisive for the level of circularity achieved. Important decisions that have a significant influence on the possibilities available to the design team must be made before the actual design process starts. For example, some basic principles that are part of the preliminary pathway are essential for creating an optimal circular design. **Chapter 4** describes these basic principles. It also features a checklist (see Checklists) for the design team to use in order to check the factors from the preliminary pathway. This allows the design team to determine the potential for the project's circular success. Figure 4 in that chapter is a perfect illustration of how circular design is not a linear process.

It must be borne in mind, however, that a circular design process also requires different collaboration in the chain. Traditional roles and partnerships are changing: the design chain is turning into an ecosystem of actors that work together. Setting up this ecosystem is the next step in the design process. **Chapter 5** describes how to set up this ecosystem, and also describes the roles of actors, their business models, value propositions and how information, including digital information, plays an important role in the collaboration between actors.

The next step for the design team is to determine the bespoke strategy. A bespoke strategy is a project-specific set of relevant design strategies. **Chapter 6** describes how the design team can do this and what the different design strategies are**.** We have given examples to clarify the seven design strategies.

This guide was written for anyone who wants to get started with circular design or has been commissioned to do so by an organisation. This guide does not have to be read linearly. For example, you might start from the different strategies. The text includes several quick links for quick and easy access to specific information. The guide assumes that readers have a basic knowledge of both circular construction and the design process. Specific terms related to circular construction are presented in **orange and bold** the first time that they are used in the text. The definitions of these terms can be found in the *Circular Construction Lexicon* (Platform CB'23, 2020a).

2 Goal and scope

2.1 Goal of the guide

Clients, designers and other stakeholders make important decisions during the design process on how to achieve circular ambitions. Consequently, design is an important process for circular construction.

Many circular designs have been created and implemented in recent years. The lessons learned provide important information, such as:

- an understanding of what is meant by circular design and what strategies can be used in this framework;
- an understanding of the choices made in the context of a circular design process, and the possible consequences;
- what basic and further knowledge is needed for the design process.

The purpose of this guide is to establish design strategies in order to set up a circular design process. The guide distinguishes the following components:

- basic principles of the design process (Chapter 4);
- coordination with non-design roles in the construction process (Chapter 5);
- a listing of possible circular design strategies (Chapter 6).

The interrelationships between these elements are shown in Figure 2.

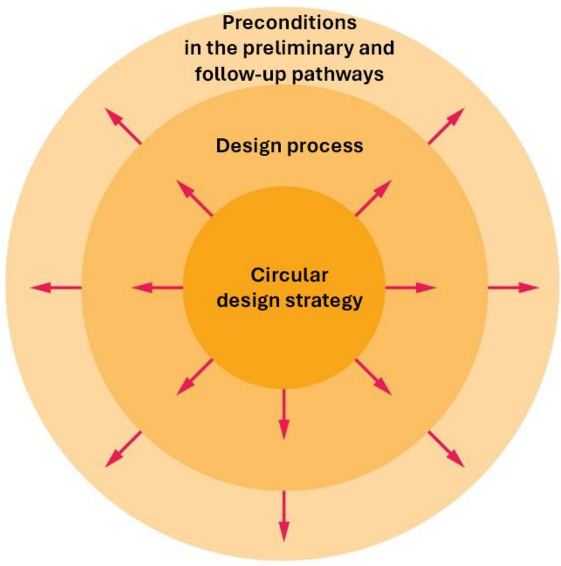


Figure 2 – The rings of circular design strategy

Central to this guide are design strategies that describe design choices and the resources that go with these choices.

When applying design strategies, the involvement of appropriate actors in the design process is important. These actors each have their own roles and they jointly contribute to the circular design.

The design process is largely influenced by the opportunities and preconditions defined in the basic principles of each built object.

Basic principles

What basic principles are needed for successful circular designs and tenders?

Although a good design process is key to utilising circular potential, much of that potential is already captured at earlier stages. For example, if an assignment, zoning plan or an organisation's vision fails to create the proper basic principles or actually creates barriers, a designer will have little room for creative circular solutions. The same goes for a tendering process: if the basic principles or preconditions leave little room, even a good tender only offers limited opportunities to achieve a circular project.

It is important that the correct areas for attention be introduced during the preliminary pathway and that decisions be made that ensure optimum freedom in general and optimum design freedom in specific for a circular design and for a circular invitation to tender. This also applies to the later phases: a designer can produce a wonderful circular design, and a tenderer can submit an attractive circular offer, but how do you safeguard that this circularity is actually achieved and utilised in later phases (construction, use and end of first use phase)?

Roles and collaboration

What roles and information needs are there in the design process and how do you ensure optimum collaboration?

The current design and construction chain is organised in a sequential and fragmented manner. Responsibility to 'monitor circularity' throughout the process has not been unambiguously assigned to one party, although circular design is about collaboration and leveraging knowledge and experience from the entire chain. The process should be adjusted to have the different chain partners communicate with each other and work together where necessary. A first step in this respect is getting to understand how best to set up a design process in terms of roles, knowledge and collaboration. How do you make sure that each party in the chain gets the place it deserves in the design process?

Design strategies

What design strategies exist and when is it best to apply a specific strategy?

Circular design is still far from commonplace; there are a range of different strategies for circular working. Knowledge of the design strategies that exist and the conditions under which they can be applied is required. What is the key element of a strategy and what are the process steps, preconditions, agreements and scale to match this? What does this mean for design freedom? How can elements within the strategies identified possibly be combined with each other?

2.2 Application

This guide focuses on the entire built environment, i.e. both the buildings and the civil and hydraulic engineering sectors. If the information concerns only one of the two sectors, this is indicated in the text.

This guide focuses not only on designers, but also on all other actors that can or should contribute to circular designs and their implementation.

Circular construction and installation have a bearing on raw materials, gas and toxic emissions, and energy. When drafting this first edition of the guide, it was decided to limit the scope to raw materials and the materials, elements and objects produced from them.

3 About circularity

3.1 Circular design in a broader perspective

Raw materials, parts and products keep their value in a circular economy. The circular model assumes that today's products are the raw materials for later: the materials of which a product consists can be reused.

A fully circular construction process revolves around closed cycles. This applies not only to material flows, but also to the built objects and infrastructure objects. Therefore, the different phases that an object goes through during its lifespan are part of a closed cycle (see Figure 3).

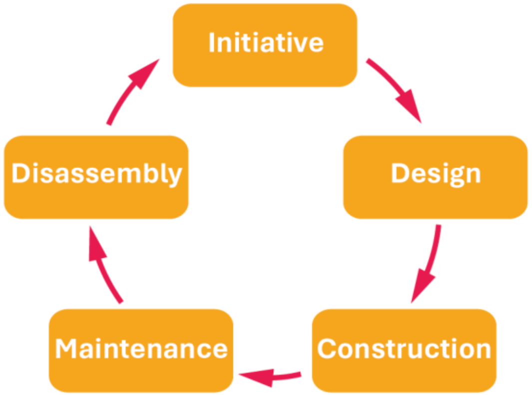


Figure 3 – Phases of an object in a closed cycle

The design phase is not a stand-alone pathway; there are also preliminary and follow-up pathways, i.e. the initiative phase and the construction phase. This is why this guide considers circular design in a broader perspective.

3.2 Definition of circular construction

There are several definitions of circular construction. This guide uses the following definitions from Platform CB'23's Lexicon:

circular construction

> *developing, using and reusing buildings, areas and infrastructure without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems. Construction which is economically justifiable and contributes to the welfare of people and animals. Here and there, now and in the future.*

Circular construction leads to a:

circular construction

> *construction (in the civil and hydraulic engineering sector and the buildings sector) designed and constructed according to circular design principles and/or built using circular products, elements and materials*

To achieve circular goals, use is made of a:

circular strategy

activity carried out with the intention of contributing to a circular economy

Examples of circular strategies are:

- lifespan extension;
- increasing adaptive capacity;
- R principles.

3.3 Definition of circular design

This guide identifies circular design strategies as part of a circular strategy. We use the following definition of circular design strategy in this guide:

circular design strategy

strategy that describes the circular design choices to be made and when to make them and the resources used for this in order to implement a circular strategy.

4 Basic principles

4.1 Everything starts with ambition

Circular design starts with an initiator's ambition. An ambition to create a more sustainable product and to follow a more sustainable project process. This ambition need not have any boundaries and gives room for opportunities for the project and the actors within a collaborative model in the project to be chosen.

Combining the ambition with general and project-specific preconditions creates basic principles for circular design. This chapter clarifies the basic principles for circular design. We have placed the basic principles in a wider perspective than just the design team's environment. We have done this because there are important relationships between the basic principles for the initiative phase and the construction phase and direct or indirect factors during the design process, such as legislation, education and urban planning developments. The basic principles in this chapter therefore concern one or more life cycles of a building or engineering construction. Figure 4 shows this in the form of a diagram.

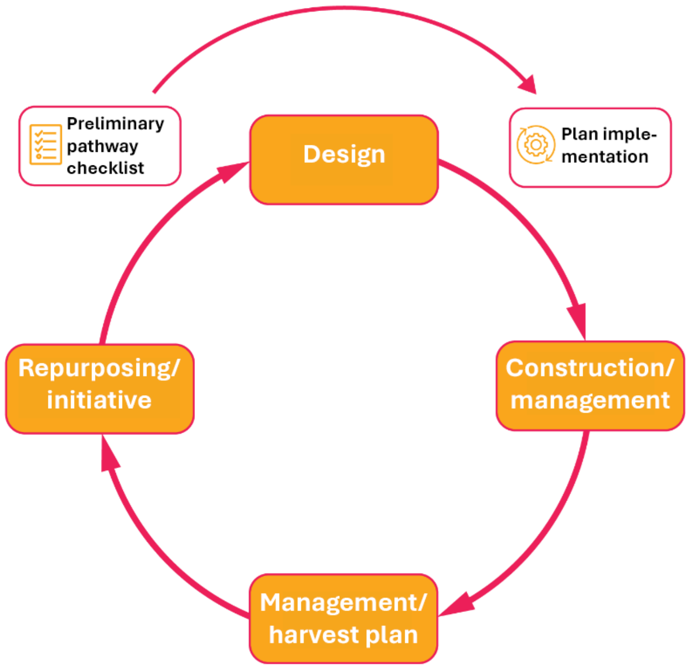


Figure 4 - The life cycles of the building or engineering construction

Preliminary pathway

We start by giving a description of preliminary pathways and their input factors for the design process. In order to provide the design team with an easy-to-use tool, a checklist for the preliminary pathway has been compiled. See checklist.

This checklist also considers factors that may not be directly in the design team's remit, but that can be influenced by the design team.

How the design choices are eventually used during the construction and use phases after the actual designing again depends on a number of basic principles: the 'output factors'. These factors – the circular promises and requirements for design products identified by the design team - are set out in a construction and use or management plan (as also formulated in Annex 1).

4.2 Client and design team

4.2.1 The client's role

Clients should be aware of the essential, central and connecting roles they play in the transition to a circular construction economy, and therefore in the circular construction process (see also section 5.2).

Setting up the circular design process is the main step. Before we can take the first step in such a process, it is good to verify one's own organisation's ambitions and strategy (organisation-wide and/or for a specific project). The Dutch Omgevingswijzer and/or Ambitieweb GWW are useful tools in this respect.

Support from colleagues and management is also needed. It is recommended to have a multidisciplinary team from within the organisation drive and support this process. Questions to be answered include: what expertise is already available in house and what is lacking? What form of collaboration best suits this specific project? How well can the circular and other results be measured in the overall financial model?

No uniform measurement methods are actually available for this latter aspect yet, but there are several measurement methods that can be experimented with. Circularity does not yet have a mature revenue model, but it does contribute to future scenarios of interest in short- and long-term investments. It also contributes to social value creation, where costs are no longer automatically shifted to the future or to another location (see also section 5.3). Those future scenarios can be linked to performance to be delivered by the object (or its functionalities or parts). This performance can be included in an invitation to tender. Platform CB'23's Circular Procurement guide goes into this in more detail.

4.2.2 Design team: construction implementation plan

The reuse and reallocation of objects, construction elements, products and materials is the main strategy of circular construction in the cycle. For materials, the emphasis is on both the biological cycle (with the use of **biobased materials**) and the technical cycle, with concrete, ceramics, plastics, metal, glass and other minerals being reused through technical processes.

In this respect, it is important that circular choices and decisions made during the design pathway are actually constructed, managed, used and safeguarded in that manner. The design team should draw up a construction and management (and use) **implementation plan** for this reason.

This implementation plan enables a design team to indicate – once the circular design process has ended (by way of handover to the next phase) – how to achieve the circular ambitions in the design during the construction phase and, after that, during the use phase. Of course, this implementation plan is complementary to the actual design.

The construction, management and use **implementation plan** can monitor circularity during the construction and management of the construction. The wording of the implementation plan should be such that it is clear for each design strategy which basic principles are part of the construction phase and which belong to use and management.

Figure 4 shows the positions of the checklist and the implementation plans in the construction's life cycle.

After the construction phase, and therefore during the use and management phase, there is a point in time for each object when new initiatives for adjustments or usage arise. The changes to the object, the use of materials released and all conceivable levels of scale in between are recorded in a materials passport or a similar information document.

Areas for attention

- A manual for the construction. Based on the construction and use implementation plan, the design team should indicate how the construction can or should be used and maintained (owners, administrators of an owners' association, facility management, tenants). Each step in the design and construction processes requires transparent information transfer (see also section 5.4) to the client, seller, real estate agent, manager, administrator or maintenance party.
- Transport to and from a construction site and site handling play important roles in LCA analyses (CO_2) and in the Aerius calculations (NO_x) in order to determine total emissions. Circular design encourages architects and consultants to locally harvest and reuse materials or components. This greatly reduces transport and handling, which in turn has a positive effect on a construction project's emissions.

4.3 Technical basic principles

4.3.1 Introduction

Technical basic principles also determine the implementation of physical and measurable circularity as part of a design process. These technical basic principles come from various sources, such as guidance documents, models, materials and opportunities databases at the system level, standards for materials passports and calculation tools. As for the calculation tools, we conveniently refer to Platform CB'23's guide for Measuring circularity and various software tools such as Dubocalc and MPG software.

4.3.2 Logistics: disassembly, transport and storage

Using secondary construction materials is high on the R-ladder. These construction materials come from the stock of existing materials, the '*urban mine*'. Where these 'mined' or 'harvested' materials have lost value over time, for example due to loss of function or wear and tear, they can be refurbished or recycled, thus giving them a new life. Secondary materials can be processed in workshops, including sheltered workshops, or returned to producers (for recycling and/or partial reuse). From a material preservation point of view, it is recommended that composite components or installation parts simply be reused for their original functions (if the prescribed aesthetic and technical quality allows it). (See also section 6.4.1 and section 6.4.5.)

The influence of logistics in circular design strategies has recently accelerated and increased as a result of the nitrogen crisis. The nitrogen crisis (and the underlying deposition calculation) has made it necessary to more consciously take the reduction of NO_x and other emissions into account in designs, for example by reducing transport and construction site handling. This means that, in addition to the circular ambition, designers should also take into account that their design can be implemented through a project for which a permit can actually be obtained. This is a new basic principle that calls for decisive attention, on top of the laws and regulations already in place that designers are expected to be aware of. Depending on the nature of the project and its location, this may mean, for example, that a design strategy that relies on locally mined and refurbished material is preferred over new, biobased material. (See also section 6.4.7.)

Areas for attention

- The design team should not only prepare an implementation plan, but also a mining plan. This means that they should determine in advance how to disassemble and re-install the object.
- Draw up a LEAN schedule to match demand and supply of released materials. This includes tightly matching supply and demand to avoid excessive inventory and products having to be discarded after their production. The construction industry often applies LEAN planning, but so far there is little coordination between LEAN planning and disassembly schedules. Disassembly schedules should also be LEAN and align with the construction schedule.
- Free up time to find additional stocks of secondary construction materials (section 6.4.6) and reusable parts of constructions (section 6.4.5).
- For renovation and transformation projects, invest in reusable materials.
- Include certain processing applications as mandatory aspects of tender specifications, for example that certain elements are taken from a construction and brought to a place where they are mechanically sorted.
- Find a regional location for temporary storage of materials (circular hubs, shops that sell second-hand construction materials, municipal depots) and for preparing materials for reuse.

Guide on Disassembly potential

A uniform measurement method for disassembly potential was developed for the buildings market by RVO and Alba Concepts (in collaboration with DGBC and W/E Adviseurs) in 2019. The measurement method was revised in May 2020 and reviewed by the same parties on the instruction of the Dutch Ministry of the Interior and the Transition team Circular Construction Economy (Dutch TT-CBE). This revised measurement methodology 2.0 is applied in BREEAM-NL and in the BCI Gebouw measuring tool.

Based on the same basic principles, a method for assessing disassembly potential 1.0 in the civil and hydraulic engineering sector was developed by Witteveen+Bos in collaboration with Alba Concepts, on the instruction of Rijkswaterstaat (Dutch Ministry for Infrastructure and Water Management; RWS) and TT-CBE. This includes specific civil and hydraulic engineering features, for example external influences such as the weather or road salt that can affect disassembly potential. This method is primarily intended for designers and is being further developed for other applications.

4.3.3 Digital infrastructure: passports and platforms

From the perspective of reusing materials, digitisation of objects and public space and greenery is an important basic principle in the circular design process. If information on the current stock of materials is lacking, it is not clear what a circular designer or design team can work with in their designs. We now record objects (buildings and civil and hydraulic engineering) to provide information on stocks of materials for future design teams.

Thus, in current or upcoming projects, the design team or developer records what materials have been used. They do this by means of lists of materials and, for example, materials passports, possibly including a BIM model or a Digital Twin.

This stock of materials can then be entered in a register, such as Madaster or through an online marketplace (e.g. Insert, Oogstkaart, Materialen marktplaats, Matching Materials, Bruggenbank). This makes materials visible to contractors, designers or manufacturers for future reuse.

Platforms are a means of recording construction product and construction material information of the existing and future stocks of materials at an early stage and making this information transparent. These platforms bring together demand (from construction contractors and design teams, for example) and supply (of released materials). Common materials or 'bulk flows' find their way to physical hubs or products where these flows are processed into new construction products and materials. This also serves the higher goal of extending the service life of materials in the chain, and it reduces demand for primary materials.

Areas for attention

- The design team prepares the materials list and/or materials passport(s) during the final design phase (final design or technical design). Linking this data to platforms keeps the information about the materials used and their lifespans accessible to all interested parties, stakeholders and shareholders.
- The use of reused materials can be promoted by communicating the technical and aesthetic qualities of the objects in question and by pilots: repeatedly trying to apply certain materials to learn from this and scale up where possible. (See also the guide on Future Reuse.)
- Designers should use the marketplace platforms that show available stocks of materials and should design based on the available stock of materials.
- Carry out a quick scan, at element level, of the parts present at the construction site, the building location or the donor building, and, where possible, at construction product level according to the decomposition in the NL-SfB coding (in this instance NEN2767 for civil and hydraulic engineering) (according to the Platform CB'23 guide for 'Passports for the Construction Sector').
- Promote efforts to make information about current stocks of materials accessible. This can be done both nationally and locally or at the project level. The government should then be or want to be the launching customer and the business controller.
- Not enough parties have joined a single platform yet, although this is necessary to create a sufficient scale of operations and provide the demand and supply needed.
- Create concrete local, circular chains for certain common flows of materials and raw materials. This is specifically relevant to large area developments and/or inner-city locations. It also promotes local employment.
- Promote active supply and demand of released materials both within and outside the project. This can be done through supply and demand platforms or within the client's own property portfolio.
- A final important area for attention is monitoring. This means that agreements must be made on how and how often to monitor the proper management, maintenance and use of materials (from the materials list). This is necessary to safeguard future reuse and to not negatively affect the value of the materials to be harvested, for example by contamination or by the addition of wet connections to other materials.

Reuse of concrete girders

SBIR consortium ‘Combinatie Liggers 2.0’ shows that precast concrete girders from flyovers that are to be dismantled can be easily, safely and cost-effectively put to high-quality reuse. The project is in its pilot phase: the consortium is developing a prototype of its circular flyover.

The consortium has demonstrated that they can safely install the dismantled concrete girders in a new bridge or flyover. The function and value of the girders are thus maintained, and the use of primary raw materials, as well as CO_2 emissions and energy are reduced. This in turn saves costs, both for the consortium and society at large.

To achieve this, the consortium has developed a method for removing the compression layer while retaining the connection reinforcement. The only damage that occurs is cosmetic damage.
It has also been studied whether the girders can be shortened to approx. 80% of their original length. When originally used in Groningen, they were 19 metres long, but the new flyover requires them to be shortened to 14 metres. This also enables the crossing angle to be adjusted for the desired new application.
(Source: Rijkswaterstaat)

Circular gauge: the Circulaire Peiler

The Circulaire Peiler (Circular Gauge) translates circular performance into a score. The scale of the gauge runs from 0 to 100. The more measures that increase circularity, the higher the score.

The Circulaire Peiler was developed by the Dutch Vallei en Veluwe water board, based on the eight circular design principles of Rijkswaterstaat and Witteveen+Bos. Examples of these principles are ‘Don't do anything that isn't really necessary’, ‘Create future-proof designs’ and ‘Extend the lifespan of existing objects’. These circular design principles are linked to performance criteria that yield a score based on qualitative and quantitative assessments.

The starting point for the tool is the European and Dutch national climate target for 2030: reducing the use of raw materials by 50% compared to 1990. The Circulaire Peiler is suitable for all phases of a project: from exploration to maintenance. The weighting factors of the circular design principles vary in each phase.

(See circulairebouweconomie.nl/interview/circulaire-peiler-een-scoremodel-voor-circulariteit 2022.)

4.4 Legal basic principles

New and innovative applications of products and materials involve areas for attention and/or restrictions from a statutory perspective. The main cause for these areas for attention and/or restrictions is often 'ignorance breeds contempt'. To ensure progress of the transition towards circular building and enable acceleration, a review of traditional legal relationships and related responsibilities is a prerequisite. A form of collaboration where everyone contributes to the team result (agile collaboration), with room for mistakes and continuous and joint improvement should become the basis for all future forms of collaboration and contract forms. Use can, and will probably have to, be made of experience gathered by other sectors, e.g. the ICT sector, to introduce and implement agile collaboration.

Adjustments will be needed, particularly on the legal front, in order to introduce agile collaboration. Traditional legal relationships (such as the

Dutch UAV conditions, i.e. the Uniform Administrative Conditions for the Execution of Works) leave little or no room for making mistakes on one's own or together and thus for agile working. More recent forms of collaboration, such as the concepts of a *bouwteam* (construction team), *tweefasecontract* (two-phase contract) and Rapid Circular Contracting (RCC), have facilitated these new ways of dealing with responsibility and liability. However, the prevailing laws and regulations and the multitude of guidelines and directives still too often tend to nip the process and product innovations that are really necessary for these new forms of collaboration in the bud.

On the other hand, agile collaboration automatically gives scope for developing solutions that are not based on pre-defined concepts, enabling material-specific and/or constructive innovations (necessary for the circular transition) to be developed in a controlled way. Examples of this are the reuse of components, construction materials or raw materials that are made available, as well as the use of new and innovative raw materials and construction materials (biobased materials, new combinations and/or compositions of materials) or innovative applications of known raw materials and construction materials.

Because of this revision and redistribution of legal relationships and responsibilities, the public law framework no longer hampers the application of the aforementioned secondary raw and/or construction materials.

Agile collaboration also opens the door to the debate about ownership, i.e. ownership of raw materials and construction materials from the design through to the harvesting, and responsibility for the correct and safe performance of the structures built using these raw materials and construction materials.

4.5 Financial basic principles and financial resources

4.5.1 Introduction

In today's economy, financial basic principles and financial resources are among the most important means to make a start to achieving a goal. Financial resources are estimated with a fairly ample margin at the start of a project, programme, or the initial phase of area development. The exact requirements for the financial resources are honed over time, i.e. the margin on the estimated resources required gradually decreases as the final result comes closer. At the same time, financial basic principles can be subject to significant changes during the lead time of a project, programme or area development, for example because external developments, such as economic developments, or internal developments (new daily administration of a municipality, new focal points in policies of a new board of mayor and aldermen) lead to adjustments to priorities for the limited social and other resources available. In this context, it should be recognised that a characteristic that many projects, programmes and area developments in the civil and hydraulic engineering and buildings sectors have in common is their long lead times of several years or even decades.

Early adaptors and early majority

Regardless of the design strategy chosen, circular and sustainable work and design are still predominantly in the 'early adaptors' and 'early majority' phases. This means that these markets still need to be brought to maturity.

Products, processes and services in a market that has not yet reached maturity often have not achieved sufficient turnover to arrive at an optimum market price determined by supply and demand. In other words, low or lower turnover will have to be taken into account until this maturity is reached. The products and processes needed for circular design strategies are therefore often more expensive than standard, non-circular products and processes.

The financial basic principles are also inseparably connected with the ambition. The balance is then expressed and weighted using the values to be invested and the values that have been created (KPIs). In principle, this is logical since circular awareness leads to overall asset management being upgraded to value management.

4.5.2 Area development

Visions for the future at the scale of the specific area or at an urban development scale are given a place in municipal or provincial visions for the physical living environment, urban development plans and zoning plans. Urban planners, landscape architects and lawyers are involved in this. Although these are outline plans that are used as such in partial designs, they often accurately and legally define the positioning, dimensions, use of materials and functions of the buildings and aboveground and underground infrastructures to be constructed. The proceeds of the land to be developed often determine the financial resources available for area development.

In the Netherlands, land prices are almost always determined on the basis of residual value. In this method, the price is the difference between the expected revenue or proceeds from a function to be constructed on the land, such as housing or a business estate, and the expected cost of constructing the function, including site preparation, etc. If a government sells or commercially operates land (e.g. by means of ground rent), it will do so only if the operating calculation for the land is positive.

Urban planners do the calculations for the operation of the land, or did them several years ago, using key figures from the non-circular economy. For instance, as regards the fitting out of the area, they can use key figures for concrete to calculate how much a bridge costs, but they cannot yet calculate the cost of a sustainable timber bridge. An early adaptor or early majority design team looking to build a sustainable timber bridge will therefore be faced with a financial issue or bottleneck. For example, the cost of a timber bridge is twice as high and therefore, a sustainable timber bridge will not be compatible with the financial basic principles.

To enable sustainable circular solutions within an area development, attention must be paid to this during the preparatory phases of the process, since collaboration from the initial phases of area developments between the local government, landscape architects, urban planners, architects, lawyers and citizens will give a better understanding of the circular possibilities, ambitions and the financial resources needed.

4.5.3 Clients' positions

Rather than focussing on cost, the key focus for clients should be value retention and value creation. Governments can take the lead in this. Many of their investments create important value for society although they are financially uneconomic.

Businesses can also shift their focus to value retention and value creation whilst achieving a business case and a revenue model. ‘Duurzaam organiseren’, a book by Jan Jonker, presents many examples on this subject. However, this calls for different ways of thinking and for letting go of existing constructions, supply chains and organisational forms. A good example of a different way of thinking is ‘De Circulaire Weg’ (see text box).

De Circulaire Weg

A circular approach to the construction, management and reuse of roads and other infrastructure, that is what the ‘De Circulaire Weg’ partner programme is all about. In this circular business model, the contractor not only takes charge of design and maintenance, but also becomes responsible for the lifespan or reuse of materials. In advance, the client focuses on circular objectives, and during the further process the client monitors performance and rewards the contractor based on how well the objectives are achieved.

The model supports these new roles in three ways:

- as part of the collaboration: focus on collaboration in the chain and mutual trust;
- as part of the contract: clear agreements on mutual responsibilities;
- financially: the financial incentives support circular options rather than frustrating them.

This results in other options being chosen that are more sustainable. The six projects of the first programme (2020-2022) showed some strong circular results, such as an ECI reduction of up to 80% and better protection of materials measured in the Material Circularity Indicator (MCI). To build on and further scale up these results, the follow-up programme was launched in early 2023. In this programme, ten existing and new partners are working together on further development and scaling-up through six new projects. The final results of this programme will be presented to the sector by late 2024. This will include a tool kit with procurement, financial model, contract and other tools.

De Circulaire Weg is a collaboration of the Municipality of Amersfoort, City of Amsterdam, Ballast Nedam, Dura Vermeer, NWB Bank, Rijkswaterstaat, Sweco and TU Delft (see www.decirculaireweg.nl).

4.5.4 Value retention

Value retention means that thought is given to the use, management and end of useful life right from the start of the design cycle. Attention should and be paid to how to best bring about collaboration with a relevant chain and the surroundings. The Total Cost of Ownership (TCO) financial model can be used to get information on the total costs during the entire lifespan until the point in time when assets and their constituent elements and materials are harvested (through demolition). A TCO can create financial incentives, including circular ones. Examples of those incentives include residual value, maintenance cost reduction through higher disassembly potential of elements and other accounting depreciation and amortisation and the associated conditions.

The focus in the linear construction economy is on the initial investment; the cost of use and residual value of materials are just marginal aspects when making decisions. To be able to assess investments in a circular design at fair value, it is important that, besides the cost of investment, the cost of use and the residual value are taken into account as well. At present, i.e. in 2023, constructing a fully circular design basically involves higher costs. Calculation models according to the principles of Life Cycle Costing (LCC) and Total Cost of Ownership (TCO) not only support arguments for circular design, but also provide a better understanding of the long-term implications of the design. In itself, value retention can be important for all construction professionals with a circular ambition that threatens to be cut short by traditional financial investment models.

Clients should think from the perspective of a larger system and the imminent circular transition, rather than only considering their own operation. In organisations and chains in transition, this means that the performance of clients is tested against the integrality of working in the social field and no longer only against budget discipline and policy goals of one's own organisation. In this regard, the design team can advise them on such areas as the new interfaces and stakeholders in the new and wider environment.

Clients can use the value in existing real estate and infrastructure for a next life cycle. This also requires rethinking the economic tool of financial depreciation on the balance sheet, which often leads to usable materials and assets being written off and destroyed. This financial method causes things of value to be destroyed, claims primary raw materials and burdens the environment through the production of new materials, assets and goods. In short, the opposite of the three sustainability goals that we want to achieve. This is relevant to the modification, replacement and renovation of buildings (buildings sector) and infrastructure (civil and hydraulic engineering). Extending the lifespans of existing objects and components and safeguarding their value through a long-term vision can turn things around.

4.5.5 Value creation

Our current economy has made things too easy for us. Several things are not accounted for when considering economic exchange and supply and demand, such as the environmental damage caused by a production process and the social and societal loss and damage caused by the use of labour in low-wage countries. These costs are externalised, leading to many different crises for which we now have to find the solutions. Examples are the climate crisis (externalising greenhouse gas emissions) and the biodiversity crisis (externalising greenhouse gas emissions and environmental damage). We have thus shifted the cost of our prosperity to the future, to future generations, and to other locations.

By reducing and eventually putting an end to externalisation of costs we place value on a good living environment, and we do justice to low-wage countries, climate conservation, and we preserve our own and only biosphere that will enable us and the generations after us to live and survive.

As a rule, one of the two following methods is used to visualise externalised costs (such as the price of CO_2) or negative external effects as social values.

The first method, based on the cost of prevention, relates the costs that have to be incurred to achieve the agreed goal (e.g. CO_2 reduction or reduced environmental impact) according to the timeline chosen. For this calculation, we take the highest-cost technique available that is used to achieve the policy objectives. We then calculate the cost of this back to today (e.g. using a Net Present Value calculation) in euros per unit of externalised cost (e.g. a euro/tonne of CO_2 emissions).

The second approach comes from the social cost-benefit analysis (SCBA) where the costs of human action are no longer externalised. The damage costs are calculated. The outcome of an SCBA reflects this generation's willingness to bear costs now and thus avoid future costs for future generations. This method often leads to higher values than those using the method based on the costs of prevention. This is partly because the SCBA method depends heavily on the discount rate chosen in the calculations.

A risk of the – generally lower – cost of prevention that often has to be incurred 'today' is that the goal is not achieved in time. The – often higher – social costs resulting from an SCBA can greatly disturb the existing economy and thus miss their mark. No choice has been made between these two methods so far. No standard has been adopted yet and the objectives of the organisation making the calculations are often decisive for which method is chosen.

An example of detailing social costs and benefits can be found in the report of the Klimaatverbond (October 2022) ‘Rekening houden met de Toekomst - Afwegingskader voor CO_2e in provinciaal beleid’. This report was commissioned by the Province of Utrecht.

An example of the use of the cost of prevention can be found in the calculation of the price of one metric tonne of CO_2 emissions that the City of Amsterdam has been using since April 2023 to calculate the benefits of investments in sustainable energy and fuels. CO_2 prices in the Netherlands are prescribed centrally by the CPB Netherlands Bureau for Economic Policy Analysis and the PBL Netherlands Environmental Assessment Agency based on three different scenarios for prosperity and living environment (Dutch *WLO* scenarios): low, high and the 2°C scenario. These scenarios were prepared in 2015, prior to the Paris Climate Agreement (CO_2 emissions to be halved by 2030).

Table 1 – Summary of greenhouse gas reductions

	Greenhouse gas reduction in the Netherlands in 2030 compared to 1990	Greenhouse gas reduction in the Netherlands in 2050 compared to 1990	Price expressed as €/tCO_2-eq. in 2015 (based on 2015 prices)	Price expressed as €/tCO_2-eq. in 2030 (based on 2015 prices)	Price expressed as €/tCO_2-eq. in 2050 (based on 2015 prices)
Low	30%	45%	12	20	40
High	40%	60%	48	80	160
2°C lower threshold	45%	~80%*	60	100	200
2°C upper threshold	45%	~95%*	300	500	1000

Source: (CPB & PBL, 2016a; 2016b).

* *Values were not reported like this in the studies, but interpreted as such following discussions between the authors of these studies and the researcher (CE-Delft) who prepared this table.*

The City of Amsterdam has tightened its policy on reducing CO_2 emissions. This includes modifying the CO_2 emission reduction target to a

60% reduction in 2030, and a 95% reduction in 2050 compared to 1990. This matches limiting global warming to 1.5 ˚C, in accordance with tighter European agreements. The WLO scenario for prosperity and living environment that most closely matches the new target of the City of Amsterdam is the 2˚C upper threshold scenario (see Figure 5). The 2030 target at the upper threshold of the 2˚C scenario is less stringent than the City's intended target, but this nationally established scenario most closely matches the new agreements. The price derived from this scenario is €500 per metric tonne of CO_2 eq. in 2030. This is expected to underestimate the actually required costs of prevention. The price of €1,000 per tonne of CO_2 eq. in 2050 is more in line with the City's 2050 target.

The City of Amsterdam has replaced the price from the 2˚C lower threshold scenario that it had been using since 2016 with the price from the 2˚C upper threshold scenario.

The Dutch government is expected to revise the WLO scenarios in 2024. This will be necessary in order to meet the higher ambition within the European context. This revision is expected to result in a higher price per metric tonne of CO_2 emissions in the first few years, matching the new social costs that the City of Amsterdam has been taking into account since April 2023.

The City applies the costs of prevention in investment decisions in which the social value of switching to a sustainable alternative is weighed. The CO_2 prices can also be used as MEAT (i.e. most economically advantageous tender) criteria.

European Union Emissions Trading System (EU ETS)

The European Emissions Trading System (EU ETS for short) is the first major system for trading greenhouse gas emission allowances in the world. This system, based on European directive 2003/87/EC, came into force in 2005 to combat global warming. In 2013, the system applied to more than 11,000 factories, power plants and other installations with a net heat surplus of 20 MW. They are in the member states of the European Union, and in Iceland, Norway and Liechtenstein. Jointly, these installations are responsible for approximately 50% of the EU's CO_2 emissions and 40% of the EU's total greenhouse gas emissions.

The system is a 'cap and trade' system. A cap is established on how many greenhouse gases can be emitted. These emission allowances are sold at auctions (or sometimes given away), after which companies can trade these allowances. Installations have to measure and report their own CO_2 emissions. If a company emits more than the number of allowances it has, extra allowances will have to be bought. Conversely, a company that emits less can sell its allowances.

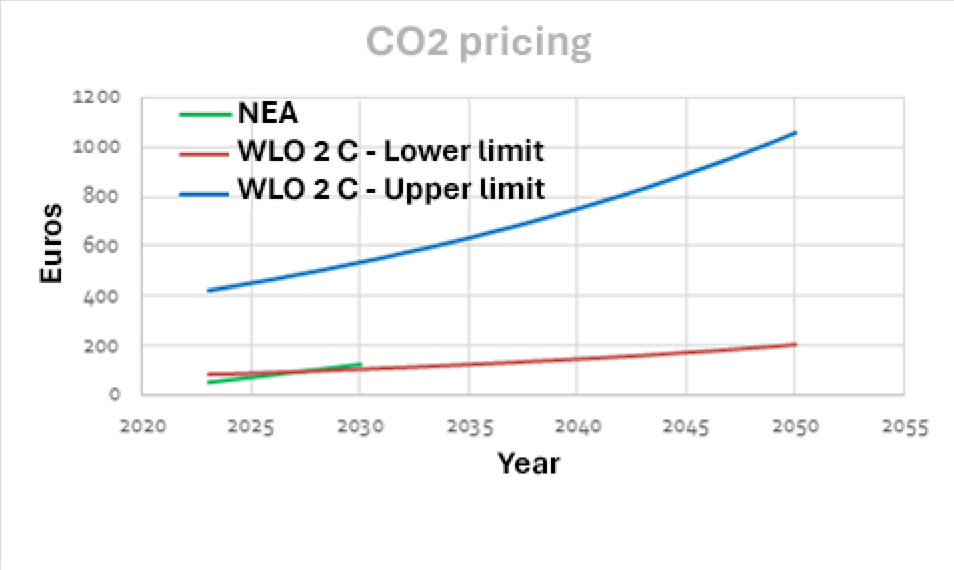


Figure 5 – The cost per metric tonne of CO_2 emissions used by the Dutch Emissions Authority (Nea).

5 Roles and collaboration

5.1 From design chain to ecosystem

Circular design projects lead to changes in traditional roles and collaborations. These changes can be profound, but depend mainly on the ambitions chosen and on how circular goals are pursued. This chapter shows how the design chain is turning into an ecosystem of actors that work together. We will elaborate the roles and responsibilities of those actors. Lastly, we will show how information, including digital information, plays an important role in shaping collaborations between actors.

5.2 Ecosystem

5.2.1 Introduction

Sustainable construction has led to the traditional, linear design chain being continually lengthened and expanded. In a way, circular design has put an end to this tradition and is transforming the process from a linear to a circular one. Rather than further lengthening the chain, a new playing field has come into being. This is a playing field in which actors relate to each other differently. Circularity leads to interests coinciding with each other. After all, existing objects and materials, new objects and materials to be added, environmental impact and business cases are all equally important. This calls for a harmony model to carefully weigh each interest at the right point in time in the design process. This ambition to achieve harmony has led to the concept of a design *ecosystem* (or network) rather than a design *chain*.

5.2.2 Changing process

Figure 6 illustrates the differences between a linear and a circular construction process. A traditional, linear process consists of phases divided into blocks, each with a clearly defined beginning and end. However, the demolition phase is rarely represented in a linear design process. It is not uncommon for the scope of the design to not go beyond choices about management and maintenance or to even stop at the completion of the construction phase (handover).

A circular process transcends the object phase and is rather a representation of value, activities and material storage during a cycle, followed by several other cycles. Because the timeline is actually open-ended, performance (in the form of values) that transcends objects is required. For the chain, this means that the traditional, linear roles of *suppliers* and *buyers* will change into those of circular *contractors* and *users*, respectively. They are in mutual contact with each other for the succession of multiple cycles.

This means that collaboration is crucial for carrying out circular processes, even more so than is the case in traditional, linear processes. The actors' roles are also often different. This has everything to do with the difference in responsibility. The responsibility of the designers in a linear process ends when handover has been completed, unless a warranty period applies. Design responsibility in a circular process is performance-based and covers the entire cycle of the construction and the raw materials.

This makes a circular process more complex. One reason for this extra complexity is that there are more relationships, more stakeholders and multiple different goals for a longer period. Since all life cycle phases of a construction (initiative, design, construction, management & maintenance, disassembly and subsequent cycles) are important during the design phase of a circular construction, all these cycles must be given a place in a circular design strategy.

It is often decided to go for construction team-style collaborations. But extra attention should also be paid to how parties that "normally" act as clients or (sub)contractors work together. Should their roles change? Can this be done in a unique project or do we prefer partners who have been working together circularly for some time? Can we arrange that as a team and adjust things if necessary? Long-term sustainability is best served by structural and integral collaboration, but this requires commitment of all participants and constant attention, as well as adjustment where necessary.

A traditional construction process is based on a design strategy in which a construction intended for a limited period of use is constructed of new materials and for a previously established investment budget. When this period ends and the construction has lost its economic (single) value (depreciation period), the construction is demolished and most of the materials are put to low-value reuse or processed as waste.

The strategies to be applied to designing a circular construction are detailed in Chapter 6 of this guide. The distinctive aspects of these strategies are the use of existing or renewable materials, the integration of management and maintenance budgets and the fact that residual value is aimed for. They thus emphasise several basic principles. Which ecosystem is required for this therefore depends on the strategy (or combination of strategies) chosen.

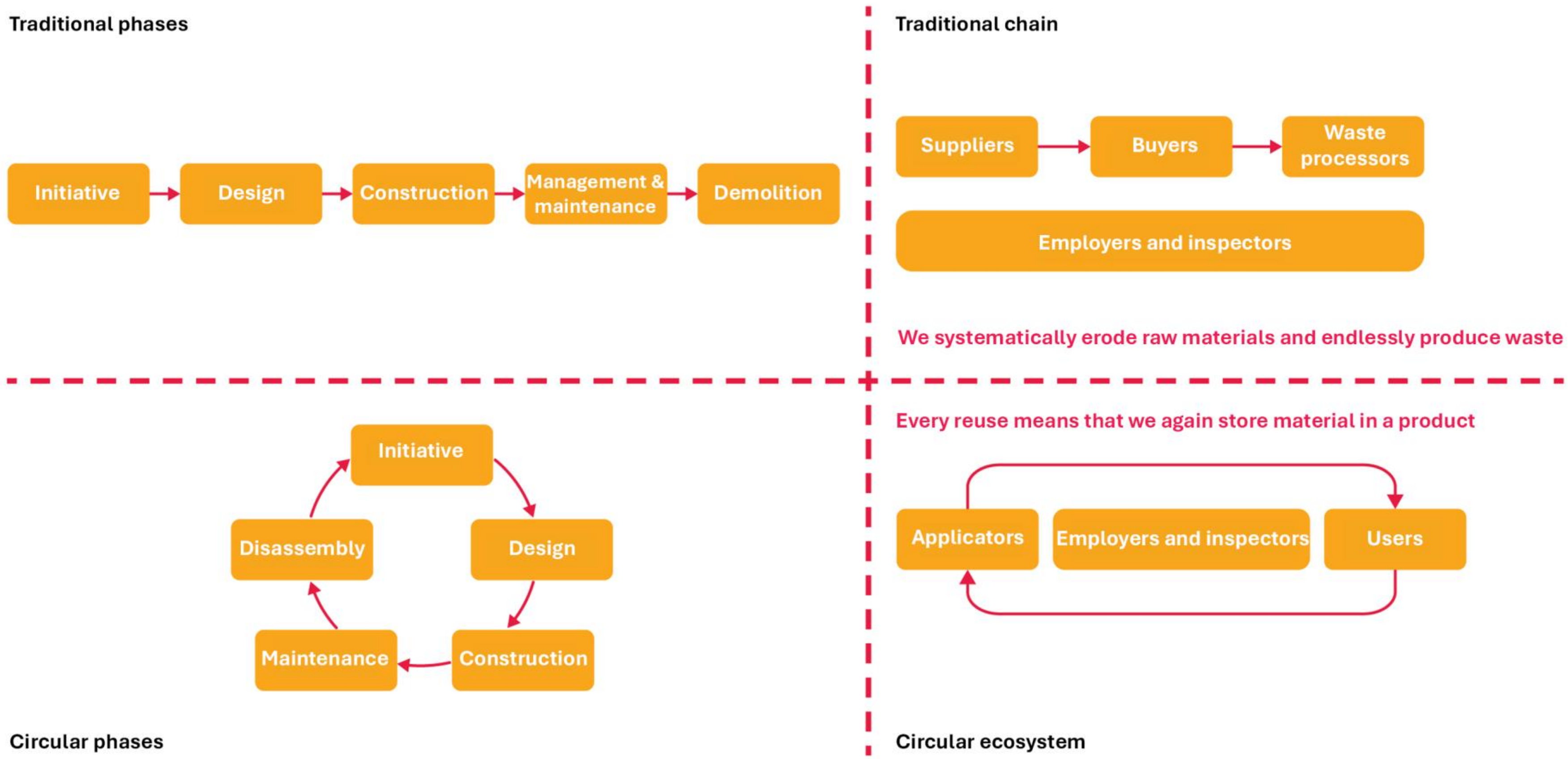


Figure 6 – Linear versus circular project phases

5.2.3 Roles and competences

A circular design process calls for some different and partly new roles alongside the familiar roles of a traditional, linear design process. An example of such a new role is that of champion for the circular design process: someone who adopts the circularity ambition right from the initiative and continually monitors it. These and other roles can be performed by existing actors, but sometimes new actors will have to be added. An outlook on this has been described in the Platform CB'23 'Passports for the Construction Sector' guide, version 2.0 (Annex C). The 'Circular Procurement' guide also extensively addresses chain partners and formulating and monitoring the circular ambition level.

Roles can be divided into four categories: initiators, designers/consultants, contractors and inspectors. Examples of roles in these categories are developer, architect, contractor and enforcer. In circular design teams, the boundaries between these categories and actors fade. Additional circular roles and/or actors are also called for, such as those of circularity champion, material scout, data miner, etc. Roles that used to be sequential now continually give input to the circular design team.

The additional roles and/or actors contribute to a circular design project through their specific competences. For example, a manufacturer of construction materials can use its knowledge and expertise to safeguard the reusability of a building component. Annex II lists some well-known and less well-known roles and/or actors and the corresponding competences that are called for. These can be new or changing competences.

In fact, one actor can have several roles. This will often be the case especially for smaller projects. A role can also change in a subsequent phase. For example, a demolition firm can have an advisory role during a design phase. Subsequently, that party can assume the role of value creator (pricing) during the tendering phase and that of contractor during the construction phase.

5.2.4 Understanding the interrelationships between roles

The *Collaboration Wheel* can be used to find a suitable form of collaboration for a circular design process (Figure 7). For each life cycle phase, this tool shows how a core team implements different circular design strategies. Together with a decision-maker, this core team is the pivotal element of a project. To play this pivotal role, it depends on information and actions from other actors. Together with the core team and the decision-maker, they make up the design ecosystem. The *Collaboration Disc* helps to clarify that ecosystem. The tool visualises the attention required for each strategy and shows the extent to which certain actors (roles) are involved in the process. Attention for the different design strategies changes over the life cycle of a construction. A wheel can be prepared for each phase. Stringing these wheels together, or stacking them up, can help identify changes over time. More specifically on the Collaboration Disc:

- A 'disc' can be filled in for each life cycle phase to identify the relative attention for the seven possible circular design strategies (see Chapter 6). A disc thus represents a snapshot in time.
- The disc shows a project team's focus on the different design strategies. If a certain strategy gets more attention, this is visualised by means of a larger (coloured) segment in the disc.
- The roles in the team for each phase are determined on the basis of the division between the design strategies. This means that the composition of the design team can be different for each phase.
- Coloured dots show the different roles in a team. Decision-making (initiator/client) is the central element (e.g. red). This is surrounded (blue) by the design team (core team) and beyond that there are the parties that provide information or other input (green).
- A construction's life cycle is represented horizontally, starting from the initiative phase. Thus, a succession of several different Collaboration Discs shows how the ecosystem of collaborating actors changes over time.

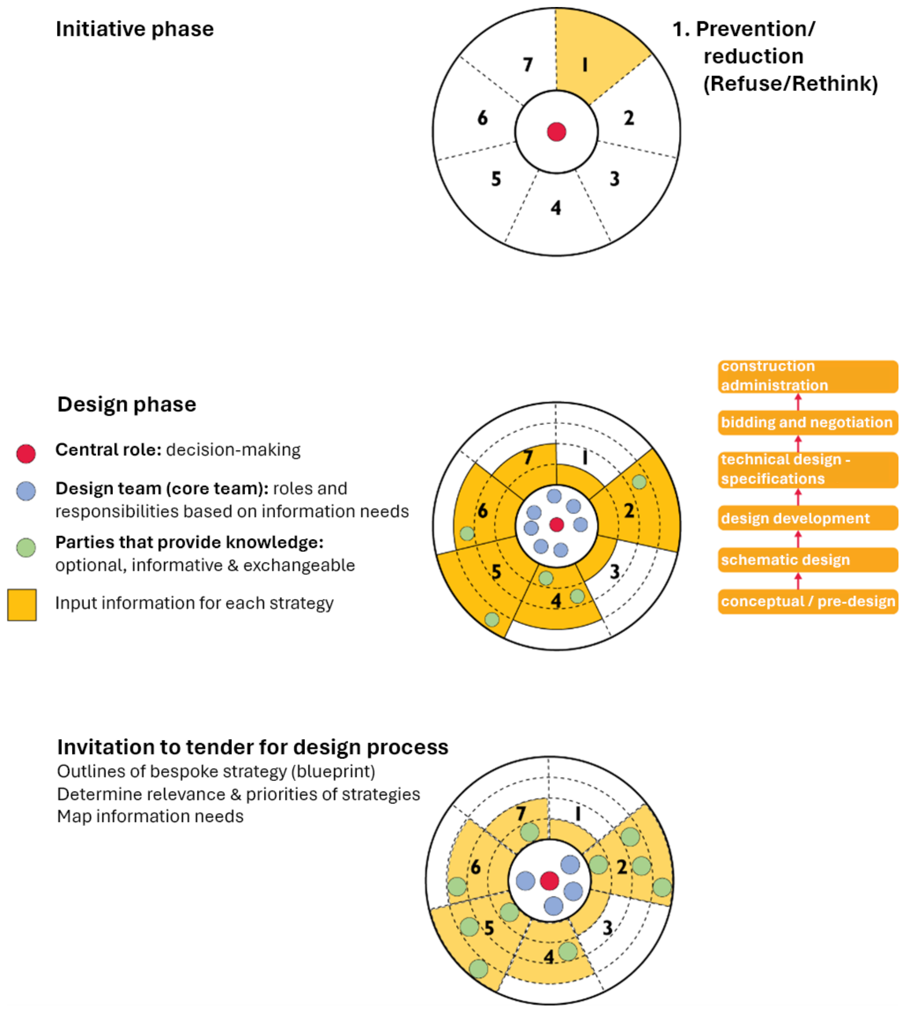
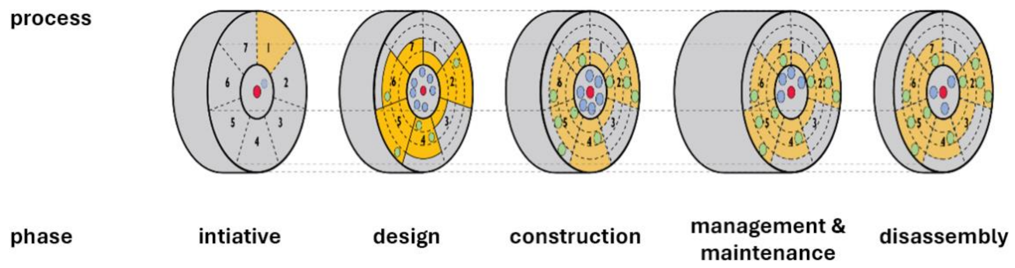


Figure 7 – Collaboration Disc for circular design process ecosystem (during initiative, invitation to tender and design)



Collaboration Disc over different life cycle stages with shifting attention for various strategies

Step-by-step plan for collaboration

The steps below suggest a possible way to apply the Collaboration Disc.

1: Definition

As is the case in a traditional design brief, the initiator defines the project during the initiative phase. In addition to the traditional definition phase of a project, the initiator determines the circularity ambition. If the initiator has insufficient knowledge to be able to determine the ambition, the team is supplemented by a party that has the necessary knowledge (such as the new role of 'circularity champion').

2: Prevention check

Together with a possible circularity champion, the initiator considers the Prevention strategy (the first segment in the tool) during the first phase. Designers can already tie in here. If prevention at the project level is not a viable strategy, the team takes the next step in the design process.

3: Knowledge definition

Based on the initiative phase and the circularity ambition, the first segment of the wheel is filled in. The roadmap can be used for this (Chapter 6). Based on that, the initiator defines the knowledge required for the circular design process. It is advisable to also appoint, or to add, a circularity manager during this step to monitor that project efforts actually lead to circularity objectives being achieved.

4: Roles in the bespoke strategy

Then, based on the first segment, the design team establishes the bespoke strategy and areas for attention for the seven design strategies for the first (design) phase. The design team sets concrete circularity objectives for each strategy. Next, the design team analyses what knowledge and information are required. Based on this analysis, the design team determines whether this must be complemented with specific knowledge (flexible layer with parties that provide knowledge). The following sub-steps can be used for this:

Defining roles for the individual strategies

4.1 **Diverge:** Schedule a kick-off meeting with the design team and develop the first segment from the Collaboration Disc. Use the design strategies roadmap from Chapter 6 for this.

4.2 **Converge:** Identify what knowledge and actors are necessary for one or more design strategies to be applied. Remove the actors for the remaining design strategies that will not be applied.

4.3 **Specify:** Organise a brainstorming session for each design strategy chosen. Identify opportunities and threats for each design strategy.

4.4 **Identify:** Identify necessary roles which the design team will have to work together with to study opportunities and threats. Add roles if necessary or remove any roles that are not relevant (Annex II). Actors can be added multiple times to different strategies. If the same actor becomes relevant to all strategies, it is advised to make that actor part of the design team.

4.5 **Organise:** Organise and divide the selected roles among the actors in the design team or find actors from outside the design team to fill certain roles. Record the considerations made in a *Circular Collaboration* working document.

5: Repeat the above for each phase

Repeat steps 1 to 5 for each subsequent design phase (preliminary - final - technical design). New discs are thus created for the individual phases. Changes are recorded by updating the *Circular Collaboration* working document.

Annex III contains suggestions for additional design roles for each strategy.

Design ecosystem

The Collaboration Disc can be used to put together a design team. Common key roles are those of project manager, architect, structural engineer, installation consultant and building physics consultant. In essence, these roles are not very different from those in a traditional design team. However, to achieve maximum circularity, other roles will be added to the design team for a circular project as well, starting with a circularity manager, whose responsibilities include driving circularity and monitoring circularity goals. If, due to the scope of a project, appointing a circularity manager is not feasible, one of the core team members can assume the role of circularity manager and/or circularity champion, for example. This role comes with the authority to continually draw attention to the most circular solutions and is important to prevent the team members from resorting to old habits.

After putting together the core team, roles related to the circular design strategies chosen can be added to the design team. Parties can be added incidentally, for example if specific knowledge about a particular part is required, or they can be added permanently, for example because donor materials need to be found and sourced during the design process (roles as data miner or purchaser). This makes the Collaboration Disc a tool to make it transparent which roles can or should be added to the core team for each design phase.

This results in an ecosystem: a network of actors (with their own specific roles) that depend on each other in order to achieve circularity ambitions.

5.3 Multiple value creation

5.3.1 Types of value

A circular design is not solely inspired by financial value. Sections 4.5.4 and 4.5.5 addressed the importance of value retention and value creation as part of the circular design process. Actors in an ecosystem create multiple values at specific points in time during the design process. Compared to a linear design process, circular collaboration is more concerned with preventing a value from negatively impacting on other values. The *Value Hill* (see Figure 8) and the *Framework Circular Design* are existing tools that can provide relevant insight.

The values or multiple values to be created are one of the six types of value or 'capitals' listed below (Six Capital model, IRC, n.d., Centrum Meervoudige Waardecreatie, HAN):

1. Financial capital: financial resources (such as funding, subsidies, investment or turnover) that enable an organisation to make products and/or services.
2. Human capital: resources expressed as human capital (such as experience, knowledge, motivation) that enable products or services to be created or provided.
3. Social and relational capital: resources expressed as social capital (such as relationships, connection, information sharing) that enable products or services to be created or provided.
4. Intellectual capital: resources expressed as unique knowledge (such as patents, copyrights, software, rights and licences) that enable products and services to be made for others.
5. Material capital: resources expressed as physical objects (such as buildings, infrastructure or machines) that are available to an organisation to produce goods and/or provide services.
6. Natural capital: resources that consist of natural resources (including all renewable and non-renewable forms) that enable goods or services to be used, such as the processing of mined

materials or the breathing of air.

Value Hill

Value is compensated, received and effectuated ('cashed in'). The points in the process and in time when value is created and is effectuated can differ for each stakeholder. Visualising these points and values in a joint model and monitoring them jointly during the design process is useful. The Value Hill provides a clear framework for this. For more information see The Value Hill, Circle Economy and Circular business models, CIRCO.

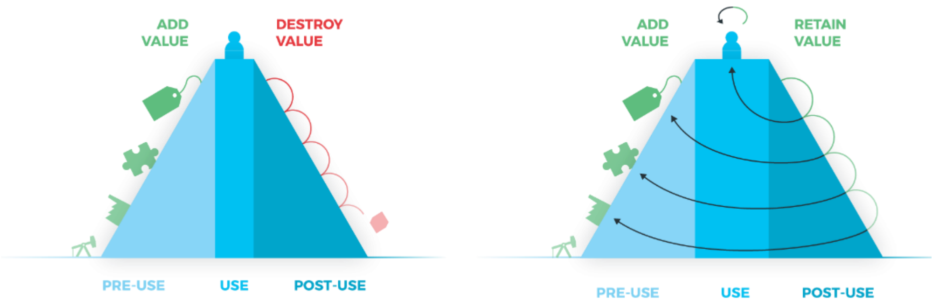


Figure 8 – The Value Hill and how value is handled (on the left: traditional, on the right: circular)

Framework Circular Design

To describe the place of the design (scope), the project team can first outline the overall picture based on the intended multiple value creation. Circonnect's Framework Circular Design provides a handy value matrix for this with four design focus areas (raw materials and production, use phase, after use and rethink) and three design dimensions (construction/product and service, business model and value system).

5.3.2 Value matrix

The design ecosystem can be given greater depth by means of a value matrix that gives an understanding of the value creation and effectuation of value between design chain partners (Table 2). The matrix shows all project actors on both axes and serves to specify how one party creates value for another party (that effectuates that value).

An example: Consider a case where a consultant has created a modular bridge for an initiator, assisted by a practitioner that manufactured the bridge parts. Several value transactions can be recognised here:

- Transaction 1 (T1): The initiator provides the consultant with financial resources for the human capital and intellectual capital to build more flexibly using modular bridge parts.
- Transaction 2 (T2): The consultant provides financial resources to the contractor for the contractor's material value of modular bridge parts.

Each stakeholder will have to add value to at least one interaction in the entire matrix. The more interlinked, the more intense the relationship with the circular construction project.

Table 2 – Value matrix for a design chain with two detailed examples for a modular bridge

		Value effectuation for			
		Initiator	Consultant	Contractor	Inspector
Value creation through	Initiator		Financial value: payment (T1)	…	…
	Consultant	Intellectual value: knowledge of flexible and future-proof construction (T1)		Financial value: payment (T2)	…
	Contractor	…	Material value: modular parts (T2)		…
	Inspector	…	…	…	

5.4 Information needs

5.4.1 Introduction

Circular design projects are characterised by new and changing information needs. This is because making material cycles closed systems goes hand in hand with making information flows closed systems (Wijewickrama et al., 2021). For example, research has shown that designers need information from both previous and future demolition phases (Van den Berg, 2019). Adequate information is essential to enable the right choices to be made. For instance, demolition contractors can inform designers about any construction materials reclaimed or to be reclaimed, and they can inform them about future disassembly and reuse possibilities. This section addresses the circular information needs of designing parties. To this end, we will introduce some basic principles and definitions and provide practical tools, such as an information needs matrix.

5.4.2 Processing information

Information arises from gathering, interpreting and processing 'data which are relevant, accurate, timely and concise' (Tushman & Nadler, 1978). Relevant examples of types of information are tender specifications, drawings, models, policy documents and analyses. Both the quality and quantity of information are important in circular design. Quality here refers to the *correctness*; quantity refers to the *completeness* of information. For example, in practice, drawings of existing constructions are often found to no longer be up to date. A possible reason for this is that a construction has undergone all kinds of changes over time that are not properly documented. This is a quality problem: the drawings do not, or no longer, reflect the correct situation. Those kinds of drawings or other documents can also be completely or partially missing: a quantity problem. Both aspects of information are important and can present design teams with major challenges.

Design teams jointly determine the type of information, the role the information plays in the process and how this information should be made available. This is partly based on the different roles played by parties in a project (initiators, consultants, contractors and inspectors). Each of these roles has important input in the provision of information within a circular process. In this respect, the parties do not have to differ from those in a traditional linear process. However, as indicated before, their mutual relationships and the way in which they shape the process together are different. This is because, in a circular design process, the available products from the existing built environment and/or circular products will have to be included in the design strategies at an earlier stage with an eye to future reuse. This has made the importance of product information at an early design stage significantly higher in a circular design process. This, in turn, helps to prevent surprises during the construction work, for example, by carrying out additional research into the origins and properties of materials.

Good sources of information for information standards (such as IFC, ETIM, etc.) and agreements on this are: BIM Loket and/or DigiGO (Digitaal samenwerken in de Gebouwde Omgeving - Digital Collaboration in the Built Environment).

Ambitions determine information needs

During the initiative phase, the initiators prepare several documents that describe and determine the vision, objectives and frameworks of the project. Relevant aspects for the design phase include a tender specification, vision/scope, functional and technical schedules of requirements and the business model with the budgets available for design and construction. The sustainability, environmental and circular performance ambitions are often defined in this context as well. This performance can be determined using various tools, such as GPR/CPG (W/E adviseurs), BCI (AlbaConcepts), MCI (Madaster). An example of a useful tool for describing the ambition levels for 12 sustainability themes for civil and hydraulic engineering projects is the Ambition web

(Ambitieweb). This tool has three levels for this: *Understanding* (current sustainability burden for each theme), *Concrete objectives* and *Added value* (zero negative effect to positive); any next level can only be achieved if all the previous ones have been achieved.

The consultants can then use information from these documents to define a circular or other design strategy in consultation with the initiator. The information required for the further detailing of the project can be identified on the basis of the design strategy chosen.

Each design strategy has its own information needs. For some strategies, crucial aspects of this are information and knowledge of the disassembly and demolition process and, for example, involving the supplier/contractor since they will have to reuse material in new constructions. After all, every project has different basic principles, preconditions and requirements.

Recognised measurement methods

Given the importance of information of the proper quality, recognised measurement methods must be used (see also the Platform CB'23 guides on 'Measuring Circularity' and 'Passports for the Construction Sector'). Determining what information is needed to achieve the project's circularity objectives is important. The initiators have a major role to play in this at the start of the project. It is very important that, in that role, they properly formulate the circularity goals at the beginning of the project and define them as SMART goals, i.e. goals that are specific, measurable, achievable, realistic and timed. At the same time, it is important to leave the design solutions up to the consultants.

Information provision and interpretation within a project start at the initiative and definition phases. This is also true for a circular project, but it does not end at handover of the construction. In the first two phases (initiative phase and definition phase), the scope, schedule of requirements and business case of the project are established. The group of initiators already processes a lot of information and choices are made on the basis of the available information during these phases.

5.4.3 Information needs matrix

An information needs matrix is a convenient tool to determine the specific information that the different design parties need. This matrix states what information specific actors need within their roles, who provides the information, when it is provided and how (format). This also brings to light any information deficiencies. The matrix provides guidance for the kick-off meetings of designing parties which can result in a schedule of information needs for the design phase. After this, the matrix can be updated and adjusted during the successive phases. The matrix is *also* intended as a mutual agreement to ensure that information that is needed is made available.

Table 3 shows a general format for this information needs matrix. The matrix contains an information demand side and an information supply side. The different parties are divided into the four categories known for this guide (see section 5.3.2): initiators, consultants, contractors and inspectors. For each party, each cell shows what information they need from the other actors for their decision-making or design activity. A memorandum from a client with circular performance indicators is an example of information provided by a client (information supply) to consultants as input (information demand) for detailing the circular design.

Table 3 – Format for an information needs matrix

		Information supply			
		Initiator	Consultant	Contractor	Inspector
Information demand	Initiator				
	Consultant				
	Contractor				
	Inspector				

In each cell, the actors together fill in what information they expect from each other; they formulate this SMART, specifying:

- What information
- In what form (format, medium)
- When (in the schedule/phase)
- For which strategy or strategies

Agreements on how information is provided include various standards and (file) formats. Use open standards and standards designated by the government (Netherlands Standardisation Forum) for this. Increasing digitisation in particular has made these agreements essential for making information available and keeping it accessible for the long term. Where possible, internal information can be in parallel with information required by third parties, such as the Handover File (*Opleverdossier* in Dutch) from the Dutch Building Quality Assurance Act (*Wet kwaliteitsborging*) and the newly announced EU regulation on QR codes to provide users with access to product information.

The format of the matrix is suitable for both the buildings and the civil and hydraulic engineering sectors. However, since each project is unique, a specific matrix has to be completed for each project.

Example of how an information needs matrix can be filled in for the various actors

This is an example from the buildings sector. The first actor in the example is the client (the initiator). This will often be an architectural/engineering firm. The first question then is: what information does the client want to collect from the architect?

If all the actors (with their respective roles) on the information needs side complete this process, the result will be a completely filled matrix. This matrix not only shows the *information* needs, but it also shows how needs can be met. This can serve as a basis for making agreements on information collection and provision.

A practical step-by-step plan to apply this matrix can be found in Annex IV.

Table 4 – Example of a completed circular information needs matrix for the buildings sector

			Information supply				
			Initiators	Consultant	Consultant	Consultant + Contractor	Inspector
			Clients	Architect/Engineer	Structural engineer	Demolition contractor	Building Inspection Department official
Information demand	Initiators	Clients		Architectural design as a result of circular ambitions and KPIs. Information on the circular goals that have been achieved.	Structural design focused on re-using existing materials, modular and disassemblable, biobased materials (low ECI).	Building scan, including hazardous materials. Disassembly price. Specifications and quantities of materials.	Minimum legal frameworks to be adhered to.
	Consultant	Architect/ engineer	Client's ambition/design wishes, circular materials used in various areas. Frameworks for financial possibilities or for additional financial possibilities.		Draft circular structural design: with circular materials, reuse, detachable, disassemblable.	Advice on the condition of materials, even after disassembly. Materials specifications, condition before and after disassembly. Disassembly price.	Laws and regulations but also the spectrum of opportunities. Other projects in the vicinity, in connection with released materials possibly being suitable for use in another project nearby.
	Consultant	Structural engineer	Client's ambition/design wishes: circular strategy (e.g. biobased materials).	Draft circular architectural design: with circular materials, circular construction method and construction details.		Condition and specifications of released circular structural elements.	Laws and regulations but also the spectrum of opportunities. Other projects in the vicinity, in connection with released materials possibly being suitable for use in another project nearby.

	Consultant + Contractor	Demolition contractor	Ambition/requirements as to the percentage of materials to be reused.	Specifications for circular materials, the condition of the building before, during and after demolition work.	Specifications for circular materials, the condition of the building before, during and after demolition work.		Mandatory items to be submitted (Dutch BLVC (accessibility, liveability, safety, and communication) plan, demolition plan, stock-taking of materials, etc.).
	Inspector	Building Inspection Department official	Final design for approval.	Final design for approval.	Final design for approval.	Provision of materials passport and disassembly (including harmful substances).	

6 Design strategies

6.1 Seven choices for circular design

Every construction project comes with specific opportunities and preconditions for bringing about a circular design. To give the design team a good start and choose relevant circular design strategies, it is essential that the opportunities are mapped during the initiative phase of a design process. This chapter discusses seven strategies, divided into four themes. At certain points in the design process, choices have to be made to achieve the strategies, and the themes provide guidance on this in the form of a roadmap.

A. Avoid and D. Optimise

1. Prevention

B. Future value

2. Design for quality and maintenance
3. Design for adaptability
4. Design for disassembly and reusability

C. Material value

5. Design with reused parts of constructions
6. Design with secondary raw materials
7. Design with renewable raw materials

The Prevention strategy occurs twice, since the greatest impact can be achieved by tapping in to as few raw materials as possible for the actual construction. This impact can be achieved early in the design process, but also later in the process, and at different levels of scale. Section 6.4.1 Prevention explains this in more detail.

The list of design strategies results from a review of different (scientific) different sources. Together, these strategies form a palette of possible circular design choices. Each strategy is described in a separate section and suggestions for practical implementation and examples are given. The relationship to other strategies is explained as well. They each contribute to a greater or lesser extent to Platform CB'23's three circularity goals: protecting natural resources, protecting the environment and protecting existing value.

A bespoke strategy (Figure 9) is a combination of relevant design strategies that a design team composes during a specific project. The sizes of the segments indicate the extent to which a strategy is applicable within a project (Figure 10). The bespoke strategy can be adjusted during the successive project phases. These successive bespoke strategies are combined in the Collaboration Wheel from Chapter 5 ‘Roles and collaboration’.

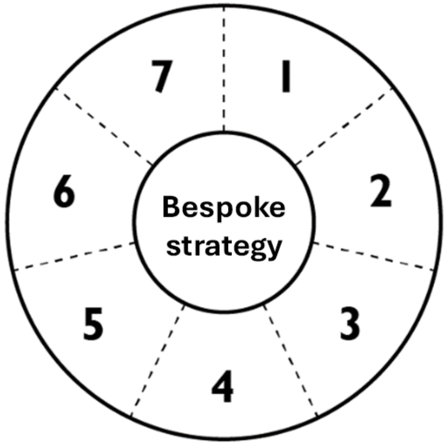


Figure 9 - The bespoke strategy

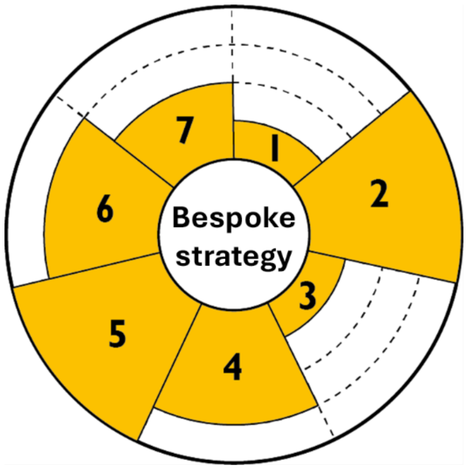


Figure 10 - The bespoke strategy with attention for specific strategies

6.2 Using the roadmap when designing

Since the feasibility and relevance of individual strategies depends on the project, this guide does not express any preference for one strategy or another. However, we have tried to specify a logical sequence for considering strategies in the roadmap.

There are certain points in the design process when choices have to be made in order to achieve the strategies. This roadmap is a handy tool for improving one's understanding of the process. It is a further development of a roadmap for sustainable structures by Terwel & Crielaard, 2023.

The roadmap aims to give clients, designers and practitioners the opportunity to identify the importance of each design strategy for different disciplines (such as architectural, structural, installation, cost and environmental). This is done for each design phase, with the possibility that attention for certain strategies evolves during the project. Attention for certain strategies in the bespoke strategy is represented by a larger or smaller segment (Figure 10). This completed bespoke strategy is a result of following the roadmap from theme A to theme D.

Figure 11 shows a simplified version of the roadmap. This figure shows how to use the roadmap: based on project-specific basic principles and a neutral bespoke strategy, all four themes of the roadmap are addressed, the key can be found on page 57. The different design strategies and the associated design choices are addressed automatically when using the roadmap. All four themes need to be gone through to develop a carefully balanced completed bespoke strategy. It is advisable to do this again in every stage of the collaboration. This will create a complete collaboration wheel.

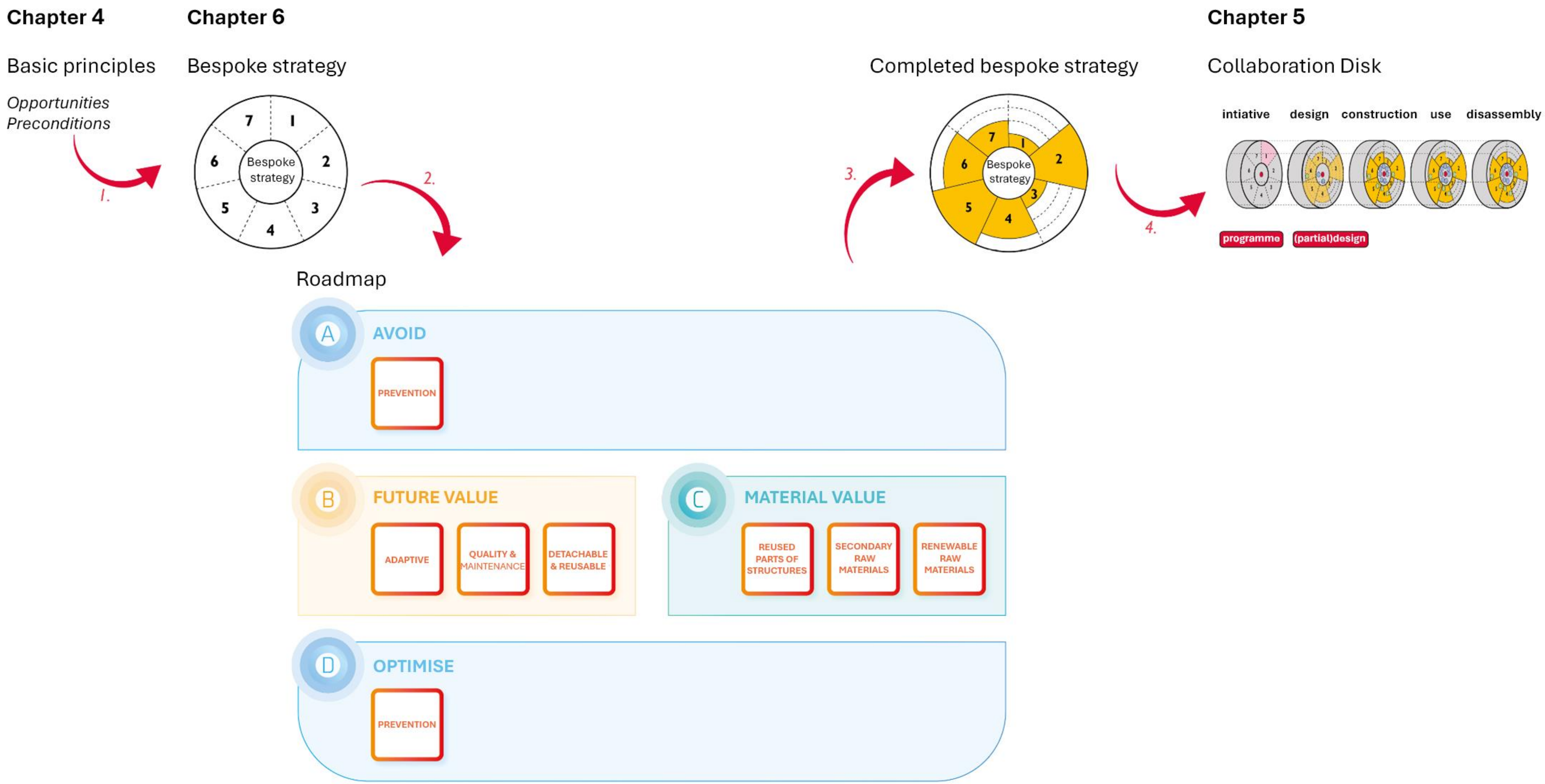
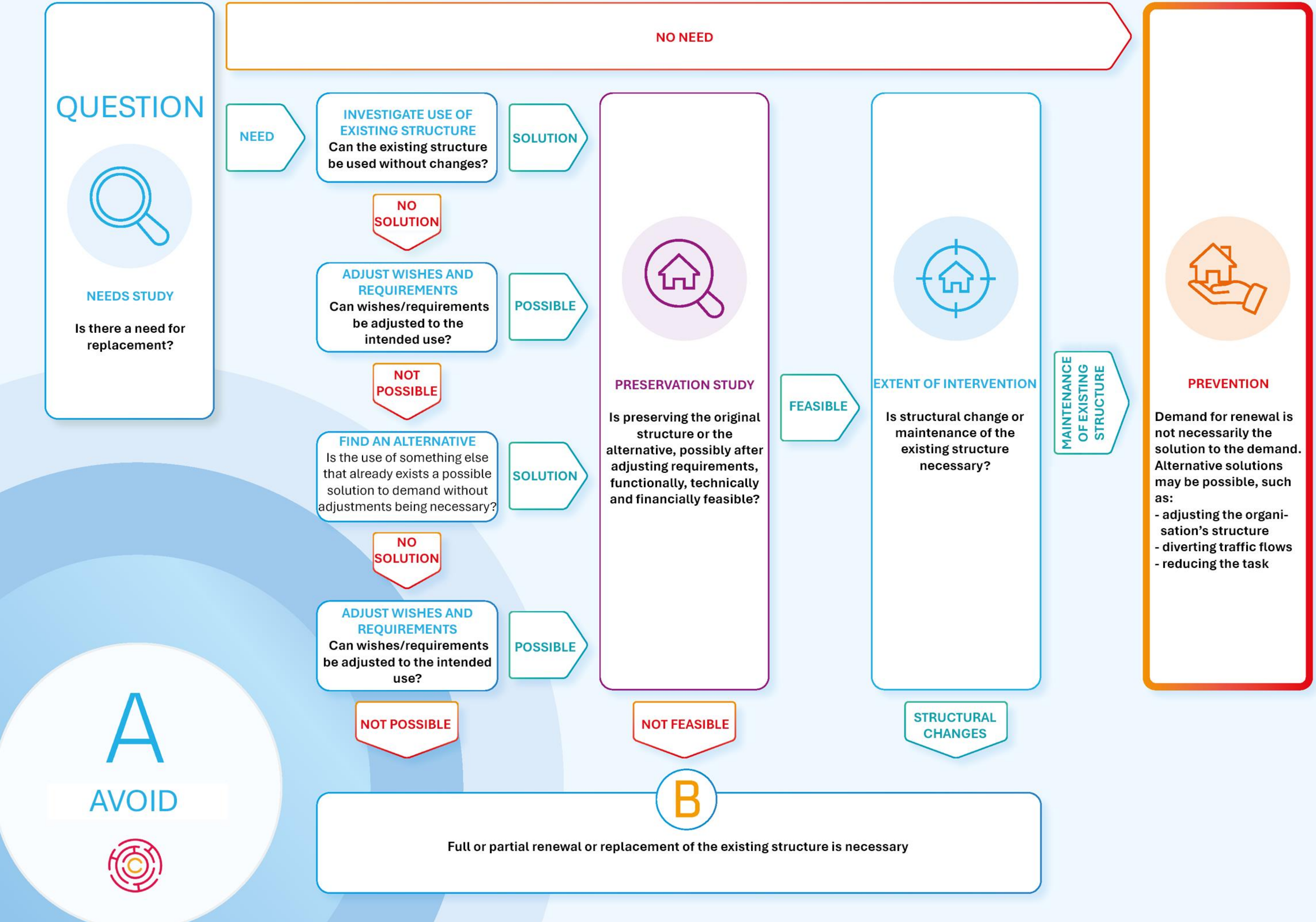


Figure 11 – **Simplified version of the roadmap**


QUESTION
NEEDS STUDY
Is there a need for replacement?
NO NEED
NEED
INVESTIGATE USE OF EXISTING STRUCTURE
Can the existing structure be used without changes?
SOLUTION
NO SOLUTION
ADJUST WISHES AND REQUIREMENTS
Can wishes/requirements be adjusted to the intended use?
POSSIBLE
NOT POSSIBLE
FIND AN ALTERNATIVE
Is the use of something else that already exists a possible solution to demand without adjustments being necessary?
SOLUTION
NO SOLUTION
ADJUST WISHES AND REQUIREMENTS
Can wishes/requirements be adjusted to the intended use?
POSSIBLE
NOT POSSIBLE
PRESERVATION STUDY
Is preserving the original structure or the alternative, possibly after adjusting requirements, functionally, technically and financially feasible?
FEASIBLE
NOT FEASIBLE
EXTENT OF INTERVENTION
Is structural change or maintenance of the existing structure necessary?
MAINTENANCE OF EXISTING STRUCTURE
STRUCTURAL CHANGES
PREVENTION
Demand for renewal is not necessarily the solution to the demand. Alternative solutions may be possible, such as:
- adjusting the organisation's structure
- diverting traffic flows
- reducing the task
A
AVOID
B
Full or partial renewal or replacement of the existing structure is necessary

ACTION

DETERMINE USE ON SITE

TEMPORARY

PERMANENT

DETERMINE LIFESPAN

What is the object's expected lifespan?

SHORT

LONG

DETERMINE REUSABILITY POTENTIAL

What is the reusability potential of the elements and materials?

HIGH

LOW

DETERMINE FREQUENCY OF CHANGE

What is the frequency of change of the different object layers related to the expected lifespan?

SELDOM

FREQUENTLY

QUALITY & MAINTENANCE;
Emphasize a long lifespan of the object. Design high quality, with a high degree of cleanliness, taking into account proper maintenance.

ADAPTIVE: EMPHASIZE
The adaptability of the object. Design for adaptability of the different object layers and consider the use of modular concepts.

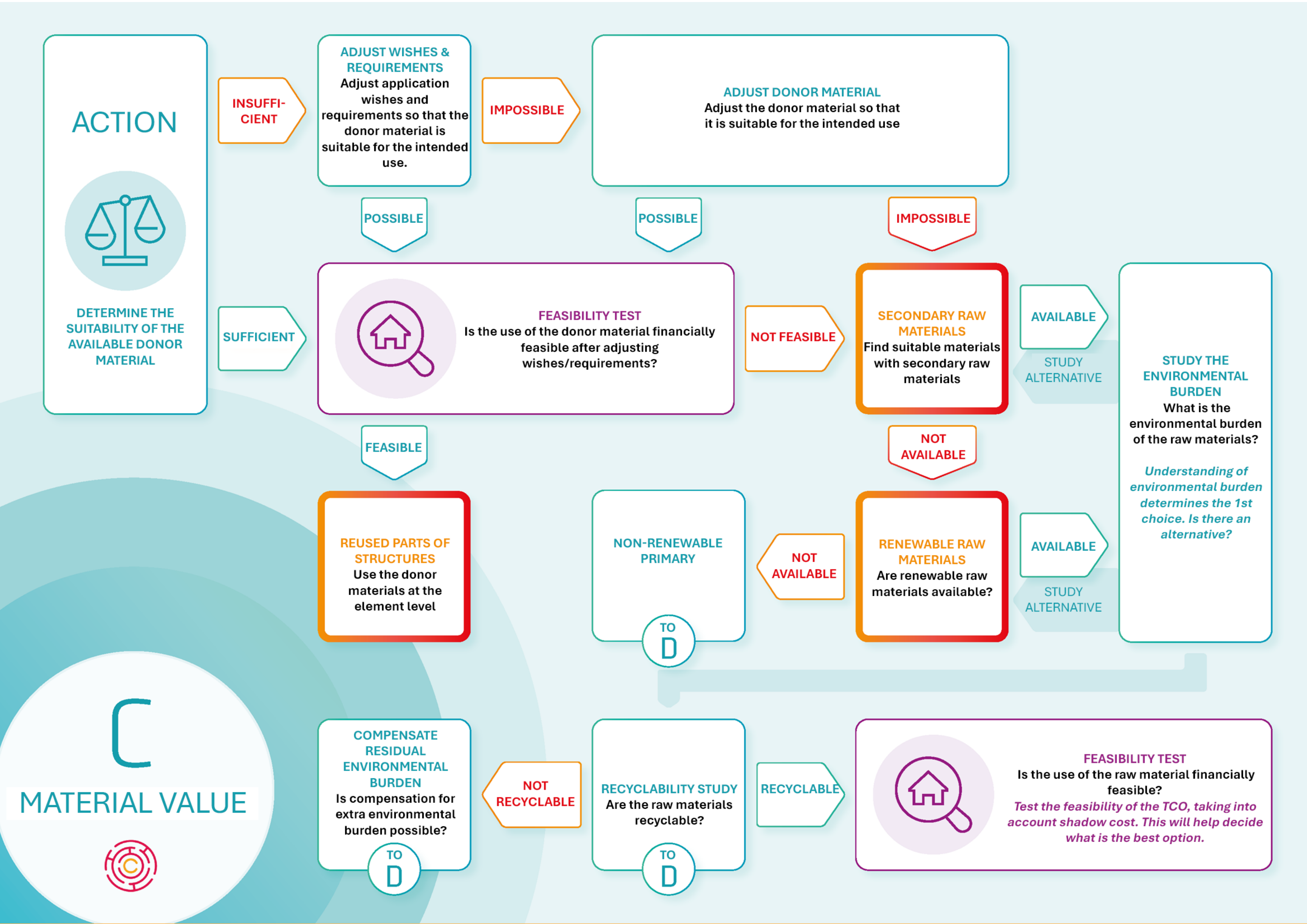
DETACHABLE & REUSABLE
Emphasize a long lifespan of the elements and materials by designing them so that they can be detached and reused.

C

Go to Material value

B

FUTURE VALUE



ACTION
DETERMINE THE SUITABILITY OF THE AVAILABLE DONOR MATERIAL
INSUFFI-CIENT
ADJUST WISHES & REQUIREMENTS
Adjust application wishes and requirements so that the donor material is suitable for the intended use.
IMPOSSIBLE
ADJUST DONOR MATERIAL
Adjust the donor material so that it is suitable for the intended use
POSSIBLE
POSSIBLE
IMPOSSIBLE
SUFFICIENT
FEASIBILITY TEST
Is the use of the donor material financially feasible after adjusting wishes/requirements?
NOT FEASIBLE
SECONDARY RAW MATERIALS
Find suitable materials with secondary raw materials
AVAILABLE
STUDY ALTERNATIVE
STUDY THE ENVIRONMENTAL BURDEN
What is the environmental burden of the raw materials?
Understanding of environmental burden determines the 1st choice. Is there an alternative?
FEASIBLE
NOT AVAILABLE
REUSED PARTS OF STRUCTURES
Use the donor materials at the element level
NON-RENEWABLE PRIMARY
TO D
NOT AVAILABLE
RENEWABLE RAW MATERIALS
Are renewable raw materials available?
AVAILABLE
STUDY ALTERNATIVE
C
MATERIAL VALUE
COMPENSATE RESIDUAL ENVIRONMENTAL BURDEN
Is compensation for extra environmental burden possible?
TO D
NOT RECYCLABLE
RECYCLABILITY STUDY
Are the raw materials recyclable?
TO D
RECYCLABLE
FEASIBILITY TEST
Is the use of the raw material financially feasible?
Test the feasibility of the TCO, taking into account shadow cost. This will help decide what is the best option.

KEY

- Strategy from the Circular Design Guide
- Design question or choice
- Assessment point

PREVENTION

OPTIMISE STRUCTURE AND SYSTEMS → POSSIBLE

NOT POSSIBLE ↓

OPTIMISE THE CONSTRUCTION METHODOLOGY → POSSIBLE

NOT POSSIBLE ↓

OPTIMISE ELEMENTS → POSSIBLE

NOT POSSIBLE ↓

OPTIMISE MATERIAL SPECIFICATIONS → POSSIBLE

FEASIBILITY TEST

Is optimising the (structural) system set-up with an eye on the environmental burden financially feasible?

D

OPTIMISE

6.3 Environmental impact assessment should be a review window

Reducing environmental impact is not reflected as a single step in the roadmap. This is because each consideration and decision made when following the roadmap affects environmental impact when considered over the entire life cycle of an element or a construction. Environmental impact assessment should be a review window with the ultimate goal of choosing a combination of strategies that maximise circularity and minimise environmental impact.

It is up to the design team to measure this effect and make sustainable choices based on it. The Platform CB'23 guide on 'Measuring Circularity 2.0' suggests a method to make circularity measurable.

The Dutch MPG (Environmental Performance of Buildings) is a mandatory calculation for new-build dwellings and offices with a gross floor area of more than 100 m^2. The Environmental Cost Indicator (ECI) is increasingly used in civil and hydraulic engineering projects. Various LCA-based calculation tools such as GPR (buildings) and DuboCalc (infra) are under development and available. These can also provide a basis for measuring environmental impact. Regular reference points in the design process are essential in this context.

6.4 Design strategies

6.4.1 Prevention

The prevention strategy focuses on avoiding new construction and, if this cannot be prevented, on designing more efficiently and more optimally. Checking whether constructions, certain functions of constructions, building parts and products are actually needed, and eliminating redundancies, can preserve resources and reduce environmental impact.

A striking example of this is the choice between installing a light pole or installing lighting in the existing crash barriers along a motorway.

Basically there are two ways to design preventively: avoiding and optimising.

A – Avoid: do not build, but provide a completely different solution or reuse an existing construction.

D – Optimise: design more efficient solutions, cleverly combine different functions and choose optimised products and use of materials.

Means

The following means can be considered when applying this design strategy (Dijcker et al., 2018) (Terwel & Crielaard, 2023):

A - Avoid

Reduce the task *and* ***investigate the use of an existing construction***

- Do not build.
- Determine the needs: Establish what is really required. Study whether there are any solutions that eliminate the necessity for certain parts.
- Adjust wishes and requirements: Be critical of the intended function and performance of the part that might be designed.
- Study whether common solutions can be replaced by alternatives that require less material to be used (dematerialisation). Note: This can affect lifespan and disassembly potential, for instance in the example where glued brick slips replace full bricks. It can also affect the environmental impact of the use of materials.

Use space and materials over time and find alternatives

- Study at what point in time the different parts are really necessary. Look for possible phasing by means of short-term, medium-term and long-term measures.
- Check whether the construction can be used more intensively (timeshare concepts or by means of concentration) and multifunctionally.
- Combine functions.

No extra control building when renovating Eerste Heinenoordtunnel

© Rijkswaterstaat, Joop van Houdt

The initial plan for replacing the tunnel's technical installations included constructing a second control building, since this would allow the old installations to remain in operation while installing the new installations and control systems. The design process for the new control building included an analysis of whether there were other possibilities, for example by freeing up space in the existing control building by dismantling non-essential installations early or moving them to a temporary housing facility. This analysis showed that smart conversion and the use of temporary modules made it possible to do the renovation and conversion without building a second control building.

D – Optimise

Optimise

- Optimise structure and systems: design the structure and the installation systems so that less material is used.
- Optimise the construction method.
- Optimise elements.
  Optimise material specifications.

Considerations

This is not an isolated strategy. Omitting things that are not needed now can affect how future-proof constructions are. See also the Design for quality and maintenance, Design for adaptability and Design for disassembly and reusability strategies.

Integral design, i.e. chiming in with other disciplines, is a prerequisite for success with this strategy. Preventive design choices can affect lifespan and disassembly potential. For example, dematerialisation by glued brick slips instead of full bricks can lead to an outer wall construction that is laboursome to disassemble.

Applicable safety and spatial planning legislation and zoning plans influence options for preserving a construction.

6.4.2 Design for quality and maintenance

The Design for quality and maintenance strategy focuses on the future value of constructions. Actually, this also applies to the Design for adaptability and Design for disassembly and reusability strategies. These strategies are about protecting existing value by extending the lifespan of constructions, elements and materials. This also contributes to Platform CB'23's other two goals: protecting natural resources and the environment.

‘To cherish’ is a concept that plays a major role here: constructions that users or other stakeholders feel great tenderness or appreciation for remain in use longer, although the technical requirements and properties of the construction do not always fully match. Examples of this are monuments or listed buildings. Cherishing is a difficult concept to measure, but it is a characteristic that must be identified in this guide.

Figure 12 shows the connections between the three design strategies for future value. It distinguishes between the different levels of scale in constructions: the entire construction, building parts or construction elements, products and materials.

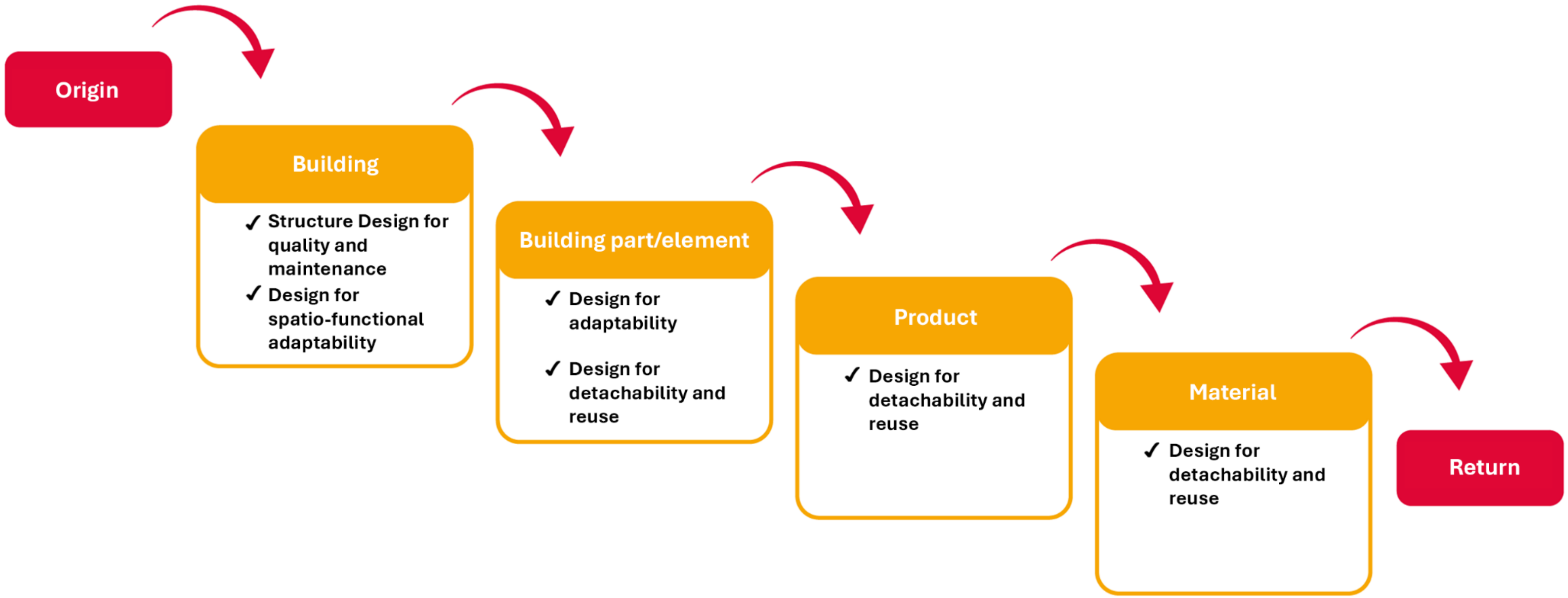


Figure 12 - The connections between the strategies for future value of constructions

Designing for quality and maintenance centres around constructing a construction that is highly valued by users and other stakeholders and that requires little maintenance. The design focuses on high quality and aesthetics and the use of robust low-maintenance products and good detailing.

Means

The following means can be considered when applying this design strategy:

Aim for a design that will be cherished

- Terms like 'precious' or 'cherished' can be used to express 'emotional value' or 'aesthetic value'. What a 'cherished' or 'precious' construction has in common with highly valued locations is that the willingness to invest will be significantly higher than if it were an anonymous construction. It is about aesthetic quality, possibly strong presence, and recognisability.

Determine a specific building lifespan and change frequency

- The 'Bepalingsmethode Milieuprestatie Bouwwerken' (Determination method for the environmental performance of constructions) does not state a specific expected lifespan of a building or a civil and hydraulic engineering construction. Stating it is the own responsibility of the parties involved. Use the 'Richtlijn specifieke gebouwlevensduur' (Guideline for specific building lifespan; W/E, 2020) to deliberately target a longer lifespan of the building during the design stage than the commonly used default values: 75 years for residential buildings, 50 years for non-residential buildings and 100 years for civil and hydraulic engineering constructions. This guideline constitutes a uniform and supported method to justify deviation from these default values. Another important key characteristic of a building, in addition to its location and adaptive capacity, is the building's quality:
    - This concerns the construction's current quality that will be preserved for decades to come. It is mainly laid down in long-cycle layers, such as the building shell/the structure and the outer walls/the skin. Installations and finishing are often adjusted over the years.
    - A construction's current condition is only a limited indication of its condition 50 or 75 years down the line. One aspect that can help predict a construction's future condition is 'robustness', achieved by using high-quality materials and careful detailing and construction (see the example in the text box for Solid 11 in Amsterdam, where a deliberate choice was made for quality and a long lifespan).
    - Design the construction such that it will become more beautiful through use and maintenance.
- Aim for a construction with the highest possible appreciation from users. It is not only the technical quality that matters, but also 'functionality' (spatial and functional quality). Functionality that has been captured in long-cycle elements involves physical building characteristics, such as access (a logical floor plan), the structural elements, the height and the storey height, and the admission of daylight (relations between dimensions and positions of openings in external walls and building depth).

Considerations

A longer functional lifespan of a construction will have a positive impact if the construction products used have a very long technical lifespan, since such products will not need to be replaced. Products with a limited technical lifespan will have to be replaced and this will undo any environmental benefit from the extended lifespan of the construction.

The more users appreciate the aesthetics and spatial quality of a construction during the use phase, the more likely they are to treat it well and to cherish and maintain it. This will give the construction a longer lifespan.

The future value/expected lifespan of a construction cannot be detached from its context. Its location plays a role in this as well. This means that a construction's lifespan in a given context can differ from the lifespan it would have in another context.

If frequent changes in usage requirements are to be expected, designing for adaptability should be combined with designing for disassembly and reusability.

Solid 11 – Design for quality and maintenance

© Peter Cook (Solid – Amsterdam) Architect: Tony Fretton

The flexible configuration options and robust self-supporting masonry outer wall of the Solids residential building on Constantijn Huygensstraat in Amsterdam make this building suitable for the long lifespan intended by its design.

“De Oversteek” Nijmegen – Design for quality and maintenance

© Thea van den Heuvel (De Oversteek – Nijmegen) Architects: Laurent Ney, Chris Poulissen; BAM Infra

The very first design proposal for ‘De Oversteek’ already devoted a great deal of attention to maintenance. Maintenance has been minimised for the first one hundred years by implementing several design elements that minimise the risk of corrosion. For instance, no water can stay on the smooth surface. The steel parts are airtight, eliminating the need for coating, inspection and maintenance. Much attention was also paid to the emotional, aesthetic and use value. Being on the bridge is a pleasant experience, both above deck and at ground level.

6.4.3 Design for adaptability

When designing for adaptability we assume that a construction can meet different future scenarios with different needs and requirements. In other words: adaptability is the capacity to respond to change. This can be at different levels of scale, in different time periods and between different functions, for example due to changes in users, seasons and requirements.

A construction’s adaptability will extend its lifespan, even if requirements change. It is quite uncommon for the use of a construction to remain exactly as initially conceived. There will be new users, new ways of working, and techniques and regulations will evolve. Designing for adaptability enables the key goals of Platform CB’23 to be met: protecting existing value, natural resources and the environment.

There is a difference between technical and spatio-functional adaptability. A construction is spatio-functionally adaptive if it can cope with changes in functions and space requirements. Examples include freely configurable floor plans and overdimensioning recesses for pipes and ducts. Technical adaptability of a construction means that connections can be disassembled, and parts can be accessed and are physically independent of each other. See the Platform CB’23 guide on ‘Measuring Circularity’ and the guide on ‘Future reuse - Disassembly potential’ and the 'Design for disassembly and reusability' strategy in this guide. However, this section focuses on spatio-functional adaptability. Most spatio-functionally adaptive constructions are also technically adaptive to enable changes and modifications.

Means

The following means can be considered when applying this design strategy:

Design with future scenarios for construction and changes

- Apply smart design of space and structure to enable different forms of future use.
- Overdimension to allow for other load scenarios.
- Reserve space for adjusting lane or track layouts.
- Allow for a greater excavation depth on the wet side of the quay or an excavation on the land side for laying cables and pipes.
- Ensure that some shafts are reserved for additional installations and piping and create higher clear storey heights and freely configurable floorplans.

Distinction between construction and object layers

- Adaptability concerns both long-cycle (the structure and the shell) and short-cycle (installations, room layout and goods) layers, see the description of shearing layers in Platform CB'23's 'Measuring Circularity 2.0' guide.
- Intervals can vary from short-term (day-night and seasons) to long-term (years, decades and even centuries). Match the technical lifespan of the material or building part to the expected functional lifespan and the building part or construction.

Document the construction

- Traceable (digital) documentation ensures that future scenarios taken into account in the design can actually be achieved if and when relevant. Platform CB'23's guide on 'Passports for the Construction Sector' goes into this in more detail.

Apply climate adaptive measures

- Climate adaptive measures are also needed to achieve and extend the intended technical lifespan. These measures account for increasing heat, drought, floods and high water levels throughout the Netherlands or sea level rise and land subsidence in the western and northern parts of the Netherlands. The Klimaatadaptief en natuurinclusief bouwen, inrichten en beheren guide on climate-adaptive and nature-inclusive construction, setting up and management, published by the Dutch Ministry of the Interior and Kingdom Relations gives more information about this.

Considerations

This strategy correlates with the Design for quality and maintenance and Design for disassembly and reusability strategies, and these strategies can reinforce each other and the circular result.

Think of adaptive capacity as an investment. Additional coordination in the design process and issues such as overdimensioning can increase the probability of an extended lifespan, see section 6.2.3 of Platform CB'23's guide on Measuring circularity. This explains why it is important that the probability that this investment will be capitalised on is high.

Margarethacomplex Kampen – adaptive capacity

© LKSVDD Architecten

The structure of the Margarethacomplex has been geared to the urban fabric of Kampen's historic town centre. The concrete carcass was constructed using the slenderest columns possible. Each storey is higher than necessary. The outer walls are a timber frame structure, allowing for future modification of the outer wall layout. The carcass can be freely laid out to accommodate changes of function and thus extend the lifespan of the construction. In addition, the carcass features concrete core activation connected to a ground source. The installations can partly be connected based on the planning grid, and some of the installations in the corridor zone are installed in a ceiling zone under the floor. The homes can be 'supplied' from there.

Maasvlakte quay wall

© ECT Rotterdam

When building the Euromax quay, Port of Rotterdam Authority provided the quay wall with the adaptive capacity to make it suitable for future developments. This was done by specifying a three-metre deeper future water depth in addition to a contractual water depth. This made the quay as completed suitable for future, larger container ships and for the connection to the adjacent Maasvlakte 2 area.

6.4.4 Design for disassembly and reusability

The Design for disassembly and reusability strategy aims for technical adaptability. This strategy requires the design to enable materials to be easily mined without any damage during or after their use for the highest-quality reuse possible. A construction or object is technically adaptive if connections can be disassembled and parts (elements such as installations and construction products) are accessible and demountable.

Please refer to the Platform CB’23 guide on Future Reuse - Disassembly potential for a practical implementation of the strategy. Figure sketches the relationship between the Platform CB'23 guide on ‘Circular Design' and the 'Future Reuse - Disassembly potential’ guide.

The basic principle for the Design for disassembly and reusability strategy is the relationship with Stewart Brand’s Shearing Layers model. This model visualises the differences in lifespan between different parts of constructions. For instance, in the buildings sector they are the structure, the shell, the interior and installations, and for civil and hydraulic engineering they are the soil, road foundations, the top layer and the technology. The Shearing Layers model is explained in the Platform CB’23 guide on ‘Measuring Circularity’. By making the layers of a construction that each have different technical lifespans mutually disassemblable, it is easier to replace, reuse and/or repair or overhaul a part of the construction.

The goal is to achieve the highest possible residual value of construction parts so that the use of primary materials can be avoided in the future. Designing for effective harvesting is possible by anticipating disassembly and standardisation by applying principles such as IMC (Integral, Modular and Circular) or IFD (Industrial, Flexible and Disassemblable). NTA 8085 and NTA 8086, for example, provide technical guidance on designing and constructing bridges and flyovers according to IFD principles.

Means

The following means, which draw from measurement methods for disassembly potential for buildings and civil and hydraulic engineering (Van Vliet et Al., 2021), (Ter Heijden & Scheepens, 2023), might be used when applying this design strategy:

Design with disassemblable connections

- Prefer dry connections and connections with added elements such as screws, bolts or interfacing elements.
- Avoid wet connections and give preference to soft connections (such as sealant) over hard chemical connections (such as glue).

Make sure that connections are accessible

- For accessibility reasons, design on the basis of a reverse construction sequence. Access to products that last less long than the building or a specific building part must be possible sooner than access to products that have the same lifespan as the building.
- Make sure that the connecting elements can be reached without causing damage to other parts.

Avoid unnecessary integration of different materials and elements

- Avoid products or elements with different lifespans passing through each other or crossing or intersecting each other.
- Avoid hybrid materials and products whose raw materials cannot be disassembled or that originate from different cycles (biological and technical).
- Ensure good separability at raw material level, so that any toxic, contaminating parts within materials can be properly removed and pure material flows remain.
- Design based on separation of parts by lifespans and the need for interim replacement.

Avoid connections that are locked in

- Design within units of the same lifespan that can function separately from each other.

- Ensure that elements with shorter lifespans that require interim replacement are not enclosed by elements with longer lifespans that do not require interim replacement.

Standardised and modular

- Use generic and standardised dimension systems to design the building parts and elements of constructions, so that reuse is more likely.
- Design standardised connections of construction parts that are modular and interchangeable.

Considerations

The measures for the Design for disassembly and reuse strategy do not create immediate impact, but are a pre-investment in the future as are designing for quality and maintenance and designing for adaptability. The strategy must be weighed against the intended lifespan and quality of the construction.

- Since pre-investing in disassembly potential can lead to a higher initial environmental impact, the use of disassembly potential should be logical within use scenarios.
- The disassembly frequency and, therefore, possibly also the importance of disassembly potential are different for each layer.
- Designing disassemblable connections can affect the qualitative performance (such as structural or thermal properties) of the entire construction or element. Weigh this against the maintenance concept and future vision for the construction.
- Designing in standardised elements can negatively impact on aesthetic differentiation within buildings. Find the right balance between standardisation where necessary and differentiation where possible.
- The disassemblable construction of the current design can lead to the proportion of elements suitable for high-quality reuse compared to secondary raw materials increasing in the future.
- Disassemblable design facilitates maintenance and/or partial replacement.

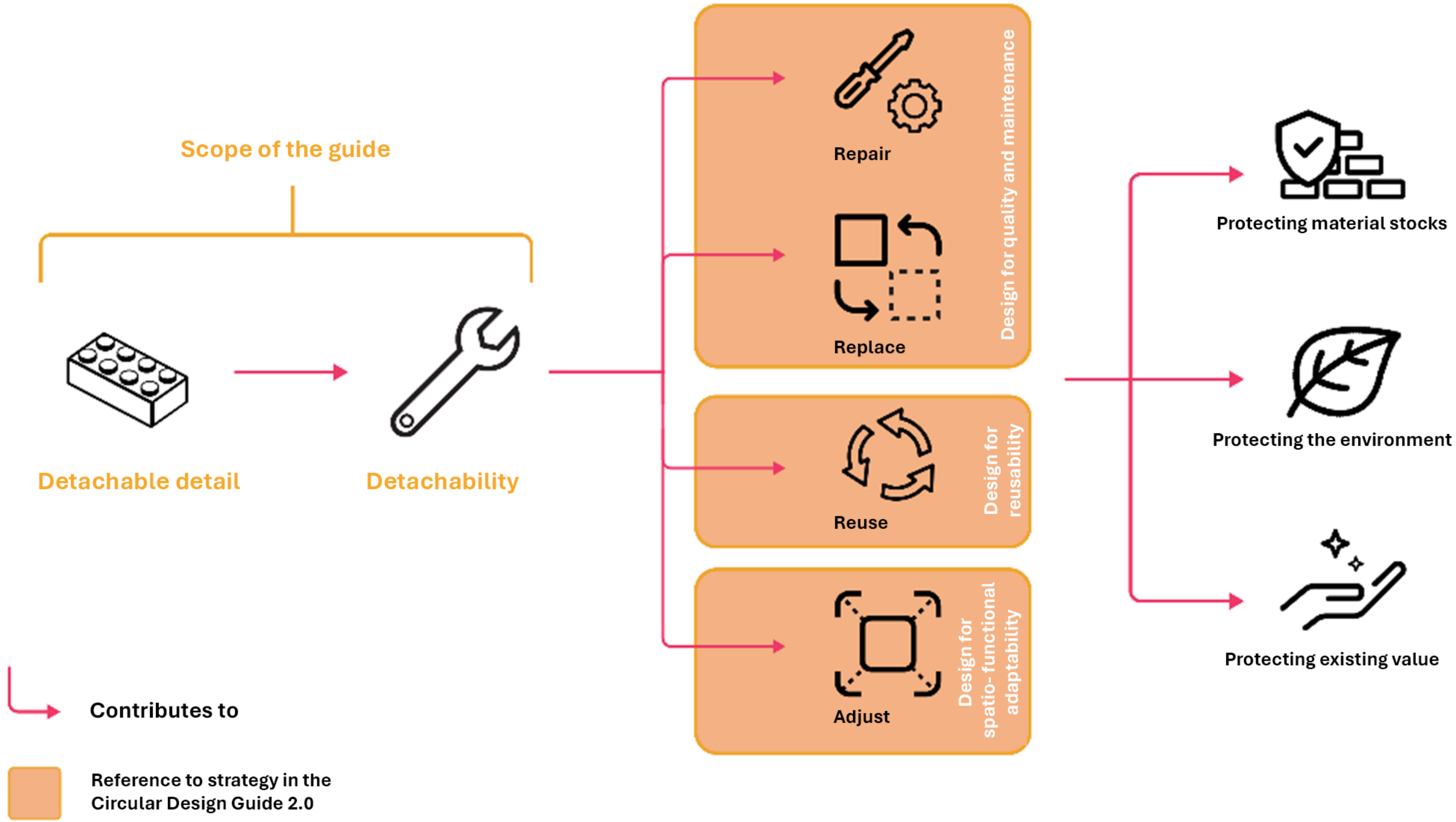


Figure 13 - The relationship between the guide on 'Disassemblable detailing' and 'Circular design'

Circular flyover

© Rijkswaterstaat, Sem van der Wal

The circular flyover consists of individual modules that can be threaded together both in the span direction and across the width of the flyover by means of a prestressing cable. Although this initially requires more raw materials than a flyover of a traditional design, disassemblable connections and a modular construction enable the flyover to be broadened in due course. The flyover can also be reused elsewhere in completely different proportions.

Temporary court

Temporary Court Amsterdam © Leon van Woerkom

The Amsterdam court had to bridge a five-year period until a permanent building was available. This resulted in a design for a 5400 m^2 temporary court with bolted connections that allowed the structural parts to be disassembled. Even the connections between the rigid floor diaphragms and the main load-bearing structure are constructed so that they can be disassembled. The foundations are also constructed from prefabricated parts to enable disassembly and reuse. The positions of the columns and the storey heights were chosen to also be suitable for use as an office building. The temporary court was built in Amsterdam in 2015 and disassembled in 2021. The existing elements will be used to construct the 'Techbank Enschede' building.

6.4.5 Design with reused parts of constructions

This strategy is about reusing parts of constructions, possibly after they have undergone treatment. The reused parts replace parts from primary raw materials.

Means

The following means can be considered when implementing this strategy:

Direct reuse without any modifications ('reuse')

- Use existing materials and products in the design and try to integrate them directly into the new function.
- Give preference to renewed reuse for materials *and* products from outside that do not require any modification.

Reuse based on extra maintenance after the end of the first lifespan ('repair & refurbish')

- When renovating or transforming, determine the suitability or unsuitability of products from the construction for assuming the same function again through additional maintenance or refurbishment.
- Study which existing products elsewhere in the same function can be part of the construction or of parts of the construction. Use marketplaces, construction hubs or demolition/harvesting companies for this.

Use new elements with reused parts ('remanufacture')

- When using newly offered products, choose the products with the highest proportion of recycled materials and semi-finished products.

Reuse products and elements in other functions ('repurpose')

- When renovating or transforming, determine the suitability or unsuitability of own products for use in *another* function through modification.
- Study which existing building parts can be used in a new function elsewhere as part of the construction or as part of parts of the construction after the least possible adaptation. Use demolition companies, marketplaces or construction hubs for this.

Considerations

Machining can be useful to ensure that the reused part fits the new use situation better and that any wear and tear is repaired. The existing value of the object is protected.

To be able to apply this strategy, the feasibility of reuse of existing objects must be assessed. We have listed some possibilities below:

- First, map the availability of reusable parts of constructions. You might have building contractors and materials dealers help you or you can consult digital sources, such as www.nationalebruggenbank.nl, www.oogstkaart.nl or www.insert.nl.
- Use inspections, condition scores (e.g. in accordance with NEN 2767), calculations and functional analyses to determine the residual lifespans of parts of constructions. Map any divergent requirements.
- Analyse the degree of impact (reduction) of retaining parts of constructions on the final circularity of the project and analyse the consequences for safety requirements.
- Do a materials scan (material properties, availability, residual lifespan, use possibilities, damage due to use and/or demolition, etc.) of released materials. Several commercial parties operate tools to perform these scans, such as Nebest's Herbruikbaarheidsscan (Reusability Scan) for civil and hydraulic engineering constructions and SGSSearch's Beslisboom hoogwaardig hergebruik (ge)bouwelementen (Decision tree on high-quality reuse of construction and building elements. The Platform CB'23 guide on 'Future reuse – Quality assessment and assurance' gives information on performance requirements for subsequent cycles.

Reuse of old kerbstones

Because of the long technical lifespan of paving materials, these objects are very well suited to being used in several life cycles. However, the design team should make a realistic assessment of the expected future condition of these objects. Reused kerbstones, for example, can differ in colour and it is important to take this into account when creating the design. The condition of the reused objects should match expectations for the final result. Of course, the assessment cannot take place until the source of reuse is known. Both the design team and the client should be aware of this uncertainty.

Zandkasteel

© Aalbers and Van Huut

'Zandkasteel', the former ING headquarters in Amsterdam-Zuidoost, is going to be transformed for use for other functions, including an educational function. The technical installation design makes optimum reuse of existing installations. A typical example of this are the air handling units that have been renovated to their full newbuild condition in spite of their advanced age.

Biopartner 5

Entrance hall of Biopartner 5 © IMd Raadgevende ingenieurs/René de Wit

Biopartner 5 is a 6,200 m² multifunctional centre with offices, laboratories and a meeting space. The structure was made of a donor skeleton built from the steel structure of a nearby premises that was demolished. 165 metric tonnes of steel were reused. Reused elements have also been used for many other parts of the building. For example, the flooring is made of carpet tiles that were rejected elsewhere and that, after undergoing some modification, were laid in an attractive pattern. Interior walls were reused from another office building and masonry rubble was used for the outer wall, to serve as the basis for a green wall.

6.4.6 Design with secondary raw materials

The 'Design with secondary raw materials' strategy is about designing with raw materials and materials that have been used previously or with residual flows from another product system. These raw materials are used in such a way that they replace primary raw materials. This strategy thus contributes to protecting natural resources and preventing waste.

The Prevention and Design with reused parts of constructions design strategies in this guide apply to the reuse of parts (elements, structural parts and structures) and complete constructions.

Means

The following means can be considered when applying this design strategy:

Aim for the highest quality use of secondary raw materials

- When taking stock of available secondary raw materials, make an estimate of the future value of the material to be recycled. Three basic grades can be distinguished here:
  - Upcycling: the process of converting secondary raw materials into new materials, components or products of a better quality, improved functionality and/or higher value than their original application.
  - High-quality secondary raw materials (recycling): here, the secondary material basically has the same quality as the original new or primary material.
  - Low-quality secondary raw materials (downcycling): the process of converting secondary materials into new materials, components or products of a lower quality, reduced functionality or lower value than their original application.

Consult digital sources

- When matching local availability to demand, public and digital sources are essential tools to help you quantify and locate raw materials that are made available; they can be combined with materials passports to qualify the raw materials. www.oogstkaart.nl gives more information about materials that are released. The Platform CB'23 guide on Passports for the Construction Sector is a first step towards standardisation of passports.

Considerations

Match released secondary raw materials - i.e. supply - to demand. Expected demand and expected supply of secondary raw materials should be compared during the design process. Properties such as volume, dimensions, technical requirements, the time when materials will be released and location are design parameters that can influence the proportion of the secondary raw material in the design. The Platform CB'23 guide on Circular Procurement goes into this in more detail.

The choice of secondary raw materials can affect environmental impact during the life cycles in several ways, e.g. due to lower production energy or more transport energy compared to the primary material. This impact must be carefully assessed when considering whether to use raw materials from primary sources or from secondary sources.

If it is decided to use residual flows (i.e. waste flows from production processes), the design team should make sure that this does not unnecessarily perpetuate the production of residual flows. A residual flow that continues to exist because there is a market for it may impede sustainable optimisation.

The design team also has a significant influence on the future reusability of this material. It is the design team's responsibility to choose the application that ensures the highest future value. This requires high disassembly potential (to prevent pollution in the future) and a clean application of the material (not mixed with other materials), see Design for disassembly and reusability.

A-quality wood and B-quality wood

Although wood in its optimum form can be used for several life cycles, nowadays it is mainly used as a fuel for energy generation when a construction has reached the end of its lifespan. If the residual flow is processed into chipboard, the raw material can be put to useful use longer.
The current state of the art of the chipboard and MDF industry allows A-quality and B-quality scrap wood to be used to a large extent as part of the raw material required to make chipboard for construction purposes. A-quality wood (unpainted and untreated wood) can be fully recycled and B-quality wood (painted, varnished and glued wood) can be partially recycled.
This allows batches of A-quality and B-quality wood with end-of-life status to still be used as secondary raw material in construction. If it is used in the form of chipboard, it can be used for all kinds of finishing and interior applications such as floorboards, formwork and joinery. This extends the active lifespan of softwoods. Chipboard and MDF can be used again as raw material for new chipboard to a high extent.

Harvested concrete

Concrete debris can be fully reused as the basis for the manufacture of new mortar and concrete products. This makes it an important secondary raw material. New techniques to reduce the energy required for crushing and recycling concrete waste are being developed.
Separating concrete debris at source prevents it from being used as a downcycled raw material for road foundations.
The concrete debris is then retained and reused to produce new concrete, for example as concrete granulate, where ground concrete particles of a certain size are used to substitute gravel in new concrete. A higher-grade method is to process concrete debris into the basic materials gravel, sand and cement stone powder. These basic materials can be used as high-quality raw materials to produce new concrete with a very high content of recovered secondary raw materials. The

partition wall at the Contactweg subway under the railway in Amsterdam is a good example of this. The concrete used in this project consists of 100% recycled gravel, 50% recycled sand and 15% recycled cement, creating a secondary composition of 75%. The project is expected to thus save 27% in CO_2 emissions and 26% ECI (environmental cost indicator).

6.4.7 Design with renewable raw materials

The use of renewable resources reduces the use of non-renewable resources and their possible depletion. This thus directly contributes to protecting natural resources. This strategy focuses on designing with as many building materials from renewable sources as possible. A renewable resource is grown, naturally replenished or naturally cleansed on a human time scale.

A renewable resource may be depleted, but sustainable management and good stewardship will prevent this from happening. Examples of renewable resources include trees in forests, grasses in grasslands, shells, clay from the Dutch river delta (sediments) and fertile soil. A renewable resource can be of abiotic or biotic (biobased) origin. Biotic raw materials come from living sources and are of plant or animal origin, including algae and bacteria (Agrodome, 2022), (NIBE, 2021).

Means

The following means can be considered when applying this design strategy:

Use local renewable raw materials

- Aim for the use of renewable raw materials from the immediate area where the extraction or generation of the raw material does not have a lasting negative impact on the local ecology. Energy is needed to transport raw materials and this can put disproportionate pressure on certain regions. An example of this is the tropical hardwood used in Europe.
- Use material from sustainably managed renewable sources. A summary of criteria and bases for assessment can be found in the Hernieuwbare grondstof en materiaal voor de bouw (Renewable raw materials and materials for construction) report.

Separate the technical and biological cycles

- Materials from renewable sources are circular by definition if the biological cycle is not broken. This is the cycle in which biological nutrients are returned to the biosphere.
- Preserving the biological cycle requires materials from the technical and biological cycles to be separable, separated, or compostable together (Ellen MacArthur Foundation, 2017). The technical and biological cycles must never be mixed. A good example is the use of biocomposites based on fully renewable raw materials.

Match the design and detailing to the sustainability of the products used

- Poorly considered detailing, insufficient protection or unfavourable orientation in a construction can cause renewable materials to degrade prematurely due to how the biological cycle works. Protect the material from weather and other external influences, and enable maintenance and replacement, see Design for quality and maintenance. For example, you can use the CUR report on Hout in de GWW (Wood in civil and hydraulic engineering) to get a summary of possible applications of wood in civil engineering structures.

Considerations

The use of renewable material does not automatically guarantee the most favourable ECI value or the lowest environmental impact. The MKI Bepalingsmethode (ECI Determination Method) can be used to check this.

Especially if biocomposites or biopolymers are used, it should be ensured that the raw materials can be separated or are biodegradable. Any renewable materials that are attached to non-renewable raw materials without the possibility to detach them again are no longer biodegradable. This places them outside the biological cycle.

For construction purposes, it is important that a product is suitable for its intended application, and that materials and raw materials are used efficiently. This may mean that non-renewable products will have to be added to a product to achieve the desired properties. This will negatively impact on reuse possibilities. Non-renewable additions can be, for example:

- flame retardants (e.g.: salts);
- fungicides (e.g.: salts, metals);
- insecticides, metals;
- adhesives for reinforcement, fossil-based;
- reinforcement, including fibre reinforcement, plastic fibres, metals.

Information about the composition of the product and the impact of the non-renewable additions on its reuse potential is required to be able to assess the renewability of a product.

Wooden flyover

© Achterbosch Architecten

The two bridges over the A7 motorway near Sneek are the first flyovers in the Netherlands to be made of wood. They are also suitable for heavy traffic. This type of road bridge is normally made of concrete or steel, because wood is not strong enough. However, using a special type of wood (Accoya acytilated wood) and prestressing the wooden girders made it possible to construct these strong wooden flyovers.

Circular flyover

© Rijkswaterstaat, Sem van der Wal

The circular flyover consists of individual modules that can be threaded together both in the span direction and across the width of the flyover by means of a prestressing cable. Although this initially requires more raw materials than a flyover of a traditional design, disassemblable connections and a modular construction enable the flyover to be broadened in due course. The flyover can also be reused elsewhere in completely different proportions.

Hotel Jakarta

© Hotel Jakarta Amsterdam

The 30-metre high main load-bearing structure of Hotel Jakarta is made entirely of wood. The beams, columns, ceilings and door and window frames are made of wood of sustainable origin (FSC/PEFC label). Because of the quality of the wood, no finish was applied to most of the wooden walls and ceilings. This reduced the use of materials, kept the timber construction system clearly visible, and ensured that all finishing materials can be reused after disassembly.

7 Results, recommendations and follow-up steps

7.1 Results

This guide describes methods and tools that designers and other professionals involved in the design process can use to elaborate and implement the project-specific circular ambitions during the design process.

This guide thus builds on the original July 2021 version (Circular Design Action Team, 2021). Practical experiences with the first version were mostly positive. At the same time, we learned that the guide should contain more concrete guidelines and practical tools for certain aspects. For instance, we opted to give concise and useful descriptions of the design strategies. We also paid a lot of attention to visualising the dynamics of the design process and the interrelationships of the design strategies, to enable a bespoke strategy to be derived for specific projects. This has led to a 'hands-on' 2.0 guide that actually supports design teams and provides practical help.

The guide contains the following three key chapters. The Basic principles chapter describes how design teams prepare the design process and emphasises the important technical, legal and financial aspects that require attention when translating the circular ambition into design strategies. The Roles and collaboration chapter explains how the design team can achieve proper coordination with non-design roles in the construction process. It shows how the collaboration wheel can be used to map an ecosystem of roles and responsibilities of the actors involved.

Chapter 6 Design Strategies deals with seven strategies, divided into four themes. The designer can also use a roadmap to go through the strategies from the four themes step by step and achieve a project-specific bespoke strategy.

7.2 Recommendations

When drafting this second version of the Circular Design Guide, the practical experiences gained from using version 1.0 were taken into account. This guide will also have to be tested in practice.

It is our opinion that organising another round of improvements is not a logical step now. The main thing now is to successfully implement the guide in daily practice. We are making the following specific recommendations (in a more or less random order), realising that the feasibility of some of our recommendations will depend on the follow-up to CB'23 and various other initiatives:

- Translate the guide into English. This will increase the accessibility of the guide both abroad and in the Netherlands. After all, designing and building means working together in many languages.
- Align the content of the Circular Design guide with that of the other CB'23 guidance documents. The Circular Design guide can play a central role in this and refer to all other guides, since the design process plays a central role in achieving circular project ambitions.
- Replace the guide in pdf form by a web application. The interactive web application should allow even easier access to the content. Designers are visually inclined; the web application should take this into account. The web application can be used to share success stories, experiences, knowledge, findings and developments that will then benefit the use of the guidance.

- Devise a communication strategy that informs and convinces different stakeholders. Identify representative target groups (education, (public) clients, interest groups such as BNA, Techniek NL, etc.) and bring the guideline to their attention. Ask them to disseminate and promote the guide through their channels. Encourage integration of the guide through circular approaches that people usually apply: teaching materials, actions, etc. In other words: use the guide as an inspiration document to improve your own manuals and procedures.
- Develop and organise workshops, seminars and training sessions to further explain the guide and discuss case studies that show the positive results that applying the guide can bring. Use the web application referred to above to provide feedback on this.

7.3 Follow-up steps

CB'23 has reached a completion stage and can only carry out some of the recommendations listed in section 7 itself:

- Translating the guide into English
- Developing a web application

As for the remaining recommendations, CB'23 will have to explore how best to accommodate them with other transition initiatives, such as the Transition Team Circular Construction Economy and Cirkelstad.

Background

Platform CB’23

Platform CB’23 was set up by Rijkswaterstaat, the Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf), De Bouwcampus and NEN (Netherlands Standardization Institute) in 2018.

Its main goal was to accelerate the transition to a circular construction sector. As indicated early on in this guide, the construction sector plays an important role in the transition to a circular economy. The activities of the platform take place in conjunction with the national implementation programme, the Transitieteam and Transitiebureau Circulaire Bouweconomie (Transition Team and Transition Agency for Circular Construction Economy). By extension, the platform is linked to the Dutch Bouwagenda (Construction Agenda).

The precise form the transition to a circular construction will take is still unknown. This is something the construction industry as a whole will have to work out. The development of this guide is a good example of this.

Development of the Circular Design Guide

Participants from all over the sector were engaged in revising the 1.0 version of the 2021 guide. NEN set up an action team for this. Many companies and organisations responded to the call to take part in this action team. The participants were selected to ensure a diversity of disciplines and perspectives.

The action team subsequently formed working groups. These working groups studied the three main topics from the first version of the Circular Design Guide:

- Basic principles
- Roles and collaboration
- Circular design

Whenever the revision of the guide reached a new stage, the results were presented to the action team members. The action team members provided feedback on these results during these joint and partly digital sessions. This method should lead to buy-in and support.

The kick-off meeting for developing guide 2.0 was held on Tuesday 1 November 2022. In total, the action team met four times. The working groups met several times.

Support team

Platform CB'23 set up a support team to coordinate the process. This support team consisted of a chair, a coordinator, core team members, a reporter and a working student. The chair led the action team and working group meetings. The coordinator representing NEN ensured that all meetings went smoothly and monitored the progress of the guide. NEN's working student was involved in improving or designing a number of images. The rapporteur's task was to compile the information provided by the members of the working group and the core team into an accessible and readable document.

Guide during the consultation round

The guide was published when it was 80% ready. Anyone could download this version and then give feedback.

After the end of the consultation round, the working group members discussed the feedback and, where necessary, incorporated it in the guide. If you have submitted any feedback and you cannot find it in this final version of the guide, please contact Platform CB'23 for further information.

Action team members

The Circular Design Guide 2.0 is the result of the efforts of the 2020-2021 Circular Design Action Team and the following members of the 2022-2023 Circular Design Action Team.

André Dröge, DCB Advies

Arie Mooiman, KNB Keramiek

Charlotte Heesbeen, Itmoos

Dennis Strijards, Heijmans

Dirk Vroegindeweij, Windesheim University of Applied Sciences

Edwin Zoontjes, Dutch Association of Demolition Contractors

Egbert Broerse, Ballast Nedam

Emma Klamer, Aveco de Bondt

Eveline Stroink, Sweco

Fenauw Hoppe, AT Lawyers

Frido van Nieuwamerongen, Arconiko architecten

Hans Wamelink, TU Delft

Jans Kruit, Rhdhv

Judith Boersma, Sweco

Karel Terwel, TU Delft / IMd Raadgevende ingenieurs

Louk Linders, HEVO

Marc van den Berg, University of Twente

Mark van den Putte, City of Amsterdam

Mark van der Vliet, HEVO

Martin Huiskes, Lksvdd architecten

Rik van Rijckevorsel, EGM

Roger Feller, BLM Wegenbouw

Stefan Dannel, TNO

Torsten Schröder, TU Eindhoven

Yaël Ben Basat, iCircl

Core team

Hans Wamelink, Chair

Charlotte Heesbeen, prime mover for the Design strategies working group

Marc van den Berg, prime mover for the Roles and collaboration working group

Roger Feller, prime mover for the Basic Principles working group

Hans Ouwerkerk, Rapporteur

Support

Nan van Oldenbeek, Coordinator, NEN

Sandra Jansen, Project Employee, NEN

The Circular Design Action Team that supported the Circular Design Guide 1.0, 2021, consisted of the following members:

Name and company

Adrie van der Burgt, Heijmans

Anne Struiksma, Nieman Raadgevende ingenieurs

Arend van de Beek, Lagemaat Sloopwerken

Bauke Geuzebroek, Knauf

Caroline Kruit, DAX Creative Company

Catherine de Wolf, TU Delft

Cincy Vissering, Betonhuis

Daan Schraven, TU Delft

Daan van Krevel, Studio DVK

Egbert Broerse, Ballast Nedam

Els Zijlstra, Material MatchMaker

Evert van Vliet, BAM Infra

Fenauw Hoppe, AT Lawyers

Frido van Nieuwamerongen, Arconiko architecten

Frits Schultheiss, HAN

Ger van der Zanden, Smart Building Design

Hans Wamelink, de Architekten Cie.

Herman Beeke, Kuipers

Hermen van de Minkelis, Sloopcheck

Jim Teunizen, Alba Concepts

Maarten de Moel, BAM Infra

Marie-Sophie Res, Alba Concepts

Marijn Emanuel, W/E adviseurs

Mark van der Vliet, HEVO

Martin Huiskes, Lksvdd architecten

Noortje Alders, ISSO

Quirien Reijtenbagh, Stichting Insert foundation

Rob Dijcker, Witteeen+Bos

Roger Feller, Kragten

Rogier Joosten, StudioR

Simone Hellebrand, Rijkswaterstaat

Stefan Dannel, TNO

Tristan Frese, Schrijf Groep

Vincent Swinkels, VSSS

Willem Stevense, Wearchitects

Yaël Ben Basat, iCircl

Core team

Hans Wamelink, Chair

Charlotte Heesbeen, prime mover for the Design strategies working group

Marc van den Berg, prime mover for the Roles and collaboration working group

Thijs Huijsmans, prime mover for the Preconditions working group

Hans Ouwerkerk, Rapporteur

Support

Finbarr McComb, Coordinator, NEN

Sandra Jansen, Project Employee, NEN

Annex I Checklists

Checklist for the design team

We created a checklist for the design team. The goal of this checklist is to assess which factors in the preliminary pathway can influence a circular design.

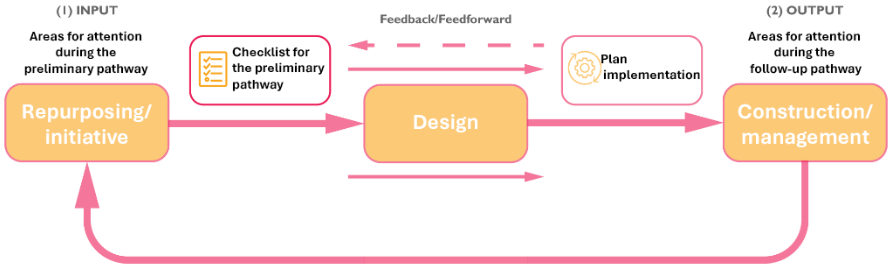


Figure 14 - Position of the checklist in the process

This checklist is consistent with the design strategies in Chapter 6. The checklist shows whether there are any critical areas of attention that pose a potential threat to a successful circular result.

Table 5 – Checklist with areas for attention for the preliminary pathway

		Prevention	Quality and maintenance	Adaptability	Disassembly potential and reusability	Reused parts of constructions	Secondary raw materials	Renewable raw materials
Government	Make the connection with the implementation of programmes that qualify as energy and circularity, including the Dutch Van het gas af, Woondeals, MIRT, Citydeal and Greendeals programmes. Also study the programmes/ambitions of the local government.	✓	✓	✓	✓	✓	✓	✓
	In case of projects (and tenders/public works contracts), take the time to study the key performance indicators (KPIs) for sustainability and circularity prescribed by the local or national government.	✓	✓	✓	✓	✓	✓	✓
Legislation and regulations	Ensure clear allocation and division of liability and risks, and insurance terms and conditions.		✓	✓	✓	✓	✓	✓
	Check whether materials released (e.g. during demolition work) are qualified as waste. If so, check whether 'end-of-waste criteria' have been established for these secondary materials and how the materials can be incorporated into a new design.		✓	✓	✓	✓	✓	✓
	Find out who owns the property rights, including the intellectual property rights, to secondary materials and explore whether contracts leave room to allow for those used materials to be reused.		✓	✓	✓	✓	✓	✓
	Take the financial feasibility into account of a design where many secondary materials are used, for example because of the relatively high labour, tax, and other costs, including the CE marking required for making those materials suitable.		✓	✓	✓	✓	✓	
Financial institutions	For circular projects, encourage another type of funding from the market, centring around the determination of TCO, the residual end-of-life value of materials.		✓	✓	✓	✓	✓	✓
	Describe/design real estate and/or its value in a way that focuses less on the object itself, but more on the composition of and linkages between the circular and other materials and products.		✓	✓	✓	✓	✓	✓

		Prevention	Quality and maintenance	Adaptability	Disassembly potential and reusability	Reused parts of constructions	Secondary raw materials	Renewable raw materials
Users in the buildings and civil and hydraulic engineering sectors	Give instructions on how to use and maintain the building (owners' association administrators, facility management, tenants) and ensure proper information transfer (seller, estate agent, maintenance party) at the time of handover.		✓	✓	✓	✓	✓	✓
	Take the social costs and benefits (SCBA) for end users into account when assessing the value of infrastructure works with local, provincial or national governments.	✓	✓	✓	✓	✓	✓	✓
	Check the relevant municipal criteria for the external appearance of buildings for any aspects that concern or may concern circular developments.	✓	✓	✓	✓	✓	✓	✓
Client	Start from the basic principle that value of existing real estate should be retained as much as possible, and replace only those products and materials that really need replacing.	✓						
Engineers and consultants	Agree that testing methods must be risk-based and must allow for secondary materials and innovative concepts (performance, warranties, uncertainties, risks, legal).	✓	✓	✓	✓	✓	✓	✓
	Have equivalent items assessed centrally by an expert panel. An example of such a panel is the CROW knowledge platform that carries out these assessments for infrastructure, public space and traffic and transport.	✓	✓	✓	✓	✓	✓	✓

Implementation plan checklist

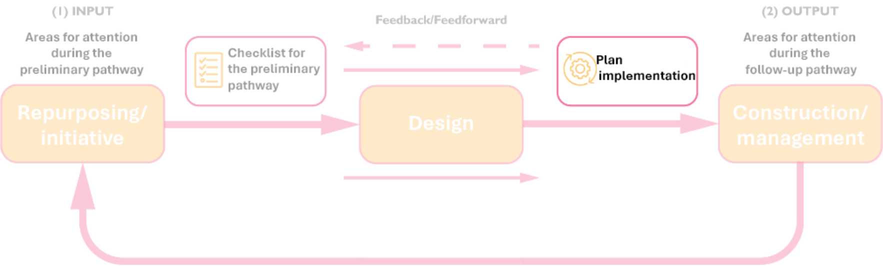


Figure 15 - Position of the implementation plan in the process

Project: ….
Prepared by/Person responsible: ….
Transfer phase cf. STB: … e.g. design ready for construction
Annexes: …, URL Consumentendossier ...

Key to the roles:

- ■ Initiators
- ■ Consultants
- ■ Practitioners
- ■ Inspectors
- ■ All/t.b.d.

Table 6 – Implementation plan for the follow-up pathway of a circular design

For all circular design strategies	
Generally during the follow-up pathway	■ Designers should address change attitudes (resistance) by remaining accessible for education and questions. ■ Include the TCO estimate made as an annex to the design.
Construction (building construction and installations)	■ Strengthen the position of product suppliers vis-à-vis the practitioner by involving them in design themselves. ■ Invite builders for advice on implementation during the circular design phase. ■ After the design phase, also follow the priorities/goals set during the construction phase.
Construction (building construction and installations)	■ Screen prospective builders/building partners for the reduction target.
Producers and suppliers	■ Provide disassembly instructions along with the instruction to post a product notification on a platform.
Maintenance/ management	■ Unambiguously record design choices in maintenance plans and circular long-term maintenance plans. ■ Actively involve management and maintenance in the design process.

Transport and storage of secondary materials	■ Go for zero-emission transport during construction and demolition work. ■ Map an object's composition early. During the project: make use of extra time to find additional buyers. ■ Reduce storage by finding a new purpose/new owner prior to disassembly. ■ Offer at an early stage, on platforms or through your own outlet or sales channel/refurbishment. ■ Offer more take-back schemes.
Passports	■ Start with a quick scan of the parts present at element level and, where possible, at construction product level in accordance with the decomposition in NEN 2767 (from the Passports for the Construction Sector guide). ■ Create a materials passport and save it in the database. Lay down connections between building parts in the passport. ■ Record any deviations to create a Digital Twin. ■ Prepare draft or final demolition specifications during the design.
Platforms	■ Support the development of 'mature' platforms with sufficient scale to absorb supply and demand. ■ Link data in the database to marketplace platforms (or make sure this feature is possible in the future). ■ Go for active supply and demand of released materials, both inside and outside the project. ■ Offer building materials in addition to construction products. They are often easier to process.
Knowledge transfer	■ Introduce a circularity team and/or manager to assure circularity in the organisational culture.

	■ Provide end of design phase/findings feedback together with programmes and area visions. ■ Provide information on how to properly install and repair products/materials (information requirement).
Users (handover)	■ Provide user instructions together with the design.
Users (handover)	■ Provide user and disassembly instructions (mining plan) when providing the design.
Prevention (section 6.4.1)	
Maintenance/ management	■ Record choices and changes in an underlying vision/underlying plan (A. Prevent) and/or Digital Twin (D. Optimise).
Transport and storage of secondary parts of constructions and/or raw materials	■ Disclose/Provide access to available depots/refurbishment workshops (hubs) by region (for C. Material value).
Users (transfer)	■ Organise sharing and/or flexible/multiple collective use (while taking adaptability into account (B. Future value).
Design for quality and maintenance (section 6.4.2)	
Maintenance/management	■ Implement management in line with the original design philosophy. Transfer it via the file from the design phase, or look it up when starting a new management cycle.

Design for adaptability (section 6.4.3)	
Construction (building construction and installations)	■ Include how reused materials may be harvested in the main calculation for safety and structural safety. ■ Support suppliers in their responsibility for product liability.
Maintenance/management	■ Apply materials in the proper layers (of Brand) and apply products with replaceable parts. ■ Implement management in line with the original design philosophy. Transfer it via the file from the design phase, or look it up when starting a new management cycle.

Design for disassembly and reusability (section 6.4.4)	
Construction (building construction and installations)	■ Assure the recording of structural characteristics of the parts to be reused, incl. the aspects of time/ageing/best before date. ■ During the design phase, enter into contracts with suppliers that take back products.
Maintenance/management	■ Apply materials with reuse in mind. ■ Implement management in line with the original design philosophy. Transfer it via the file from the design phase, or look it up when starting a new management cycle. ■ Explore options for reuse.
Transport and storage of secondary materials	■ Arrange/budget space (on the actual site, during the lifespan, or externally with 'market') to properly store released building parts.
	■ Align supply and demand for secondary materials well in time (from the initiative phase by notification on a platform).
Platforms	■ Designers should use the marketplace platforms that show available stocks of materials. ■ Carry out project-specific stock-taking of materials specifically for the project in question if this information is not available. ■ Include reuse of local material stock in tender criteria. ■ Ask and/or offer listings of materials and substances, digital marketplaces and local logistics hubs for circular area development.
Maintenance/management	■ Apply materials in the proper layers (of Brand) and apply products with replaceable parts.

Design with reused parts of constructions (section 6.4.5)	
Generally during the follow-up pathway	■ Make mutual agreements on warranties when applying materials directly without any modifications.
Transport and storage of reused parts of constructions	■ Engage (additional) parties that offer refurbishment. ■ Facilitate regional logistics efficiency with storage facilities if needed.
Platforms	■ Set up concrete circular chains for material and raw material flows locally and facilitate refurbishment and high-quality recycling.

Construction (building construction and installations)	Include how reused materials may be applied in the main calculation for safety and structural safety. Support suppliers in their responsibility for product liability.
Maintenance/management	Apply materials in the proper layers (of Brand) and apply products with replaceable parts.
Design with secondary raw materials (section 6.4.6)	
Generally during the follow-up pathway	Make mutual agreements on warranties when applying materials directly without any modifications.
Construction (building construction and installations)	Include how reused materials may be applied in the main calculation for safety and structural safety. Support suppliers in their responsibility for product liability.
Producers and suppliers	Give warranties for products with a high recycling content or made from recycled materials.
Maintenance/ management	Apply materials with a technical residual lifespan.
Transportation and storage of secondary materials	Separate on site and avoid emissions when separating. This ensures cleaner waste flows (logistics, equipment, post-separation traceable). Engage (additional) parties that offer refurbishment. Facilitate regional logistics efficiency with storage facilities if needed.

Platforms	Set up concrete circular chains for material and raw material flows locally and facilitate refurbishment and high-quality recycling.
Maintenance/management	Apply materials in the proper layers (of Brand) and apply products with replaceable parts.
Design with renewable raw materials (section 6.4.7)	
Construction (building construction and installations)	Apply materials in the proper layers (of Brand) and apply products with replaceable parts.
Maintenance / management	Utilise maintenance interventions for circular improvements, checking the design/file.

Annex II Roles and competences

Table 7 – Summary of roles and competences in the Initiators category

Roles	Description	New in the circular process
Investor	Invests in the development of constructions for sale or rental.	Has an interest and a stake in an area development and the marketability of the real estate, which is influenced by possibilities for changes to functions or easy adaptability.
Developer	Develops or buys a construction for sale or rental.	Develops and procures for optimum quality, not for the lowest price, based on new business cases, protecting materials, the environment and value. There is a new revenue model where the collateral increases in value through rising materials and environmental value, regardless of the real estate value. Possibly new competences to develop more than just a construction.
Private client	Develops or buys a construction for own private use.	
Professional client	Develops or buys a construction for own professional use.	
Government client	Develops or buys a construction for public use.	
Circularity champion	Puts circularity on the map for the project, and asks for corresponding ambition.	Enthuses the project team about circular construction, provides appealing examples. Makes sure that the objective of circular construction is never lost sight of.

Roles	Description	New in the circular process
Funder	Finances and provides credit for investors, developers, private, professional or public clients, with their risk profile being covered by the value of the collateral based on asset value.	Represents the importance of the residual value, which can be positively affected by, for example, disassemblable components of a building. Provides money on condition that materials value rises independently of real estate value. Predicts the adaptive value of a construction and carries out a financial evaluation. Potentially generates new competences for cross-building development. Supports the initiator(s) in preparing new business cases, with assurance of materials, environmental impact, value creation and value retention.
Occupant/user	Uses, rents or buys a construction to be developed.	Involves functional requirements in the initiative and design phases for added value creation. Gets a functionally more appropriate or more flexible project in return for this. Professional resident/user representation on the design team may be a new role or competency.

Table 8 – Summary of roles and competences in the Consultants category

Roles	Description	New in the circular process
Technical consultant (architect, engineer, installation consultant, building physics consultant)	Translates the requirements into feasible variants, e.g. a building or infrastructure design.	Creates modular, disassemblable and reassemblable designs based on existing circular methods in consultation with subcontractors, predicts adaptability and gives information about the origin and duration of material. Integral collaboration between the designing parties is crucial in order to be able to input all the necessary information into a coherent overall design.
Financial consultant (cost estimator)	Monitors the budget of the construction to be constructed.	Integrates the costs of construction with the budgets for reuse, operation and future residual value. Provides projects with new forms of trade and leasing opportunities of secondary and other materials and products.

Roles	Description	New in the circular process
Process/project manager	Monitors the process planning.	Matches supply and demand of necessary and available material and product flows and ensures timely supply and/or delivery of secondary materials. Evens out the profit and risk allocation between the commissioning and contracting parties in the complex field of different interests, for the common good.
Circularity manager	Is responsible for the circularity team and directs actors from the development team (initiative, design and construction) based on the circularity objectives for the project.	Coordinates the substantive choice of circular strategies and safeguards the trade-off between the protection of materials, the environment and value. Is on the project's management team. Safeguards circularity in the project through quality and/or quantity reviews at defined points in time (e.g. at the end of a phase). Is also an inspector in this capacity (table 10).
Procurement consultant	Gives advice on how to procure and supervises and coordinates the procurement process for the client.	Procures for the client. Assures the application of a circular business model (cross-structural).
Environmental consultant (ecologist, biologist, toxicologist, LCA consultant)	Advises the design team on environmental impact.	Identifies environmental values, translates them into financial values and integrates them into the business case.
Communications consultant	Takes care of and monitors communications from/to project parties, building users and general PR, maintains the project website and social media, in order to propagate circularity and create/increase buy-in and support.	Shares public project knowledge and increases involvement of building users and other stakeholders. Ensures and monitors transparency in internal (e.g. building users) or external project communications.
Social consultant (anthropologist, sociologist)	Advises initiators and the design team on social impact.	Identifies social values, translates them into financial values and integrates them into the business case.

Roles	Description	New in the circular process
Executive consultant (legal, financial, insurance consultant)	Advises initiators and the design team on legal, financial and insurance aspects	Provides advice and develops models and preconditions in order to safeguard materials, environmental impact, value creation and value retention
Data miner (digitiser)	Collects detailed data on existing constructions.	Gives advice to the development team, preferably from the initiative phase, to maximise the team's understanding of promising circular developments. This role can also be taken up by demolition companies or specialised materials traders (see Contractors).
Materials passport consultant	Gives advice on obtaining a materials passport.	Supports contractors and designers on the choice of materials and construction methods by providing information on materials and construction methods.

Table 9 – Summary of roles and competences in the Contractor category

Roles	Description	New in the circular process
Contractor	Constructs the construction as designed within a predetermined time and financial budget.	Integrates, acts as an intermediary, assembles and takes responsibility for combining various materials and products into a construction. Performs based on quality agreements. Is preferably appointed right from the design phase to contribute to feasibility and affordability in the design process.
Supplier	Supplies the necessary elements for a construction.	Offers products for a defined useful life, helps ensure the disposal and reuse of its own products in a successive cycle and also offers refurbished products.
Producer	Produces raw materials, materials, products and construction elements for a construction.	Works together with suppliers in recovering and reusing its own construction elements, products, materials and raw materials. Also increasingly focuses on refurbishing existing construction parts. A new

Roles	Description	New in the circular process
		competence will be inspecting existing products for new certification and reuse.
Administrator (maintenance party)	Is responsible for or provides service (or external service) for maintaining a construction.	Works together with suppliers, contractors and/or consultants to extend the lifespan and useful life of a construction, keep the construction reusable or make its parts replaceable before the end of the construction's lifespan
Demolition company (materials/product miner)	Dismantles and removes existing raw materials, materials, products and construction elements for reuse.	Ensures that the dismantled or removed materials and products can be put to high-quality reuse.
Materials trader	Provides storage capacity and trades in secondary materials.	Offers storage for future released products and materials for reuse in collaboration or in competition with suppliers, manufacturers, materials/product miners. Ensures the logistic distribution of material flows to be reused.
Leasing company (materials and products)	Enables temporary use of (new) circular materials and products together with or for manufacturers and suppliers of reusable construction elements, products, materials and raw materials.	Actively informs and supports investors, financiers and cost estimators about opportunities of leasing products due to the relatively new form of service provision.
Insurance company	Insures constructions during the use phase.	Offers – together with contractors, suppliers and manufacturers – insurance products that make the use of secondary materials, products and construction elements feasible.

Table 10 – Summary of roles and competences in the Inspectors category

Roles	Description	New in the circular process
Regulator	Develops valuation and assessment systems.	Develops systems and tools for the valuation of secondary material by establishing standards, labels, quality marks or margins of deviation, integrating them into regulations and making them applicable for materials traders.
Regulations inspector	Carries out checks for minimum legal requirements and grants licences.	Establishes laws and regulations that encourage and facilitate reuse of existing areas and constructions and new circular development by rewarding circular development processes and sanctioning linear development processes. Extends equivalence for non-standardised licensing pathways. Prepares zoning plans that anticipate adaptability of constructions. Coordinates with the Dutch Building Quality Assurance Act (WKB) and checks compliance.
Certifier	Certifies materials, products and construction elements.	Also certifies secondary materials, products and disassembly and reusability of construction elements in a successive cycle. Needs agreement with manufacturers, suppliers, contractors, maintenance parties and insurance companies for this.
Performance inspector	Measures environmental, structural, lifespan, energy, safety and building physics performance.	Measures materials, environmental and value protection performance. Estimates performance based on design. Ensures the relationship between digital and physical reality. Establishes performance after completion and handover of a construction, on an annual or longer term basis during use and after transformation or removal. Monitors after the different phases have ended.

Annex III Mapping of roles for the individual strategy

To make sure that a proper ecosystem is set up (section 5.2), this annex lists the design strategies and the considerations that may lead to a role or an actor in the ecosystem being identified or designated. In the traditional linear process, the considerations are located in the phase before the design phase. Design strategy considerations form an iterative process within the circular *design* process.

The lists of considerations given are comprehensive but not exhaustive. If other considerations not identified here are suggested during a brainstorm session, they can be added by means of a role and they can be a reason to invite a specific actor. Each role comes with its specific responsibilities and powers. They have to be fulfilled by the actor in question. As indicated in Chapter 5, it is not uncommon for actors to have multiple roles and therefore the roles with their respective responsibilities and powers must be clearly and multilaterally defined for each actor within the project team.

When transitioning to the next phase (e.g. design phase to construction phase), some roles pass to other actors (e.g. the role of biobased materials designer in the design phase passes to the biobased materials contractor). Roles can also change during the process (e.g. the demolition contractor gives advice on donor materials or disassembly/detachability prior to the demolition process, and becomes a supplier afterwards).

There is always a core team consisting of a number of key roles, such as those of client, circularity booster, engineer, architect, building physicist and structural engineer. Members are added to the core team depending on the strategy in question.

Design for prevention

This strategy focuses on avoiding new construction and/or the use of new materials and, if new construction cannot be prevented, on designing more efficiently and more optimally.

Additional roles for this strategy can be:

- Housing consultant: assesses whether existing constructions are a solution to space needs.
- Organisation expert: determines how much space is actually needed (and considers flexibility to avoid space and possible construction being needed in the future).
- Product supplier: determines whether all parts of a particular product and/or packaging are needed, or whether fewer materials will suffice (e.g. another size of masonry bricks).

Design with reused constructions and parts of constructions

This strategy is about reusing constructions and parts of constructions, possibly after they have undergone treatment.

Additional roles for this strategy can be:

- Data miner/materials scout: maps the availability of materials and building parts within the project.
- Urban miner (harvests materials): knows and has a good view of the market of materials and building parts available for reuse.
- Technologist/building physicist: for example, a building technologist to determine whether a building part that is to be reused still meets current technical requirements, and if not, how it can be improved. Examples are concrete technologist, fire safety expert or standards expert.
- Lawyer: deals with the differences in regulations and warranties between old and new materials.
- Facilities manager: has extensive knowledge of materials/maintenance/installations in their own existing building(s).

- Chemical engineer/materials consultant: analyses whether reused materials/building parts contain undesirable/toxic/non-degradable substances.

Design with secondary raw materials
This strategy is about designing with raw materials that have been used previously or with residual flows from another product system. These raw materials are used in construction products and other products in such a way that they replace primary raw materials.

Additional roles for this strategy can be:

- Supplier of products with secondary raw materials: coordinates and makes arrangements for the availability and quality of such products with secondary raw materials at an early stage.
- Chemical engineer/materials consultant: analyses whether reused materials/building parts contain undesirable/toxic/non-degradable substances.

Design with renewable raw materials
This strategy focuses on designing with as many building materials from renewable sources as possible. Renewable resources are grown, naturally replenished or naturally cleansed, on a human time scale.

Additional roles for this strategy can be:

- Building biologist: charts the health effects of construction using renewable materials. Besides circularity, this can be an important consideration and a reason for choosing this strategy.
- Building physicist: renewable materials are often more susceptible to moisture, mould and insects. To avoid these risks as much as possible, a building physicist can adjust calculations or detailing accordingly.
- Supplier of renewable raw materials

Design for quality and maintenance
This strategy focuses on high quality and aesthetics and the use of robust low-maintenance products and good details.

Additional roles for this strategy can be:

- Financial consultant/accountant: can think about favourable or more favourable financing if a construction has a longer lifespan.
- Facilities manager: has an understanding of building parts and finishes that are susceptible to physical, mechanical and/or chemical damage and weathering.

Design for adaptability
The basic principle when designing for spatio-functional adaptability is that a construction can meet different future scenarios with different needs and requirements.

Additional roles for this strategy can be:

- Housing consultant: looks at how a construction can be and remain as adaptive as possible to allow continued use.
- Financial consultant/accountant: if a construction is adaptive it is likely to have a longer lifespan and favourable or more favourable financing can then be considered.
- Facilities manager: understands user and occupancy needs.

Design for disassembly and reusability
This strategy pursues technical adaptability. This requires the design to enable materials to be easily mined without any damage during use (maintenance) or after use for the highest-quality reuse possible.

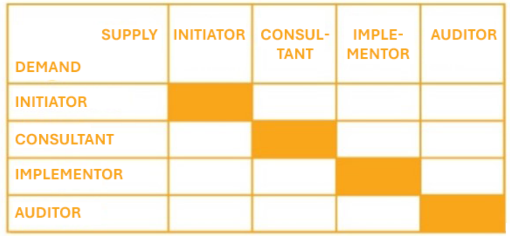
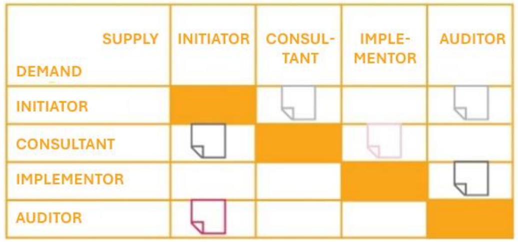
Additional roles for this strategy can be:

- Demolition contractor: if the person who has to take the building apart is already involved in the design of the building, less 'waste' will be created when disassembling the building after use

- Contractor: advises on how the building parts to be installed are best kept accessible and disassemblable.

Annex IV Step-by-step plan for agreements

Seven steps can be distinguished to make the value matrix and the information needs matrix and other tools suitable for practical use:

Step	Activity	Value creation or information provision
1	**Plan a kick-off meeting** with the design parties involved. Invite parties from all four categories mentioned in section 5.1 (initiators, consultants, contractors and inspectors) to this meeting.	
2	**Plot the parties in an empty table** at A0 size. Affix it to the wall. The parties are placed on both the horizontal and vertical axes, in the same sequence. The vertical axis represents the demand/the party that the demand has originated from; the horizontal axis represents the supply/provider. Colour in the diagonal at this point.	
3	Have each party **write down on separate post-its what value or information is needed** over a given period of time to promote circularity. This can be during one project phase. Use different colours for each phase or for each information medium.	
4	Invite each party to **stick** the **post-its in the correct columns in the empty table**. In doing so, the parties should think about who can best deliver the required value or information to them.	

Step	Activity	Value creation or information provision
5	**Discuss the result with each other**. The parties should first check that the requested value or information can actually be delivered at the desired time and in the desired form. They should also think about whether they might be able to offer more or other value or information. Adjust the matrix until consensus has been reached.	
6	**Record agreements in a document.** This forms the basis for agreements. Those agreements should also be specified over time. The value matrix provides information on what all parties contribute to value creation and value requirements, while the colours indicate at a glance when, i.e. during which phase, the interaction takes place. The information needs matrix provides information on information demand and supply, while the colours indicate at a glance how the information can be shared.	
7	**Review and update the matrix** during the circular (design) project if needs or requirements change. Suitable points in time are the transitions to other project and life-cycle phases, as these are points when the circular ecosystem changes. Keep in mind that providing specific information takes time and therefore costs money. Exchanging the proper information can save time and money at other points in the project.	

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