Guide to

Facilitating Future Reuse

Understanding obstacles and recommendations for embedding principles into building regulations

Platform CB'23

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Preface

As a society, we are on our way to creating a completely circular economy and we aspire to reach that goal in 2050. The construction industry's role in the transition from a linear to a circular economy is a very important one.

In a circular economy, materials and products are put to high-value reuse or upcycled. Of course, this also applies to construction products and structures. The need for this is underlined by the current material shortages in construction, but present-day laws and regulations have not been tailored to these principles. As a result, there is a lot of ambiguity when it comes to reuse. And what's more, it is not uncommon for legislation and regulations to stand in the way of product reuse, or for there to be no relevant laws and regulations in areas such as demolition, the determination of residual value, design requirements and product certification. This makes it hugely expensive to establish the value or residual value of products to be reused, for example, and to demonstrate that they meet new-build/alteration requirements. Providing warranties or insurance on reused products is also difficult. The current regulatory system does not encourage the fitting out of structures and construction products for future reuse and upcycling either.

This makes reuse and upcycling less attractive from an economic point of view than traditional use, i.e. the use of new materials. This guide is entitled 'Facilitating Future Reuse' and was written in order to provide tools for the further development of circular construction regulations. This explains why this guide differs from the previous guides prepared by CB'23. The action team focused on highlighting the many obstacles standing in the way of product reuse and has formulated recommendations for adapting or supplementing technical legislation and regulations and seizing opportunities for the future. In doing so, we have addressed existing structures, new-build structures and products.

This focus on legislation and regulations also makes clear that the primary target audience for this guide consists of policymakers in the Dutch Ministry of the Interior and Kingdom Relations (BZK), the Dutch Ministry of Infrastructure and Water Management (I&W), Rijkswaterstaat (RWS), NEN and various organisations that draft agreements and determination methods, such as the Dutch National Environmental Database foundation (NMD), CROW and industry organisations and certification bodies (CBs). This has resulted in a set of recommendations and instructions on how to further develop public and private building regulations.

But we should not let this keep us from reusing products and future-proofing structures right now. There is much we can already do. This guide also provides many examples and plenty of inspiration for this.

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Summary

Existing building legislation and regulations are not clear on product reuse and even lead to obstacles where existing structures, new structures and product performance are concerned. The *Guide to Facilitating Future Reuse* identifies these obstacles and gives recommendations and guidance for the development of public and private regulations.

Existing structures

When reusing products, it is important to know about their condition. This information is typically made available as early as during the management and maintenance phases of structures (both in the buildings sector and the civil and hydraulic engineering sector). However, in practice, the reusability of products is considered scarcely or not at all when carrying out maintenance inspections or structural reassessments. Although there are many different guidelines and standards relating to these products, none of them provide any insight into the reusability of these products and feasibility in actual construction practice.

For reuse to become the standard, explicit and preferably generic agreements will have to be laid down in the regulations. This includes the properties that used construction products should have to ensure that the structures in which they are installed comply with regulations. Unambiguous agreements are required for assessing the quality of used products. A guideline, e.g. a NEN standard or an NTA, subject to public law, might be drafted for generic rules. This would then allow quality assurance to be developed. Marketplace certification can then tie in with this. The current guide provides pointers for quality assessment, but also concludes that this can be done generically only in part. Particularly where it comes to construction applications, the relevant product groups will need to develop specific rules to assess the quality of existing products for new applications.

The Dutch Buildings Decree (Bouwbesluit) should also explicitly include reuse alongside new build and existing structures. For example, more clarity is needed on quality assessment and on the use of quality declarations and possible exemptions from rules on new builds.

The MPG, a Dutch acronym for MilieuPrestatie Gebouwen (Environmental Performance of Buildings), must be calculated when designing and constructing a building. The civil and hydraulic engineering sector uses the ECI, the Environmental Cost Indicator, for this. The MPG and ECI are rooted in the Dutch Bepalingsmethode milieuprestatie bouwwerken (Determination method for the environmental performance of structures) and the associated Nationale Milieudatabase (National Environmental Database), stating the environmental performance of products. The determination method provides for the consideration of products to be reused. The model-based rules work in outline, but can further facilitate reuse through generic implementation of what is known as the ‘H-factor’ (reuse factor; *hergebruiksfactor* in Dutch) in the NMD and calculation tools. This allows for the valuation of reusable products and a transparent representation of them for low-threshold application.

New structures

New structures must be adaptable to future use. The more flexible the design of structures is (both in the buildings and civil and hydraulic engineering sectors), the greater the probability that the construction products and construction elements can be reused. Modular and standardised construction can support this. Flexibility mainly relates to the extent to which a structure allows for adaptations to user requirements and wishes. Adaptability may be desired in terms of layout, sale, expansion and change of function. Modular construction, where producers manufacture parts of a structure in a factory, requires a certain degree of standardisation. A major challenge in modular construction is finding the optimum balance between flexibility (‘everything’ is possible)

and standardisation (not everything is possible). The following solution was found for IFD in the civil and hydraulic engineering sector: the dimensions of connections are always the same, but the elements that are connected to them can be highly diverse. This might also be a solution for the buildings sector.

'Detachability' is a frequently used word in the context of the circular economy. Detachability is mainly considered to be a means of enabling reuse. It is about designing a structure in such a way that it can be easily taken apart again. Detachability is, however, not a term used in legislation and regulations. This makes sense, because detachability is only a means, and not an end in itself. To encourage detachability during, for example, the design process, this should preferably be standardised through standards and NTAs. For this purpose, knowledge can also be exchanged between the buildings sector and the civil and hydraulic engineering sector. It will then be easier for clients pursuing reuse to refer to standards.

In order to encourage future reuse, it is important that various scenarios for maintenance, replacement, reuse, adaptability, etc. are considered as early as during the design phase. This should also become a mandatory element of the 'application for an environmental permit', via the upcoming Besluit Bouwwerken Leefomgeving (Environment Buildings Decree) if possible. In fact, it looks like it will not be necessary to include specific requirements in the Building Decree, since new structures are already required to meet sustainability requirements. Consequently, future-proof structures with reuse potential will score better for this aspect.

Product performance

The requirements we place on products and materials tend to be based on one-time use in a structure. At present, products do not have to meet any performance requirements specifically related to subsequent cycles. Developing product performance requirements for subsequent cycles will enable such requirements to be defined, make them part of the design and provide information when assessing the reuse of materials from existing structures. However, the development of these requirements for subsequent cycles is not something that will happen automatically. Development has already been set in motion for some product groups (such as concrete, steel and façades) and by some pioneers. To achieve uniformity and further stimulate the market, a horizontal national guideline will need to be drafted. This guide is a first effort in this direction. Specific product groups, yet to be defined, might help further develop or test this guideline. Of course, due to future European harmonisation, these efforts will have to be aligned with European developments concerning the CPR and standardisation in CEN TC350 SC1 on circular construction.

Producers play a major role in developing product performance requirements for subsequent cycles. In addition to technical performance for subsequent cycles, producers will need to reduce the ECI from the perspective of product use in multiple cycles and already put arrangements in place for the use of secondary and renewable materials. They will need to take responsibility for this themselves or have obligations imposed on them for the products they market. It should also be possible to introduce an obligation through extended producer responsibility (EPR), as already used in other sectors, for construction products. Pending that obligation, guidelines are needed for defining the specific technical aspects producers need to manage.

In addition, setting requirements for products could be relevant for encouraging circular construction. This guide identifies possible requirements in terms of the percentage of secondary raw materials ('recycled content') and for stating possibilities for future reuse. At present, there is little legislative incentive for producers to use secondary materials and close their own cycles. It should be noted that efficiency according to the CB'23 *Measuring Circularity* guide is the guiding principle here. In other words, the use of secondary materials should result in the protection of material stocks and a reduction in environmental impact (ECI).

Results

The main focus of this guide is to facilitate reuse through regulations. An action list of recommendations for adapting or developing technical regulations is provided as a 'tangible' result of this guide. The action list considers both public legislation and regulations and technical standards, as well as private tools and certification to reward those leading the way and thus help the market move forward.

The most urgent priorities are (1) the development of generic rules in the form of, for example, an NEN standard or an NTA for the quality assessment of products to be reused from existing structures, and (2) explicit clarification of the concept of 'reuse' in the Dutch Building Decree and investigation of how reuse can be further encouraged by adjustments to the Building Decree. This is because quality assurance professionals need more reference points for reused products, partly because of the implementation of the Dutch Building Quality Assurance Act (Wet kwaliteitsborging voor het bouwen, Wkb) in 2022, and the Environment Buildings Decree (Besluit Bouwwerken Leefomgeving Bbl) that will replace[1] the Dutch Building Decree in 2023 as a consequence of the newly introduced Environment and Planning Act (Omgevingswet, Ow).

To further encourage future reuse through the Dutch Building Decree, the priority should be investigating whether establishing the future scenarios for a structure and its products can become a mandatory element of the 'application for an environmental permit'.

At product level, the priorities are (1) developing a horizontal guideline that will allow product groups to unambiguously define and declare performance for future reuse and recycling, and (2) studying the possibilities for an EPR of construction products in further detail and establishing the technical aspects producers should provide.

Quick wins to encourage reuse with immediate effect include further facilitation in the NMD, and extension of existing standards, assessment guidelines and other guidelines on reuse.

Further actions should build on the above.

How to continue

The recommended actions are interrelated and follow a particular sequence. They make up a suite of actions that should be implemented as a whole. The follow-up to this guidance should ideally be for an organisation that sets an agenda to control and coordinate the suite, or for a team of policymakers to be given a sufficient mandate to take things forward through executive organisations.

However, this will not be sufficient to set the reuse market in motion without external involvement. An alternative approach is a separate regime for used products, combined with some type of mandatory use or a benefit when products are reused. This will be a strong incentive for the development of quality assurance and it will stimulate the market to invest in research and the verification of reused materials, activities that are currently still expensive and time-consuming. Reuse will thus become a more integral and explicit part of the MPG/ECI. A further, more experimental idea might be to allow only the use of secondary materials and reused products in construction in the future. This guide does not explore this idea. A fundamental discussion about these ideas on reuse is currently going on in the Netherlands.

[1] This guide was drafter before the implementation of the new Dutch legislation.

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 of reducing the global consumption of materials and the associated environmental impact. A circular economy thus contributes to the broad 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 expanded.

The construction industry 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 (Transitieteam Circulaire Bouweconomie 2019).

1.2 Unambiguous agreements

What the transition to a more circular construction sector should look like, and what this will require is a quest: a quest for better decisions, alternative discussions, different questions and other relationships within the sector.

The transition is already happening. Several experiments have been carried out in recent years and organisations have been gradually changing their working methods. An important next step will be collating existing ideas and experiences and using them to formulate clear-cut, unambiguous agreements. Such agreements will anchor circular thinking and actions in daily construction practice. The guides published by Platform CB'23 – about definitions, measuring, passports, designing, procurement and reuse – are a first step towards these agreements on the different aspects of circular construction.

The definitions from Platform CB'23's *Lexicon* are used in all guides. The Platform CB'23 guide to *Measuring Circularity* translates circular construction into three goals. Together with their underlying indicators, these goals enable more circular decisions to be made. How this works in practice is described in the Platform CB'23 guides on *Circular Procurement* and *Circular Design*. Evaluating a construction project in accordance with the method described in the guide to *Measuring Circularity* is only possible if the necessary data has been collected and stored during the construction process. The Platform CB'23 *Passports for the Construction Sector* guide provides guidance for this. The *Passports for the Construction Sector* guide also helps to set up a system that makes information available for a range of circular construction goals. For example, it helps future builders to reuse materials. The Platform CB'23 guide to *Future Reuse* gives recommendations for circular regulations, covering both public (statutory) and private (standards, guidelines, certification) regulations.

All Platform CB'23 guides can be downloaded free of charge from the website www.platformcb23.nl

1.3 The how and why of the guide

This guide is about future reuse and was prepared by the Platform CB'23 Toekomstig hergebruik faciliteren action team (Facilitating Future Reuse Action Team, hereinafter: the action team). A list of members of the action team can be found at the end of this guide.

In a circular economy, materials and products are put to high-value reuse and upcycled. A recent report published by the EIB and Metabolic (2022) on material flows in construction and infrastructure (*Materiaalstromen in de bouw en infra*) confirms the urgent need for this, given the current raw material shortages. Product reuse also leads to a considerable reduction of the environmental performance of buildings (MPG). However, the circular use of materials, products, elements or entire structures is often not yet put into practice because legislation and regulations, certification options or concrete tools create obstacles, are unclear or do not exist. An often-heard statement is that regulations form an obstacle to circular construction, since current regulations are geared towards a linear economy. In effect, reusability is not a focus of building regulations as yet. A structure's expected service life, safety aspects, functionality, etc. are tailored to single-cycle use. It is about time that existing building regulations were reviewed while asking ourselves what might have to be changed to enable circular use without running unnecessary health and safety risks and whilst preserving the other functionalities required.

This action team was initiated because of the need to articulate the relevant regulations and to provide tools for the further development of regulations on circular construction, i.e. public law and private law legislation and regulations (including certification) throughout the chain, covering the entire scope, all the way from the products and structures on the drawing board to the use of products and materials from existing structures. This guide provides the necessary general and performance requirements for high-value reuse and upcycling, both for today's structures and those of tomorrow in subsequent cycles.

This guide uses the knowledge from previous guides on how to measure circularity and what constitutes circular design. In turn, this guide provides inroads to give substance to the topic of 'future reuse', for example in passports and procurement, and opportunities to encourage circular design through legislation and regulations. Various previous studies and publications have also been used. They are listed at the end of this guide in the Literature section.

1.4 Structure of this guide

The action team addressed three topics in the chain for future reuse:

- High-value reuse from existing structures: public law and private law legislation and regulations and guidelines that can facilitate reuse from existing structures **(Existing structures, chapter 4)**.
- New structures[2] and considerations for subsequent cycles: public law and private law legislation and regulations that can encourage design and construction for reuse **(New structures, chapter 5)**.
- Product performance in subsequent cycles: including product performance requirements for future reuse and recycling in public law and private law legislation and regulations (including certification) **(Product performance, chapter 6)**.

Figure 1 shows the interrelations between these three subjects, each of which has been elaborated by a working group.

Chapter 7 contains the results, recommendations and follow-up action.

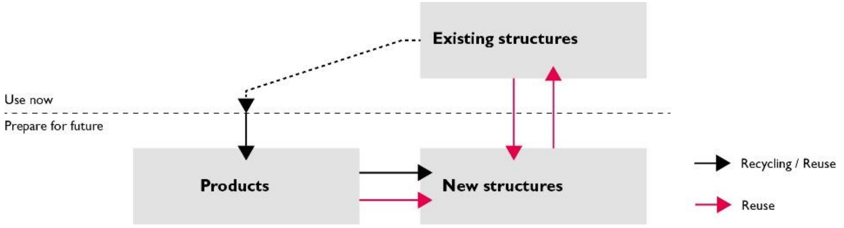


Figure 1 – Interrelations between working group topics

This guide also includes the following annexes:

- Explanation of legislation and regulations (Annex A);
- Backgrounds to the analysis of new structures (Annex B);
- Layers of Brand (Annex C);
- Backgrounds to the analysis of product performance (Annex D);
- Reuse in the Determination Method for the Environmental Performance of Structures (Annex E);
- Glossary.

[2] This also includes large-scale renovation, but that situation was not specifically considered.

2 Goal and scope

2.1 Goal of the guide

This guide explores how regulations can be improved and put to more effective use in order to stimulate the high-value reuse of building structures, elements, products and materials in subsequent life cycles. It also aims to provide tools for the further development of regulations on circularity.

By 'regulations' we mean both public regulations (legislation) and private regulations (standards, certification and other guidelines and agreements). We consider these regulations for the entire chain, from reuse of materials from existing structures all the way to the design of new structures and the application of products.

2.2 Scope

This guide focuses on the entire built environment, i.e. both the buildings and the civil and hydraulic engineering sectors. If the information provided relates to only one of the two sectors, this is indicated in the text. We have considered both existing and new-build structures. To avoid unnecessary complexity, renovation and restructuring, etc. have not been explicitly considered.

Where we use the term 'construction products', we mean only those construction products as defined by the European Construction Products Regulation (CPR) and installations. This does not include interior construction, although the circular principles for these products will be the same. We use the term 'structures' to refer to both infrastructure works constructed by the civil and hydraulic engineering sector and to structures as defined by the term '*bouwwerken*' in the Dutch Housing Act (Woningwet)[3].

The recommendations in Chapter 7 are intended for those who draft legislation, standards, assessment guidelines and other (public or private) assessment systems throughout the chain (from producer guidelines to, for example, demolition guidelines, certification and tools such as BREEAM). Clients, property owners, designers, engineering firms, competent authorities and other market players can then use the legislation and regulations for their projects and tenders. Provinces, water boards and municipalities can also use such legislation and regulations. This is all the more true for municipalities because the new Environment and Planning Act gives them extensive scope to impose requirements and rules.

In practice, there are many more factors that are instrumental when deciding whether, and in what way, reuse or recycling will take place. Since this guide cannot be exhaustive the focus is placed on building regulations. Regulations on, for example, property rights, taxes (VAT), purchase and liability are not discussed. Neither does the guide address any other aspects that can be obstacles to reuse, such as economic and financial aspects, the timing of demolition and the onward sale of materials, availability, aligning demand and supply, market development and supporting action that may be needed to promote high-value reuse and upcycling. The Transitieteam Circulaire Bouweconomie will study some of these aspects ('De circulaire bouweconomie', RVO, December 2021). Education is also important, as those who put circular construction into practice are the people on the ground, doing the work ('Leren voor morgen', 2022).

[3] When he Dutch Housing Act is replaced by the Environment and Planning Act (Omgevingswet), the Environment Buildings Decree (Besluit Bouwwerken Leefomgeving Bbl) will replace the Dutch Building Decree.

3 Basic principles

3.1 Definition of high-value reuse

This guide addresses high-value reuse in terms of the reuse of products, elements and structures and the upcycling of materials . We have used the existing CB'23 Lexicon[4] when writing this guide.

Reuse and recycling can take place at different levels, ranging from materials to a complete structure. Whether the reuse of a product or the recycling of a material qualifies as high-value reuse or upcycling is measured against the goals of circular construction over the course of several cycles. Upcycling should:

- protect material stocks;
- protect the environment by reducing environmental impact;
- achieve value retention.

The CB'23 *Measuring Circularity* guide provides the method for measuring and determining whether the reuse of a product or the recycling of a material (ranging from structures to raw materials) is efficient, i.e. contributes to the goals.

Various models can be used to achieve these goals and thus facilitate high-value reuse. The Dutch Betonakkoord (Concrete Agreement) developed the Bouwwaardemodel (Construction Value Model) for this. This is based on the assumption that materials and components retain their economic value and create value.

[4] *Reuse*: the reuse of construction products, components or elements for the same function, possibly after they have undergone treatment. *Recycling*: recovering materials and raw materials from discarded products and reusing them to make other products.

This guide focuses on increasing the *potential* for high-value reuse of products and upcycling of materials. We have not considered all possible levels of reuse and recycling, but instead have focused on product reuse, because this is still infrequent[5]:

- **Existing structures**: the reuse of products/elements being released from existing structures.
- **New structures**: the reuse of products/elements that will be released in the future from structures being built now.
- **Products**: the future reuse of products and the upcycling of materials when the products are released from structures.

For products, we consider both the reuse of products and the upcycling of materials in order to keep both options open in the future. This is because the upcycling of materials is always required for closing the chain at some point, possibly following the high-value reuse of the product.

We apply the principle that 'upcycling' or 'high-value reuse' should be at least equivalent in terms of application. The aim is that material to be upcycled should be kept within the same chain. However, in the end, the efficiency of the possible ways in which products are reused and materials are recycled will determine whether the term 'high-value reuse' or 'upcycling' can be applied. Efficiency will need to be considered in further detail when drafting legislation and regulations.

[5] Incidentally, this is also the case for the reuse of structures, but we had to limit the goal and scope of the guide.

3.2 Future reuse from a chain perspective

In legislation and regulations, the current performance requirements for 'first life' form a coherent whole throughout the chain. Introducing performance requirements for subsequent cycles will, of course, also require the same coherence. Traditionally, we place design and implementation requirements on products and materials. Nowadays, it is not uncommon for usage, management and maintenance requirements to be set on structures and products too. There are no requirements from a demolition/disassembly and reuse perspective, at least not yet.

Several types of legislation and regulations apply to the different phases in the chain (see Annex A). The requirements and preferences that can be applicable in the demolition and reuse phases should be included in or added to the legislation and regulations. Further details of this are provided in chapters 4 to 6.

3.3 Opportunities and obstacles

In a general sense, when it comes to existing structures, people are looking for the opportunities offered by the current standards, legislation and regulations that enable the reuse of products from current existing structures. When these structures were built, this was not done with an eye to allowing products and elements to be reused. When it comes to new structures and products, we are actually looking for requirements for incorporating into the design the opportunities for the later reuse of an object and the products it contains.

High-value reuse from existing structures

Since present-day legislation and regulations have not been tailored to reuse, there is a lot of ambiguity when it comes to their correct application. The obstacles identified include the following:

- Determining technical residual value (quality) is often difficult. Quality is usually assessed on the basis of requirements for new products, which is often difficult and/or costly.
- It is sometimes difficult to demonstrate that these products meet new-build/alteration requirements and how they meet structural design requirements. The equivalence provision in the Dutch Building Decree is intended for special situations and will depend on the competent authorities.
- Issuing certificates or providing warranties or insurance on reused products is therefore also difficult.

In brief, there is a need for regulations on reuse that offer a more practical approach to assessing and applying products that become available. There are opportunities here for quality assurance in respect of circular demolition, for new forms of (risk-controlled) quality assessment, and for clearer requirements for reuse,

on the condition that a structure remains safe and functional. In principle, the functional requirements for products and structures remain the same, regardless of whether a product is a reused product or not. However, a certain degree of risk can be accepted and the usefulness of the functional requirements can be reconsidered for some applications.

Furthermore, the efficiency of reuse for circular construction will continue to be the basic principle.

New structures and subsequent cycles

The current requirements for structures are geared towards single-cycle functioning. People have a good idea of what circular design for future cycles means, but the guidelines for this are fragmented or have been set out in detail for only a few specific sectors. Legislation and regulations offer few incentives for applying circular design principles. This creates opportunities for offering the market a more comprehensive and more harmonised approach.

More clarity on the range of products with properties for circular design is also desirable, as is more clarity on designing using products coming available from other structures, including the expected environmental impact benefits.

Product performance of subsequent cycles

Requirements for products are set based on the desired performance for a structure. At present, setting performance requirements for subsequent cycles is rare and, because of this, it is uncommon for construction companies to develop or provide them, a few pioneers excepted. Legislation and regulations do not promote or require the consideration of performance in subsequent cycles. Specific legislation and regulations may also apply that focus on one-off applications only – the release of hazardous substances, for example. The desire to protect people and the environment also applies to subsequent cycles, but this can be an obstacle to reuse. The use of secondary materials is not encouraged either and there may be technical reasons for limiting their use. Possible opportunities are offered by circular requirements for structures that also influence product performance, making sector-wide agreements on such performance, and further developing producer responsibility.

Here again, the efficiency of reuse and recycling will be decisive in order to establish the performance to be delivered by products. The CB'23 measurement method will be used to assess this efficiency, taking into account multiple material or product cycles.

4 Existing structures

4.1 Introduction

In this chapter, we look at the steps taken from an existing structure to the reuse application. An understanding of the standards and guidelines that apply to each step is important here. In addition, the objects, elements and materials that become available give more information on the potential for reuse.

We first describe the situation in the current buildings sector and the civil and hydraulic engineering sector. For a comprehensive overview of material flows in construction, refer to the 'Materiaalstromen, milieu-impact en energieverbruik in de woning- en utiliteitsbouw' report (2022) published by the Economisch Instituut voor de Bouw (EIB) and Metabolic. Since demolition and new-build figures are most relevant for the reuse of materials, we have used these figures as our basis. The maintenance of structures also generates considerable material flows, but these are not considered here.

We end this chapter by citing some real-life examples that provide pointers for getting started on reuse within current legislation and regulations now.

4.2 The buildings sector and the civil and hydraulic engineering sector

Buildings sector

To have an idea of the materials coming available from homes and offices, it is best to consider demolition numbers. Of all houses demolished in the period 2016-2017, 50.7 % were built before 1960 (EIB, 2019). The materials released from these buildings were mainly timber and masonry. Non-residential buildings show a different trend. Of all the non-residential buildings demolished in the same period, 60.6 % were built after 1970. The materials released from these buildings were predominantly concrete and steel. The majority of non-residential buildings are industrial buildings, followed by education and office buildings. A comprehensive overview of material flows in the buildings sector can be found in 'Materiaalstromen, milieu-impact en energieverbruik in de woning- en utiliteitsbouw' (2022).

Civil and hydraulic engineering sector

According to a study by Bloksma & Westerberg (2021), the total number of civil engineering structures in the Netherlands is 213,000. This number includes all structures, from the largest bridge in the Netherlands – the Van Brienenoordbrug – to the smallest culvert under a local road. Two types of structures stand out here. Bridges (and flyovers) account for a total of 84,573 structures with concrete, steel and timber as the main materials. The number of culverts in the Netherlands is also considerable: 82,642. Noise barriers are also an interesting type of object because of the long-term noise remediation programme (MJPG) that is scheduled for the Netherlands for the next few years. Large amounts of materials are expected to become available in the near future.

For both residential and non-residential construction, more new structures are being built than are being demolished. Consequently, even if all the materials made available through the demolition of structures can be reused, there is still not enough to meet the demand for new construction projects.

4.3 Steps

4.3.1 Introduction

Construction materials, construction elements and installations from existing structures go through several stages before reuse. The type of material, the application and/or object, element or material determines the specific legislation and regulations under public law and private law that are applicable or non-existent. The outlines of these specific aspects are discussed as individual steps of the process in 4.3.2 to 4.3.7.

Figure 2 – Steps in the process

4.3.2 Management and maintenance

A good deal of relevant information about the performance and functioning of objects, elements and materials already emerges during the management and maintenance phase of structures. This information provides an understanding of the maintenance needs and structural safety of structures. However, maintenance inspections and structural reassessments for ascertaining the reusability of materials are rarely carried out, even though they can provide valuable information regarding the reuse potential of objects, elements and materials. Depending on the type of structure and the materials used, there are many different standards and guidelines on inspection and the study of materials. Some examples are NEN 2767, CUR 72, CUR 117, CUR 121 and NEN-ISO 2859. Where the structural assessment of a structure is concerned, NEN 8700 and the Dutch guidelines on the assessment of engineering structures (Richtlijnen Beoordeling Kunstwerken, RBK) apply. None of these standards and guidelines, however, give further information on the reusability of materials and its structural feasibility.

4.3.3 Taking stock of construction materials and other materials

There are no specific standards and guidelines on how to take stock of construction and other materials and what should be included in such a stocktaking exercise – the structural and material-specific performance of objects, elements and materials, for example, or establishing the presence of harmful substances according to Article 8.9 of the Dutch Building Decree. A collective of engineering and demolition companies is considering a certification scheme and training pathway to give further substance to the act of documenting construction material stocks. Taking a broader approach to this as part of NEN 2767, specifically tailored to reuse, is an option that might be considered in this respect as well.

Alongside these inadequate technical aspects, there are no specific incentives for reuse. At present, stocktaking, disassembly for reuse and finding a market for materials still cost more time and money than a traditional demolition project. But the right impetus and more detailed stocktaking will serve as a positive stimulus for the reuse revenue model.

At present, standard contract documents / requirement specifications contain the provision that released materials become the property of the contractor. On the one hand, that may be positive in terms of reuse, since the demolition contractor knows the onward sale possibilities and can organise this efficiently. On the other hand, there are arguments for deleting this article as a default provision, so as to make clients aware that they should consider how to deal with materials and products that become available. Before deleting the article, its pros and cons should be examined in more detail. Actually, the article does not need to be included in construction contract documents at all. This is up to the client to determine, and specific agreements can always be made in consultation with the contractor.

4.3.4 Bringing supply and demand together

After taking stock of the materials and products contained in a structure, the search for a new purpose for them as reused items begins. The stocktaking should take place as early as possible to facilitate repurposing. During the design process, architects look for materials and products that they might be able to reuse in their project.

Clients with a large number of structures can look at their own construction or renovation projects when seeking to repurpose materials and products. If these offer no possibilities, they can look for other opportunities to sell released materials and products. There are several online platforms that link up the supply and demand of materials and products. The comprehensive listing of the available materials and products on one platform provides an overview of materials and products coming available near to new-build or renovation projects. That information allows architects to make a design using the materials available. There are considerable differences in the setup of and approach taken by the individual platforms and the range of materials and products offered. Certifying and centralising platforms could make a positive contribution to the impact reuse has. This can be investigated as part of the broader Dutch research into data for the circular economy under discussion. A link with 'passports' also makes good sense.

When it comes to promoting demand, a calendar of materials can help bring supply and demand together by providing information on material requirements over time.

Once a buyer has been found for materials and products, this can be included in the tender for a demolition contractor, by stipulating that the demolition contractor will have to disassemble them and offer them to the buyer, for example.

Taking stock of demand is an important step in promoting reuse of materials and products. This alignment of supply and demand is essential for achieving the best matches.

4.3.5 Demolition/disassembly

BRL SVMS-007 and the Dutch Circular Demolition Project Verification Scheme (Verificatieregeling Circulair Sloopproject, VCS) require a plan to be made for the demolition process (both for civil and hydraulic engineering and for the buildings sector). Before and during the demolition process, stock is taken of the materials and products released. This includes assessing that the materials and products as released comply with the specifications resulting from the stocktaking exercise. Once the demolition activities have been completed, an account of substances and materials is prepared according to the VCS. A certifying body verifies this account of substances and materials. This makes it possible to demonstrate how much material of a certain quality was released from a project.

The DGBC Beoordelingsrichtlijn BREEAM-NL Sloop en Demontage (DGBC BREEAM-NL Demolition and Disassembly Assessment Guideline), and, as part of that, the Slim Slopen (Smart Demolition) Tool developed by the Municipality of Rotterdam also encourage circular demolition. The Slim Slopen Tool is being updated and allows for 'measuring' the environmental impact (CO_2 and NO_x) of demolition projects.

Better information on the history, quality and removability of products when structures are being demolished would help save time and costs in the future. This can be achieved by preparing a materials passport for a structure and the products used (see also CB'23 guide *Passports for the Construction Sector*). Also refer to documents such as 'Sloopcheck, wat kunnen we leren van slopers?'.

4.3.6 Removal and storage

Since materials are generally not immediately used again upon being released, storage will usually be required. Additional sorting and selection of materials and products also takes place at the demolition contractor's storage location. Transport and storage can affect the quality of the construction product for reuse, due to the same types of products having different origins, for example. If this is the case, requirements can be set for this in the context of quality review for reuse.

Waste legislation

It should be assessed whether waste legislation applies to released materials. Items that can be reused immediately do not reach the stage where they are considered to be waste. This is the case for all elements and building parts, such as timber, doors, installations, steel sections, steel structures, concrete elements, concrete products, door frames, window frames, etc. Some materials, including stony material (rubble), are recycled. 'End of waste' applies to certified recycling granulate via a Dutch Ministerial Regulation. 'End of waste' also applies to steel sections and steel structures that can be reused. However, some flows are contaminated and subject to a waste regime, e.g. steel with asbestos or chromium 6. A waste regime also applies to insulation materials with flame retardants. This means that these flows cannot be used directly and will have to be removed as waste. Waste regulations also apply to mixed and other flows that go to waste processors. However, most materials for reuse released during demolition are not subject to waste regulations.

4.3.7 Quality assurance, from stocktaking to availability for reuse

The quality assurance of products to be reused is necessary in order to remove uncertainties or unfamiliarity among, for example, designers, contractors, quality assurance professionals or competent authorities, and to demonstrate that they meet the requirements in a new application.

A demolition contractor will first have to carry out a quality assessment. The assessment method used must be appropriate in terms of the process, the material in question and the desired application. The first quality assessment should take place while the construction element is in use in the 'old' situation, since it is possible to demonstrate its quality while it is being used.

Based on the Reuse Decision Tree, a schedule was drawn up for the buildings sector as part of an exploration of performance requirements (see Figure 3). An example for the civil and hydraulic engineering sector are the first steps taken by Rijkswaterstaat, in collaboration with Nebest as part of the Closing the Loop consortium, within the Passports for the Construction Sector process, to shortlist parameters relevant to reuse in civil and hydraulic engineering.

Figure 3 – Steps for the technical assessment of possibilities for product reuse (SGS INTRON, 2021), based on the reuse decision tree

In principle, the quality or the residual quality of products to be reused is now based on requirements for new products (step 3) and material-specific aspects (steps 4 to 8). This is often costly, hard to perform or unclear. Certification is not yet possible and it is often not possible to give any guarantees for certification.

Individual assessment methods should be defined for the various product groups but, given the diversity of materials and products in a structure to be demolished, applying such a dedicated assessment method would be quite labour-intensive. The simplest possible generic quality assurance methods, using product-specific guidelines, should therefore be looked for. A risk-controlled approach seems the most practical in this regard. If there are potential safety risks, research should demonstrate performance. For other performance aspects, default values and making a plausible case for performance will suffice (SGS INTRON, 2021). This should be set out in an NTA or a sector guideline. Recent initiatives, such as an NTA on the reuse of structural steel elements, the NEN working group ‘Hergebruik constructieve betonnen elementen’ (on the reuse of structural concrete elements) and the CROW pre-advice committee Hergebruik Betonnen Elementen (on the reuse of concrete elements) offer scope for further defining the quality assurance process at the material level, all the way from stocktaking to the reuse application.

At present, many reuse materials and products are used in structures not covered by the Dutch Building Decree. Also considering the material flows released, a method to assess steel structures and structural concrete elements should be given priority.

Product standards for newly marketed products should also define how the performance of reused products can be determined, taking safety factors into account, e.g. by providing default values for specific post-use performance. The Eurocodes should have an annex in which this is detailed, for example.

Case study
Structural engineers include recovered steel and aluminium in the new structure. The technical requirements they set for the materials are derived from EN-1090-2. Based on these requirements, a test plan is drawn up and – in this case – the client has someone carry this out. When the materials are supplied to the contractor who will perform the work, they are accompanied by the test plan in the form of a '2.2 inspection document'. This gives them the assurance that the material meets the requirements set for it in the design. The contractor can then handle the material as per their regular quality checks, checks for deformations, transport damage, etc.

4.3.8 Designing and building with products for reuse

4.3.8.1 Dutch Building Decree

When designing with reuse in mind, designers often depend on the available products and any existing information on them. The structural design of the new structure will be different from a traditional design because the properties of the elements, materials or products to be reused are not always known.

According to the Dutch Building Decree, every structure in the Netherlands must comply with safety regulations (structural safety, fire safety and other safety), as well as health, sustainability, usability and accessibility regulations. The regulations are classified into regulations for existing structures, structures to be newly built, and structures to be renovated or transformed. The Dutch Building Decree also contains regulations for construction and demolition work. To summarise: the construction materials, construction elements and installations in or on structures must both individually and in combination have the right properties to ensure that the structures in which they are or will be installed comply with these regulations. The extent to which certain properties are required depends on their use and location within a structure. Any regulations that apply to a particular use function in the structure and/or the type of structure (temporary, floating) also play a role.

Whether construction materials, construction elements and installations in or on structures comply with the applicable properties is usually demonstrated with performance declarations and a quality declaration (Section 1.3 of the Dutch Building Decree / Section 2.1.4 of the future Environment Buildings Decree). These sections of these decrees are based entirely on new, newly marketed materials and products.

The use of a quality declaration according to Section 1.3 of the Dutch Building Decree / Section 2.1.4 of the Environment Buildings Decree is usually not possible when reusing existing materials or construction elements in a structure. However, there is a possibility of equivalence and this is already being applied successfully in practice. But this equivalence is reserved for special cases. Moreover, builders are dependent on the competent authority's approval of an equivalence proposal. Some real-life examples of projects are given in 4.4. RVO will also publish a report on the application of the principle of equivalence in the Dutch Building Decree.

For circular construction and, specifically, reuse to become the standard, explicit and preferably generic stipulations will need to be laid down in the regulations. A guideline, e.g. an NEN standard or an NTA, subject to public law, might be drafted for generic rules.

Quality assurance professionals want to have reliable reference points to determine whether a structure complies with the regulations, especially since the Dutch Building Quality Assurance Act (Wkb) came into force. Products reused in their entirety do not have any performance descriptions. For the time being, generic rules can be based on, for example, the 'deemed to satisfy' principle to complement the equivalence route, and these rules can be controlled by public law. An example of a possible method to define this:

- Develop generic rules for groups of materials, construction elements and installations in or on structures that are placed on the market for reuse in their entirety, so that they will most probably have the right properties and the structures in which these materials and products are installed will comply with the regulations.
- Use the VBTWN's review matrix for categories to identify materials, construction elements and installations in or on structures that are placed on the market for reuse in their entirety. Use generic testing rules for this in the sense of expert judgement required up to and including performance characteristics of the new product multiplied by an ageing factor.

The introduction of the second generation of Eurocodes, due to replace current building regulations in all European countries on 1 April 2028, will offer opportunities for unambiguously introducing circularity in future building regulations. The new generation of Eurocodes will not only set requirements for new-build structures, but also for existing structures. These do not explicitly mention reuse, but each part of the Eurocodes must contain a national annex that regulates the level of structural safety and does not contain any conflicting provisions. If a chapter on reuse of existing elements/parts is included in every national annex during the translation and calibration period, which will take about three years (from 2025), it will be clear with effect from 1 April 2028 how reuse should be approached.

Until then, the NEN 8700 series of standards on existing buildings/alteration can stipulate how the current generation of Eurocodes can deal with safety and in particular structural safety in case of reuse[6]. The Dutch Building Decree and the underlying directly administered standards NEN-EN 1990 (series) and NEN 8700 (series) only indicate a new-build level (NEN-EN 1990) and existing structures (broken down into Rejection, Use and Alteration). A reuse level is missing here. This needs to be further developed in national annexes until there are fully-fledged standards for the reuse of various products.

The current Dutch Building Decree pays explicit attention to the rebuilding situation in relevant sections. This should also be the case for the reuse situation by addressing, for instance, the minimum safety level and how to determine this. An example of what might be proposed in this regard is that the new-build level is the target level for elements to be physically rebuilt, unless this is disproportionate. The minimum level would then be the level obtained on a legal basis. Attention should also be paid to making sure that products to be reused meet Dutch BENG (Nearly Energy Neutral Building) requirements.

[6] Just like Rijkswaterstaat, some provinces have introduced guidelines to supplement the Eurocode, e.g. ERBI. Adjustments should also be reflected in them.

In addition, the Dutch Building Decree contains several provisions on usability and user safety. Examples include minimum dimensions for doors and handrails. In the past, these dimensions were often smaller or different. The Dutch Building Decree should facilitate the reuse of materials and products in similar applications.

4.3.8.2 Guarantees

A quality assurance system forms the basis for risk control in order to give further substance to responsibility and liability, and the possibility of taking out insurance. Perhaps a system similar to the system used for recycling could be set up for reuse, with an accredited processor indicating the conditions a product must meet. If a structure is demolished, weighing receipts must be provided to indicate to which processor a product has gone. This will make the flow traceable and ensure that its quality has been assessed before processing. As far as we know, this does not yet exist for reuse.

4.3.8.3 CE marking

For the purpose of quality assurance, there is also the question of whether second-hand products should be CE marked. This is also addressed in the Reuse Decision Tree project (project Beslisboom hergebruik). CE marking ensues from the European Construction Products Regulation (CPR). The CPR concerns products placed on the European market for the first time. It does not cover the direct reuse of construction products or materials without the intervention of a manufacturer. CE marking is therefore not a requirement for product reuse, but second-hand products can be required to provide the same performance.

It is not always clear what 'without the intervention of a manufacturer' means and which operations result, or do not result, in a 'new' product, e.g. in case of repairs and maintenance, when cutting a product into parts, the use of the brand name or not using the brand name. More clarity is needed for the market.

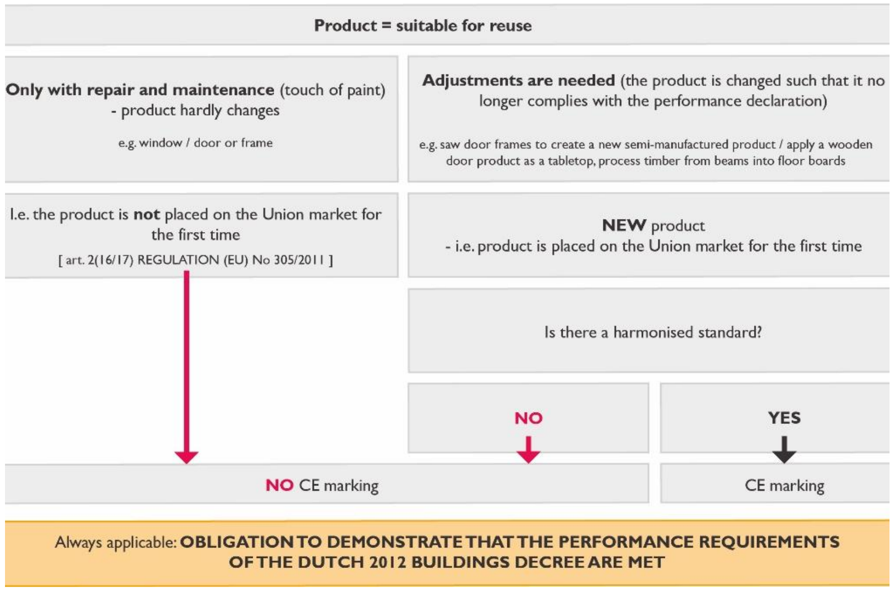


Figure 4 – Proposal on CE marking (Source: Ingenii Bouwinnovatie)

4.3.8.4 Environmental performance and reuse

The MPG, a Dutch acronym for MilieuPrestatie Gebouwen (Environmental Performance of Buildings), must be calculated when designing and constructing a building. The civil and hydraulic engineering sector uses the ECI – the Environmental Cost Indicator – for this. The MPG and ECI are rooted in the Dutch Bepalingsmethode milieuprestatie bouwwerken (Determination method for the environmental performance of structures) and the associated Nationale Milieudatabase (National

Environmental Database), stating the environmental performance of products. The determination method provides for the consideration of materials and products to be reused (see Annex E). Model-based rules, with calculations using the H-factor (reuse factor), are included for this.

The model-based rules generally work, but should be refined in some situations since the method should not be a barrier to reuse and should be pragmatic, suitable for use by demolition contractors, intermediaries or other parties that put the product to be reused on the market. Demolition can lead to many different flows being released. Since an average project can easily involve 40 different materials, it should also be possible to calculate ECIs for small series of materials. To enable practical use, these ECIs should be easy to access. Applying these model-based rules to the already available product cards in the NMD and making them accessible is a relatively simple step that would take little time to apply.

Other possibilities are offered by carrying out LCA calculations for category 2 product cards for many products that can be reused. These calculations provide a more accurate approximation of the environmental impact. At present, this is not feasible for smaller product flows, since these products are very specific and the costs of making an LCA calculation are relatively very high. The model-based rules are a good solution for this.

It is expected that the availability of the ECIs of reusable materials will stimulate their reuse. This is because the ECI of reusable materials is a lot lower than the ECI of new materials. This has a positive impact on the MPG, which is becoming increasingly more stringent.

Recommendations for improving the current MPG-ECI system and for more accurately and objectively valuing the environmental impact of recycling or reuse have recently been published.

4.3.8.5 **Tax barriers**

Although economic and tax aspects are outside the scope of this guide, they are considered to be major obstacles to the successful reuse of products and materials from existing structures and that is why we will briefly go into this issue here.

VAT forms a significant tax barrier. In the Netherlands, 21 % VAT has to be paid on used construction products, even though VAT is already paid when the products enter their first life cycle. This does not apply to transactions between consumers, but it does apply to materials and products sold by companies. Other companies can set off this VAT for tax purposes, but housing associations and consumers cannot. This makes circular materials and products less attractive than new materials. The Dutch government claims to be bound by European rules and therefore not able to change this for the construction industry.

Furthermore, the cost of labour in the Netherlands is high, whereas materials and raw materials are relatively low in price. This is to the disadvantage of circular construction, which is even more labour-intensive than current construction sector methods. Prefabricated construction may offer more opportunities than in-situ construction.

4.4 Inspirational examples

Since examples always help to visualise theoretical concepts, we provide some examples of how materials have been harvested and reused in new projects below.

4.4.1 Used precast beams in a new bridge and flyover

Circular flyovers Photo: RWS

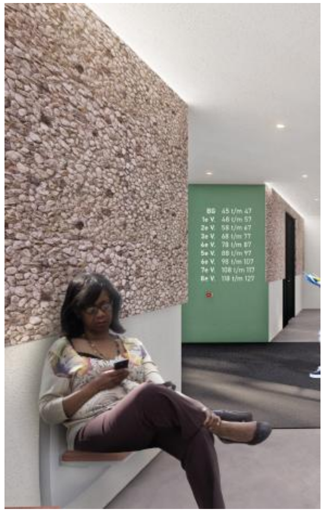
The 'Liggers 2.0' consortium, consisting of Dura Vermeer, Haitsma (precast concrete), Vlasman (concrete and demolition works) and Royal HaskoningDHV, with SGS Intron for independent quality control, came up with the idea of disassembling pre-stressed precast beams from existing beams and reusing them in new flyovers. Rijkswaterstaat chose this idea in response to a call for tender for a circular flyover.

The beams of two flyovers on national roads (the Kromwijkdreef flyover on the A9, part of the IXAS Gaasperdammerweg project, and the Europaweg flyover on the A7, part of the Zuidelijke Ringweg Groningen project) have now been disassembled and taken to temporary 'Liggers 2.0' consortium storage locations. The compressive layers of the inverted T-beams have been removed. The beams are being repurposed. Some of the beams will be made part of a circular bridge in Appingedam. The design of this bridge makes cross girders at the ends of the beams superfluous, meaning they will be easier to disassemble and make suitable for a third lifecycle. Some of the other beams will be used to build a completely new flyover. Liggers 2.0 is also supplying beams for a bridge in the Dutch province of Drenthe.

Research has shown that the beams are still free from any deterioration, even though they have been in use for approximately 40 years. This has led to the conclusion that the residual service life of these beams is well over 100 years.

All the beams have been checked to the new-build level stipulated in the building regulations. The circular beams basically comply with the Eurocodes. As not all materials comply with the Eurocode for new construction, the material properties were translated into Eurocode specifications, based on Eurocode 0, NEN 8702 and RBK. In general, it has been found that beams made after 1967 (and therefore based on the Dutch 1967 guideline on precast concrete [Richtlijnen prefab-beton 1967]) have sufficient minimum bracket reinforcement to also meet the Eurocode detailing requirements. Since building regulations do not provide a reuse level, it is not clear to what extent NEN 8702 may be used to determine the capacity of the beams.

4.4.2 Bo-ex Utrecht



Concrete gravel boards were reused in the lobby and in other areas. Photo: Bo-Ex

A project by the Utrecht Bo-ex housing association involved considering the circular possibilities for the materials released from a ten-storey apartment building dating from 1970. The opportunities for both reuse in the new building that would replace the apartment building and for applications elsewhere were reviewed. To this end, the Stichting Insert foundation and the BOOT engineering firm worked together to determine which products could be removed from the old apartment building for reuse in the new building. With the involvement of the architect (JVST), the parties looked into whether these products could be incorporated into the design. The products from the old apartment building that could not be used in the new one were made available for reuse elsewhere on Stichting Insert's platform for used materials. Further details of two of the products that were reused in the new-build apartment building are given in 4.4.3 and 4.4.4.

4.4.3 Concrete gravel boards

After some processing, the concrete gravel boards could be reused as exterior walls of the new apartment building and they could be used to finish the walls in the lobby of the apartment building. A residual service life study showed that the quality of the concrete was sufficient for reuse in this new situation and that the elements thus met the requirements set by the Dutch Building Decree.

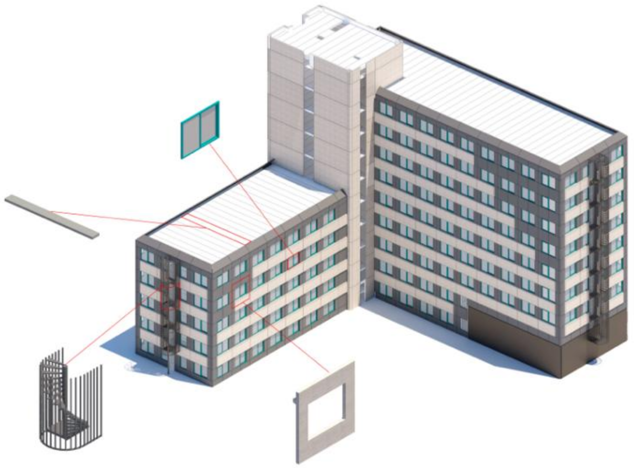
4.4.4 Balcony railings

The old balcony railings were welded together to meet current requirements. Photo: Bo-Ex

The balcony railings from the old apartment building were used as balustrade railings in the new apartment building. The railings from the old apartment building initially failed to meet height requirements and the spacing between the bars exceeded the maximum spacing allowed. To meet these requirements, the railings were welded together in a staggered construction, alternatingly placing them horizontally and vertically. The railings were also regalvanised and spray-painted.

4.4.5 Hollowcore slab flooring

The Prinsenhof A office building in Arnhem is being demolished in the most circular way possible. An ambitious aspect of this project is the reuse of more than 7000 m^2 of hollowcore slab flooring. The floor slabs are being disassembled in consultation with the original skupplier and reused directly, i.e. as they are, in a sports centre and other buildings. The door and window frames are being put to new use in the bicycle shelters near the donor building. The materials are therefore being reused very locally. Several other materials are being harvested and reused as part of the Prinsenhof A project to achieve a reuse rate of more than 90 %.



Disassembly of the Prinsenhof building, source: https://www.gelderland.nl/nieuws/aftrap-circulaire-sloop-prinsenhof

4.4.6 Donor steel

A new sports centre is being built in Waddinxveen and a great deal of steel is needed for this structure. The former town hall in Waddinxveen was demolished before the new sports centre was built, and this structure contained a lot of steel. In consultation with the architect and the structural engineer, it was decided that this steel should be used for the new sports centre, and this is now happening. This means that direct reuse will take place at a distance of less than two kilometres from the donor structure. Because reuse is in the locality, the environmental impact and transport costs are virtually negligible.

Donor steel from the Waddinxveen town hall, source: https://www.hartvanwaddinxveen.nl/nieuws/algemeen/2%202578/staal-van-oud-gemeentehuis-verwerkt-in-nieuwe-sporthal

5 New structures

5.1 Introduction

A structure's adaptive capacity includes all properties that enable a structure to retain its functionality in a sustainable and economically viable manner throughout its technical service life and if any changes in function, needs and circumstances occur (Lexicon CB'23). The *Measuring circularity* 2.0 guide (2020, chapter 6) provides tools for reporting on adaptive capacity.

The higher the adaptive capacity of a structure, the higher the probability of reusability, in its entirety and as components. The following properties of adaptive capacity can apply to new structures. To which extent and in what proportions a new structure is adaptable is determined by the future scenario used:

- flexible;
- modular and standardised;
- detachable (suitable for disassembly and re-assembly).

These properties, which can also be seen as design strategies, are addressed in this chapter. The design strategies mentioned in this guide supplement section 4.4 on Design for future-readiness in the *Circular Design* guide. For each individual section, we will describe the applications of these properties and actions to improve them, using the 'Layers of Brand'. Information on the Layers of Brand can be found in Annex C. We have added the *surroundings* layer to the Layers of Brand and removed the *stuff* layer. The *surroundings* layer covers more than only the location; it also extends to precast parts being able to reach the location, for example. For more backgrounds when analysing new structures, please refer to Annex B.

The Layers of Brand can also be used, in part, for civil and hydraulic engineering.

Table 1 – Layers of Brand (not fully complete)

Layer of Brand/ Schmidt (Eng.)	Meaning in the buildings sector	Meaning in the civil and hydraulic engineering sector
Surroundings	Facilities, public space and the natural environment surrounding the 'site'	Network/system (also referred to as the ecosystem/town and country planning) of which the object or sub-object is a part
Site	Location, land	Location, land
Skin	Façade, roof and lower floor	Top layer, guide rail, edge boards
Structure	Foundation and load-bearing structure	Structures (engineering structures, locks, etc.), foundation under roads incl. centre layer
Services	Installations	Technical facilities (electrical and mechanical engineering), such as pipes, tubes, pumping stations and pumps

5.2 Future scenarios

In order to be able to use the proper design strategies and to future-proof new structures, it is important that the expected future scenarios of the object or structure be established in advance.

Different scenarios should be distinguished here:

- **Small-scale maintenance and restoration**
  Technical maintenance and/or minor reconfiguration
- **Large-scale maintenance and restoration**
  Technical maintenance and/or major reconfiguration.
- **Expansion and infill development** The location in particular should allow for horizontal expansion, and the zoning plan and the structure should allow for vertical expansion. In the case of vertical expansion, account should be taken of the load-bearing capacity of the foundations and the structure. In the case of horizontal expansion, the stability system must be taken into account. The detailing must be such that the structure is easy to expand.
- **Repurposing**
  Changing functions. This also covers unexpected use: from church to dwelling, for instance. In such cases, large spans and a storey height allow for a previously unexpected rearrangement.
- **Relocation**
  Relocation of the structure as a strategy means enabling its future disassembly/re-assembly in parts and/or in its entirety. A new *site* must be available. New structures with a customary expected service life of 50 years can also be developed such that they can be relocated.
- **Demolition: disassembly**
  Partial and total demolition of the structure in its optimum form: using a strategy of disassembly/re-assembly and the maximum and high-value reuse of parts of the structure and of products and materials used.
- **Demolition: traditional**
  Partial and total demolition with low-value reuse. The structure is lost. If the building's adaptive capacity is insufficient, there will have to be very good reasons to save it from demolition. Valuing the structure for social and/or cultural reasons then outweighs financial/economic or technical/functional reasons.

However, looking into the near or far future will always be difficult. It is quite common for a flyover on a national highway in an urban area to require adaptation within 40 years, whereas a major bridge in a city (such as the Erasmus bridge in Rotterdam) will need to continue to function even after the end of its service life. In the latter case, designing for low or lower maintenance costs and for the structure being mostly not suitable for disassembly is advised. In other words, designing for long-term use rather than for reuse is the more sensible choice. In the first case, designing for disassembly and for reuse (adaptability) makes sense. This is why it is important to determine in advance which future scenarios are realistic. The choice of one or more future scenarios means using one or more measures/design strategies. The extent to which the different measures affect the future scenarios is shown in Table 2.

Table 2 – The extent to which the different measures affect the future scenarios

Future scenario			1	2	3	4	5	6	7
Design strategy	Buildings sector	Civil and hydraulic engineering sector	Small-scale maintenance	Large-scale maintenance	Expansion and infill development	Repurposing	Relocating	Demolition: dismantling	Demolition: traditional
Flexibility	Adaptive capacity	IFD	+	++	o	+++	o	-	-
Modularity and standardisation			+	++	+	+++	+++	+++	-
Detachability			+	++	+	+++	+++	+++	-
Industrial	-		+	+	+	+	+	+	-

For civil engineering structures in the civil and hydraulic engineering sector, we use the concept of IFD (industrial and flexible construction, suitable for disassembly) instead of the concept of adaptive capacity. More information on the IFD principles can be found in Annex B[7].

In civil and hydraulic engineering, we have the Dutch NTA 8085 and NTA 8086. These NTAs deal with 'industrial and flexible construction, suitable for disassembly'. Agreements have been made on dimensioning, standardisation etc. This increases the probability of improving the facilitation of future reuse. Unfortunately, we do not have this for the buildings sector yet, although a lot of research has been done into IFD principles. The advice is to prepare an NTA relating to IFD for civil and hydraulic engineering structures and for structures in the buildings sector.

5.3 Design strategies

5.3.1 Flexibility

We take flexibility to mean the extent to which a structure allows for adaptations to user requirements and wishes (SEV Realisatie, 2007). Two types of flexibility are distinguished: process flexibility and flexible use. Flexibility is all about the freedom of choice for the first user before/during implementation and during use.
Adaptability may be desired in terms of layout, sale, expansion and change of function. An important design strategy is the technical separation of layers of structures with greatly different service lives. The degree of separation of the different layers also determines the degree of detachability. See also the *Circular Design* guide on this subject.

Layers of Brand (layers of structures)

The Layers of Brand principle is explained in Annex D and is also described in the *Measuring Circularity* guide.

Table 3 – Layers of structures

Part	Flexibility measure
Surroundings	The number of facilities determines suitability for different functions.
Site	The site presents possibilities or impossibilities for sale and/or expansion, both horizontally and vertically.
Structure	Consideration of different load scenarios. Columns instead of load-bearing walls, recesses and possibilities for recesses in structures at strategic locations. A higher storey height enables suitability for multiple functions. Possibilities for recesses for installations.
Skin	Multifunctional daylight openings, ventilation options, sound insulation and fire resistance.
Systems	The degree of flexibility is increased by installing systems outside the floor zone (below or above) or as detachable installations in the (hollow) floor zone. The storey height can be reduced by using hollow floors and incorporating detachable installations into the floor. Lower storey heights mean that less material is needed. Spatial possibilities for adding/increasing installations.
Space plan	Typology of accessibility. Overdimensioned floor plans. Possibility for future integration, such as sanitary facilities in a non-residential building for future use as a residential building. Adaptability of noise and fire resistance.

[7] In civil and hydraulic engineering, IFD is the most frequently mentioned strategy for circular construction. In architecture, Flexibility and Disassemblability is part of the concept of adaptive capacity. Industrialisation is a production method that can be used in the design strategies under section 5.3.

Differences in civil and hydraulic engineering

NTAs provide guidelines for applying the IFD principles when designing fixed and movable bridges by standardising both interfaces between the main parts of the bridge and configurations. This aims to simplify design work and basic principles at every design stage and to save costs in the design, implementation and management phases of a fixed bridge. Applying IFD can also contribute to objectives related to circularity and the reuse of materials, and to lowering social costs and reducing inconvenience at the time of replacement. The NTAs, on the other hand, do not specifically focus on circularity and it is recommended that this be considered when updating the two NTAs. By 'flexible' we not only mean the extent to which the bridge and its parts can be adapted and expanded, but also the extent to which the parts can be easily finished for the specific project. In addition, structures are often part of a functional network. Adaptability is often based on the functionality of such a network.

In conclusion, the *Measuring Circularity* guide explains the differences in life-cycle cost calculations between the buildings sector and the civil and hydraulic engineering sector.

5.3.2 Modularity and standardisation

Modular construction offers possibilities for future reuse and is a construction technique involving the manufacturer manufacturing parts of a structure in a factory. These ready-made modules are then fitted together or assembled on top of each other on the construction site or in the factory. For modular construction, we distinguish between:

- 2D elements such as walls, floors, façades and roofs;
- 3D modules, such as complete bathrooms, wet rooms and residential modules/units;
- skid installation: coupled installations and parts of installations (e.g. heat pump + boiler + roof duct and chimney) on a frame;
- hybrid forms where, for example, the meter cupboard, stairwell recess and installation column have been integrated into one module.

These forms of modular construction have the following in common:

- A limited number of variables are possible.
- The process is standardised to the greatest extent possible.
- Series are larger.
- As much as possible is prefabricated, enabling proper quality monitoring and other benefits.

Given how much is standardised and prefabricated, we advise defining the quantity of existing materials/products required to be applied.

A major challenge in modular construction is finding the optimum balance between flexibility ('everything' is possible) and standardisation (not 'everything' is possible). The following solution was found for IFD in the civil and hydraulic engineering sector: the dimensions of connections are always the same, but the elements that are connected to them can be highly diverse. This might also be a solution for the buildings sector.

Enabling modularity requires a certain degree of standardisation. Agreements on standardisation can be made at different levels in construction (both in the civil and hydraulic engineering sector and in the buildings sector):

- at the process level: standards, determination methods, guides;
- at the technical level: connections, details, etc.;
- at the material/raw material levels;
- at the dimensioning and interfaces levels, connections for now and for the future;
- at the information exchange/data level (see Chapter 7 'Data' in the *Passports for the Construction Sector* guide.

Layers of Brand

Table 4 - Layers of Brand

Part	Modularity and standardisation measure
Surroundings	Taking into account transport in respect of the dimensions of modular elements.
Site	Assume the module size dimensions in terms of expandability.
Structure	Assume standard construction (same reinforcement in all elements) and standard dimensions. Maintain standard detailing. Modularity in dimensions (e.g. module sizes of 300, 600, 900).
Skin	Apply standard fastening systems. Standard dimensions of façade elements.
Systems	Apply standard fastening systems. Work with interchangeable/replaceable installation modules
Space plan	Modularity is subject to the prejudice that this will reduce architectural variety. If mainly standard solutions for detailing are devised while allowing for sufficient variation in dimensions, sufficient design freedom will remain.

Differences in civil and hydraulic engineering

As is the case with the buildings sector, a modular design in civil and hydraulic engineering, combined with standardisation, contributes to maximising labour and raw materials efficiency, and also encourages reusability and flexibility (adaptability).
Unlike the buildings sector, however, and in terms of modularity, IFD mainly aims to assure the function as quickly as possible in the event of damage: the IFD parts and connections have fixed dimensions and can be installed quickly according to the plug-and-play principle. What's more, a bridge can be more quickly adapted to more or heavier utility vehicles, since, provided that there is a bandwidth, the bridge can easily be widened or extended lengthwise. And it can also be applied to multiple product reuse. Elements such as the beams of a bridge or flyover in particular are highly suitable for standardisation across several life cycles. Annex B gives further information on the IFD principles.

5.3.3 Detachability

Detachability is a term that is widely used in the context of the circular economy. Detachability is never an end in its itself, but instead a means for enabling replacement and reuse. The Platform CB'23 *Circular Design* guide deals extensively with designing using reused products. The term detachability is addressed in the guide as well.

To enable a better interpretation of detachability, we are using the terms and definitions according to Table 5, in addition to the CB'23 'Lexicon'.

Table 5 – Definitions of detachability and suitability for disassembly

Term	Definition	Source
suitable for disassembly and/or detachable	A product that is designed for disassembly. Disassembly is the non-destructive dismantling of a composite construction product or element.	Lexicon CB'23
detachability (disassembly)	The detachability of a structure is the extent to which objects are suitable for disassembly at all levels of scale, without compromising the function of the object itself or surrounding objects, thus protecting their existing value.	DGBC

Term	Definition	Source
design for disassembly	Design for disassembly aims to design a composite construction product or element in such a way that it can be disassembled non-destructively. This disassembly should preferably be easy to carry out.	Lexicon CB'23
suitable for re-assembly	A product that is designed for disassembly and that can then be put to high-value reuse. Besides enabling simple disassembly (see the definition of 'disassembly'), being able to easily assemble it again is just as important.	-
suitable for relocation	Modules/structures allowing relocation in their entirety. This is mainly relevant for temporary construction (according to the Dutch Building Decree: *'a structure intended to be present in a particular location for a period not exceeding 15 years'*). But suitability for relocation can also be relevant for non-temporary construction (i.e. meeting new-build regulations).	-

To summarise, detachability is used for:

- the reuse of modules/structures (suitability for relocation);
- the reuse of elements, products and materials (second or third life cycles);
- maintaining and replacing elements during the management phase (replaceability);
- a structure being flexible and adaptive (adaptability).

Detachability measurement methods

There are methods for assessing the detachability of an element or product. The most well-known one is the 'Meetmethode voor losmaakbaarheid v2.0' (Measurement method for detachability) developed by the Dutch Green Building Council (DGBC). This measurement method for detachability is based on the 'Disassembling the steps towards Building Circularity' study.

In 2021, ISSO developed a method in order to shed light on detachability in the Standaard Referentiedetails (Standard Reference Details). These Standard Reference Details offer parties involved in design, implementation and supervision a practical tool for good and proper construction on the one hand, and for compliance with the minimum statutory building regulations for partition structures on the other. The reference details are a suitable means for showing how the products can be disassembled at the end of a building's service life.
This guide does not go into the further details of the measurement method and detachability.

Layers of Brand

Table 6 – Layers of Brand (not fully complete)

Part	Detachability measures (not exhaustive)
Surroundings	Not relevant
Site	Structures such as bicycle shelters, storage units and fences should also be constructed to be detachable if necessary. Foundation slabs must also be easy to remove.

Part	Detachability measures (not exhaustive)
Structure	Consider making the load-bearing structure detachable/suitable for disassembly. Examples of this are using dry joints on hollowcore slab flooring and steel structures and the construction of beams in flyovers and bridges so that they are suitable for disassembly.
Skin	Direct reuse of façades and roofs is often not possible. After their first life cycle, they no longer meet new requirements, legislation and regulations. Moreover, façade elements hardly ever fit on a new object. The standardisation of dimensions and details and modularity are important to enable future reuse. In addition, detachable detailing in façades and providing, for example, good air sealing and sound insulation have been found to still be somewhat of a challenge.
Systems	Many installations have shorter service lives than, for example, the façade or the load-bearing structure. In addition, installations are subject to changing regulations (often more stringent, e.g. in terms of energy efficiency) and new technologies such as IoT, data mining and sensoring. It is quite common for these parts to be replaced during the service life of the building or for installations to be adapted. This also applies to road furniture and installations in the civil and hydraulic engineering sector.
Space plan	The necessary flexibility/freedom to configure a structure is greatly dependent on the different functions of buildings. The detachability (and thus the reusability) of parts (wall elements, ceilings, etc.) plays a major role in this. The standardisation of elements and detailing, along with modularity, is also important.

Differences in civil and hydraulic engineering

Although the application of detachability and construction that is suitable for disassembly in civil and hydraulic engineering are still in their infancy, Bailey bridges have existed since 1943, when military engineers started using this type of bridge to quickly build a (temporary) bridge that was suitable for disassembly, using basic elements, without any special tools being required. IFD is partly based on this. The basic idea is that the application of IFD enables a bridge to be disassembled more easily so that it can be rebuilt in another location. For now, the Cruquiusbrug bridge in the Dutch province of North Holland is the only example of a bridge built entirely according to IFD principles. The province of North Holland now plans to build all bridges according to IFD principles. Several pilot projects have also been implemented/started. An example of this is the first circular flyover near Kampen. This flyover can be completely disassembled. The Keizersveer bridges (formerly the Moerdijkbrug bridge) are also about to start their third life and the Small Business Innovation Research (SBIR) has led to several projects, such as circular flyovers.

5.3.4 Legislation and regulations

Normative documents

We can use standards, guidelines and guides, or adapt them where necessary, to make it easier for designers, contractors and managers to build in a circular way, with a focus on reuse. Much can still be gained by sharing knowledge between the buildings sector and the civil and hydraulic engineering sector.

Developing normative documents seems to be the best route for encouraging design for reuse. Clients wishing to incorporate reuse can then refer to such documents.

To improve the rating of adaptability (flexibility, modularity, standardisation and detachability), the standards can also be used by private assessment systems for structures, such as BREEAM and GPR.

Dutch Building Decree

To encourage future reuse, it is important to consider different scenarios in advance (during the design phase). Examples of aspects of such scenarios are maintenance, replacement, reuse, adaptability, etc.); see also 5.2 for this. We therefore recommend that the future scenarios for a structure should also be recorded when submitting an application for planning permission ('aanvraag omgevingsvergunning' in Dutch). To what extent this is legally possible and whether the Dutch Environment Buildings Decree can be adapted to this still requires further examination.

Specific design requirements would not seem to be necessary, since new structures are already subject to sustainability requirements. Future-proof buildings with reuse potential will – and will have to – score better on this.

However, the MPG method needs to provide for this. Some improvements are recommended. One proposal is to investigate the possibility of using the MPG calculation during the design phase, based on aggregated data from the NMD key figures per product family. During the phase where the contract documents are drawn up, specific products from that product family can then be selected to provide further details (see the DigiGo[8] pathway). In the future, using the measurement method from the Platform CB'23 *Measuring Circularity* guide may become

[8] https://www.digigo.nu/over+digigo/wat+is+digigo/default.aspx

mandatory. Furthermore, other parties have also recommended clarifying reuse in the MPG by means of guidelines for modelling the design (of buildings).

Passports

The government has not yet set any unambiguous requirements relating to the information in the materials passport. Achieving more unambiguity is recommended and the CB'23 action team for Passports for the Construction Sector is taking important steps to achieve this. For the purpose of legislation and regulations, using the consumer file under the Dutch Building Quality Assurance Act (Wet Kwaliteitsborging voor het bouwen) can be considered. However, this is up to the action team in question.

Products

As regards the quality of products, and the assessment of it, after a first, second or third life, a uniform product-dependent and materials-dependent method is called for. Why this is required and the possibilities for this are set out in chapter 4 of this guide.

For design using reused products, it is important to know the quality of the products and how to use this in calculations, as also mentioned in chapter 4. Quality assurance and guarantees must be clear.

To design for the future, it is also important to know the characteristics and performance offered by new products – detailing, for example. It is also important to know the application conditions under which a product can or cannot be reused in the future and whether any guarantees that the product will be taken back are offered. But materials passports with information on the composition of products are important as well. These aspects are addressed in chapter 6 of this guide.

6 Product performance

6.1 Introduction

At present, products do not have to meet any performance requirements specifically related to subsequent cycles. The requirements placed on products and materials tend to be based on one-time use in a structure. There are no requirements from a demolition/disassembly and reuse perspective, at least not yet. Developing product performance requirements for subsequent cycles will enable such requirements to be defined, make them part of the design and provide information when assessing the reuse of materials from existing structures.

This chapter addresses the requirements to be met by producers when marketing a product, and how those requirements can be supplemented by requirements for product reuse and the upcycling of materials in future cycles. This chapter provides a general elaboration. Detailed elaborations should be drafted for the individual product groups.

However, basing principles only on future potential is not sufficient for actually closing cycles. It is imperative that we ensure right now that reusing existing products in new structures will become easier, and we need to reduce the use of primary resources. This should have consequences for the technical regulations for the marketing of products, such as the use of recycled and renewable (and other) raw materials (including bio-based resources), and the reuse of parts or products, which may, if necessary, have been refurbished, when designing and producing new construction products.

6.2 Steps

A producer of a product to be newly marketed goes through the following steps to arrive at product performance and product information:

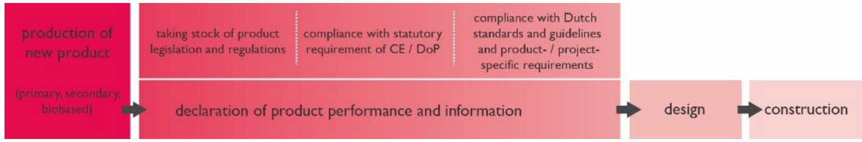


Figure 5 – Steps in the product performance declaration process

6.2.1 Review of relevant legislation and regulations

This concerns general legislation relating to products and raw materials which may also be relevant to subsequent cycles, for example:

- European Regulation (EC) No 1907/2006, better known as the REACH Regulation, is relevant in relation to subsequent cycles. REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. In the European Union, authorisations (prohibited unless exempted) or restrictions (limitations) have been imposed on some hazardous substances designated as 'SVHC' (substances of very high concern). Reference is made to Annex XIV for the list of authorisations and to Annex XVII of the REACH regulation for the list of restrictions. Criteria for qualifying substances as SVHC include if a substance is carcinogenic, mutagenic or toxic for reproduction (CMR), or if a substance is persistent, bioaccumulative and toxic (PBT). Reference is made to the CLP regulation for the CMR category and to Annex XIII of the REACH regulation for PBT (ECHA: Authorisation - ECHA (europa.eu)).

- As a supplement to the REACH regulation, the Dutch RIVM has identified a larger group of substances as ZZS (Zeer Zorgwekkende Stoffen - substances of very high concern). The application of substances of very high concern (Dutch ZZS) may cause a product to become hazardous waste in the future, which may hinder its reusability and recyclability. The purpose of the policy is to replace substances of very high concern (Dutch ZZS), but new substances of very high concern (Dutch ZZS) may be identified in the future. For future potential, it is desirable to know what a construction product is composed of. Several materials passports already require this information to be provided.
- The Dutch Soil Quality Decree (Besluit bodemkwaliteit): the Dutch Soil Quality Decree applies to stony products. This decree concerns application in one cycle. Shaped building materials are tested less rigorously than building materials that have not been shaped, although they can be used in a subsequent cycle as a building material that has not been shaped. The time aspect regarding possible subsequent chemical reactions is not considered either. This should be taken into account for future potential, as already elaborated for concrete in CROW-CUR Guideline 2.
- Waste legislation: Where the use of secondary materials is concerned, it makes a difference whether a material is considered to be a waste material or not. This affects its transport (regulated internationally via the European Regulation on shipments of waste and the production authorisation).
- Electronics regulations: All electronics are covered by the WEEE regulations, even if they have been integrated with other construction products or other products and are not easy to remove. Specific rules on recovery apply. Specific agreements are needed to be able to reuse or recycle the construction products as well.

Depending on the product group, other general laws and regulations may also apply that have to be considered in relation to potential obstacles to future reuse.

6.2.2 Legal obligation of CE marking and DoP

Producers have to comply with the legal obligation regarding CE marking and a Declaration of Performance (DoP), i.e. providing a declaration of product performance. The declaration of product performance is controlled by the European CPR[9]. The performance details to be declared for individual product groups are established through European harmonised product standards and are derived from the basic requirements set by the CPR.

The current CPR does not yet take performance requirements for subsequent cycles into account. For instance, the details of basic requirement 7 of the CPR – Sustainable use of natural resources – have not been developed. The European Commission has made proposals for a new basic requirement (8) in the CPR which will at least mention the life-cycle analysis and possibly make declaring the environmental ‘Climate change’ impact mandatory. It may also become possible to set

[9] The Ecodesign Directive 2009/125/EGC is decisive for the CE marking of products that use energy (including installations in structures). This document does not go into this directive in any more detail, since the CPR applies to most construction products. See also https://ec.europa.eu/commission/presscorner/detail/en/ip_22_2013

product requirements, including requirements on, for example, recycled content, sustainability and detachability. See Annex A.

The product standards on which the CE marking and DoP are based will have to be updated and expanded further to the new requirements in the CPR. Given the extensive and lengthy processes required for this, the more logical route would be to first regulate performance requirements for subsequent cycles via national documents and legislation and regulations. Examples of national documents are assessment guidelines (Dutch BRL), NTAs and guidelines such as CROW or other sector guidelines. They focus on specific product groups. Section 6.2.4 describes how this can be elaborated for the individual product groups.

Setting product requirements via the CPR is contradictory to the current Dutch approach, where we only work with performance requirements for individual structures. The requirements for a structure serve as the basis for performance requirements relating to the product in the application. The CE mark and DoP only indicate the performance levels. By including performance for subsequent cycles in the technical regulations for individual product groups, it can also be determined whether performance requirements for subsequent cycles at the level of individual buildings are being met. This means that we will need to further detail performance for subsequent cycles for each product group (see 6.2.4).

However, product requirements may be relevant in the Netherlands for encouraging circular construction. Examples are possible requirements regarding 'recycled content', e.g. for PET bottles. Since 2025, these have to be made of at least 25% recycled plastic. At present, there is little legislative incentive for producers to use secondary materials and close their own cycles. The efficiency according to the CB'23 *Measuring Circularity* guide must be the guiding principle here. In other words, the use of secondary materials should result in the protection of material stocks and a reduction in environmental impact (ECI) and value retention.

Example: Italian building regulations (CAM Edilizia, 2017) require a certain percentage of 'recycled content' for various product groups.

Section 9.5.2 of the Dutch Environmental Management Act (Wet milieubeheer) does actually make it possible to set requirements for products:
(9.5.2.-1) To promote reuse, prevention, recycling and other useful application, and/or to promote the efficient management of waste or otherwise in the interest of environmental protection, rules can be laid down by a general order in council regarding the manufacture, importation into the Netherlands, application, possession, provision to another party, receipt, collection, useful application and sale of substances, mixtures or products or waste designated by the general order.
(9.5.2.-3e) (…) to provide publicly available information on the extent to which such substances, preparations or products are suitable for reuse and are recyclable.

6.2.3 Dutch standards and guidelines and specific requirements

Producers have to demonstrate compliance with building regulations. The following applies in this regard:

1. Legislation such as the Dutch Building Decree or the Dutch Soil Quality Decree requires conformity with certain standards for product performance or determination methods. Manufacturers have themselves assessed for this through private assessment guidelines and quality declarations.

2. Both manufacturers and builders/contractors need to comply with the relevant product-specific parts in the contract documents (RAW contract documents system, Dutch guidelines on the design of engineering structures (ROK), etc.).

Manufacturers/contractors may also be faced with additional guidelines and quality declarations based on market demand, advantages or requirements set out in tenders, etc.

Certification, through requirements in assessment guidelines, makes it possible to include performance requirements for the future that are in line with application requirements in the Dutch Building Decree, with requirements from contract documents, etc.

6.2.4 Horizontal guideline

As stated in previous sections, performance requirements for subsequent cycles need to be defined for the specific products in question: the relevant performance criteria, what to declare and what legislation and regulations may have to be adjusted or supplemented will all need to be defined. In anticipation of, and in addition to, the preparation of the new CPR, national documents such as Dutch assessment guidelines (BRLs), NTAs or other national guidelines can be drafted. Industry agreements are also good options for this. The initiative to draft such documents should be taken by the actual product groups. It is logical that product groups of a relevant size and causing an environmental impact (where positive effects can be achieved) start with this. Pioneers may want to continue with this or are already working on it. Examples are concrete, steel, the façade industry, flooring, roofing, etc. Such agreements cannot be enforced at present, but they can be facilitated. One of the means for this is a 'horizontal guideline' in the form of an NTA or BRL or other guidance.

A uniform approach

A national 'horizontal guideline' provides uniformity for defining product-specific requirements, and offers guidance for including performance requirements for future reuse and recycling. This is based on the example of determining the environmental performance of products (Environmental Product Declarations – EPD) by means of an LCA. This is governed by the horizontal standard EN 15804 that applies to all product groups. This standard is detailed further in Product Category Rules (PCRs) for specific product groups. PCRs are developed to supplement European product standards, or as supplementary guidelines to national EPD programmes, for example. In the Netherlands, EN 15804 was implemented via the Determination Method and NMD.

Defining product-specific performance criteria will be a major operation for producers of construction products. It would be logical to start with the most relevant product groups that can help develop and test the requirements. Alignment with the new CPR must also be ensured, since production is not only for the Netherlands and we actually want to achieve European harmonisation. Assurance can take place by agreeing on a uniform 'horizontal' approach in the Netherlands and using that as input for follow-up action when the European Commission drafts the CPR. The CEN TC350 SCI subcommittee, which was recently formed for Circular Construction, can play a role in this regard as well.

Example: A horizontal guideline indicates that it should be possible to determine the residual service life of the product after its first use. Product groups can further specify this.

Example: A horizontal guideline indicates that the degree of recyclability of the product must be further specified. Product groups can informatively or normatively indicate the percentages that are realistic and efficient for the product group in question, partly depending on service life and possible types of use (e.g. loads) that can affect reusability.

Example: A horizontal guideline indicates that the possible percentages or classes of 'recycled content' must be identified, primarily based on efficiency. Product groups can informatively or normatively indicate the percentages that are realistic and efficient for the product group in question, partly depending on, for example, availability. The use of classes facilitates a growth process.

Performance for the future

What aspects of performance for the future should a horizontal guideline cover? Table 7 suggests some aspects that can be included by a product standard, guideline or assessment guideline (BRL) in the form of performance requirements or performance classes. These aspects are important for different product groups to varying degrees. It is advisable to use the different layers in a building according to the Layers of Brand (see Annex C) as a starting point. This model is less relevant to the civil and hydraulic engineering sector, but the principle of 'layers' in a structure with different service lives can be applied as a conceptual model to structures in infrastructure too.

Since it is often difficult to come up with conditions for future reuse, a possible productive approach to this would be to consider the situation in which a product is no longer suitable for use. Factors that affect this during operation and maintenance, such as the use of agents that cause pollution, can be included in manufacturer's instructions. Factors such as loads during use are important for quality assurance when the products are released from a structure.

Annex D suggests some technical and environmental performance aspects that can be addressed to increase the potential for reuse and upcycling when drafting a horizontal guideline. A precondition here is that the safety requirements in the chain must remain equal.

It is also noted that, for the purpose of the CB'23 *Measuring Circularity* guide, the goal of 'value retention' is being defined in more detail. Similar topics to those listed in table 7 are suggested in that publication. This will require further fine-tuning in due course.

Table 7 – Possible aspects for expanding product standards, guidelines and/or assessment guidelines, to be further developed for individual product groups

1. Determine the possible forms of product reuse and material recycling (potential),	e.g. by analysing the material flows, considering the potential functionality of products and materials in subsequent cycles. The 10R strategies can serve as a basis for describing the possibilities. The aim is to formulate the highest-value forms of reuse and upcycling and to use secondary materials within one's own chain where efficient (in accordance with the CB'23 *Measuring circularity* guide).
2. a. Determine the material-related factors that influence the reuse and recycling potential. Also indicate when a product is no longer reusable. b. Determine requirements or classes for these factors. c. Determine what information is needed for subsequent cycles (for a 'passport').	E.g.: • Characteristics of material/product for reuse performance in second/third life cycle(s). • Composition. • Material-specific aspects (based on standards for new raw materials and new products (CE marking/DoP)). • Structural or other calculation rules. • Sustainability* and determination of residual service life after first use. • Environmental aspects (substances of very high concern [Dutch ZZS], ingredients, emissions).
3. a. Determine the factors that influence the potential for reuse and recycling that are related to performance in the application ('key performance indicators'). b. Determine requirements or classes for these factors. c. Determine what information is needed for subsequent cycles (for 'passport'). d. Establish the monitoring and the type(s) of maintenance required during design/construction/management that must be established in order to extend future possibilities.	• 'Detachability' and 'design-for-disassembly': fastening options and 'disassembly manual', combinations with other materials and preventing such combinations. • Application factors important for performance in subsequent cycles. • Factors that influence recycling/reuse possibilities during use: degradation, deterioration, loads, maintenance, incidents/exposures. • Factors important for safe demolition. • Sustainability*
4. Establish producer responsibility for performance in the chain.	

* There is a relationship between technical sustainability and reuse and recycling, design and the use of alternative materials. This should be included in the considerations for requirements or classes of reusability/recyclability and the use of environmentally friendly raw and secondary materials. This is part of 'measuring circularity', as laid down in the CB'23 guide on this subject.

Dealing with reused products

Reused products are assessed in the same way as 'new' products. In principle, the desired performance can remain the same in the subsequent cycle, but in case of a used product or raw material, it may be necessary to be able to demonstrate in other ways that that performance is actually achieved. Some performance requirements do not allow the customary test method to be applied, for example because it is too destructive or because use leads to another type of performance limitation (such as steel fatigue).

To facilitate reuse, guidelines with performance requirements for the future (and subsequently also for European product standards) should specifically address this. If guidelines and product standards can indicate how the performance of reused products can be assessed in the future, this can also be used when assessing products from existing structures.

In chapter 4 it was already noted that, for quality assurance purposes, some second-hand products have to be CE marked. The proposals for the new CPR refer to a possible 'declaration of performance for used product' for certain types of reuse (see Annex A). It may be possible to make use of this.

Example: The product standard for insulation materials with default values for the thermal performance of new insulation materials. These values could be expanded to include default values for used materials.

Renewable materials and products

The use of renewable materials, including biobased materials, will have to be assessed for its efficiency for circular construction in the same way as the use of other materials (primary/secondary). If insufficient product standards or other standards are available, this will have to be facilitated to ensure a reasonable choice.

As is the case with other product groups, there is no framework for the future reuse for renewable materials and products. There are only performance requirements that indicate how a product currently needs to be made in order to achieve a certain performance level and these mainly apply to timber. Again, there are no minimum requirements that indicate when a product is no longer suitable for use.

6.2.5 Producer responsibility

Producers play a major role in developing product performance for subsequent cycles, with an eye to future reuse (for value retention of products for subsequent cycles), the use of secondary and renewable materials (to preserve stocks of materials), lowering the ECI and CO_2 footprint, as well as to protecting the environment. They have to take responsibility, or obligations have to be imposed on them, for the waste management of the products they market.

Systems for extended producer responsibility (EPR) can contribute to achieving high-value forms of reuse. See also the plea for this in Nederlands juristenblad (2022). According to Copper8/Rebel (2022), the EPR now often still focuses on the recycling or upcycling of materials. Reuse-focused EPR requires further preconditions, such as measuring circularity, tax incentives for circularity and Product-as-a-Service.

It should also be possible to introduce an obligation through extended producer responsibility (EPR), as already used in other sectors for construction products. The basis for this should be provided by guidelines that should relate to:

- Return guarantee: the producer or the industry issues a return guarantee at application and material level. This guarantee states that the product will be accepted for return, along with the applicable conditions.
- Detachable detailing: the producer or industry/consortium ensures that detailing (at the product level) or an ETT (Erkende Technische Toepassing; recognised technical application) at the object/structure level is provided to ensure that the product or object/structure is detachable and suitable for reuse/upcycling.

- Disassembly/Re-assembly instructions: these instructions show how to install, disassemble and reassemble the product[10] so that it will be suitable for reuse/upcycling in the second cycle.
- Maintenance instructions: these state the obligations for the owner of the structure to extend the service life by keeping the product in the proper condition.
- Materials passport/BIM model: the producer makes sure that data is available for future use.

An EPR can have far-reaching consequences for producers and several things will have to be examined to embed this in the law. It is probable that this better suits certain specific product groups, for example in relation to application and whether a long-cycle or short-cycle product is concerned. A further examination of the possibilities and impossibilities is recommended.

6.3 Setting requirements for product performance for first and subsequent cycles

Declaring product performance for subsequent cycles will only lead to more circular structures if this is reinforced by regulations from the 'demand side'. Clarity as to which products already provide for use of secondary raw materials and future reuse and recycling will be conducive to this. This can be achieved by, for instance, introducing this distinction in the NMD. Recommendations have recently been made to modify the contents of the NMD for this too, enabling clients to search more specifically for such products and to include requirements in contract documents that products and/or manufacturers must meet. Examples of such requirements are:

- The product must have been tested in accordance with the circular performance requirements in the applicable (N)EN standard or, if no such standard is applicable, a BRL and a KOMO quality declaration and KOMO attestation with a product certificate.
- Specific percentages of secondary material based on possibilities suggested by the sector.
- A certain extent of recyclability based on possibilities suggested by the sector.
- The manufacturer must have an LCA of the product in which scenarios for future reuse have been examined. To achieve the most efficient scenarios (leading to a lower ECI), the manufacturer will have to provide relevant performance requirements.
- Manufacturers must offer an efficient solution for the high-value processing of the construction and demolition waste relating to the product. The aim here is the reuse or closed loop recycling of materials.
- The manufacturer must issue a take-back certificate for the project.

Since stimulating the demand side is not part of the scope of this guide, we will not go into this in any further detail.

[10] Disassembly and demolition are not part of the EPR, but they should be part of it to make this truly effective.

7 Results, recommendations and follow-up action

7.1 Results

Current building regulations do not pay sufficient attention to the reuse of products from existing structures and the fitting out of new structures and products for reuse. The result of this guide is an action list that can be used to adjust or develop technical regulations where necessary. This is an important step towards embedding reuse in building regulations.

We do this in table 8, where we indicate who should take action in response to specific recommendations. In this context, the action team is of the opinion that private tools can be useful as well. Where legislation and regulations are aimed at those who lag behind (the public) and the 'bulk', such tools can actually reward the pioneers and thus help the market progress. The action team realises that more knowledge is available in the market than could be made accessible through a one-off consultation. Fine-tuning and further elaboration will therefore be necessary when developing the details of the actions. This guide provides the pointers for this.

Furthermore, the action team notes that other tax and economic barriers mentioned in this guide should not be ignored, otherwise reuse will not be a success. This also applies to social aspects (people in the field who will be the ones to implement circular construction).

The *technical characteristics (performance) of products and structures* tie the actions together: the characteristics that allow products from structures to be made available for reuse, and the characteristics that have to be assessed for reuse. These are the characteristics that new products and structures will need to provide. They are also the characteristics that prevent a structure or product from being reused, which should become clear throughout the chain. Based on this guide, the action team has concluded that those characteristics should be partly based on product-specific definitions. Although a generic system is desirable, it is not easy to establish generic performance requirements for subsequent cycles. This guide gives instructions to help further detail the technical characteristics for various product groups and structures and to make assessing them for reuse possible.

The action list has resulted from the following findings:

Reuse from existing structures

To promote product reuse from existing structures, legislation and regulations require:

- generic rules for the technical quality assessment of products released from existing structures:
    - specific details for product groups relevant in terms of size and the environmental gains to be achieved, such as steel and concrete, and
    - refinement of the Eurocodes for the reuse of structural products;
- substantive refinement of the process for stocktaking of construction materials and assessing them for reuse, with a link to rules on inspections and demolition;
- a quality assurance system for the process all the way from taking stock of construction materials to offering products again, partly based on generic and specific technical rules;
- expansion of the Dutch Building Decree to include the 'reuse' situation (in addition to new-build and existing structures) in order to achieve more clarity on possible exemptions and quality assessments;
- further facilitation of the MPG calculation for structures with reused products. One way in which this can be done is by offering inclusion in the NMD of product cards for materials that can be reused frequently or generic implementation of the

H-factor in the NMD to be able to value reusable materials. And this includes facilitating the tools to calculate the MPG when using reused products. Product cards can be accommodated as part of this, together with the application of the generic H-factor. The goal is to transparently represent reusable products for low-threshold application.

Designing new structures for subsequent cycles

Although the design principles are known and were established in the CB'23 guide on 'Circular design, working agreements for circular construction' and models such as the Bouwwaardemodel (Construction Value Model), there is a need for standards that flesh out specific design principles: for IFD in the buildings sector, for detachability and related construction details. Pre-normative research is also still needed for the suitability for relocation of entire structures and for standardisation and modularity. These topics have been the subject of discussion for a long time and publications on them exist, but they are not yet sufficiently covered in standards. We are also seeing little knowledge sharing between the buildings sector and the civil and hydraulic engineering sector.

According to the action team, developing normative documents seems to be the best route to encourage design for reuse, simply because clients who want to incorporate reuse can refer to them. Private assessment systems for structures, such as BREEAM and GPR, can also use the standards for this purpose.

This can be further supported by requiring, if possible through the Dutch Building Decree, that transparency is given on the future scenario that was the basis for the design. Requirements in the form of design requirements do not seem necessary since new structures are already subject to sustainability requirements. Future-proof buildings with reuse potential will – and will have to – score better on this. However, the MPG method needs to provide for this.

Product performance requirements for subsequent cycles

At present, if products are placed on the market, various characteristics (performance aspects) derived from the requirements of the European Construction Products Regulation (CPR) must now be declared via the CE marking and DoP. Specific national requirements may also apply. New proposals for the CPR will result in sustainability performance and performance for subsequent cycles also becoming part of the CE marking and DoP. To contribute to the circular ambitions of the Netherlands with effect from 2023, it is important that relevant product groups and pioneers already detail this in national guidelines now. Some product groups (such as concrete and façades) and pioneers are already doing this actually. To achieve uniformity and further stimulate the market, we recommend drafting a horizontal national guideline for this. We advise involving relevant product groups, such as the steel and concrete sectors and other parties that are already interested, in this or having them test the standard. Of course, for the purpose of future European harmonisation, these efforts will have to be aligned with European developments concerning the CPR and standardisation in CEN TC350 SC1 on circular construction.

Intensifying the further development of product-specific requirements as sketched above will show what legislation will need to be adapted in order to provide requirements that take future reuse into account or pose no obstacles to it. This concerns, for example, the Dutch Soil Quality Decree or, where obstacles are concerned, waste legislation.

In addition, it is useful to take action to develop Extended Producer Responsibility (EPR) for construction products. EPR offers possibilities for closing product chains and better pursuing circularity goals (raw materials, the environment, value). We recommend first drafting guidelines as a basis for an EPR scheme. Embedding it in law will also require further aspects, such as feasibility, to be studied, covering legal issues, the support base and differences between long-cycle and short-cycle products.

Table 8 – Summary of advice broken down for specific legislation and regulations

	Legislation and regulations	Advice	Purpose	Who	Detailed description
1	**Standards and (CUR) recommendations for the inspection and maintenance of existing structures/alteration** (NEN 8700, RBK, etc.)	To be expanded by an assessment of the reusability of products and technical feasibility.	To be able to use inspections as a natural opportunity for assessing the reuse potential of existing structures.	NEN	Use possible product-specific standards on reuse. Include how to use the current generation of Eurocodes.
2	**Eurocodes**, national annex on Reuse calculation rules	Include rules on reuse in national annex.	Availability of calculation rules as the basis for quality assessment and design.	NEN	As part of the development track for a national annex.
3	**BRL SVMS-007** **Dutch Circular Demolition Project Verification Scheme**	Develop a standard or guideline for the stocktaking of construction materials or extend NEN 2767 to include this, including a substantive definition of structural and material performance and the assessment of harmful substances.	Substantive basis for market players who assess the potential in existing buildings.	NEN or board of experts (public/private)	Development of substantive details in line with standards to be developed for inspections and maintenance. Use possible product-specific standards on reuse. Use possible materials passports.
4	**Standards/ NTA**	Develop generic rules for the quality assessment of products, construction elements and installations in or on structures to be reused, and for how to demonstrate that they have such properties that the structures in which these materials and products will be installed comply with the regulations.	Substantive basis for parties wishing to design/build using products to be reused. Also the basis for quality assurance.	NEN BZK I&W	A risk-controlled quality assessment for products to be reused, after stocktaking of construction materials. Use product-specific standards for reuse (such as the NTA on the reuse of structural steel), Eurocodes and product standards for new products. Use materials passports.
5	**Guidelines/BRL**	Develop a quality assurance system for products to be reused.	Provides a basis for guarantees and for demonstrating compliance with legislation.	CROW CBs	Makes use of rules on quality assessment, among other guidance. Also consider quality control during the process from stocktaking of construction materials to storage.
6	**Guidelines/BRL/data strategy**	Develop a certification system for materials platforms	Uniformity in data on products for reuse	Current marketplaces together with CBs	This may possibly be connected to NL data strategy and developments concerning passports.
7	**Dutch Building Decree**	Make clear how quality declarations will be used for reused products or if CE marking is or is not required. (specific attention to the definition of 'placing on the market again')	Gives more guidance on quality assurance for parties that market reused products.	BZK I&W	

	Legislation and regulations	Advice	Purpose	Who	Detailed description
8		Make the 'reuse' situation clear in the Dutch Building Decree and examine how reuse can be further encouraged by adjustments to the Dutch Building Decree without reducing the basic requirements for structures.	Offers the possibility to differ from new-build requirements where disproportionate.	BZK	
9		Promote the use of Passports in the construction sector	Data on materials and their application in a structure can facilitate reuse in the future.	BZK I&W CEN TC350/SC1	CB'23 on Passports is working on this. No legal requirement for now. Product groups can detail relevant content for a 'passport' (data for the future) (see recommendation 24). Possibly also via a consumer file pursuant to the Dutch Building Quality Assurance Act
10		Examine imposing an obligation for providing transparency regarding the future scenario for the structure and the products.	Supports awareness of circular design and facilitates requests for proposals by clients.	BZK	
11	**Nationale Milieudatabase (National Environmental Database)** 10.1 Products to be newly placed on the market	Based on the LCA analysis, use not only the ECI 1-point score but also the percentage of secondary material used for the product performance.	Offers the sector the possibility to combine MPG/ECI with specifying for products in which the environmental burden has been reduced by using secondary material.	NMD foundation	Provide verifiable definitions of secondary material, alignment with ISO 14021 'recycled content'.
12		Facilitate recognisability of products with improved reuse potential and/or report the potential environmental gain of foreseen reuse (link to value retention) in addition to the ECI.	Offers the sector the possibility to combine MPG/ECI with specifying for products that provide performance for subsequent cycles.	NMD foundation	Also based on product performance in subsequent cycles from standards and guidelines and reflected in the NMD viewer.
13		Ensure a good link between guidelines for detachable construction and the end-of-life processing scenarios in the determination method for the environmental performance of structures	Offers the sector an opportunity to promote itself in respect of the potential through a unified mindset where the goal (reduction of environmental pressure) and the means (detachability) are concerned	NMD foundation	When updating the processing scenarios, check them for that connection.
14	10.2 MPG	Adjust the MPG assessment method so that flexibility and adaptivity can be assessed objectively.	Gives a better understanding of environmental impact through improved reuse potential for subsequent cycles.	NMD foundation CEN TC350/ SC1	Also based on guidelines for IFD and detachable construction.
15	10.3 Second cycle when placing a reused product on the market	Provide an explicit option to choose a reused product, by means of cat. 2 cards and fixed calculation rules (H-factor).	Offers designers more options to select reused products in their calculations.	Tool holders NMD foundation in collaboration with e.g. Veras and marketplaces	Make ECI for reuse available in the NMD. Disseminate ECI information, e.g. in collaboration with marketplaces

	Legislation and regulations	Advice	Purpose	Who	Detailed description
16	**Contract documents**	Examine whether it is necessary to adjust the provision in standard contract documents that any materials that are released become the contractor's property.	Get clients to think more purposely about future value retention and how to handle materials that become available.	RAW, Stabu, Veras	Examine in more detail where sufficient knowledge and skills are available in the process to achieve the desired effect.
17	**Guidelines for IFD construction**	Develop NTAs for IFD construction for the buildings sector	Provides more guidance to designers. Also offers possibilities for requests for proposals by clients.	NEN	Cf NTA 8085/8086 for civil and hydraulic engineering/bridges.
18		Study into standardisation and modularity (possibly still pre-normative)	Standardisation and modularity promote reusability, but it is not yet sufficiently clear what exactly this means, what will or will not have to be standardised, etc.	NEN	Distinguish between the different Layers of Brand here (at least: structure, skin, services).
19	**Guidelines for detachable construction**	Develop standards/NTAs at different levels of reuse (structure, element, product) on how to build detachably.	Provides more guidance to designers. Offers the possibility for more uniform requests for proposals by clients than private methods.	NEN	Following ISO 20887 and the existing DGBC 'Meetmethodiek voor losmaakbaarheid v2.0' (Measurement method for detachability). In addition to product level, the application in an element must also be addressed, to avoid the application undoing the detachability of a product. Additional research into possibilities to use detachability in a broad perspective may be needed here.
20		Draw up the guide on detachable detailing (incl. many examples and reference details).		ISSO (CB'23)	
21	Research, including pre-normative research	Examine the alignment between 'detachability/construction suitable for re-assembly' and passports for materials and buildings.	Puts useful arrangements in place for detachability in passports for actual future use.	(CB'23)	Link detachability to possibilities for assurance of detachability, possibly through contracts, in order to maximise the probability of high-value reuse.
22		Examine detachability and the suitability for relocation of modules and (temporary) structures.		ISSO in collaboration with modular builders	
23	**Private agreements for sustainable structures** (BREEAM, GPR, etc.)	Ensure that flexibility and adaptability are appreciated more highly.	Rewards environmental impact through improved reuse potential for subsequent cycles.	Private parties	Also based on guidelines for IFD and detachable construction and possible adjustments to NMD.

	Legislation and regulations	Advice	Purpose	Who	Detailed description
24	**Product standards or sector/other guidelines**	Define efficient percentages/classes of recycled content (percentage of secondary raw materials) and reusability (possible reuse/recycling percentages based on characteristics and take-back guarantees) Where possible, do not use maximum percentages, or provide preconditions for deviations.	To efficiently close cycles. To provide buyers with a better understanding, enabling them to set efficient requirements for this.	Industry organisations, sectors, CROW, NEN (NTA) Product standards: NEN, CEN, EC (longer term)	CPR (and/or Ecodesign) offer possibilities in due course. Until then, establish this nationally. Some impetus will have to be created to get the sectors to do this.
25		Develop a horizontal guideline/NTA/standard that product groups can use to unambiguously define performance for future reuse and recycling, including the properties and possible material characteristics ('passport') to be declared.	Offers guidance for unambiguous further detailing per product group. Can be suggested internationally with CEN TC350 on Circular construction.	NEN CEN TC350/SC1	Together with producers of construction products and the biobased sector. With NEN mirror committee on Circular Construction. Also define when reuse or upycling is NOT possible. If necessary, differentiate requirements according to the different layers of Brand.
26		Lobby the EC for the implementation of sustainability performance via CPR BWR8	Offers the possibility to define performance for future reuse and recycling at European level.	BZK	Together with producers of construction products, recyclers and reusing parties. Ensure alignment with Dutch developments.
27	**Assessment guidelines for construction products**	Implement performance requirements for the future that are consistent with application requirements from the Dutch Building Decree, with requirements in contract documents, etc.	Offers the possibility for certification of performance requirements for reuse.	CBs	Making use of a horizontal guideline and, once available, product standards or guidelines.
28	**EPR for construction products**	Draft a guideline as the basis for EPR for construction products.	Can be an impulse for the development of products with improved reuse and recycle possibilities.	NEN, producers, knowledge parties	Develop instructions that producers have to pass on in the chain. With possible input from Veras and other parties
29		Examine legal aspects and feasibility of EPR for construction products.		I&W, BZK	Together with the construction products sector.
30	**Dutch Soil Quality Decree**	Provide requirements that take into account the use of products and materials in multiple cycles, where relevant.	Removes obstacles to multiple reuse.	I&W	

	Legislation and regulations	Advice	Purpose	Who	Detailed description
31	**Dutch Environmental Management Act**	Examine the possibility and desirability of recycled content and requirements for construction products (Section 9.5.2-1).	Allows requirements to be set for certain products (contrary to the Dutch Building Decree). Parties asking for requests for proposals/designers can use this.	I&W	Following on from the efficient possibilities to be defined by the product groups themselves.
32		Examine the possibilities for requiring information on reusability and recyclability from the producers of construction products (Section 9.5.2-3e).		BZK/I&W	Further to what product groups themselves develop, or further to materials passports, and to new CPR. Possible alignment with the Dutch Building Quality Assurance Act.

7.2 Recommendations

The recommendations in table 8 are intended for the parties taking action as specified in the table. They are also the target groups for this guide, as identified in the preface. These are the bodies that will have to set to work on the action points to facilitate (future) reuse for everyone.

7.2.1 Implementation of action points

The recommendations in 7.2 are in a certain sequence because some action points are interrelated. Thus, technically speaking, reuse from existing structures hinges on the ability to assess the products to be reused according to an accepted system, based on which quality assurance can be developed. Product groups should provide more information for this. However, to expand product declarations with performance requirements for the future, unambiguity is needed about what this will entail and this should possibly be linked to extended producer responsibility. Designing new structures with future reuse in mind supports the availability of products that offer performance for subsequent cycles and facilitates the probability that actual reuse will take place in the future. Facilitation from the NMD is also considered to be an important impetus, both for new products and for products to be reused from existing structures. Here, the NMD also relies on product declarations and better information on the design aspects of structures that can facilitate the reuse of products.

Taking into account foreseen amendments to legislation and regulations, we make the following recommendations:

Urgent and priority actions

Due to timing, the most urgent actions in table 8 are related to the implementation of the Dutch Building Quality Assurance Act (Wet kwaliteitsborging voor het bouwen, Wkb) in 2022, and the Environment Buildings Decree (Besluit Bouwwerken Leefomgeving Bbl) that replaced the Building Decree in 2023 as a consequence of the newly introduced Environment and Planning Act (Omgevingswet, Ow). Quality assurance professionals want to have reliable reference points to determine whether the structure complies with the regulations, especially after the entry into force of the Dutch Building Quality Assurance Act. Products reused in their entirety do not have any performance descriptions. To summarise, urgent action points are:

- (action point 4/7 from table 8): development of generic rules in the form of an NEN standard or NTA for the quality assessment of products to be reused from existing structures.
- (action point 8 from table 8): clarification of, explicitly, the ‘reuse’ situation in the Dutch Building Decree and examination of how reuse can be further encouraged by adjustments to the Dutch Building Decree.

To better understand the technical aspects for the assessment of existing products, and to increase the circular design possibilities and assess them via the NMD, priority must be given to:

- (action point 9 from table 8): Passports. We refer to the CB’23 Passports in the Construction Sector action team for this.
- (action point 10 from table 8): Examine an obligation to provide transparency regarding the future scenario use of the structure and the products (possibly via the Dutch Building Decree).
- (action point 25 from table 8): develop a horizontal guideline/NTA/standard that product groups can use to unambiguously define performance for future reuse and recycling and declare this.

- (action point 28/29 from table 8): draft a guideline in preparation for an examination of options for an EPR for construction products.

Quick wins

Some action need not wait and can probably be achieved quickly and will further encourage reuse:

- (action point 1 from table 8): standards and recommendations for the inspection and maintenance of existing structures/alteration (NEN 8700, RBK, etc.).
- (action point 3 from table 8) Circular demolition: develop a standard or guideline for the stocktaking of construction materials or extend NEN 2767 to include this, including a substantive definition of structural and material performance and the assessment of harmful substances.
- (action point 27 from table 8): expand assessment guidelines on construction products by adding performance requirements for the future.
- (action points 11, 12 and 15 from table 8) NMD: in addition to applying the ECI of the percentage of used secondary material, provide for reuse/reuse potential and provide for a choice of reused products via the H-factor.

The other action points from table 8 can be detailed further after or in parallel with the above urgent and priority actions and quick wins.

7.2.2 Reuse as the new norm

Logically, the guide mainly focuses on improving existing regulations and incorporating used products in and aligning them with new products and materials. This is not sufficient to set the reuse market in motion without external involvement. Further 'pull' will most likely be required. An alternative approach is a separate regime for used products, combined with some type of mandatory use or a benefit when products are reused. This will be a strong incentive for the development of quality assurance and it will stimulate the market to invest in research and the verification of reused materials, activities that are currently still expensive and time-consuming. Reuse will thus become a more integral and explicit part of the MPG/ECI.

A further, more experimental idea might be to allow only the use of secondary materials and reused products in construction in the future. This would work according to the principle of 'apply or explain'. Where primary raw materials are needed, it would be up to the builder in question to demonstrate why secondary materials are not possible. This is an experimental idea that needs further elaboration. This elaboration should answer questions such as 'Under what circumstances is deviation allowed?' and 'What frameworks will be used for testing this?'.

7.3 Follow-up action

The above suggestions require a more fundamental discussion on where we want to go with reuse in the Netherlands. Although these suggestions also go beyond what a guideline can provide,

it is the action team's opinion that both these suggestions and the recommendations in the guide should be followed up on. This might be done, for example, by an organisation that places these issues on the agenda, or by a team of policymakers with a sufficient mandate to promote this in respect of implementing organisations, within which further detailing and refinement can take place. However, this will explicitly require coordination and control in order to keep track of the progress of the action points proposed.

Background

Platform CB'23

Platform CB'23 was set up by Rijkswaterstaat, the Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf), De Bouwcampus and the Royal Netherlands Standardization Institute, NEN for short, 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 platform carries out its activities in collaboration with the national implementation programme, the Transitieteam and Transitiebureau Circulaire Bouweconomie (Transition Team and Transition Agency for a Circular Construction Economy). By extension, the platform is linked to the Dutch Bouwagenda (Construction Agenda).

The precise form the transition to 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 guide to *Facilitating Future Reuse*

Parties throughout the sector contributed to the development of this guide. Action teams were set up for this. Many companies and organisations responded to the call to take part in these action teams. The participants were selected to ensure a diversity of disciplines and perspectives.

The action teams subsequently formed working groups. These working groups each gained a deeper understanding of one part of the guide and developed it further. The working groups for this guide addressed the following topics:

- High-value reuse from existing structures;
- New structures and considerations for subsequent cycles;
- Product performance of subsequent cycles.

Whenever the guide reached a new phase, the working group members presented their results to the action team members. Other members of the action team could give feedback on the work of the working group members during these joint (digital) sessions to create buy-in and support.

The online kick-off meeting for developing guide 2.0 was held on Tuesday 5 October 2021. In total, the action team met four times. The working groups held several digital meetings and the prime movers in each of the working groups also had regular meetings.

Support team

Platform CB'23 set up a support team to coordinate the process. This team consisted of a chair, a coordinator, a work-study student, a rapporteur and prime movers for the working groups. 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 drew up the reports of the meetings and assisted the coordinator and rapporteur where possible. The rapporteur's task was to compile the information provided by the members and prime movers 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. The '80% version' was introduced by a short film on the Platform CB'23 website. Anyone could download this version and then give feedback.

Alignment of the guide

Where appropriate, the guide has been aligned with the contents of the previously published guides on *Circular design*, *Circular procurement*, *Measuring circularity* and *Passports for the Construction Sector*.

Members of the 2021-2022 action team

The following organisations were members of the 2021-2022 action team:

Alba Concepts

Antea Group

AT Osborne

Betonhuis

Bork Groep

Core-Identity

CROW

DCBAdvies Duurzaam & Circulair Bouwen Advies

De Groene Jongens

Municipality of Rotterdam

Amsterdam University of Applied Sciences

Lomans

Madaster

Mineral Wool Association (MWA)

Modulo Milieustraten BV

ProRail

The Province of North Holland

Repurpose

RVO

RWS

Sloop Check

studio FFAM

TNO

TU Delft

TwynstraGudde

VERAS

VMRG

VORM

Witteveen+Bos Raadgevende Ingenieurs

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Chapter 6 Products

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Annexes

A. Explanation of legislation and regulations
B. Background information to the analysis of new structures
C. Layers of Brand
D. Background information to the analysis of product performance
E. Reuse in the Determination Method for the Environmental Performance of Structures

Annex A Explanation of legislation and regulations

CPR, CE marking, DoP

The European Construction Products Regulation (CPR) has been in force since 2011. European Regulations have immediate legal effect in each member state. In the Netherlands, the CPR has been embedded in the Dutch Building Decree. The CPR applies to individual construction products and to kits, i.e. assemblies of separate components marketed by a single manufacturer. The CPR concerns products that are permanently incorporated into a structure or building parts. Elements that are part of a system integrated in a structure (e.g. smoke detectors) are also covered by the CPR.

Two key elements of the CPR are the CE marking and the associated Declaration of Performance (DoP). CE marking can be considered as a mandatory product passport for trading products in the European Union. CE marking is a trademark and not a quality mark, i.e. it does not say anything about the quality of the product. However, minimum requirements are set in regard of safety, health, sustainability and the environment (the 'basic' requirements). Liability rests with the manufacturer. This includes the responsibility to carry out the conformity assessment, prepare the technical dossier, issue the EU declaration of conformity and affix the CE mark on a product.

A DoP and the CE marking are mandatory for any construction product covered by a harmonised European standard. Annex ZA of a harmonised European product standard provides the connection to the CPR. This entails that the essential characteristics are specified for the product category, such as mechanical resistance, stability and hygiene.

Annexes ZA 2 and 3 of a harmonised standard assign the product category an AVCP. This indicates how to carry out a check at the production site (FPC) and how to assess product performance.

If no relevant harmonised European standard exists, a European Technical Assessment (ETA) can serve as a standard for a product category. Then, too, DoP and CE marking are mandatory. A manufacturer asks a Technical Assessment Body (TAB) whether an ETA exists or can be created for a construction product that is not, or not completely, covered by a harmonised standard. The TAB issues the ETA based on a European Assessment Document (EAD) approved by the European Organisation for Technical Assessment (EOTA).

Sustainability aspects in the CPR

As explained above, the CE marking and the DoP contain the 'essential characteristics' (performance details) related to the basic requirements for structures. At present, these are only technical characteristics, but this is expected to be expanded to include sustainability characteristics. The CPR already includes basic requirement no. 7 on sustainable use of natural resources. This reads as follows:
'The construction works must be designed, built and demolished in such a way that the use of natural resources is sustainable and in particular ensure the following:

a) reuse or recyclability of the construction works, their materials and parts after demolition;
b) durability of the construction works;
c) use of environmentally compatible raw and secondary materials in the construction works.'

However, since the European Commission has not detailed this basic requirement, product groups could not define the relevant details for this requirement in their product standards.

A proposal to amend the CPR has been submitted, which involves replacing basic requirement 7 by basic requirement 8. The proposed text for this reads as follows (from the draft annex):

'Sustainable use of natural resources of construction works:

The construction works and any part of them shall be designed, constructed, used, maintained and demolished in such a way that, throughout their life cycle, the use of natural resources is sustainable and ensures the following:

(a) use of raw and secondary materials of high environmental sustainability and thus with a low environmental footprint;

(b) minimizing the overall amount of raw materials used;

(c) minimizing the overall amount of embodied energy;

(d) minimizing the overall use of drinking and brown water;

(e) reuse or recyclability of the construction works, parts of them and their materials after demolition.'

The environmental impacts from the LCA are mentioned as essential characteristics for declaration, proposing that the declaration of 'climate change effects' be made a mandatory requirement. This would not be a problem for Dutch products, since this is already calculated for the ECI as well. The proposal also suggests including the temporary storage of biogenic carbon or carbon uptake where possible. The details for this have not yet been developed for the Netherlands.

The above is mainly relevant in the context of 'Measuring circularity'. However, where necessary, the European Commission also wants to be able to set requirements for the sustainability labelling of products in relation to some 'product inherent environmental requirements', some of which are relevant for future reuse and that have to be addressed by the harmonised product standards (annex, Part C.2):

(a) maximising durability in terms of the expected average service life, the expected minimum service life under worst but still realistic conditions, and in terms of the minimum service life requirements;

(b) minimising whole-life-cycle greenhouse gas emissions;

(c) maximising recycled content wherever possible without safety loss or outweighing negative environmental impact;

(d) selection of safe, environmentally benign substances;

(e) energy use and energy efficiency;

(f) resource efficiency;

(g) identification which product or parts thereof and in what quantity can be reused after de-installation (reusability);

(h) upgradability;

(i) reparability during the expected service life;

(j) possibility of maintenance and refurbishment during the expected service life;

(k) recyclability and the capability to be remanufactured;

(l) capability of different materials or substances to be separated and recovered during dismantling or recycling procedures.

It is also mentioned that product standards should address the minimum amount of recycled content.

Some aspects relevant for future reuse are also mentioned as regards product information (annex, part D), such as:

- information on installation, maintenance, use, deconstruction and demolition;
- instructions for repair, deconstruction, reuse, remanufacturing, recycling or safe storage.

CE marking and reuse

The CPR concerns products placed on the European market for the first time. The CPR does not cover direct reuse of construction products or materials, without the intervention of a manufacturer. This means that CE marking is not required in this case, but second-hand products can be required to provide the same performance.

The new CPR proposals propose using a 'declaration of performance for used product' (Article 12) for certain forms of reuse. The following passage is also interesting: 'Member States shall set-up requirements for de-installers and the certification to be provided in accordance with the last sentence, including on the definition of stresses that render the product unsuitable.' This means that establishing when a product is no longer suitable for reuse becomes important.

Supplementary certification and regulations

Standards, guidelines and certification schemes are not mandatory, but they can be suggested by legislation. For example, the Dutch Building Decree 2012 includes several references to standards as a method for assessing compliance with the requirements of the Dutch Building Decree. Standards are drafted and revised by Dutch (NEN), European (CEN) or global (ISO) standards committees. Accredited testing, inspection and certification bodies are responsible for assessing compliance with standards. Certification schemes that set out how the assessment takes place, including supplementary requirements and determination methods, are then applied in addition to the standard. This complies with regulations specific to the Netherlands, such as the 2012 Dutch Building Decree and the Dutch Soil Quality Decree. Companies that receive a positive assessment are certified and are allowed to use a certificate or quality mark. KOMO guidelines, certificates and attestations are often used in the Dutch construction industry.

Action taken when putting products into the market includes:

a) The manufacturer determining the legislation and regulations (mandatory or voluntary) relevant to the product to be marketed.
b) The manufacturer complying with the statutory obligation in connection with CE marking and DoP. The following six steps can be used for this:
    1. Identify the applicable directive(s) and harmonised standards.
    2. Check product-specific requirements.
    3. Determine whether an independent conformity assessment is required.
    4. Test the product and check its conformity.
    5. Make the required technical documentation available and keep it up to date.
    6. Apply the CE mark and prepare the EU Declaration of Conformity.

We then have declared product performance.

c) The manufacturer complies with standards and directives referred to in Dutch legislation:

1. Legislation such as the Dutch Building Decree or the Dutch Soil Quality Decree requires conformity with certain standards for product performance or determination methods. Manufacturers have themselves assessed for this through private assessment guidelines and quality declarations.
2. Both the manufacturer and the builder/contractor comply with the relevant product-specific parts of the contract documents (RAW contract documents system, Dutch guidelines on the design of engineering structures (ROK), etc.)

d) The manufacturer/contractor complies with supplementary guidelines and quality declarations based on market demand, advantages or requirements of tenders, etc.

Annex B Background information to the analysis of new structures

IFD principles

Industrial principles are:

- industrial construction (series construction and using standardised and prefabricated elements);
- flexible construction (expandable and adaptable);
- construction that is suitable for disassembly (reusable).

The EIB report shows that IFD construction allows for benefits for society to be gained by applying prefabrication, standardisation and adaptable construction on a large scale. Not only can up to 15% be saved on the service life costs of bridges (construction and maintenance), but the construction time and traffic disruption can also be greatly reduced. And the CO_2 emissions are lower than those for the existing methods.

Two Dutch NTAs have been drafted for IFD in civil and hydraulic engineering: NTA 8085 for fixed bridges and NTA 8086 for movable bridges. These NTAs provide guidelines for applying the IFD principles when designing fixed and movable bridges by standardising interfaces between the main parts of the bridge and standardising configurations in order to simplify the design work and basic principles in all the design phases and to save costs during the design, construction and management phases of a fixed bridge. Applying IFD can also contribute to objectives related to circularity and the reuse of materials, and to lowering social costs and reducing inconvenience at the time of replacement. A modular construction combined with standardisation contributes to maximising labour and raw materials efficiency and also encourages reusability and flexibility (adaptability).

Methods for achieving the objective are:

- the standardisation of dimensions at interfaces;
- the classification of the main details of bridges and flyovers into dimension classes;
- the classification of bridges and flyovers into standard lengths and modular widths;
- reducing engineering by applying a limited number of dimension classes or span lengths.

The dimensions of the following parts will be standardised:

- the space taken up by bearings or supports;
- transitions;
- edges of bridges;
- connections for handrails, vehicle barriers and lighting;
- cable guides.

Furthermore, suggestions are being made for standardising:

- length dimensions, e.g. by means of a couple of discrete steps;
- the use of space and the thickness of the bridge;
- the types of bearings or supports;
- the construction of edge beams.

Bridges are future-proofed by making them adaptable for future situations and reusable as separate parts as much as possible. To achieve this goal, the following basic principles are applied to the different parts:

- fixed dimensions and a standard coupling.
- produced off-site; only assembly takes place on site;
- transportable and hoistable;
- easily fully detachable without causing any damage;
- easy to inspect during use and after disassembly;
- optimally designed for the most efficient use of materials;
- provided with a materials passport recording the properties and keeping track of the state of the parts;
- easy to replace or repair if necessary.

IFD and modular

In addition to the full reusability of materials and the prevention of residual waste flows, the application of modular construction according to IFD principles offers the following advantages:

- Failure costs are reduced by:
  - producing in a factory under controlled conditions, enabling a reliable minimum quality to be guaranteed;
  - optimising parts through series production in large numbers (less error-prone and less customisation);
  - a more predictable quality of the bridge, provided the parts can also be industrially assembled on site.
- Integral safety is promoted by:
  - manufacturing under protected conditions and in a factory environment with permanent safety measures;
  - less traffic nuisance, reducing the probability of possibly unsafe situations.
- Time can be saved while preparing, during the construction phase and in the future, also while carrying out renovation work and adaptations.
- For repairs and adaptations, the necessary parts are promptly available. They are in stock or can be easily produced and they can be easily disassembled and reassembled.
- There is more flexibility to adjust the width of bridges, both when the function of the bridge changes or if there are any changes to the underlying infrastructure.

The broadest possible application of the IFD principles offers even more advantages in the following areas:

- Project preparation. This will be simpler and will involve lower costs because the engineering will become simpler due to standard details.
- Implementation. Bridges with standardised details can be designed and constructed more effectively, faster and at lower cost.
- Upkeep, maintenance. The standardised interfaces mean that more parts can be exchanged and make striving for optimum reusability and thus circularity possible.

Prototype of a circular flyover

The idea for the Open Leeromgeving (Dutch for Open Learning Environment) resulted from the collaboration between Rijkswaterstaat, Van Hattum en Blankevoort and Spanbeton when developing the first circular flyover. This flyover was opened in Kampen on 14 January 2019. Later that year, the flyover was disassembled without any damage being caused, and then reassembled. The Open Leeromgeving ran parallel to this project and the experience gained from the prototype was shared with the group.

The flyover is circular: there is no waste, no new raw materials are needed and raw materials used are reused in the most high-value way possible. This is the first concrete flyover in the Netherlands to be built this way.

The following basic principles were applied to the circular design of a bridge deck:

- dimensions of existing engineering structure N18 (20 m span);
- circularity takes priority over costs and design;
- concrete as the main material;
- designing with existing knowledge.

A circular bridge deck with the following properties was then chosen:

- modular design ('Lego block' variant);
- dimensions of the elements: 2.5 m long, 1.25 m wide;
- variable spans: 15 to 25 m;
- connection based on prestress (without adhesion);
- blocks connected together by a male/female connection (the shear keys);
- cold connection (no adhesion between the blocks).

The deck assembly and disassembly methods had not been used before either, but the assembly shows some similarities with installing regular beams. The assembly work plan addresses the specific differences. The precise alignment of the beam in the x and y positions in particular was precision work and the application of a cementitious joint filler for this application was completely new. Extra attention was paid to safety when making preparations for the installation phase. A safety meeting was held and the risks and the necessary control measures were identified during this meeting. Based on this, the design took account of the transverse prestressing accidentally coming loose. More information on assembly and disassembly can be found on the website of Rijkswaterstaat.

Annex C Layers of Brand

The ‘Shearing layers’ concept was devised by architect Frank Duffy, after which it was developed by Stewart Brand in his book: *How Buildings Learn: What Happens After They're Built*.

The concept is based on distinguishing different layers in a building, each with its own specific service life. The layers are site, structure, skin, services, space plan and stuff: fixed and loose fixtures and furnishings. The average service life decreases from layer to layer. Future reuse is facilitated by designing the building so that the different layers are mixed together as little as possible. A transparent, simple design prevents such mixing.

In practice, different types of buildings are found to resist the mixing of these layers to varying degrees. During their service life, office buildings require a higher degree of separation of layers than residential buildings.

The future cannot be predicted; a high adaptive capacity gives the greatest potential for expected or unexpected future reuse.

Adding an extra 'environment' layer is particularly important for the civil and hydraulic engineering sector. This sector tends to form a network in which interrelationships between different fields influence the adaptive capacity required from each individual field.

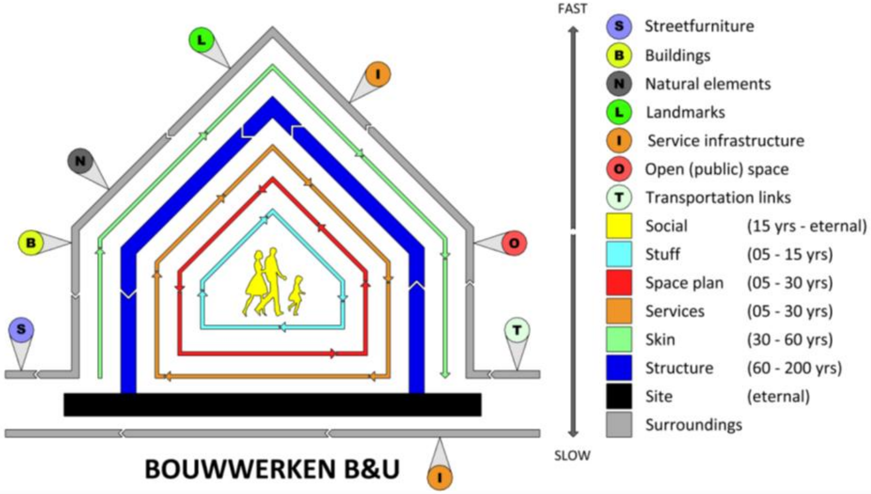
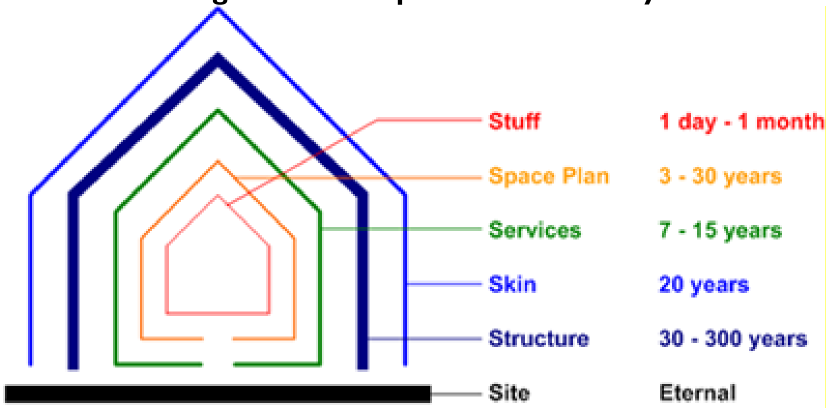


Figure D1 – Layers of Brand in relation to the buildings sector

Figure D 2 – Explanation of the layers



Annex D Background information to the analysis of product performance

Possible demolition, recycling and reuse requirements for products

Table E1 - List of technical performance aspects relevant when assessing products and materials in existing buildings for recycling and reuse

Existing structure		Construction element/product	Construction material	Raw material / ingredients
Demolition	Overall assessment	• Location in the structure • Recognition/further identification/condition		
		• Detachability	Detachability/separability	
Recycling	Assessment for recycling (existing techniques)	N/A	- original technical/functional quality of materials - possible contamination, deterioration - degradation - technical/functional quality of the material of the product to be recycled - possibly aspects related to waste status (transport, storage, end-of-waste criteria) - (possibly ECI of product to be recycled)	- Original composition/presence of substances of very high concern (Dutch ZZS) - Influence on environmental performance of the product to be recycled
Reuse	Assessment for reuse in intended subsequent application	- original and required new technical/functional quality - applicable CE marking/waste aspects - degradation - residual service life - calculation rules for the new application - possibilities for processing - load during use - (possibly ECI recycle product)	- possible contamination, deterioration environmental performance in the event of reuse	Presence of substances of very high concern (Dutch ZZS)

Table E2 - Example of the use of Layers of Brand

		Site	Structure	Skin	Services	Space Plan	Stuff
Product composition							
	raw materials		X	X			
	chemical components						X
	potentially hazardous substances/REACH	X	X	X	X	X	X
	…						
Material-specific properties							
	insulation value		X	X			X
	mechanical resistance		X	X			
	stability		X	X			
	…						
The environment							X
	emissions						
	…						
Safety							
	fire safety		X	X	X	X	X
	risk of exposure to chemicals		X	X	X	X	X
	user safety				X		X
	…						
Energy							
	energy requirement during the use phase				X		
	…						
Circular design and service life							
	modularity of the product					X	X
	wear resistance		X				X
	…						
Visual aspects							
	colour homogeneity						X
	…						

Suggestion for a horizontal guideline for defining product performance for subsequent cycles

We provide an example below to show what we mean by a horizontal guideline, but we have not defined it in full detail yet. The memorandum items are intended for those drafting the horizontal guideline.

START OF EXAMPLE

Horizontal guideline for construction products - Determination and recording of the future product performance of construction products for circular construction

Contents **Page**

1 Introduction and scope

memorandum item

2 References

memorandum item

3 Terms and definitions

memorandum item

4 Abbreviations

memorandum item

5 Establishing product performance

Product performance is normally established in product standards, guidelines and quality declarations. Which aspects of performance are important is derived from the envisaged applications in a structure and the applicable legislation and regulations. Product performance for future reuse and recycling shall be derived from the possible future applications after first use.

EXAMPLE The residual service life is important in terms of the future reuse of a product. Product performance for the future can include the determination of the residual service life and/or factors that determine the residual service life.

NOTE: Product performance for the future can also possibly already be applied to products that are now being released from existing structures, e.g. if it is established how the residual service life can be determined.

The following general step-by-step plan can be carried out to determine the relevant product performance:

Step 1. Determine the possible forms of product reuse with the goal of achieving higher-value forms that lead to a lower environmental impact and higher circularity, taking account of safety requirements in the chain.

NOTE: Possible future forms of reuse and recycling can only be identified on the basis of the knowledge we have today, based on both existing and innovative techniques and possibilities.

EXAMPLE The 10R strategies are an example of how to identify different possibilities for reuse and recycling. The quality of the options can then be verified by measuring whether the circularity goals (preservation of resources, lower environmental impact, value retention) will be achieved.

Step 2. Determine the factors pertaining to the actual product and to the product as part of its application that influence the potential for the reuse and recycling options identified. Establish the performance, performance classes or requirements applicable to these factors (see chapter 6.

Step 3. Determine what information needs to be declared for subsequent cycles or needs to accompany the product when it is put into the market.

NOTE Such information can also be used, for example, for a materials passport.

6 Performance

6.1 Factors that are of influence

The factors that can be distinguished are factors related to

- the actual product and the material(s) it is made of;
- the application and the way in which the product is fitted or installed;
- the use and maintenance of the product in the application;
- its removal from a structure and making it suitable for reuse or recycling.

The factors that can be important are also determined by a product's position in a structure, which is determined by the 'Layers of Brand' for buildings.

6.2 Product-related factors

memorandum item, to be defined in more detail:

- Characteristics of material/product for reuse performance second/third life cycle(s);
- Composition:
- Material-specific aspects (based on standards for new raw materials and new products (CE marking/DoP);
- Structural or other calculation rules;
- Determination of residual service life after first use;
- Environmental aspects (substances of very high concern (Dutch ZZS), ingredients, emissions).

6.3 Application-related factors

memorandum item, to be defined in more detail

- 'Detachability' and 'design-for-disassembly': fastening options and 'disassembly manual', combinations with other materials and preventing such combinations.
- Application factors important for performance in subsequent cycles.

6.4 Factors related to use and maintenance

memorandum item, to be defined in more detail

- Factors that influence recycling/reuse possibilities during use: degradation, deterioration, loads, maintenance, incidents/exposures.

6.5 Factors related to removal and making the product suitable

memorandum item, to be defined in more detail

- Factors important for safe demolition.

7 Data for subsequent cycles

memorandum item

8 Producer's responsibility

Annex

Bibliography

Annex

End of example

Annex E Reuse in the Dutch Determination Method for the Environmental Performance of Structures

The system of the Dutch National Environmental Database (NMD) with the Determination Method for the Environmental Performance of Structures offers a method for analysing and calculating the environmental effects and efficient use of raw materials when construction products and materials are reused. The following degrees can be distinguished:

a. Reusable in its entirety, to be put into the market as a material/product.
b. Not suitable for putting into the market as a material/product.
c. Not or only partially suitable for putting into the market as a material/product.

Figure F.6 shows a further subdivision, representing the relationship with the calculation of environmental performance.

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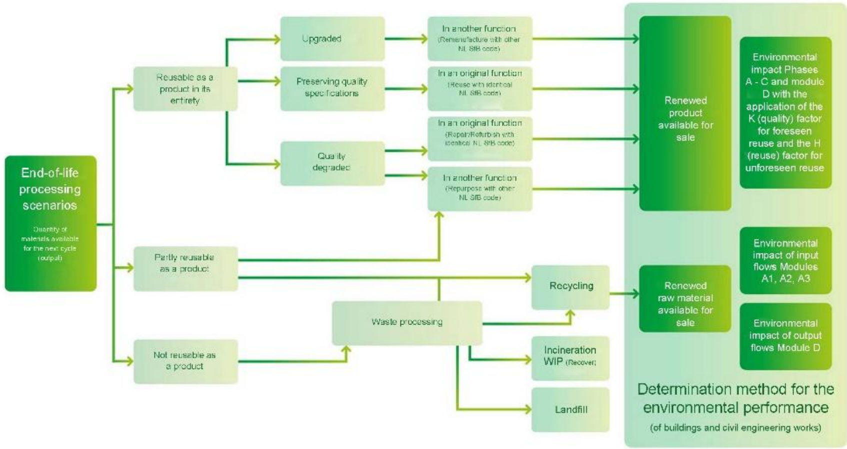

Figure F.3 – Diagram with a subdivision for calculation of the environmental performance for the NMD system

If a material that is released is not put into the market as a usable material/product, including it in the lifecycle analysis of a product as a secondary material (reuse and recycling) in the input of flows of raw materials is preferable. Since we presume that this procedure is known,

this annex deals with materials that can be reused in their entirety and that are put into the market as material or as a product. This may also be the case if a material released is partly used as a secondary material as raw material or if part of it is put into the market as material or as a product. Material that is released and that has undergone further processing and is put into the market is considered to be a new product.

1. Why calculate the environmental performance of materials/products that are reused in their entirety?

Environmental performance is becoming an increasingly important factor of buildings. The limit value for environmental performance in the Dutch Building Decree took effect on 1 January 2018. Environmental performance is determined using the Dutch Determination Method for the Environmental Performance of Structures (Bepalingsmethode Milieuprestatie Bouwwerken; January 2019), applying the latest current version of the Dutch National Environmental Database.

The environmental impact categories from the NMD's product data are used as indicators for environmental protection. These categories are based on the Dutch Determination Method for the Environmental Performance of Structures and are derived from the European Life Cycle Analysis (LCA) method for construction products: EN 15804:2019. The industry provides the LCA calculation to the NMD for inclusion in the database. The NMD checks this calculation and weighs the results for the different environmental categories to a 1-point score: the ECI.

The NMD contains a wide range of data on construction materials. At present, this mainly concerns materials/products that have not been used before and information collected from relatively costly and producer-specific LCAs that include ‘recycled content’ (secondary materials).

This explains why it is important to determine whether materials released from existing structures can be incorporated into a new product, or be incinerated, or, and preferably, be reused in their entirety in an equal or different function.

2. The level of the score for released materials for reuse in their entirety

The amendment to the Dutch Determination Method for the Environmental Performance of Structures version 1.0 (July 2020) introduces a model-based rule for products/materials reused in their entirety. A reuse factor H was introduced to be set off across the impact categories of a product to be put into the market with equal functionalities. Most materials that are currently released from demolition and are then reused fall into this category.

Through this model-based rule, the determination method assumes that there is an acceptable approximation of the actual environmental burden in the event of reuse (so the environmental impact is not nil). A default reuse factor of 0.2 is therefore assumed. This means that the score is multiplied by 0.2; this is applied to modules A1-A3, C3, C4 and D relating to the initial or most representative product in the NMD. The reuse factor H will be reviewed annually. Of course, the model-based rule is not applied to product data already prepared from a reused product, such as a renovation portal (Renoportal).

The model-based rule is therefore a generic approximation of the environmental burden for reuse. For almost all materials, the environmental burden will be lower in practice. This can be considered as a worst-case estimate. For example, if a steel structure or a hollowcore slab flooring can be reused as a structural part in a virtually unchanged state, the environmental burden will be much lower than the result of the calculation based on the factor 0.2 compared to the original product.

3. Practical issues when calculating the score of demolition materials

Despite the introduction of the H-factor, there are some practical areas for attention when calculating the score of materials released from demolition and put into the market in their entirety:

a. The original producer is not known. Relating materials released from demolition to the 'initial or most representative product in the NMD', as assumed by the Amendment, is complex.
b. There is a great deal of variation in the numbers and quantities of materials released. For small series or individual products released from demolition, in practice it is complex and costly for individual demolition contractors to calculate the score (for modules A1-A3, C3, C4 and D as mentioned, relating to the initial or most representative product in the NMD).

Every product to be reused is unique and there are no formulas for carrying out an LCA analysis. Many different flows of materials are released from a demolition job. An average project can easily involve 40 different materials. This would require a calculation to be done and applied.

Glossary

- **WEEE Directive**: Waste Electrical and Electronic Equipment Directive;
- **AVCP**: *Assessment and Verification of Constancy of Performance*, i.e. the conformity systems for performance assessment and verification of performance resistance. A harmonised system that determines how to assess products and how to verify the constancy of the assessment results. This system assures the reliability and accuracy of the DoP. There are five systems, varying from the large-scale involvement of third parties to self-declarations and checks by manufacturers. Source: Assessment and Verification of Constancy of Performance (europa.eu);
- **BWR**: *Basic Works Requirement*;
- **CE marking**: *conformité européenne*, or in accordance with European regulations; obligation for products, including construction products, covered by a harmonised European standard or for which an ETA has been issued;
- **CPR**: *Construction Products Regulation* (EU) 305/2011;
- **DoP**: *Declaration of Performance*, a declaration that gives information on the performance of a product, mandatory for construction products covered by a harmonised European standard for which an ETA has been issued;
- **EAD**: *European Assessment Document*, a European harmonised technical specification for construction products, developed by EOTA for situations where a product is not fully covered by harmonised European standards. Contains a general description of the construction product, the list of essential characteristics agreed between the manufacturer and EOTA, the methods and criteria for assessing product performance in relation to these essential characteristics, and the principles for production checks to be applied in the factory;
- **EOTA**: *European Organisation for Technical Assessment*;
- **EN**: *European Standard*;
- **Essential characteristics**: performance of a construction product in the application as well as product properties, expressed by level, class or descriptively;
- **ETA**: *European Technical Assessment*; a document with information on the performance assessment of products. The procedure has been established in the CPR and allows manufacturers to draft the DoP and apply CE marks;
- **FPC**: *Factory Production Control*;
- **ISO**: *International Organization for Standardization*;
- **KOMO**: a collective quality mark for the Dutch construction industry administered by the Stichting KOMO foundation; different forms of KOMO certificates are product certificates, attestations for the performance of a product when applied, process certificates for realisation processes, etc.;
- **NEN**: The Royal Netherlands Standardization Institute;
- **PCR**: Product Category Rules;
- **RAW system for contract documents**: *Rationalisatie en Automatisering Grond-, Water- en Wegenbouw*; a set of legal, administrative and technical conditions used in the Netherlands to put together contracts in the civil and hydraulic engineering sector;
- **ROK**: *Richtlijn Ontwerp Kunstwerken*; a framework for the safe and sustainable design of the engineering structures of Rijkswaterstaat;
- **TAB**: *Technical Assessment Body*;
- **WKB**: *Dutch Building Quality Assurance Act (Wet Kwaliteitsborging voor het bouwen)*.