Guide to

Passports for the Construction Sector

Parts 1 + 2

Working agreements and substantiation for

passports in a circular construction sector

Platform CB'23

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Preface

A circular economy aims to reduce global consumption of resources and to produce less waste. Such an economy thus contributes to the comprehensive sustainability challenge we face: combating climate change, loss of biodiversity and the overburdening of our planet. This calls for a change to our current systems, which are designed for a linear economy. The implications this will have for the construction sector include: more upcycling of materials, products and elements and a different approach to producing, tendering for, designing and implementing construction projects.

The guides published by Platform CB'23 – about definitions, measuring, passports, designing, procurement and reuse – are a first step towards agreements on the different aspects of circular construction.

The definitions from Platform CB'23's *Lexicon* are used in all guides. The 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 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 *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 guide to *Future Reuse* gives recommendations for circular regulations, covering both public (statutory) and private (standards, guidelines, certification) regulations.

Passports for the Construction Sector 2021/ 2022 action team
Materials passports, or 'passports' for short, are considered to be an important means of promoting a more circular approach throughout the construction sector, which spans the buildings sector and the civil and hydraulic engineering sector. This guide suggests guidelines for further standardising passports for the construction sector. This edition expands on two previous editions published in the summers of 2019 and 2020 respectively, incorporating the experiences gained in 2020-2021 from a project aimed at implementing passports for the construction sector.

Criticisms of the first two editions of this guide specifically mentioned its accessibility and practical applicability, which has inspired us to include a step-by-step plan for preparing a passport. Besides this 'Quick Start Guide' (QSG), we have written more detailed instructions on how to draft a passport.

In order to make the QSG more easily accessible, an online tool has been developed as well to promote the use of passports in both the buildings sector as well as the civil and hydraulic engineering sector. In view of this, we have also drastically changed the structure of the guide. This document now consists of two parts:

- Part 1 'Drafting a passport'

- Part 2 'Guidelines, preconditions and recommendations'

Part 1 gives users who want to draft and/or use passports the right tools and structure, in line with the agreements laid down in the guide. Part 1 provides all the information needed to prepare a passport. Part 2 can be used as a reference for those who want more detailed information about the choices made.

The Passports for the Construction Sector action team hopes that these changes have resulted in an easily accessible guide which will take circularity and sustainable construction a major step forwards.

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Summary

In the construction sector, materials passports, or 'passports' for short, are rightly considered to be an important means to achieving a more circular construction sector, as they promote reuse of resources at the material, product, element and object levels. Our use of the term 'construction sector' in this guide covers both the buildings sector and the civil and hydraulic engineering (infrastructure) sector.

Being able to compare and exchange digital representations of objects in the construction sector is essential to achieve circular construction. This requires passports to be **comparable and interchangeable**. Since passport administrators have not made any agreements in this respect, there is a risk that this will not actually come about.

The definition of a materials passport:

"A materials passport is a digital document recording an object in the buildings and the civil and hydraulic engineering sectors. It documents what an object consists of both in qualitative and quantitative terms, how it was built and where it is located. It documents the ownership of the entire object and/or its parts."

Passport versions

Various stakeholders have their own ideas on the desired form and content of a passport, based on different interests, different perspectives, different phases, different **levels of scale** and, above all, different sectors and disciplines. This guide offers a method and format aimed at achieving uniformity in the great diversity in passports for the construction sector. This should result in passports for different purposes and uses, but all based on one and the same standardised format to enable the various different passports to be compared and linked.

This guide features a Quick Start Guide (QSG) that makes it easier to prepare passports, thus optimally supporting the transition to a circular building economy.

We have developed the *Longlist of Passport Items* tool to systematically collect all the ideas, proposals and requirements for passport items mentioned by stakeholders in a 'longlist'. This longlist catalogues all items that can be included in a passport, depending on their intended use. The QSG is an easy tool to reduce the longlist to a shortlist with essential information.

Preconditions

Easy access to the passport is an important precondition for use of the passport to become commonplace. Offering the passport in a digital format makes it possible - and easier - to convert data about products, components and materials into usable information. This information needs to be stored openly and be compatible with several, often decentralised, platforms and management systems used by government bodies, producers and building contractors, taking into account different data formats, variants of resource management software and other ways in which information is stored and made accessible.

Passports in the civil and hydraulic engineering sector can be considered as knowledge carriers for correctly storing data in the data systems (management systems) used by government bodies, producers and construction companies. This guide offers guidelines for this which, based on NEN 2660-2, can be put into practice using the *Longlist of Passport Items* and the *Quick Start Guide* (QSG).

Data

Data governance focuses on monitoring and safeguarding the 'accuracy' of data. Data governance (a.k.a. data management) is an important consideration when using passports. The data management of passports should be recorded in a structured and harmonised manner, be accessible, offer exchange possibilities, and it should enable the data to be analysed taking into account clients' existing management systems, suppliers' quality systems and contractors' working methods.

Since passports touch on various data environments and need input from those environments, we have scrutinised standards from existing legislation and regulations. Data quality is all about the accuracy and completeness of material-related data. The construction sector can improve the quality and completeness of data by introducing ***Passports for the Construction Sector*** for both new-build and existing projects and properties.

Data governance is mainly about how this data can be properly managed and made accessible to users. The basic principle is that the data remains with the source and the source is also responsible for this data. This perspective of data ownership leads logically to shared ownership. A possible customary format for this could be a centralised-decentralised hybrid model with centrally agreed open standards and guidelines being applied and implemented at a decentralised level. We can achieve a scalable and cost-efficient **circular economy** by using a hybrid model and implementing applied technologies and applications according to the proper standards and guidelines. An important principle in a hybrid model is that data must be freely accessible to both the public and the private sectors where possible. This makes the construction and demolition sectors in the Netherlands one big 'construction market'. A scalable and cost-efficient circular economy can be achieved by using a hybrid model and implementing applied technologies and applications according to the proper standards and guidelines. Interoperability and linked data are important for effective and especially efficient cooperation in the supply chain.

This third edition of the guide for Passports for the Construction Sector is not the final one. The passport will continue to evolve. The last chapter sets out subsequent steps focusing on the post-implementation phase.

Structure of this guide

This guide was written for readers with different knowledge levels regarding circularity. However, they are all assumed to have a basic knowledge of the construction sector and of circularity.

Specific terms related to circular construction are presented in **orange and bold** the first time that they are used in the text. The definitions of these terms can be found in the *Circular Construction Lexicon* (Platform CB'23, 2020a). Where applicable, an indication is given of items specific to the buildings sector and those specific to the civil and hydraulic engineering sector.

The guide for Passports for the Construction Sector consists of part 1 'Drafting a passport' and part 2 'Guidelines, preconditions and recommendations'. The information provided in part 1 enables passports for the construction sector to be drafted quickly and efficiently. Part 2 provides a further explanation of, and justifies, the agreements on passports for the construction sector.

Part 1 – Drafting a passport

Chapter 1 describes the goal and scope of 'Passports for the Construction Sector'.

Chapter 2 describes a step-by-step plan to quickly start preparing passports for the construction sector. This plan is in the form of a 'Quick Start Guide' (QSG) where users are given options to guide them through the process.

Chapter 3 provides more detailed instructions on preparing passports for the construction sector.

Chapter 4 presents examples of passports prepared using the QSG.

Part 2 – Guidelines, preconditions and recommendations

Chapter 5 describes guidelines for configuring passports for the construction sector.

Chapter 6 describes the preconditions that play a role when making and using passports for the construction sector.

Chapter 7 is about data management of passports. The use of passports in the buildings and civil and hydraulic engineering sectors calls for a sound data governance strategy.

Chapter 8 lists the results, subsequent steps and recommendations.

PART 1 – Drafting a passport

1 Introduction to passports for the construction sector

1.1 Platform CB'23

The Netherlands is on the brink of transitioning to a **circular economy**. A circular economy is a way of reducing the global consumption of raw materials and of reducing waste production whilst continuing to improve prosperity across large sections of the population. A circular economy thus contributes to the comprehensive sustainability challenge we are facing: combating climate change, loss of **biodiversity**, the overburdening of our planet and the depletion of raw materials. This calls for a change to our current systems, which are designed for a linear economy.

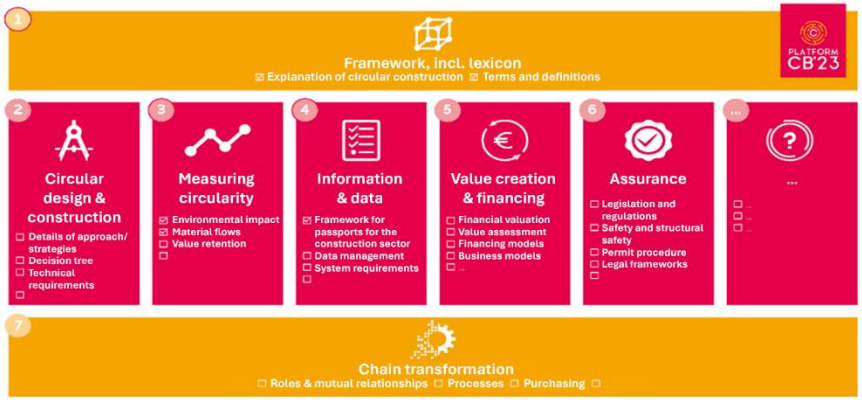

Figure 1 – Topics of circular construction

[1] The Netherlands is not alone in this. Construction and demolition have also been prioritised in the transition to a circular economy at European level.

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, Dutch national government, 2016) and will be gradually expanded.

The construction sector plays an important role in the transition to a circular economy.[1] The objectives for the Dutch construction sector are set out in the *Transitieagenda Circulaire Bouweconomie* (Transition Agenda for the Circular Construction Economy) (2018) and the associated *Uitvoeringsprogramma's* (Implementation Programmes). When this guide refers to the 'construction sector' we mean both the buildings sector and the civil and hydraulic engineering (infrastructure) sector.

Platform CB'23 is committed to agreements that support the transition to a circular construction economy. Platform CB'23 sees a need for unambiguous agreements on seven interlinked main topics; the number of main topics may change in the future. These main topics are shown in figure 1.

1.2 Goal and use of passports for the construction sector

A **passport for the construction sector** ('passport' for short) ensures that the correct information is available in the right manner when the need for such information arises. The need can be an actual need, but availability can also anticipate future needs. By recording information about the objects, passports support the three pillars of circular construction: protecting stocks of materials, protecting the environment and value retention.

Here, the primary goals of the use of a passport are **upcycling** materials, reducing the use of primary **raw materials** reducing the production of **waste**.

A passport shows which materials were used during the construction process and how they were processed. The format of a passport must be laid down unambiguously, but its content may vary. Passports in the civil and hydraulic engineering sector can be seen as knowledge carriers for correctly storing data in the data systems (management systems) used by government bodies, producers and construction companies. This guide offers guidelines for this which, based on NEN 2660-2 (decomposition), can be put into practice using the *Longlist of Passport Items* and the *Quick Start Guide* (QSG).

1.3 Goal and use of the guide

Passports can be developed and managed by the market in various ways, leading to different 'passport brands', each with their own identity. This creates a diverse range of possible passports, to meet a variety of needs and enable the exchange of information and objects in the construction sector, which is essential for a circular construction world.

The goal of the *Passports for the Construction Sector* guide is that anyone who wants to prepare and/or use a passport for the construction sector can do so relatively easily according to the same principles and guidelines. We are introducing the QSG in this guide for this very purpose.

1.4 Passport versions

Passports for the construction sector come in various different forms to match generally accepted levels of scale, processes and phases that characterise the construction sector. The distinction between infrastructural objects (roads and engineering structures) and structural, utilitarian objects (buildings) is important. This roughly matches the distinction between the buildings sector and the civil and hydraulic engineering sector, although objects from the buildings sector can also be part of projects in the civil and hydraulic engineering sector (lock keeper's cottage). These different types of objects can be recorded together in one passport again at the levels of scale of complexes and areas.

Further information can be found in chapter 5 'Passport versions or levels of scale of a structure'.

1.5 Preconditions

The availability of information for a circular construction sector depends on various factors that are regarded as preconditions. Examples of preconditions are standardisation (deciding which data to record and how to record it), digitisation (including data management, identification, exchangeability, linking the digital data world to the physical data world and the physical, built world) and legislation and regulations (concerning data such as ownership, assurance of marketability, transparency and valuation).

You can read more about this in chapter 6 'Preconditions'.

1.6 Data

The information requirement, based on the available data, is at the heart of the use of a passport for the construction sector. What is important for the passport is that the completeness, reliability and accessibility, and thus the practical usability, of data are guaranteed to an optimum level.

The data addressed in this guide concern the local context (area, complex) and the nature and composition of the structure itself (element/part of a building/component, construction product, material or raw material).

The passport reflects the product characteristics and is suitable for future reuse. This means that, at the moment of completion, the data must represent the structure *as built* and during the use phase it must be represented *as is*. What is essential in this context is that passport data is reliably communicated to the data portals where the future availability of building components is concerned, so that these portals can use it to obtain information about the identity, quality, quantity and time of availability of secondary construction and other materials.

As such, data and data availability play a central role in passports for the construction sector. This makes monitoring this data essential in order to safeguard a circular construction economy for the future.

Data governance refers to the monitoring of data, and specifically the accuracy of data. The data management of passports should be recorded in a structured and harmonised manner, be accessible, offer exchange possibilities, and enable the data to be analysed. If a materials passport can be defined as the combination of different pieces of data with different origins (product data, usage data, data concerning the availability for reuse, etc.), it is essential that this different data can be linked together easily. Several technologies are available for this purpose, such as linked data (LD).

You can read more about this in chapter 7 'Data'.

2 Quick Start Guide (QSG)

2.1 Setup and scope of the QSG

Recording materials and products in the construction sector by means of object-related passports is vital to a circular building economy. To optimally support the transition to a circular construction economy, preparing passports should be as easy as is possible. That is why this guide puts forward a Quick Start Guide (QSG). It guides the compilers of passports through the steps required to collect and enter all the data that makes the passport complete.

The QSG is primarily intended for compiling passports at the complex, structure or element levels (see 5.2), rather than on the product or materials levels.

The step-by-step plan can be implemented using this guide. An online tool has been developed in order to make the QSG more accessible.

2.2 QSG step-by-step plan

2.2.1 Step 1: Select either the civil and hydraulic engineering sector or the buildings sector as the sector in which the object will be used

Select either the civil and hydraulic engineering sector or the buildings sector as the primary sector in which the object will be constructed or used.

2.2.2 Step 2: Select the phase and level for the passport from the matrix

At which point in the construction and use process does the passport come into being? And does the passport describe an element (part of the structure), a structure or a complex (possibly several structures plus the immediate surroundings)? Select a point from the matrix in figure 2.

Passport matrix

Figure 2 – Passport matrix

2.2.3 Step 3: Select the usage goal for the passport

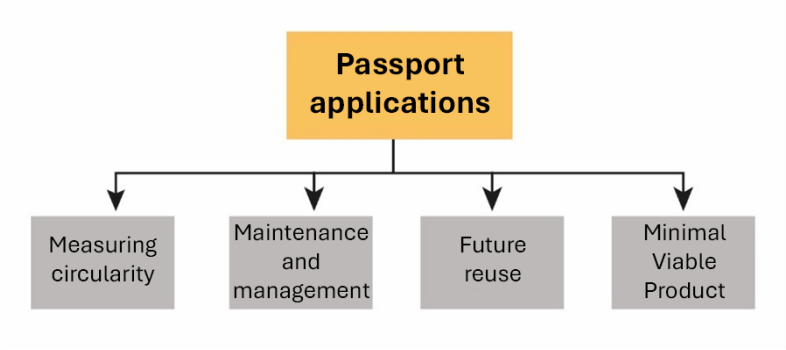

Figure 3 – Passport applications

Passports for the construction sector are essential in a circular construction economy but their practical use is where their true value and usefulness lie: how will the passport be used, what is its goal? Which need does it fulfil? This is what the user decides in this step.

2.2.4 Step 4: Fill in the data fields in the shortlist

The data fields in the 'shortlist' are determined as a result of the preceding choices. This shortlist contains a list of data fields to enable passports to be created for the sector, phase and need selected. Plenty of information is already available in other documents or information carriers. This step involves filling in the data fields in the shortlist.

2.2.5 Step 5: Consult source material for any missing information

Some data fields remain empty after step 4. This information is not yet available from the process followed, but it is relevant and necessary for the intended purpose of the passport. The missing information will have to be found in this step, e.g. by searching databases of product information. But it may also be necessary to collect the information from the supply chain. Suppliers know a lot, but not everything. Suppliers will then have to consult their own suppliers.

2.2.6 Step 6: Complete the shortlist

The source material research in step 5 is used to collect the missing information. A complete shortlist is created by combining this information with the information from step 4. This is the basis: the contents of a passport for the construction sector. This information can be stored in an in-house or third-party asset management system. Users can also supply data to 'passport builders': organisations that can supply and store passports for the construction sector.

2.2.7 Step 7: Determine the output format

Based on a system's specifications – either the passport builder's or your own system – select an output format for exporting the data from the QSG and supplying it to the passport builder. By following these seven steps to create a passport for the construction sector, the goal of the QSG has been achieved.

2.3 Explanation of the QSG (online version)

The Quick Start Guide questions can be answered online. A shortlist will be automatically generated when the questions have been answered. Users can download the shortlist and fill it in. The online tool can be accessed via the website: www.platformcb23.nl.

3 Instructions for use

3.1 Goal of the instructions for use

Our aim in providing the QSG is to facilitate the making of passports. The instructions explain the steps to be taken according to the QSG in order to create a passport for the construction sector.

3.2 Step 1: Select a passport for either the civil and hydraulic engineering sector or for the buildings sector

There are some differences between the civil and hydraulic engineering sector and the buildings sector:

- The civil and hydraulic engineering sector (infrastructure) is mainly a public matter with a limited number of owner-clients. There is a primary or essential connection with the landscape of which the object is a part.
- There are very many different stakeholders in the buildings sector. The objects are primarily intended to accommodate human activities/people.

This difference is reflected in all layers of society or the economy. Of course, there are also several contiguities and overlap (a building as part of an infrastructural object), as is also reflected in the terminology and structure of the decomposition of the objects. Step 1 is therefore the choice between the civil and hydraulic engineering sector and the buildings sector.

3.3 Step 2: Select the levels of scale and the phases

3.3.1 Introduction

The information recorded in a passport depends on the current *phase* of the object and its current *level of scale*. There is quite some overlap of information between the different phases. The information is aggregated if there is a higher level of scale. This structure prevents the same data from having to be entered several times. And adding the relevant information enables value to be created at all levels of scale, independently of the underlying levels of scale.

In order to indicate the different points in time (the phase) at which data for a passport comes into being, use is made of the Life Cycle Assessment (LCA) method, according to NEN-EN 15804. Only the life cycle phases from this method are used here, not the actual measurement method, so that passports will also be compatible with existing standards and tools.

3.3.2 Levels of scale

Data sets for passports must be established and managed in keeping with the prevailing levels of scale in the sector. These levels range from raw material to area. Against this background, a passport version is a passport for a specific level of scale, which corresponds to the stages about which information can be provided. This classification is based on the decomposition model of NEN 2660. The terms used apply to both the buildings sector as well as the civil and hydraulic engineering sector. In this context, the word ‘structure’ not only refers to a building (buildings sector), but also to a bridge or road (civil and hydraulic engineering sector).

This means that the following passport versions can be applied in practice:

- passport for a structure or an object to be managed;
- passport for an element, construction part or component;
- passport for a part or a construction product (the most detailed object level);
- passport for material;
- passport for raw material.

A passport for a building or a road uses the passports established at lower levels of scale. It combines (or 'nests') these passports together at a higher level of scale via the building or road model. The passport at the structure level is not complete until the project has been completely finished.

3.3.3 Phases

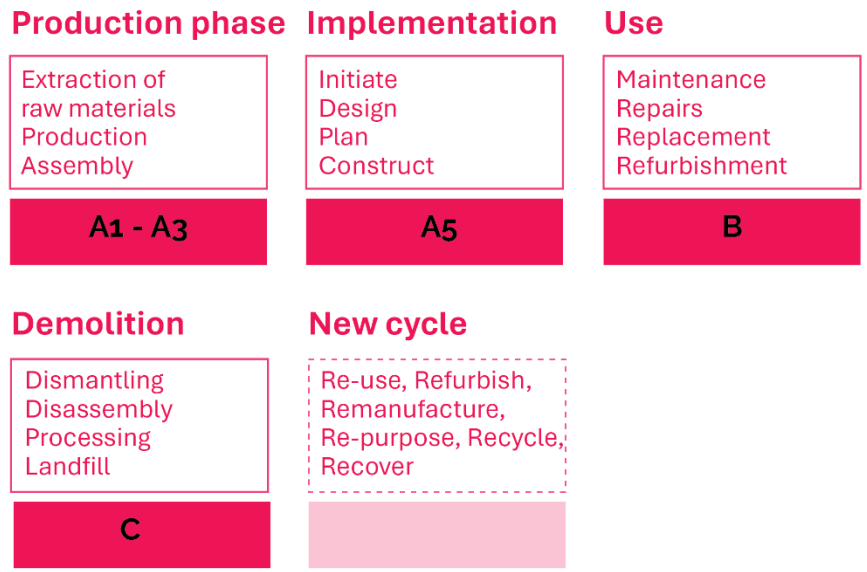

Figure 4 - Life cycle phases which form the basis for preparing a passport

If a passport is prepared in the first phase, the information in a passport during the subsequent phases will supplement the data already recorded. Users' information needs differ from phase to phase.

Irrespective of the level of scale, the actual passport contains the data that is relevant during 'the service life' of the structure or the object to be managed. For example, a structure does not actually exist until it has been completed. A passport is not relevant for this level of scale until the *as-built* situation has been reached. The data is then managed in the use phase, so that all the required data is up-to-date, reliable and fully available during the management phase and before the demolition phase. This is different for the construction product or material level

of scale, because when a structure has reached the end of its life, a construction product or material can be reused in another structure.

3.4 Step 3: Determine the goal of the passport

The further circular construction, and the guide alongside it, develops, the more passport applications (goals) will arise. In this edition, the guide and the QSG are limited to the following applications:

- MVP (*Minimal Viable Product*): the basic set of information required for any passport, regardless of its application or goal;
- measuring circularity: the data needed to fully implement the 'Measuring circularity' method and any future measuring methods;
- maintenance and management;
- future reuse.

3.5 From a longlist to a shortlist

The *Longlist of Passport Items* is a table with all relevant data, from all phases, at all levels and for all applications or goals served by a passport. Since a passport serves a specific purpose of an object in a certain phase and at a certain level, a selection will have to be made from the longlist, creating a shortlist based on the criteria selected (buildings sector or civil and hydraulic engineering sector, phase and level, and goal).

The QSG makes this data selection process manageable and provides a fixed (basic) format for the information to be collected when preparing a passport.

The shortlist can therefore be seen as the minimum dataset required for a passport, depending on the goal, phase and level.

3.6 Steps 4, 5 and 6: Complete the shortlist

3.6.1 Introduction

The goal, phase and level selections for a specific passport have resulted in a shortlist. A major share of the data is made available from the project data, a BIM model of the project, the product information and product databases. Some data will be missing. The person who is compiling the passport will have to go and find the missing data for any specific goals, such as for measuring circularity, by consulting databases or by retrieving data from the supply chain by asking product suppliers or contractors who have taken on a project for data.

3.6.2 Sources of information and data for the longlist/shortlist

Several sources can be consulted for finding product data, including the following:

- Dutch National Environmental Database www.milieudatabase.nl
- NIBE www.nibe.info
- 2BA www.2ba.nl

Some databases require a login/subscription. One of the supply chain parties involved (e.g. an installer with access to the 2BA database, or the party that made an MPG calculation on the Dutch National Environmental Database) should be able to help with this. Consult this party as to the provision or sharing of data under the motto: circular construction is also about pooling resources with the supply chain!

3.7 Step 7: Determine the format and the completed shortlist as input for passport builders

The completed shortlist is not yet a passport. It is the information for each part of the object. This step concerns entering this data in a system that can generate a passport. The organisation in question can enter this data in its own asset management system, but it can also be done by a commercial passport builder. The importance of this step is that the relationships between all the data gathered are and continue to be recorded: the object to which the data applies, the goal, the phase and the level.

When using this data to generate the passport, the passport builder will have to meet the following conditions:

- Identity
- Safety and safeguarding over time
- Transparency
- Supervision
- Interoperability
- Completeness to be circular

3.8 Data for passports

The QSG was set up to give new users, who have no experience of creating passports for the construction sector, an easy start. However, easy does not mean little work. It mainly depends on the data already available as part of the process.

This guide has a chapter dedicated to data since there are so many aspects involved in this topic; see chapter 7. Data sources, data storage, data governance, linked data, all these aspects are important for the role played by passports in the transition to a circular construction economy and in the actual circular construction economy.

New users probably do not really care about such in-depth details, but it is important that they learn something about this, particularly in view of what is done with the output of the QSG. Where does the data go that the user collected in the seven steps? And what should users pay attention to from that point on? Chapter 7 has more information about this.

3.9 Preconditions

Since the use of passports for the construction sector is still being developed and is part of the transition to a circular construction economy, chapter 6 of this guide also goes into the preconditions that determine the introduction and use of passports for the construction sector. As these preconditions are not of immediate importance to new users who want to use the QSG to immediately get started, the preconditions have not been directly translated into the QSG.

4 Use cases

How does the Quick Start Guide (QSG) work in practice? This part shows examples of different passports made using the QSG.

4.1 Passport for the civil and hydraulic engineering sector: a bridge design

Phase: *A5* (Implementation)

User: Consultant or designer of a bridge

Goal: *Understanding of the degree of circularity (measuring)*

An engineering firm is asked to design a bridge and to show how circular it is.

The engineering firm's architect consults their client's asset manager to discuss the criteria to be met by the new bridge. He also asks if any bridges in the administrative area concerned are up for replacement and if they might have parts that can still be used. The architect has to record the materials used in a materials passport.

The engineering firm has all the specifications of the construction materials, prepares the right drawings, structural engineering calculations and visualisations, arranges permission from the municipal building authorities and has the necessary three-dimensional design and surveying technology at its disposal. All this information is included in a materials passport, so that, if the structure ever needs to be renovated or repaired, it will be clear which materials and parts can be replaced or reused as modules. The asset manager uses this as the basis for the long-term maintenance plan.

The approach

The employee of the engineering firm uses the QSG and first selects the **sector**: civil and hydraulic engineering sector. After this, the employee selects the **phase** in which the passport is compiled: A5 Implementation phase. The third step is selecting this materials passport's **goal**: to measure circularity.

The QSG results in a list, a *shortlist,* of all the information which will be in the materials passport: information at *plan level*, *element level*, *product level* and *materials level*. The information must be provided in terms of the quantities and the qualitative characteristics of the materials and products.

As part of the tender documents, the client may provide information delivery specifications (IDS). The contours of a materials passport are part of this. Information can be collected about such things as materials, raw materials, suppliers and the origins of the raw materials to be used in combination with the QSG shortlist.

The client updates the asset management system with the information supplied. The information can then be included in the existing asset management system or provided to a passport builder. If the client already has a supplementary module for a materials passport as part of its asset management system, it is easier if the contractor can access it and fill in the information there.

4.2 Passport for the civil and hydraulic engineering sector: dyke maintenance

Phase: *C (use)*

User: *Owner, manager of an object in the civil and hydraulic engineering sector (a dyke)*

Goal: *Understanding of the degree of circularity (measuring)*

The client has asked the maintenance contractor to inspect an existing dike and prepare a long-term maintenance plan based on the inspection.

The contractor will have to retrieve information from the client's archives, including any previous renovations to the dike, about all calculations, materials used and structural engineering calculations. A measured survey of the dike using GPS should also be carried out. Based on this, a materials passport will be drawn up, followed by a long-term maintenance plan.

Approach

The employee of the contractor's firm uses the QSG and first selects the **sector**: civil and hydraulic engineering sector. After this, the employee selects the **phase** in which the passport is compiled: C Use. The third step is selecting the **goal** for which this materials passport will be used: learning more about the dike conditions.

The QSG results in a list, a *shortlist*, of all the information which will be in the materials passport: information at *plan level*, *element level*, *product level* and *materials level*. The information must be given in terms of the quantities and the qualitative characteristics of the materials and products.

The client provides an IDS as part of the tender documents. The contours of a materials passport are part of this. These contours are used in combination with the QSG shortlist to collect all the necessary information: on materials, raw materials, suppliers, the origins of the raw materials as well as other aspects.

The client updates the asset management system with the materials passport supplied. The client can include this information in the existing asset management system or supply it to a passport builder. If the client already has a supplementary module for a materials passport as part of its asset management system, it is easier if the contractor can access this and fill in the information there.

4.3 Passport for the civil and hydraulic engineering sector: road renovation or demolition

Phase: *C (demolition)*

User: *General contractor/foreman of a road renovation project*

Goal: *Meeting the client's requirement to provide a materials passport for the processing of the materials used*

The client has asked the contractor to renovate the road in question. This involves removing the entire road structure and surface layer and constructing a new road. The asset manager provides the contractor with the data and instructs the contractor to record all the materials used in a materials passport.

The contractor's firm gets all the specifications from the suppliers, has the right drawings and contract descriptions and has three-dimensional surveying technology at their disposal. All this information must be stored in a materials passport, so that, if the structure ever needs to be renovated or repaired, it will be clear which materials have been used. The asset manager can also prepare a long-term maintenance plan based on the passport.

Approach

The contractor's employee follows the QSG and first selects the **sector**: the civil and hydraulic engineering sector. After this, the employee selects the **phase** in which the passport is compiled: C Maintenance phase. The third step is selecting this materials passport's

goal: maintenance activities and specifically recording any changes due to maintenance activities.

The QSG results in a list, a shortlist, of all the information which will be in the materials passport: information at *plan level*, *element level*, *product level* and *materials level*. The information must be given in terms of the quantities and the qualitative characteristics of the materials and products.

The client provides an IDS as part of the tender documents. The contours of a materials passport are part of this. These contours are used in combination with the QSG shortlist to collect all the necessary information: on materials, raw materials, suppliers and the origins of the raw materials.

The client enters the supplied information in the asset management system. If the client already has a supplementary module for a materials passport, it is easier if the contractor can access it and fill in the information there.

4.4 Passport for the buildings sector: a design for social housing

Phase: *A5 (Implementation)*

User: *Architect*

Goal: *Recording materials and products for the current and future life cycles of the building*

An architects' firm has to complete a building design passport in connection with the application for planning permission for a housing association. The housing association stores the information in the asset management system so that it will be available throughout the life cycle of the building.

The architect applies for an environmental permit on the basis of the final design. Part of the completion of this phase is delivering a passport for the building to the client. To compile the information uniformly, the architect uses Platform CB'23's Guide for Passports for the Construction Sector.

Approach

The architect follows the QSG and first selects the **sector**: the buildings sector. After this, the architect selects the **phase** in which the passport is compiled: A Design and structural engineering phase. The third step is selecting this passport's **goal**: recording all the materials and products used to construct the building.

The QSG results in a *shortlist* of all the information which will be in the passport for the building: information at *building level*, *element level*, *product level* and *materials level*. Both the quantities and the qualitative characteristics of the materials and products must be collected, as well as information on the actual building, such as its location, Land Registry details and ownership.

Much of this data is already available in the project records or is part of the BIM model created on the basis of the design. An exported list from the BIM model can provide that information. The MPG calculation required for the permit application also provides a lot of product information. Any missing product information is provided by the design team, gathered from various online databases, or supplied by the actual producers.

This information is used to fill the shortlist and thus create the basis for a passport for the building. The format in which to deliver the shortlist is agreed in consultation with the client and the IT employee who manages the asset management system. It might be an Excel file, for example.

In order to turn it into a passport for the building, the asset management system records the list of materials and products and the building information. The passport is also given a unique ID; other project-related information can be linked to this ID. The asset management system enables the data to be shared in the future, e.g. via an API or export functionality. The asset management system ensures the right degree of data monitoring.

And finally, it is important that the data on the materials and products specified as part of the design are updated to the *as built* situation.

4.5 Passport for the buildings sector: maintenance to an educational building

Phase: *B (Use)*

User: *Maintenance company*

Goal: *Information about the CO_2 impact of the use phase and specifically of material flows during the use phase, based on the maintenance carried out*

Any modifications and regular maintenance are recorded in the passport for an educational building during the use phase. As such, the passport provides an up-to-date view of the materials used and the state of these materials and it provides information on the CO_2 emissions based on the flows of materials in the use phase.

An employee of a maintenance company who is responsible for the property maintenance of this educational institution wants to make a passport for a building. This passport will provide information about the condition of the building and the flows of materials arising from the maintenance activities (e.g. parts from installations).

Approach

The employee follows the QSG and first selects the **sector**: the buildings sector. After this, the employee selects the **phase** in which the passport is compiled: B Use phase. The third step is selecting this materials passport's **goal**: maintenance activities and specifically recording any changes due to maintenance activities.

The QSG results in a list, a shortlist, of all the information which will be in the passport for the building: information at *building level*, *element level*, *product level* and *materials level*. The information must be given in terms of the quantities and qualitative characteristics of the materials and products. Information for scheduling maintenance to the building, such as about detachability, must be collected for this as well.

The contractor provides a bill of materials, including third-party materials, to the client upon completion of the building. It contains full information on the materials and products used to construct the building. This list is the basis for entering the requested information in the shortlist. Any missing information is gathered from suppliers or from product databases.

In this example, the resulting list is entered in the in-house maintenance software/FMIS system. The changes, including dates, of each maintenance activity are entered, to produce an up-to-date summary of the history of the building in terms of materials and products, the latest state of affairs (quality, amortisation) and the flows of materials going into and coming out of the building in connection with the maintenance activities. Whenever a maintenance cycle is completed, the FMIS system thus updates the owner's materials passport via linked data.

This information then provides further details as to the CO_2 emissions of the products and materials and helps the owner assess its CO_2 policy.

4.6 Passport for the buildings sector: renovation or demolition of an office

Phase: *D (Reuse)*

User: *'Demolition company/harvester' of used construction products*

Goal: *Identifying and mapping quantities, qualities and values of the products harvested*

A passport is prepared for a building which is to be demolished. This will enable an assessment of the construction elements and products for reuse or recycling to be carried out. The client can use it to account for what is done with their building, construction products and materials. The demolition company can use it to find buyers for the construction products and materials for reuse, e.g. through online marketplaces.

The project leader of a demolition company prepares a passport of the building in order to identify and record the materials and products released: the quantities, qualities and characteristics. This information can be used by the project leader in order to offer the materials and products to projects where they might be reused or to companies that can recycle the materials. The passport for the building shows the agreements with buyers and can demonstrate that no waste flows were incinerated or sent to landfill. The passport makes it possible for the demolition company to fulfil its contractual obligation in respect of the client to account for the material flows after demolition.

Approach

The project leader follows the QSG and first selects the **sector**: the buildings sector. After this, the project leader selects the **phase** in which the passport is compiled: D Reuse phase. The third step is selecting this passport's **goal**: to report the harvest and the reuse.

The QSG results in a list, a shortlist, of all the information which will be in the report which is formulated as a passport for the building: information at *element level*, *product level* and *materials level*. The information is given both in terms of the quantities and the qualitative characteristics of the materials and products, such as the condition of the elements and products according to NEN 2767.

The project leader draws up his own list of the products and materials used in the building to be demolished, based on the, generally incomplete, information on the building provided by the client. These two sources are used to complete the shortlist as well as possible. The information that is missing – which will be quite a lot for such an old building – is retrieved from comparable buildings to the extent possible. For the parties who buy these materials and products, generic information is better than no information.

Once the shortlist is complete, it can be used for various different purposes, one of which is to make the shortlist available to a passport builder who can use the report to provide additional information, such as the financial value of materials. The shortlist can also be linked to a platform where used construction materials and products are offered for sale. Ideally, the list should be completed before actually demolishing or dismantling the building. Developers, architects and builders can then take the future supply of materials and products into account and this will minimise any storage time.

Eventually, after all materials and products have been delivered, a report is prepared on the basis of the passport compiled for the building. It provides justification for what has happened to all the materials removed during the demolition process and where they ended up, giving the client, the government and the demolition

company itself more information about the objectives of making the construction sector totally circular.

PART 2 – Guidelines, preconditions and recommendations

5 Passport versions or levels of scale of a structure

5.1 Introduction

This chapter describes guidelines for configuring passports for the construction sector. Achieving uniformity is key here.

The completeness and accuracy of a passport depends on several factors:

1. a structure's life cycle phase, in combination with the effort (and therefore financial investment) it takes to obtain and record the proper data;
2. the value that can be created using this data, which depends on the quality and quantity of the data;
3. the accuracy with which the passport is kept up to date during the use phase;
4. the extent to which the government has imposed an obligation;
5. the level of scale at which the passport was drawn up.

A matrix of the levels of scale and life cycle phases in the construction sector has been prepared in order to shed light on the various possible passport versions. This matrix is discussed in paragraph 5.5.

In practice, passports which have been created at various levels, from different perspectives, and with different goals are currently already being used in different sectors. In order to provide a basis for the desired datasets in passports in this guide, a *Longlist of Passport Items* was developed in order to be able to discuss the content of passports as concretely and perceptively as possible. This longlist was then used as a tool to suggest passport versions with minimum required content.

5.2 Structure of and relations between passports

A clear passport structure is important for the effective use of passports for the construction sector. The following basic principles apply:

- A passport is shaped like a pyramid, with the information at higher levels being compiled from information about objects from underlying levels of scale (e.g. a building consisting of a collection of elements). The scale levels are 'nestable', so that information can be transferred from the underlying level. A primary requirement for this is that the data for material passports is structured in line with NEN 2660-2.

- The information requirement depends on the decomposition level (level of scale) of the object.

- The passport is in line with the structure of NEN-EN 15804, *Sustainability of construction works – Environmental product declarations - Core rules for the product category of construction products,* and the four phases of the **life cycle**: production phase, construction phase, use phase, demolition and processing phase. The information requirement depends on the current life cycle phase of the object.

- A passport consists of static elements: a snapshot of the object, related to a formal record of performance for a specific goal, such as planning application, completion, mortgage, insurance. See also www.stelselcatalogus.nl/stelselplaat.

- A passport consists of dynamic elements. These elements are adjusted over time, in response to changes, e.g. a life cycle analysis (LCA) score. It is important to add the date when the elements were entered.

- The content of a passport does justice to the different interests of private and public chain partners. Without having been explicitly detailed in this guide, the following should be taken into account:

    - public interest: health, circularity, impact on ecology, asset management and maintenance;

    - private interest: intellectual property, commercial interests, ownership structure.

- The passport is in line with data that is already available or will be available through the performance declaration, product specifications, **EPDs (Environmental Product Declarations)** and other labels and certificates.

- Passports are consistent with international developments (such as the information security guideline NEN-EN-ISO/IEC NEN-EN-ISO/IEC 27001) and future European guidelines and directives initiated by the European Commission, such as the Sustainable Product Initiative (EU; 30 March 2022).

- Producers should be prevented from repeatedly having to provide the same information in different ways for recording, certification and accountability purposes.

Figure 5 is an illustration of the passport structure. One of the things that the interfaces show is where the input for the passports can come from. The figure also shows how passports interact between the different levels of scale. The lower part of the figure shows a number of goals for which passports can be used. The yellow bars show that there are different data requirements for the individual goals

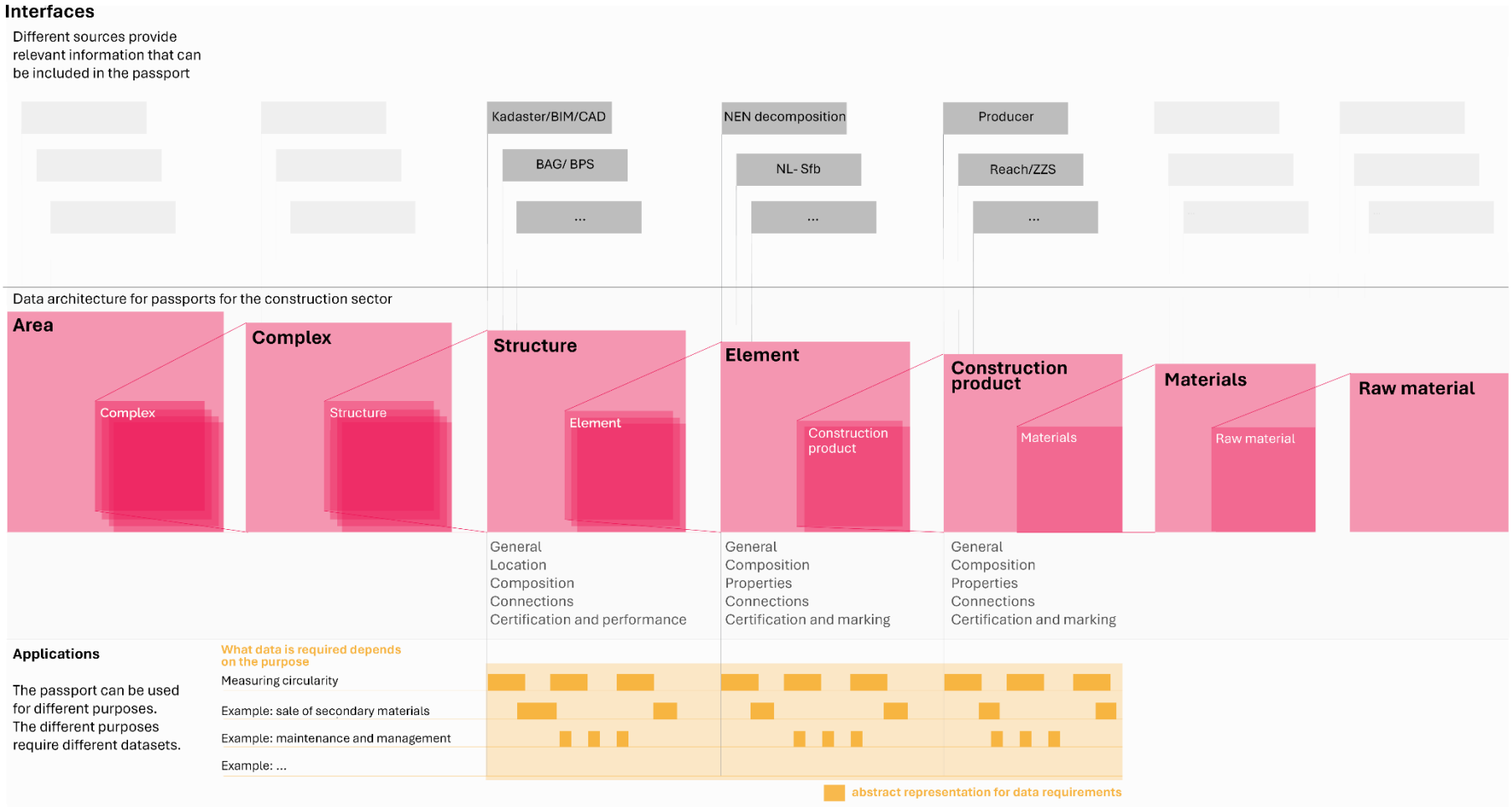

Figure 5 – Data architecture for passports for the construction sector

5.3 Levels of scale

As stated in the introduction to this chapter, different levels of scale are used for the passports. These levels range from raw material to area. The information at a certain level of scale always consists of a link to passports at an underlying level of scale, with data being 'inherited'. This data is supplemented with data added at this scale level, e.g. information about the composition of the connections made.

This method of structuring ensures that data does not have to be entered repeatedly, whereas adding the relevant information enables value to be created at each level of scale – independently of the underlying levels of scale. In addition, this offers possibilities for producers to set up a system which enables products to be traced (where are things located) using the correct product and object identifications. Owners of buildings can automatically get upgrades of information in underlying passports.

The levels of scale are based on the modelling rules of NEN 2660-2.

There are divided into levels of scale for physical space, physical objects, materials and raw materials. The number of levels of scale for physical space and physical objects can vary for each professional discipline (buildings, roads, engineering structures, sewers, etc.). That is why table 1 first gives a generic description of the levels of scale and then fills them in as examples for a building (the buildings sector) and a road (civil engineering). In principle, the 'materials' and 'raw materials' levels are the same in all cases.

Table 1 – Levels of scale for passports

	Level of scale	Buildings example	Civil engineering example
Physical space	Level 1 Level 2 … Level n	Area Complex	Road network Road segment Carriageway Road section Lane Lane section
Physical object	Level 1 Level 2 … Level n	Structure Element Building part Construction product	Road construction Element Building part Component Part
	Material Raw material	Material Raw material	Material Raw material

Where this guide refers to NEN 2767-1, *Condition assessment built environment – Part 1: Methodology,* the level of scale entitled 'object to be managed' means the same as 'structure', and 'construction parts' means the same as 'construction product'.

5.4 Life cycle phases

In order to indicate the different points in time at which data for a passport comes into being, use is made of the Life Cycle Assessment (LCA) method, according to NEN-EN 15804, *Sustainability of construction works - Environmental product declarations - Core rules for the*

product category of construction products. Only the life cycle phases from this method are used here, not the actual measurement method (see figure 6). If a passport is prepared in the first phase, the information in a passport during the subsequent phases will supplement the data already recorded. For example, if a passport is not drawn up until the demolition phase, the information needed will be more specifically tailored to the purposes of the user in this phase. The data needed at that moment is more limited.

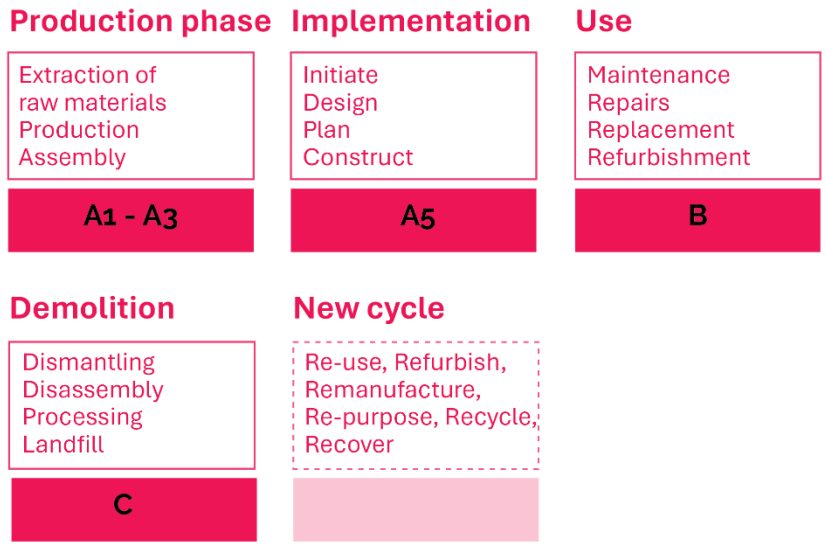

Figure 6 – Life cycle stages which form the basis for preparing a passport

Irrespective of the level of scale, the actual passport contains the data that is relevant during 'the service life' of the structure or the object to be managed. For example, a structure does not actually exist until it has been completed. A passport is not relevant for this level of scale until the *as-built* situation has been reached. The data is then managed in the use phase, so that all the required data is up-to-date, reliable and fully available during the management phase and before the demolition phase. This may differ for the construction product or material level of scale. When a structure has reached the end of its life, a construction product or material can be used again in another structure.

These two examples show that the life cycle phases of objects, products, materials and raw materials do not have to be in sync with the different levels of scale. Regardless of the level of scale, the *as-built* moment and the end of the use phase are important in order to ensure that a passport meets requirements.

Requirements can also be set on the content of passports for interim situations, but it should be taken into account that the data may be subject to many changes in these phases. This can be due to adjustments and revisions in the design and production phases, or it can be due to the detailed development of demolition specifications in the demolition phase.

5.5 Matrix of passport versions

Table 2 contains a matrix of passport versions, with the different life cycle phases on the horizontal axis and the different levels of scale on the vertical axis. Each intersection in this matrix represents a situation in which a passport can be drawn up or updated. There are also some intersections which are not, or less relevant in practice. They have been given a different colour (O) in the figure.

The data captured in a given situation need not be limited to the data that is generated in that phase. For example, it can also relate to previous phases and subsequent phases. For example, if the decision is taken to prepare a passport during the construction phase, data from the production phase will also be required.

The basic principle is that passports for structures should be complete, up to date and reliable for the goal for which they were made at the end of the construction phase *(as-built)* and at the end of the use phase.

Table 2 – Passport versions

	Level of scale	Production Extraction etc.	Implementation Initiation etc.	Passport up to date	Use Maintenance etc.	Demolition Dismantling etc.
Physical space	Level 1	O	O	X	X	O
	Level 2	O	O	X	X	O
	…	O	O	X	X	O
	Level n	O	O	X	X	O
Physical object	Level 1	O	O	X	X	O
	Level 2	O	O	X	O	O
	…	O	O	X	O	O
	Level n	O	O	X	X	X
	Material Raw material	X	X	X	X	X
		X	X	X	X	X

X = version and point where requirements must be fulfilled

5.6 A longlist as a basis

The *Longlist of Passport Items* (figure 7) should be considered as a tool to transparently achieve a degree of standardisation in the content of passport versions. The basic notion underlying this tool is as follows: all the ideas, proposals and needs for passport items mentioned by stakeholders so far have been placed on a 'longlist'. This longlist contains all the items that can be included in a passport, depending on their intended use. Wherever possible, the source(s) of the data in question has (have) been indicated for each passport item as well.

Subsequently, several columns were added to the longlist of basic data for the passport items. Options can be marked, e.g. by crosses ('x'), to quickly and flexibly show the effect of changes to passport items on the content, scope and use of the passport. The resulting passport can be viewed and discussed immediately by selecting the options marked.

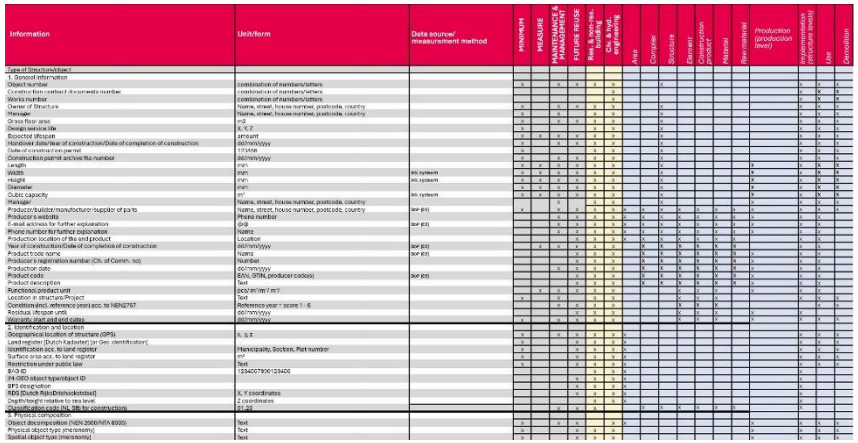

Figure 7 – Impression of the *Longlist of Passport Items*

In order to keep track of the many possible passport items, the following categories were identified in the longlist:

- general data;
- identification and location of the structure/object;
- physical composition of the structure/object;
- sustainability performance, certificates and performance declarations;
- safety, health and environmental hygiene;
- circularity;
- technical data;
- other.

In addition, several columns have been added to the longlist to enable selections to be made to generate a passport version. These columns concern the following categories:

- sector (buildings or civil and hydraulic engineering);
- level of scale;
- life cycle phase;
- goal;
- target group;
- availability of data.

5.7 Examples of passport versions

The main goals concerning circularity and the use of a passport for the construction sector can be identified in the longlist:

- MVP (*Minimal Viable Product*)
- Measuring circularity ('achieved circularity')
- Management and maintenance
- Future reuse

The complete longlist is available as an Excel file which can be downloaded from www.platformcb23.nl.

6 Preconditions

6.1 Introduction

This chapter presents an extensive discussion of the preconditions which are crucial in order to promote the use of passports for the construction sector such that the practice will eventually become self-evident.

6.2 Preconditions for use

Action will have to be taken to achieve broader use of passports. However, this will not happen until users themselves indicate which information they would like to have in order to use the passport. Sufficient attention must therefore be paid to the users (i.e. customers) and their information needs when making a passport.

The users of the passport are looking for the value of the built environment (from raw material to structure). For example, what the financial **residual value** is, which parts can be harvested and which raw materials the building contains. This means that the passport should show the correct information to enable this value to be retrieved from the passport. In other words, the situation should change from: 'what do we think should be in it?' to: 'where do we find the value?'

When using existing materials in a structure, databases of information will have to be generated. This initially requires a push system. But once there is a demand for this data, an economy with added value creation (pull system) will emerge.

Figure 8 gives a broad idea of how various stakeholders in the construction and deconstruction chains play a role in recording and utilising the data on the composition and value proposition of the built environment. Value proposition is taken to mean: the composition of all the values a structure represents. There should be optimum information about 'what' is 'where' for the system as a whole. The use of unique identifiers enables elements to be traced, even 'when' this situation changes or has changed.

As a further explanation of figure 8, the combination of BIM and passports is a means of illustrating the availability of construction materials, products, elements and systems. It also provides information about the current value proposition of the built object. As such, the passport, in combination with the BIM, plays an essential role in asset management. To avoid any duplications and inaccuracies, verified ID management (ID here means identification database) is important. This is identified in the figure as centrally managed, but in practice it could equally be a locally managed system.

Existing buildings without relevant BIM or passport information will have to be looked at on a case by case basis starting from economic arguments to establish whether information can be obtained and recorded afterwards. When it comes to material and functional reusability, specific approaches for the individual building categories will often have to be resorted to.

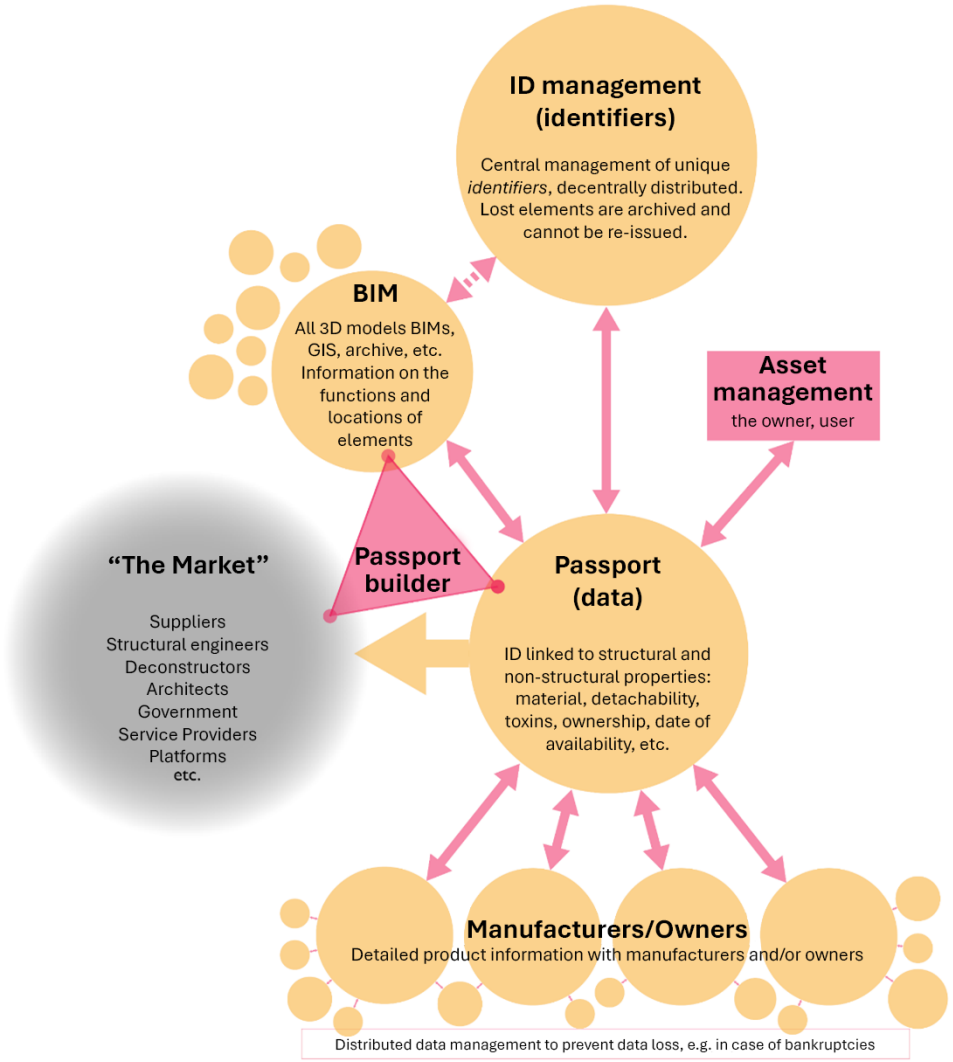

Figure 8 – Stakeholders and their roles in recording and using data

6.3 Roles as regards data needs

Clients, project developers, contractors and producers are all involved in the construction of a structure. For more information about roles and responsibilities and their interconnections, see Annex B 'Preconditions', paragraph 2.

6.4 New roles

As soon as passports with sufficient content are more widely accessible, new user groups will emerge. New (possibly user group roles) will be: Management, Financial services, Consultancy services (marketplace for information) and Storage. For more in-depth information about the new roles, see Annex B 'Preconditions', paragraph 3.

6.5 Building Information Model (BIM)

Plenty of information, specifically geometric information, is recorded in BIM models during the design and production phases. The primary function of BIM models is to record the spatial information and quantities for the construction process. Most BIM models do not contain detailed information on products and their interrelationships (e.g. detachability). This is where the aspect of 'linked data' comes into play: the product information and its circular characteristics can now be linked to the BIM model. This then all comes together in the passport.

6.6 Access

6.6.1 Introduction

Where access is concerned, reference is made to information modelling in accordance with NEN 2660-2. It is to be expected that much of the data for the passport items has already been captured in

existing application-specific software and will only need to be merged together in the passport. This makes accessibility and interchangeability of this data between systems (interoperability) essential. Interoperability of systems depends on good information modelling in order to be able to efficiently share or exchange data with internal and external stakeholders. However, this requires a good relationship or connection between the relevant stakeholders' object type libraries. For more in-depth information about information modelling, see Annex B 'Preconditions', paragraph 4.

6.6.2 Open standards

Offering the passport in a digital format makes it possible to convert data about products, components and materials into usable information.

How this information is stored is left to users' discretion as long as it is compatible with multiple platforms, data formats, resource management software and any other means of storing and accessing information.

It is important that materials which are released from the construction sector are used not only in the construction sector, but also in other sectors. In order to safeguard this interoperability, the systems chosen must be technologically agnostic to a certain extent. In other words, it must be possible to communicate between different sectors and their systems. This is why the action team decided to use web technologies such as linked data and, more specifically, RDF-compatible formats as an open and flexible basis for exchanging data and semantics.

6.6.3 Traceable

Every organisation which manages passports or has other parties manage passports must keep records of these passports. If the passport records (i.e. not the actual data) are managed centrally, central management will in all cases continue to be responsible for keeping the passports traceable as long as it owns them. The question remains who will do this. Making data accessible, e.g. by means of linked data technology, is proving to be quite a lot of work for asset managers, producers and contractors in the civil and hydraulic engineering sector. The same is expected to be the case in the buildings sector.

6.6.4 Reducing the information burden

In order to reduce the information burden, it is advisable to retain references to the product information and to capture them at source in standards, similar to EAN (European Article Numbering) information. Capturing data and storing it as back-up, in case data is no longer available at source (producer), is an important starting point to keep the information burden for collecting and long-term management of information within manageable proportions. With regard to the release of materials, the better the information from the source, the greater the chance of materials being upcycled.

In order to keep the information burden low and feasible, the complexity of the information of all passport versions should also be considered. The basic principle is to separate the minimum information necessary from the desired set of information.

6.6.5 Interchangeability

The interchangeability of data is guaranteed by firstly standardising the ID and product codes used, and secondly by proper management. In this context, it is worth considering making agreements on mandatory data exchange.

6.6.6 Object identification

Where tracking and tracing of materials is concerned, a combination of distributed data system technology and the use of barcodes, QR codes and/or RFID technology will help to make information about products, components and materials available both reliably and securely.

Using the same product codes on both the input and output sides is a prerequisite for enabling good access to the data. After all, a circular construction chain can only be 'seamless' if there is no need to translate from one coding regime to the next. There will be fewer differences between suppliers of 'primary' construction materials and suppliers of secondary construction materials in the future. An extra indication of the 'use generation' of an asset, installation or part would seem to be a good addition to the passport. This will lead to informed decision-making about previously used assets during construction and deconstruction. Using these codes and knowing which **secondary materials** are available is also important in connection with the preliminary or final design and the corresponding BIM. A unique identification code for each product is essential in order to be able to track a product over multiple use cycles. After all, the success of the passport depends on the reliability of the information about the value of the material and its composite parts. A fixed ID is required in this regard.

6.7 Application to existing structures

The passport delivers its added value if it is effectively used to promote circular reuse at the end of the useful life of the object in question. This means that parts of an existing object with a shorter **lifespan** than the overall object will need a passport sooner than the overall object. This is different to construction data for new-builds in that little is known about the future new cycle. Information is recorded in order to be able to serve a future need which is as yet unknown. In the case of new builds, circular design already covers this need. When considering existing builds, the action team assumed that objects had not yet been designed circularly, and that most of these objects had reached the end of their design phase or **functional lifespan**.

Hardly any existing objects in the Netherlands currently have updated passports. The passport for an existing object or element records the final situation (the phase just before demolition/disassembly) and its specific content depends on efficiency. In turn, the efficiency of a passport depends on the need for and availability of information:

- need for information: arises from the envisaged application of the construction materials in the new cycle;
- availability of information: the available data and how up to date the technical dossier of the existing built object is, which often depends on the age of the dossier.

Information requirement
Gaining an understanding of the envisaged application of construction materials in the new cycle will enable the passport to be used more effectively.

Since incorporating information about all existing structures into passports as well would be too much work, it has been decided to not do this until changes are made to the structures. This can be done by involving experts to draw up passports for existing objects or a part that needs replacing just before the actual **disassembly, reconstruction** or replacement. In so doing, future and realistic scenarios for reuse and the corresponding information requirement will be considered.

Take the example of a bridge girder. If the most realistic probability is that it will be given a new function at a new location without dismantling it down to its raw materials, it will be less relevant to

capture data at raw materials level. However, this data will have to be readily available and easy to add. The basic principle also has to be: it is better to record too much information than too little. In the example of the girder being reused as is, its dimensions, **detachability** and load-bearing capacity are particularly important for the new cycle. However, issues with chromium-6 and asbestos in the past actually argue in favour of recording data at the raw materials level. It is therefore recommended that extra time and budget be set aside for a passport with a deeper level of decomposition in the case of structures or parts with a high toxic risk. An alternative is to make a reference to the dossier; see the next paragraph.

Availability of information
The necessary data for the passport can largely be taken from the dossier. However, this dossier must be accurate: up to date, complete and including a condition assessment. No usable passport can be compiled without up-to-date data. If a dossier is of poor quality (which can be verified by random samples) and hardly represents the real-life situation, a new mapping exercise will be necessary. This mapping exercise could consist of an on-site survey where measurements and photos are taken, recalculations and a condition assessment are made and, if necessary, trial loading and laboratory research are carried out, depending on the predicted information requirements of the **circular strategy** chosen.

6.8 Current circular KPIs (key performance indicators)

To be able to use passports effectively in order to make circularity measurable, they will have to be able to provide input for the KPIs.

Please refer to Platform CB'23's guide for *Measuring Circularity in the Construction Sector* for the KPIs for materials

6.9 Basis for standardisation

6.9.1 Introduction

This section focuses on the level at which information is available, who owns the information and how privacy has been arranged. Decreasing the information burden and interchangeability are also part of this.

6.9.2 Semi-decentralised

As far as many public authorities are concerned, the basic principles for determining when and at what level the information should be available come down to choosing the structure of this circular economy process:

- Leading role: In this approach, the public authority itself keeps records of materials, quality, properties and availability according to the market. Additional responsibilities are: looking ahead (e.g. 5 years), regulations for contractors/demolition companies, and also for the purchasing contractor, perhaps through providing management including quality assurance.
- Incentivising role: This involves a joint role in a circular society. Creating demand by imposing obligations on the contractor to use existing materials, raw materials and construction products. Such an approach will create demand and parties will develop services in response to this demand. In combination with market value, demand for information will also be created (pull system).

A logical middle way is to centrally direct and stimulate standardisation. Permanent agreements will have to be made about this with government bodies, sector organisations and umbrella bodies such as the Dutch National Environmental Database (NMD), Stichting Bouwkwaliteit (SBK), CROW, Bouwcampus, Bouwagenda and NEN.

Data storage will always be the responsibility of the asset manager concerned, not of a national authority.

Table 3 illustrates the data storage possibilities for the individual higher levels of identification registration and underlying data for each level of scale.

Producers provide documentation to contractors. Possibility: arranging alignment with passports and management of source documentation. More information about centralised, decentralised and hybrid models can be found in in 7.2.3 'A centrally-decentrally controlled model'.

Setting up a system for collective registration and management is an important future requirement. This is most likely to be a hybrid system with decentralised management of passport information. Such a system will have consequences for the government, i.e. additions to the cadastral registers, and market parties (registration and communication about continuity of information). The government's support is crucial here to enable the feasibility and scalability of passports, not only in financial terms, but also in order to safeguard uniform data collection methods.

Table 3 – Data storage options

Degree of centrality	Central registration system	Semi-decentralised	Decentralised data system	Decentralised data system
Organisation	Task for one party/public authority	Multiple parties	Market, many contractors	Market, many producers
Format	One format	One basic-format	Several different formats	Several different formats
Service model	Assignment	Data services models	Free market	Free market
Identifier registration	Body set up by the government, to act like a license plate registration	For each database		
Area				
Complex				
Structure			Owner (Contractor > Client)	
Element			Owner (Contractor > Client)	
Construction product		Possibility after ten years	Current situation	Batch info: retained for ten years
Material				
Raw material				

6.9.3 Ownership

An owner is an organisation, and that organisation has to commit itself to the guideline of publicly announcing whether it will manage the data itself or arrange this through third parties.

Every passport is part of a decomposition structure of a higher level. The owner of an area or structure also owns the underlying parts. This is different for lease or other service agreements. As part of the circular economy, service contracts which show other owners in a decomposition have become much more common. Arrangements can be made for each project about how ownership will change if materials are removed.

As regards ownership, it is important to know when the structure, construction element or product will come back onto the market to be reused (15, 50, 75 or even up to 200 years). Who owns the relevant data or passport in the meantime, and what information do they contain?

Traditionally, a structure including all construction elements is handed over to the owner, even if a building is sold on to another owner after its completion. This means that the owner also owns all the components. A completion document is provided for this. This information is necessary in the event of maintenance to ensure it is properly carried out.

The construction elements and products present will have to be mapped at the end of the structure's life. The issue then is an element's or product's residual value. This will quite probably be different information from that needed for delivery or maintenance. However, it is still connected to the object. When elements or products are sold, they will be accompanied by the necessary information.

Of course, a future situation may arise where the owner of a structure is only the user of the structure and the supplier remains responsible for maintenance and ownership. This is great from a **cradle-to-cradle** philosophy. A supplier then takes back its own products. It has all the data. If a supplier is taken over or otherwise acquired, this information will still be of value to the person who subsequently takes on the product.

In all cases, the warranty period and the accompanying liability must be clearly defined. Since it would be difficult to keep a supplier eternally responsible for managing the product specifications, we recommend transferring this responsibility to the owner of the object. A company's 'trade secrets' will have to be taken into account however. No conclusive answer is available yet to the question of where this information goes if a business is discontinued or changes ownership. Ownership is addressed in more detail in 7.2.2 'Ownership and management of data'.

6.9.4 Privacy

Once the need for a circular economy had been established, the issue of ensuring sufficient legal protection against breaches of people's rights to privacy also emerged.

In order to arrive at a system of circular information exchange, the information will have to be separated from personal information. And the guidelines for data owners will have to become more stringent.

At present, a *Privacy Impact Assessment* is being carried out to demonstrate the residual risks after separation.

6.10 Transparency

Asset managers should make their data publicly available so that interested parties can gain access to the composition of available

materials and assets. Of course, privacy considerations and trade secrets make this a tricky issue. The current model is based on decentralised passport builders, with innovative forms of passport content and contractual conditions to encourage choices and data transfer. However, without central management and a marketplace, it will hardly be possible for users to find data on materials. This calls for proper incentivisation and coordination.

In a competitive environment, data on all materials (in the Netherlands) often consists partly of secret, inaccessible information about **sustainable**, innovative materials. Some of it is publicly accessible information and sometimes data can be obtained subject to certain conditions. This makes it difficult for producers or clients to share the information whilst keeping it partly public and partly privately owned. In a fully circular economy, both forms will have to be available and traceable to each other (Figure 9).

A translation of the current forms of transparency has been chosen:

- public, publicly retrievable;
- conditionally available because of commercial benefits, risk because of management;
- secret because of sensitivity from a competition point of view, existing agreements between client/contractor, patents.

As a consequence of the precondition that there should be explicit information about a product or material, a storage standard will have to be established. Parties will not only have to store their information and provide access to it according to that standard but will also have to promote transparency of this data. This task can be assigned to several parties (with central management by recognised decentralised parties), or to a single party (fully centralised management).

All situations require information about these products or materials to be quickly available to the public. The links between the different data elements will have to continue to be maintained. How the information can be made transparent at a central body will have to be investigated.

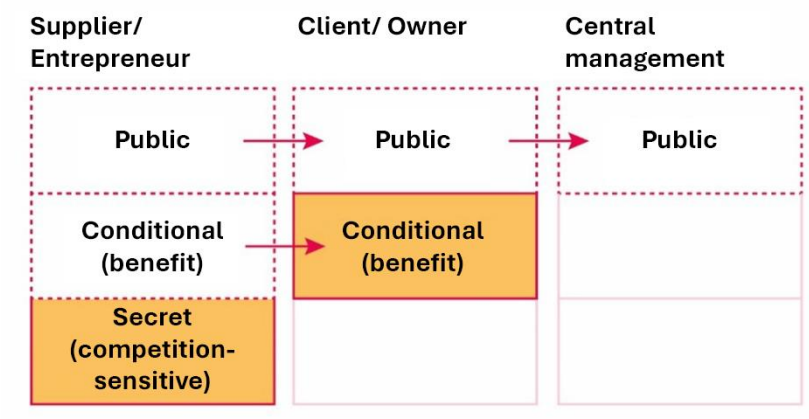

Figure 9 – The positions of supplier/entrepreneur, client/owner and central management

7 Data

7.1 Introduction

A materials passport features extensive product-related data and many references to external data. Safeguarding the availability and reliability of this data is crucial. This chapter is about how to handle data in the broad sense of the word and how to keep this data up to date. This is because the party that maintains the passport dataset (e.g. the asset manager) is not always the party that manages the primary product data. The latter parties might also be producers, distributors, maintenance providers or other third parties. However, at present there are no guarantees that all information will find its way from the producer to the asset manager (trade secret) or will continue to be accessible for ever (discontinuation of business operations).

7.2 Data management

Data management is about correctly managing the data provided for passports.

7.2.1 A look at the sector

The construction sector is faced with an enormous quantity of data, which makes it far from easy to digitise the built environment and all associated processes. To carry out circular projects smoothly it is crucial that concrete agreements are made as regards data management. Some of the aspects to be addressed by these agreements are:

- management and control;
- central/decentralised/hybrid;
- exchange method;
- data provision;
- data integration and interoperability of data and datasets;
- data architecture that promotes the above aspects.

The desired output of circular and other data about the built environment will have to be assessed. Applications and data files will have to be linked together on this basis. In doing so, it will be necessary to look beyond the business processes.

7.2.2 Ownership and management of data

Who owns and manages data and for how long should data be stored? The basic principle of responsibility for data is that the data remains with the source and the source is also responsible for this data. Against this background, warranty provisions can give clarity as to the ownership of data in passports, since providing and updating the data on the 'product' for which a passport was prepared is the supplier's responsibility during the warranty period.

This means that the supplier is always responsible for all the 'required' 'product-related' passport data recorded in an Information Delivery Specification. The question is what happens to the data after the warranty period. Another consideration is that an owner/administrator should always have a copy of the product data. This can be assigned in-house and/or outsourced to a third party. Any 'non-product related' data (data relating to a product's processing, management, maintenance and end of life) is the responsibility of the owner/manager of the building in which the product has been used. The underlying principle here is 'who owns the technology' and 'who manages this technology'. This perspective of data ownership leads to shared ownership as a logical next step.

Take a smartphone, for instance. Buying it does not make you the owner of the design and the data concerning the smartphone (composition). You own the usage data, such as the data consumption (internet and the number of minutes called), and your browser's

search history. This makes shared data ownership a logical starting point for assigning responsibilities to the owner(s) of the data in question.

The built environment also requires data to be stored for the entire lifespan of a building or civil and hydraulic engineering object. It is not uncommon for buildings or civil and hydraulic engineering objects to have a lifespan of at least 75 years up to a maximum of hundreds of years (especially in a circular economy). Current legislation imposes a shorter retention period than a building's lifespan, or the point where a **passport for a building** should be consulted several decades later for renovation or for adapting spaces. The civil and hydraulic engineering sector assumes different expected lifespans, varying from 15 years for the surface layers of cycle paths to 100 years for bridges.

7.2.3 A centrally-decentrally controlled model

Central or decentralised control is a much debated topic when it comes to digitising the construction sector. This aspect was also discussed at length in chapter 6. Should the national government have central responsibility for data quality and for managing data and datasets? Or should this be decentralised, using innovative technology? Neither of these two options seem to be realistic in practice. The customary shape this tends to take is a centralised/decentralised hybrid model with centrally agreed open standards and guidelines being implemented at decentralised levels, usually by applying specific software or applications.

An important principle in a hybrid model is that certain pieces of data become freely accessible to the public sector where possible. The owner of the original data will have to determine which information is sensitive business information and they will have to be able to control access to the information so that it is only available to authorised private or public parties. This hybrid model enables a scalable and cost-efficient circular economy to be achieved.

7.3 Data quality

Data quality refers to the accuracy of the available data and the degree to which available data is suitable for its intended purpose. A number of quality requirements must be met to be able to exchange data. The data thus becomes valuable to others.

7.3.1 Onion-skin model

The onion-skin model for data accessibility can be applied to quality requirements. Backx (2004) summarises the quality requirements in this model. Figure 10 shows the onion-skin model.

The model shows that data is not accessible for reuse by another party until:

- it is known which data can be obtained and where it can be obtained;
- it is clear how and under what conditions the data is available (accessibility);
- the data has been made suitable for reuse (usability).

Recording data in a structured and harmonised way increases the value and the application possibilities of passports.

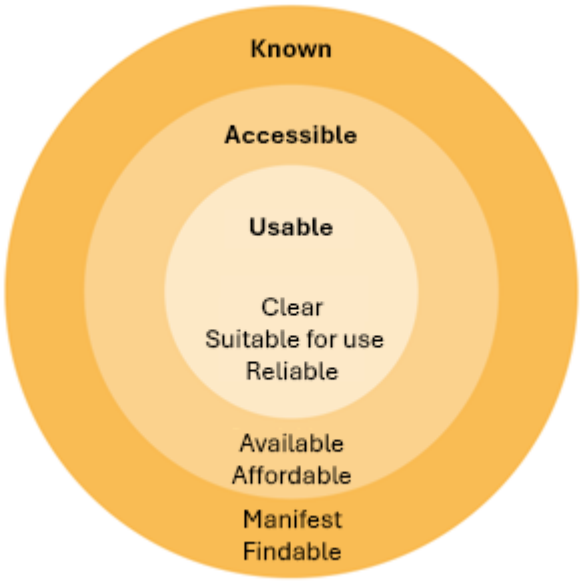

Figure 10 – Onion-skin model of data accessibility

7.3.2 Data quality during the life cycles of structures

The data quality of passports for the construction sector concerns the degree to which product-related data is available and accessible for reuse purposes. The better the data required for the reuse of materials has been recorded, the greater the probability that these materials will actually be reused. The more accurate the data, the higher the data quality will be. Such data can concern the type of material, the quantity or the functional performance, or other aspects.

In the construction sector, the Information Delivery Specifications (ILS) seem to be the proper method for recording data requirements for materials used.

When data is recorded, considerable differences often occur between the 'as-planned' data, which comes from building plans and drawings of a building, and the 'as built' data (upon completion) or 'as-is' data (during the use phase), which comes from a building's or civil and hydraulic engineering object's actual situation. If stakeholders of a circular construction economy are not properly informed about the materials present in a building or a civil and hydraulic engineering object and the state of these materials, this will impede the transition to circular construction.

It is essential that this data is updated regularly, e.g. whenever maintenance, renovation or other transformation work is carried out on a structure. Existing technologies and software packages which have already become well-established in the sector can be used for this purpose.

7.3.3 Mapping and recording data

In order to assure the highest data quality, several different experts in specific professional fields (such as architects, engineers and contractors) have to record attributes of buildings and of objects in the civil and hydraulic engineering sector in a passport during their design and construction. Attributes are the basic properties of entities. For example, the colour 'red' is an attribute of the entity 'brick'. Further information about attributes, entities and relationships is given in Annex C 'On the way to data interoperability'.

The attributes chosen must relate to the design or production phases, the use phase and the end of useful life phase. This ensures that data is recorded which is in keeping with the real-life situation, the as-is and as-built situations instead of the as-planned and as-developed situations of a building or a civil and hydraulic engineering object.

The Longlist of Attributes in Annex A to this guide serves as an example of essential attributes that can be included in the passport.

This list might be the basis for a future shared standard of attributes necessary for a circular construction sector.

7.4 Interoperability and linked data

Interoperability and linked data enable effective and especially efficient cooperation in the construction chain. However, commonly used data formats only allow us to link data to a limited extent. Furthermore, such data formats often lack an agreed information model with definitions of the concepts, relationships and properties used in a dataset, or the data cannot be exchanged and consulted in a standardised manner.

Being able to smoothly and quickly link all the different data is essential in order to prepare a materials passport. Standards independent of software applications ensure long-term interoperability between different digital systems of various stakeholders. This makes the ability to exchange data according to such open standards at any time an important requirement for digital systems for creating and managing materials passports.

One of the most sophisticated interoperability technologies is the 'linked data' (LD) technology. It enables different pieces of data in conceptual information structures and/or datasets to be linked. Since the LD standards have been created at web level, they are not restricted to a specific application domain or geographical area. Over the years, the application of LD in the construction sector has been given more attention. This has resulted in new specifications being developed, including in the Dutch context, which are an expansion of international web standards.

To keep an exchanged passport dataset unequivocally verifiable and to protect it against data loss, the use of 'ledger systems' such as a *centralized ledger* (e.g. government records) or *distributed ledger* systems (such as blockchain) combined with *dataset hashing* seems to be the obvious choice. Copies of datasets prevent data loss and the temporary or permanent unavailability of an online dataset from the primary source. A detailed technical explanation of ledger systems and actions to prevent data loss are not part of the scope of this guide.

Annex C 'On the way to data interoperability' gives a better understanding of some possible applications of and action points for the use of LD in the context of materials passports in the construction sector.

7.5 The importance of clear agreements and guidelines

Good data management in the sector, including assuring data quality and interoperability during the life cycles of built objects requires clear agreements and guidelines laid down in open standards. More specifically, agreements are needed on:

1. the process of and responsibility for data (data provision and management);
2. how to exchange data between parties;
3. the content of datasets to be exchanged.

Additional agreements can be made about linking to external data sources, such as the Key Register of Addresses and Buildings (in Dutch: Basisregistratie Adressen en Gebouwen - BAG).

The Information Delivery Specification (ILS) which has been referred to elsewhere in this document is mainly used in order to record agreements between the construction partners during a construction project. The attributes required for a materials passport have to become part of the information structure prescribed in the IDS. This also shows which data a passport should contain. Provinces and municipalities already have a standard for data delivery that they use in their tendering procedures. The information requirement, e.g. the Longlist for Mandatory Data Passports, can serve as part of the IDS.

The international basic standards for linked data contain technical specifications for the data formats to be used and the correct design of exchangeable information structures. NEN 2660-2 provides a detailed elaboration of these standards for information structures applied to the construction sector.

Other initiatives, such as IMBOR (Informatiemodel Beheer Openbare Ruimte - Public Space Management Information Model), CB-NL (Conceptenbibliotheek Nederland - Dutch library of concepts) and Rioned can be linked to these information structures.

A further explanation of technical specifications, including a practical example based on the Longlist of Attributes, can be found in Annex C 'On the way to data interoperability'.

8 Results, subsequent steps and recommendations

8.1 Results

This guide features a Quick Start Guide (QSG) that makes it easier to prepare passports, thus optimally supporting the transition to a circular building economy. The QSG presented in this guide guides those compiling a passport through the steps required to collect and enter all the data that makes the passport complete.

8.2 Subsequent steps

Since the Guide to Passports for the Construction Sector is a work in progress, the subsequent steps are aimed at the post-implementation phase. Several preconditions will have become clearer then as well.

Subsequent steps to take passports for the construction sector to the next phase are:

- managing the longlist of Passports for the Construction Sector (see 3.5) or outsourcing its management;
- describing the use of the longlist or having it described;
- placing the passport data of the longlist in separate tabs for each level of scale;
- preparing passport versions for, and with, validated measurement methods and goals;
- having the accuracy of datasets in the longlist checked by reputable parties;
- preparing a measurement method or tool for measuring the quality and quantity of the data.

8.3 Recommendations

Passport versions

For the purpose of promoting circularity and the use of passports:

- passports need to be harmonised;
- it would be helpful if public use of the passports was promoted and if the government imposed some degree of obligation;
- an assessment of the longlist should be carried out with market players in order to assess the availability of data;
- functional management of the long list is necessary;
- it is important that passports are easy to retrieve, thus making datasets of government bodies and companies publicly accessible (taking into account privacy and sensitive business information).

Preconditions

- The government needs to define a clear strategy for the time it will take to achieve a mature passport system. In order to create value and accelerate a circular economy, steps will have to be taken before 2025. That is why the strategy should definitely include a requirement that a passport will become mandatory by 2025. The maturity model may help to create a strategy for this in a timeline.

- Take a pragmatic approach to existing structures. Start with a quick scan of the parts present at element level and, where possible, at construction product level in accordance with the decomposition in NEN 2767 and then present this in a schematic view. Next, consult experts and jointly establish the circular opportunities for the new cycle, given the current knowledge, and then determine which information requirements this will lead to. After that, check that the data is

available in the technical dossier. If any crucial information is lacking, it will have to be obtained through research. After this, the passport can be prepared.

- Setting up a system for collective registration and management is an important future requirement. This is most likely to be a hybrid system with decentralised management of passport information. This will have consequences for the government, i.e. additions to the cadastral registers, and market parties (registration and communication about continuity of information). The government's support is crucial here to enable the feasibility and scalability of passports, not only in financial terms, but also in order to safeguard uniform data collection methods.

- It will have to be investigated how unambiguous information about a product or material, to be assigned to the market parties, can be made accessible via a central body.

- Above all, it will be necessary to maintain a discerning attitude in order to avoid an excessively high administrative burden.

Data

- The ambition to use passports in the buildings and civil engineering sectors calls for a sound data governance strategy. The data management of passports should be recorded in a structured and harmonised manner, be accessible, offer exchange possibilities and allow the data to be analysed.

- In order to ensure clarity and uniformity in the sector, it is essential that, where data is concerned, everyone uses the same technical terms and the same definitions. Platform CB'23's *Circular Construction Lexicon* has been prepared with this in mind, to be compatible with all the different guides.

- A semantic dataset is very valuable for circular construction. It links circular attributes to construction materials, components, products and buildings, and indexes them efficiently. The added value of a semantic web for combining data from different organisations is that an unambiguous logic emerges. It enables the accessibility of sensitive data to be protected, based on the data owner's preferences. Several different technologies exist for this. Which one of them is the most convenient will have to be deduced from NEN 2660, and the actual market.

- Besides recording data in the 'standard' relational database, it is important that the quality of the passport and the data contained in it is safeguarded by recording it and making it accessible by means of available technologies.

- Data linked to a construction project should be freely accessible to the public sector, taking into account privacy and business-sensitive information.

Background

Platform CB'23

Platform CB'23 was set up by Rijkswaterstaat, the Dutch Central Government Real Estate Agency (Rijksvastgoedbedrijf), De Bouwcampus and the 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 activities of the platform take place in conjunction with the national implementation programme, the Transitieteam and Transitiebureau Circulaire Bouweconomie (Transition Team and Transition Agency for Circular Construction Economy). By extension, the platform is linked to the Dutch Bouwagenda (Construction Agenda).

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

2023 as a dot on the horizon

CB'23 is short for Circular Building in 2023. The platform thus identified its dot on the horizon as 2023. This was close enough to both keep the pressure on and yet far enough away to enable concrete results and agreements to be reached.

Development of the guide for Passports for the Construction Sector, 3rd edition

Parties throughout the sector contributed to the development of this guide. The third edition of this guide builds on the first two editions.

Contrary to the two previous editions, this guide was prepared by one working group. This small, effective structure ensured optimum in-depth refinement of the guide to Passports for the Construction Sector.

The different versions of the documents prepared by the working group were read by a limited group of parties who added their comments. The kick-off meeting for developing this guide was held in October 2021. Due to Covid-19, all meetings took place online.

Support team

Platform CB'23 set up a support team to coordinate the process. This support team consisted of a chairman, a coordinator, working student and a rapporteur. 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 of the working group 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 introductory film on the Platform CB'23 website. Anyone could download this version and then give feedback.

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

Alignment of the guide with the other action team

At the same time as the Passports for the Construction Sector action team was active, work on Measuring Circularity and the guide to Future Reuse also took place. The structure and planning schedule of these products was largely similar to that of Passports for the Construction Sector. During the development of this guide, there were a number of alignment moments during which the action teams were informed of each other's activities.

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Annex A

Longlist Attributes

Information	Unit/form	Data source/ measurement method	MINIMUM	MEASURE	MAINTENANCE & MANAGEMENT	FUTURE REUSE	Res. & non-res. building	Civ. & hyd. engineering	Area	Complex	Structure	Element	Construction product	Material	Raw material	Production (production level)	Implementation (structure level/s)	Use	Demolition
Type of Structure/object																			
1. General information																			
Object number	combination of numbers/letters		x		x	x	x	x			x						x	x	x
Construction contract documents number	combination of numbers/letters							x									x	x	x
Works number	combination of numbers/letters							x									x	x	x
Owner of Structure	Name, street, house number, postcode, country		x		x	x	x	x			x						x	x	x
Manager	Name, street, house number, postcode, country		x		x		x	x			x						x	x	x
Gross floor area	m2		x		x	x	x	x			x						x	x	x
Design service life	X, Y, Z		x				x	x			x						x	x	x
Expected lifespan	amount		x	x	x	x	x	x			x						x	x	x
Handover date/Year of construction/Date of completion of construction	dd/mm/yyyy		x		x	x	x	x			x						x	x	x
Date of construction permit	123456		x				x	x			x						x	x	x
Construction permit archive file number	dd/mm/yyyy		x		x	x	x	x			x						x	x	x
Length	mm		x	x	x	x	x	x			x					x	x	x	x
Width	mm	ink. systeem	x	x	x	x	x	x			x					x	x	x	x
Height	mm	ink. systeem	x	x	x	x	x	x			x					x	x	x	x
Diameter	mm		x	x	x	x	x	x			x					x	x	x	x
Cubic capacity	m^3	ink. systeem	x	x	x	x	x	x			x					x	x	x	x
Manager	Name, street, house number, postcode, country				x		x	x			x					x	x	x	x
Producer/builder/manufacturer/supplier of parts	Name, street, house number, postcode, country	DoP (CE)	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Producer's website	Phone number				x	x	x	x	x	x	x	x	x	x	x	x	x	x	
E-mail address for further explanation	@@	DoP (CE)			x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Phone number for further explanation	Name				x	x	x	x	x	x	x	x	x	x	x	x	x	x	
Production location of the end product	Location					x	x	x	x	x	x	x	x	x	x		x	x	
Year of construction/Date of completion of construction	dd/mm/yyyy	DoP (CE)		x	x	x	x	x		x	x	x	x	x	x		x	x	
Product trade name	Name	DoP (CE)				x	x	x		x	x	x	x	x	x	x	x	x	
Producer's registration number (Ch. of Comm. no)	Number					x	x	x		x	x	x	x	x	x	x	x	x	
Production date	dd/mm/yyyy				x	x	x	x		x	x	x	x	x	x	x	x	x	
Product code	EAN, GTIN, producer code(s)	DoP (CE)				x	x	x		x	x	x	x	x	x	x	x	x	
Product description	Text					x	x	x		x	x	x	x	x	x	x	x	x	
Functional product unit	pcs/ m^1/m^2/ m^3/			x	x	x	x	x				x	x	x		x	x	x	
Location in structure/Project	Text		x		x		x	x				x	x	x			x	x	x
Condition (incl. reference year) acc. to NEN2767	Reference year + score 1 - 6				x	x	x	x				x	x	x				x	x
Residual lifespan until	dd/mm/yyyy					x	x	x				x	x	x		x	x		
Warranty start and end dates	dd/mm/yyyy		x		x	x	x	x				x	x	x		x	x	x	x
2. Identification and location																			
Geographical location of structure (GPS)	x, y, z		x		x	x	x	x	x								x	x	x
Land register [Dutch Kadaster] (or Geo identification)			x			x	x	x	x								x	x	x
Identification acc. to land register	Municipality, Section, Plot number		x			x	x	x	x								x	x	x
Surface area acc. to land register	m^2		x			x	x	x	x								x	x	x
Restriction under public law	Text		x			x	x	x	x								x	x	x
BAG ID	1234567890123456						x	x	x								x		
IM-GEO object type/object ID						x	x	x	x								x		
BPS designation						x	x	x	x								x		
RDS [Dutch RijksDriehoekstelsel]	X, Y coordinates					x	x	x	x								x		
Depth/height relative to sea level	Z coordinates						x	x	x								x		
Classification code (NL-Sfb for construction)	01.23				x	x	x			x	x	x	x	x	x		x		
3. Physical composition																			
Object decomposition (NEN 2660/NTA 8035)	Text		x		x	x		x	x							x	x	x	x
Physical object type (meronomy)	Text		x			x	x	x								x	x	x	x
Spatial object type (meronomy)	Text		x			x	x	x								x	x	x	x

Figure A.1 – A fragment of the longlist

Annex B
Preconditions

B.1 Maturity model

Table B.1 – Maturity model

0	1	2	3	4	5
Linear	Individual	Connection	Decentralised	Economy	Network

The use of passports has matured gradually, mirroring the way the circular economy has developed. Topics and relevant actions have to be considered for each stage of maturity and can be chosen according to ambition.

Linear

- Procurement follows design and direct costs.
- Architects follow aesthetics based on 'anything is possible'.
- No questions concerning the circular economy.

Individual experiments

- Set up individual circular registration
- Benefit/necessity is clear to specialists

Connection

- Forms of collaboration
- Registration according to the passport principle
- Accelerating by means of alternatives which get people to join the transition
- Benefit/necessity of circular economy is clear to everyone

Decentralised system

- Ad hoc recording with minimum passport components collected centrally
- New structures emerge for materials, passport and storage
- Transition is in full swing

Economy

- A fully economic system with 100% circular procurement
- Structural recording with standard passport components collected centrally
- Thinking and acting according to circular principles as the new economy.

Network

- Fixed working method through network expansion in all projects
- The financial world, also with government input, has embraced the circular economy

B.2 Roles as regards data needs

Every user or stakeholder looks at the information in a passport from their own point of view. The information provided by a passport should therefore be in line with the user's requirements.

The information requirements for the passports of individual user roles are shown in figure B.1.

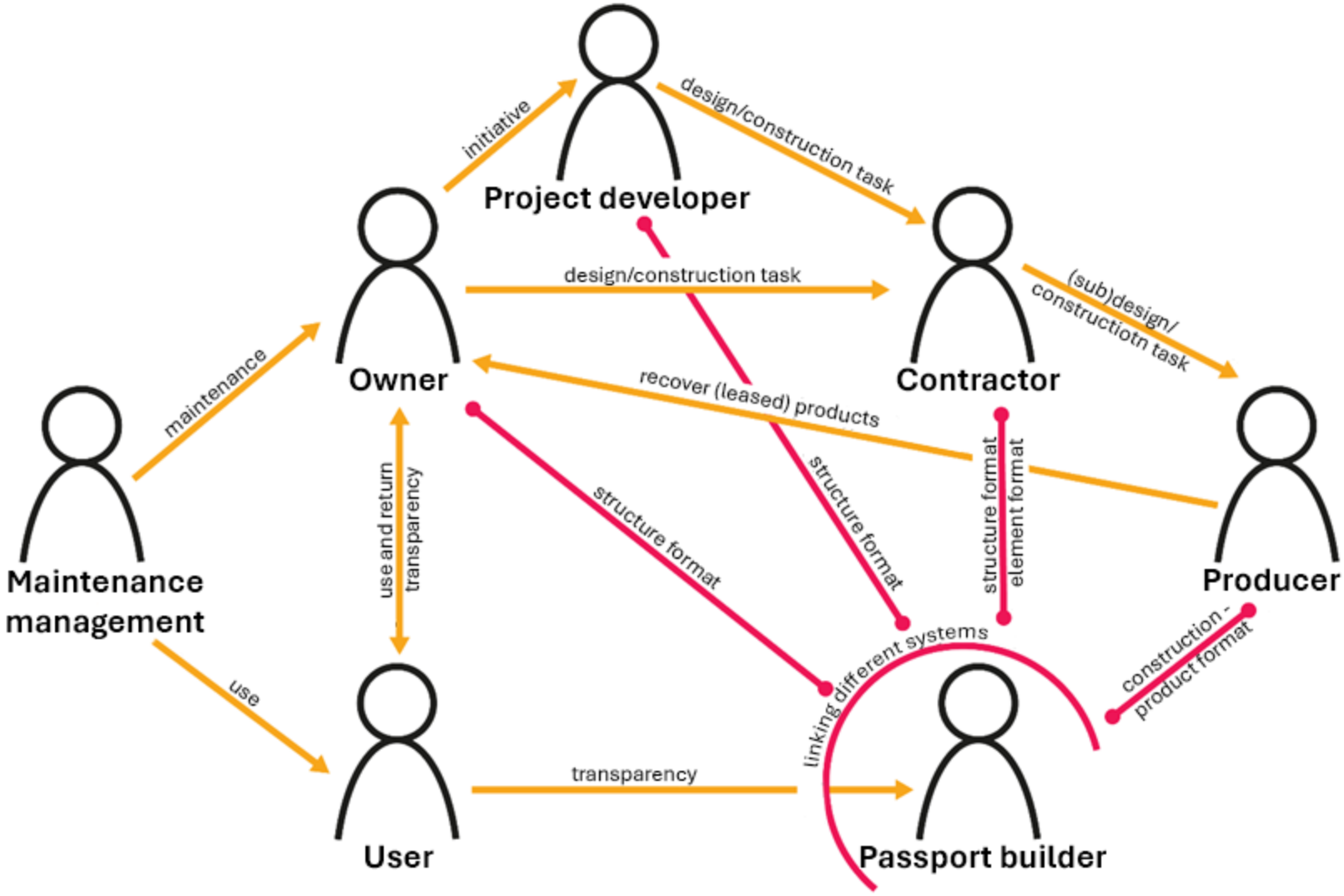

Figure B.1 - Roles and relationships between users

Table B.2 clarifies the users' roles or perspectives.

Table B.2 - Users' roles and perspectives

Client Owner*	• Initiative - start of useful life of structure. • The initiator's role is performed by the owner or a project developer. The assignment to construct a structure is carried out by the contractor. • Initiative - restart of a structure's service life (at the end of its functional service life). • Release of structure (parts, materials, raw materials) - end of useful life of structure. • Ownership - during the useful life of the structure. • The owner's role is performed by the government, a company or a private person. • Management - during the service life of the structure. • The manager's role is performed by the owner, property management or the user.
Contractor	• Temporary ownership - during construction. • Is the temporary owner from the start of (re)construction until completion. • Designer/builder. • Designs and/or constructs/refurbishes the structure (possibly with other parties). • Finds a location/space/parts/materials/raw materials for the structure. • Does the procurement for constructing/refurbishing the structure.
Producer/manufacturer/ supplier	• Is a specialist in their own part of the project. • Is aware of the availability of their own or third-party materials and/or raw materials. • Wants to trace their own parts.
User	• Is the permanent or temporary owner or the tenant, private person, government. • Is looking for or entitled to transparency. • Either has or does not have the possibility to make any changes to the structure.
Passport builder	• Sets up the data format. • Manages this data. • Is responsible for the availability and legibility of this data.

*The owner is also included under Client.

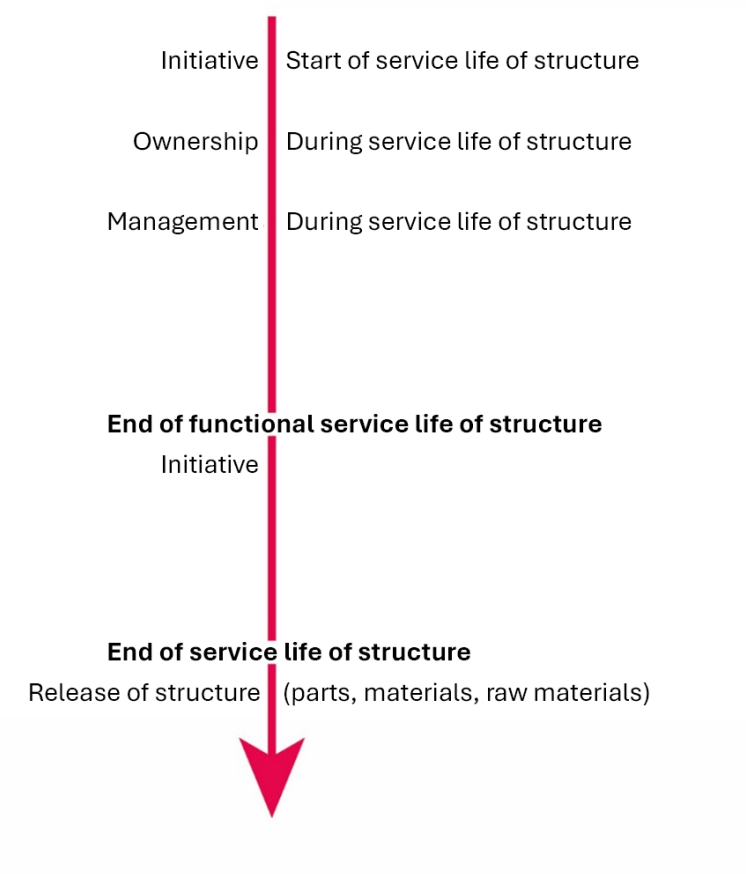

Figure B.2 – Timeline of the useful life of a structure

If we zoom in on the information that the stakeholder needs to provide for a passport, we get the following list:

Client

- *Management of the assets*: materials and the corresponding raw materials, types of connections, specific service lives and possibly measurement data.
- *Value of assets quantified*: materials, raw materials, types of connections, surface area and quantities, technical condition of construction elements, residual service life, financial value.
- Tracing the owner of leased products.
- **Service life extension** *of assets* (possibly with other function): technical condition of construction elements, construction elements' load, residual service life, design principles, building physics aspects.
- *Reuse*: changes in design principles, transportation possibilities, standard parts linked to serial numbers and/or types, and/or customisation, disassembly plan.
- *Measuring sustainability and circularity*. See the guide for *Measuring Circularity*.

Contractor

- *Extending the service life of assets* (possibly with another function): technical condition of construction elements, construction elements' loads, residual service life, design principles, building physics aspects.
- *Reuse*: design principles including changes, transportation possibilities, materials, standard parts linked to serial numbers and/or types, and/or customisation, disassembly plan.
- *Release of raw materials/materials/parts:* when are which raw materials released, what is their technical state and residual service life, what loads have they been subjected to?

- Leasing of building structure/part/material: traceability of leased product.

Producer/manufacturer/supplier

- *Release of raw materials/materials/parts:* when are which raw materials released, what is their technical state and residual service life, what loads have they been subjected to?
- Leasing of building structure/part/material: traceability of leased product.

User

- *Transparency of assets*: transparency in respect of user of what is being put into use.
- *Background information* (such as a city archive or land register).
- Changing structure/part: record changes.

Passport builder

- What do the users of the passport systems want?
- To have data available from different systems in order to fill passport formats. Some standardisation is required as is access to these systems. The various information requirements are shown in Table B.3.

Table B.3 – Various information requirements

	0 Linear	1 Individual	2 Consistency	3 Decentralised	4 Economy	5 Network
Client	Information available in several locations	In addition to available information, collect information for reuse. Include BIM model + passport in invitation to tender	Include passport in invitation to tender	Include the measuring of circularity in invitation to tender	The passport builder provides a list of the owners of construction parts	Asset valuation model Measurement of circularity linked to passport
Contractor	Supply the requested information	Test of information in passport	Provide requested information in a passport	Deliver passport in accordance with formats in own system	Harvest charts linked to passport system	Construction parts can be traced back in passport system
User						Record changes in the passport
Producer	Supply the requested information	Keep tests of own parts	Convert test into a passport model Provide requested information in a passport	Deliver passport in accordance with formats in own system		

B.3 New roles

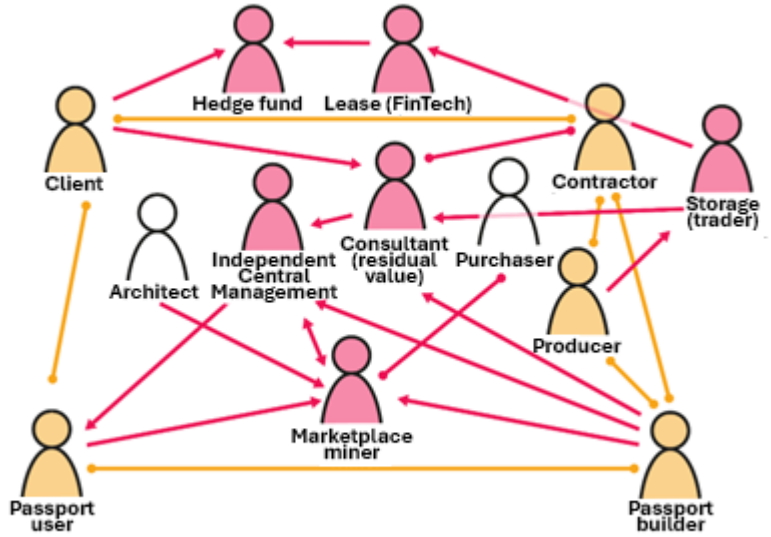

Figure B.3 – New roles (user groups) and relationships

As soon as passports with sufficient content are more widely accessible, new user groups will emerge. Based on their specific roles, they will also set their requirements on the content of a passport.

New roles (possibly user groups' roles) will be:

Management

- Central management organisation.
- Sustainability as part of permits. In addition to the 'welstandscommissie' (building aesthetics committee), the information from passports will be included in the characteristics of the area.

Financial services

- Fintech leasing, a way to lease out materials/products and shift the risk to the trading market.
- Hedging of materials, i.e. reducing risk by hedging financial transactions with alternative transactions or measures. A new form of value trading based on supply and demand.
- Cloud services.
- Marketplace.
- Data storage/access.

New advisory services (market place for information)

- Strategic advisory services.
- Advisory services, e.g. for determining value or residual value.
- Data mining.

Storage

- Physical storage, temporary storage pending change of ownership or processor, or new assignment.
- Traders.

B.4 Standards Committee 351225

The effective and efficient registration and recording of information of the built environment has become more important than ever. More and more clients in the Netherlands and Belgium have started initiatives or are considering an initiative for developing efficient and effective decomposition for the built environment. This may well lead to a proliferation of decompositions that have not been developed according to a clearly defined method which in turn hampers the exchange of information within and among organisations.

Demand for a clearly defined methodology and semantics of decomposition was reinforced by the publication of NEN 2767, describing both a condition assessment method and decomposition structures based on NEN 2660. However, the committee received reports from the market that the decompositions prepared are used more broadly than merely for carrying out condition assessments. Many managers use the NEN 2767 decompositions as basic principles to organise the decompositions of their physical assets as part of asset management.

However, the current decompositions were not developed for this purpose and are actually not, or no longer, sufficient. It is not clear to users why the NEN 2767 decompositions are constructed as they are, how they can be used, and how they can be related to other standards. Standards committee 351225, *Regels voor informatiemodellering van de gebouwde omgeving* was therefore set up in order to clarify various aspects, including decomposition throughout the built environment. To this end, the existing NEN 2660 is being updated in order to create a reference framework for other information models and standards/guidelines that refer to physical and spatial concepts in the built environment such as IFC, NL/SfB, NEN 3610 and IMGEO/IMBOR. In addition, a connection is also sought with standards that refer to semantically correct modelling of assets, for example ISO 15926 and the open CB-NL standard.

Annex C

On the way to data interoperability

D.1 Introduction

Assuring *data interoperability* is crucial in order to obtain sustainable materials passports for the construction sector, i.e. sources of reusable data. A materials passport brings together data sourced from different stakeholders and digital systems. A materials passport should also be able to be transferred, e.g. between the contractor and the client upon completion of a construction project or between the former and the new owner of a building when a building is sold. It should also be possible to make parts of a materials passport accessible via digital portals which facilitate the reuse of building components. This annex explains how standardised linked data (LD) technologies can help to achieve this.

We first explain the term 'data interoperability'. We then go on to explain the meaning of LD and we will list the relevant standards. And finally, we show why these LD technologies can play an important role in the context of data interoperability. We use an example of data exchange during a construction project to demonstrate this.

A technically complete explanation of all aspects of LD is beyond the scope of this annex. We would like to refer interested readers to the other standards mentioned in this annex and the many online resources available which provide a broad introduction to this subject from different perspectives. Some of these resources are included as references [1-4].

D.2 Data interoperability

In line with the New European Interoperability Framework [1] we identify the following four layers of data interoperability:

- *legal* interoperability: legislation and contracts on data exchange;
- *organisational* interoperability: business processes and related requirements for data exchange;
- *semantic* interoperability: data formats and the meaning of data (definitions of object types, relationships, properties and data types);
- *technical* interoperability: the technical infrastructure to support data exchange and communication protocols.

The four layers of interoperability influence each other and must be sufficiently safeguarded together to enable successful data exchange. This annex mainly focuses on semantic interoperability.

D.3 The principles of linked data

Linked data (LD) is a specific, fully standardised way of structuring datasets in such a way that data is provided with a meaningful context in order to obtain information which can be read and interpreted by machines. LD can be applied in several different knowledge domains, including the built environment.

The LD principles are based on a series of international standards which jointly enable sustainable and application-independent data exchange between systems. Figure D.1 shows the standardisation layers for LD.

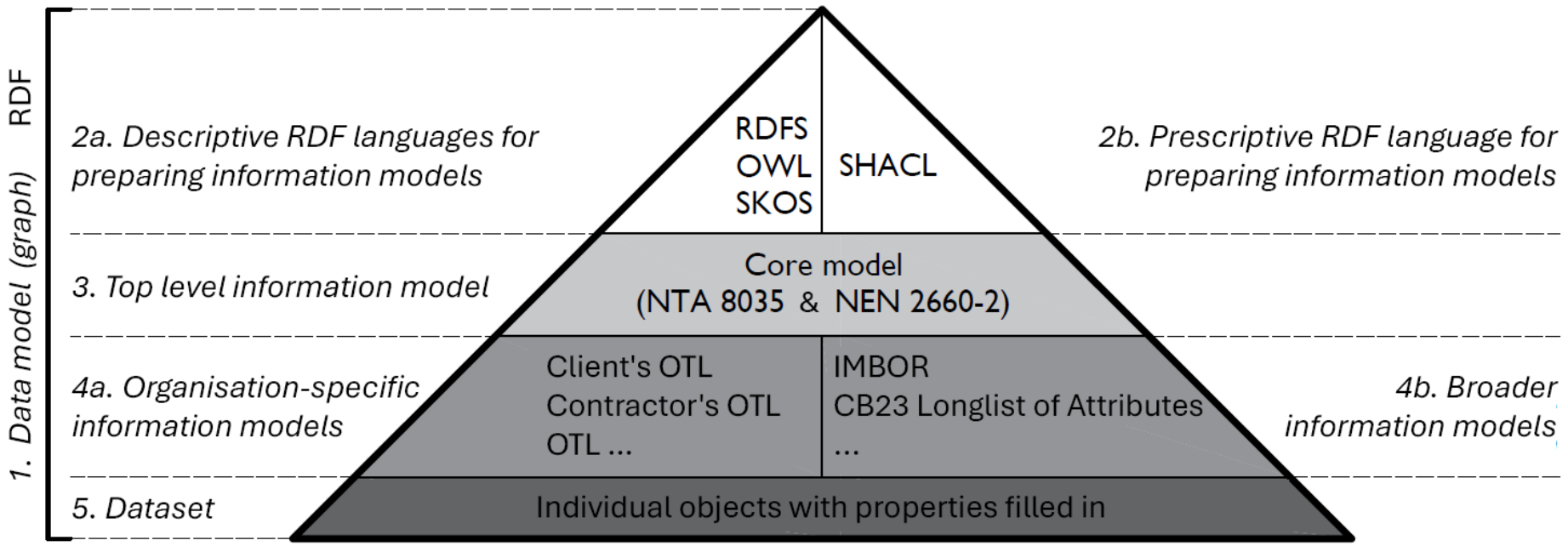

Figure D.1 – Standardisation layers for LD

Firstly, there is a need for an abstract data model (1 in Figure D.1), i.e. a specific data storage method. in the case of LD, the use of an RDF specification is required [6-7]. The RDF data model implies that a focused graph data structure is applied. This data model can be used both for both information models and for data sets structured according to these information models.

Using one or more RDF languages, an information model can be created that covers a certain knowledge domain (2 in Figure D.1). These languages can be divided into three *descriptive* (2a in figure D.1) languages and one *prescriptive* language (2b in figure D.1). The descriptive languages are used to describe concepts (types of objects, types of attributes, value types and types of relationships) so that the meaning of the data is clear to all parties. The prescriptive language serves to define constraints and information requirements (e.g. a certain type of attribute must have been assigned to an individual object of a certain type of object). The choices of descriptive languages are RDFS [8], OWL and/or SKOS. SHACL [12] is available as a prescriptive language. All these languages can be used separately or in combination in order to create an information model.

These languages provide different modelling patterns and combinations to create an information model and apply it to a dataset. Since the information can be modelled in various ways, other parties (and their applications) have to take all possible combinations into account. There was a growing need in the Dutch construction sector to agree on modelling patterns and to provide a basic set of top concepts in a 'core model' (3 in Figure D.1). Examples of such top concepts are 'Physical Object', 'Activity' and 'Information Object'. The first specification that fulfilled this need was NTA 8035, now replaced by NEN 2660 (parts 1 and 2).

Using NEN 2660-2 as a basis enables consistent composition of information models (4 in Figure D.1). Individual organisations, both clients and contractors, have a need for information models tailored to their internal business operations without any dependency on external organisations (4a in Figure D.1). These information models are often referred to as Object Type Libraries (OTL) in the Dutch context. An example is the 'Guardrail' object type defined in RWS's OTL. This is a specialisation of the abstract 'Physical Object' object type from the core model in NEN 2660-2. Initiatives have also been started to define broader information models for different organisations (4b in Figure D.1). Examples of this are IMBOR as well as the Longlist of Attributes in Annex A both of which follow the principles of NEN 2660-2 and extend the core model. Current practice has shown that the existence of both types of information model is justifiable. If they logically refer (link) to each other, they can even reinforce each other in some cases.

One or more information models can be used in an LD dataset (5 in figure D.1). It is also relevant to follow the modelling patterns agreed in NEN 2660-2 at dataset level. Here, individual objects are classified as object types from the OTLs and/or the other relevant information models. Attribute, value and relationship types from the information models are applied to such individual objects. This means that LD technologies can be used as a standardised method to define relationships between:

- individual objects in an LD dataset;
- individual objects/attributes/relationships in an LD dataset and conceptual definitions from an LD information model;
- conceptual definitions of different LD information models;
- individual objects of different LD datasets.

D.4 The usefulness of linked data – an example of data exchange during a construction project

We would like to clarify the technical principles of interoperability and LD by the following example of a project in the civil and hydraulic engineering sector: the construction of a new bridge over an existing road. We will be tracing one specific object: a section of guardrail on the side of the bridge. Here we also distinguish between information models (types) and datasets with asset data (individuals).

The project in the civil and hydraulic engineering sector starts with a client who has specific expectations with respect to a contractor who is going to build a certain bridge design. The dataset provided by the contractor upon completion of the bridge has to comply with both structural requirements for the bridge to be built and information requirements. The Information Delivery Specification (IDS) states which party is to submit specific data and when it should be submitted. The client uses their OTL when drawing up the IDS in order to be able to describe the exact data to be exchanged. Where an IDS tends to be only a piece of text in the current practice, people are still needed to interpret the content. However, there are possibilities to use LD to define information requirements such that interpretation by a computer is possible and maximum interoperability is achieved.

In our guardrail example, the client retrieves the 'Guardrail' object type (incl. generalisation relationship to the NEN 2660-2 'Physical

Object' object type) with the required 'Manager' and 'Attachment' attributes from their LD OTL to process it in their **information modelling environment**.

The client also wants to comply with the information requirements for a materials passport according to this guide. To do so, the client makes a selection from the Longlist of Attributes (see Annex A) based on the type of construction, the use cases and the situation. This results in an LD information model for the client with such elements as the object type 'Element' (incl. generalisation of relationship to the NEN 2660-2 'Physical Object' object type) and the required attributes 'Year of construction/Date of completion of construction' and 'Type(s) of connection(s)'. LD enables these two information models to be linked together in a standardised manner to enable interpretation by a computer. Firstly, the 'Guardrail' object type is linked to the 'Element' object type through a *specialisation* relationship. As a consequence of this standard relationship, individual objects of the 'Guardrail' type will also have to comply with the required attributes for 'Element'. In addition, the client has linked their own 'Attachment' attribute to the 'Type(s) of connection(s)' attribute using an *equal to* relationship. To comply with the information requirements, the client only needs to fill in one of the two attributes. The upper part of Figure D.2 shows what this information model looks like.

In the next step, the computer-interpretable information requirements are converted and published in RDF to become a standard LD information model (the lower part of Figure D.2). The modelling patterns used in the published information model are in line with NEN 2660-2; the languages used in this example are RDFS, OWL and SHACL.

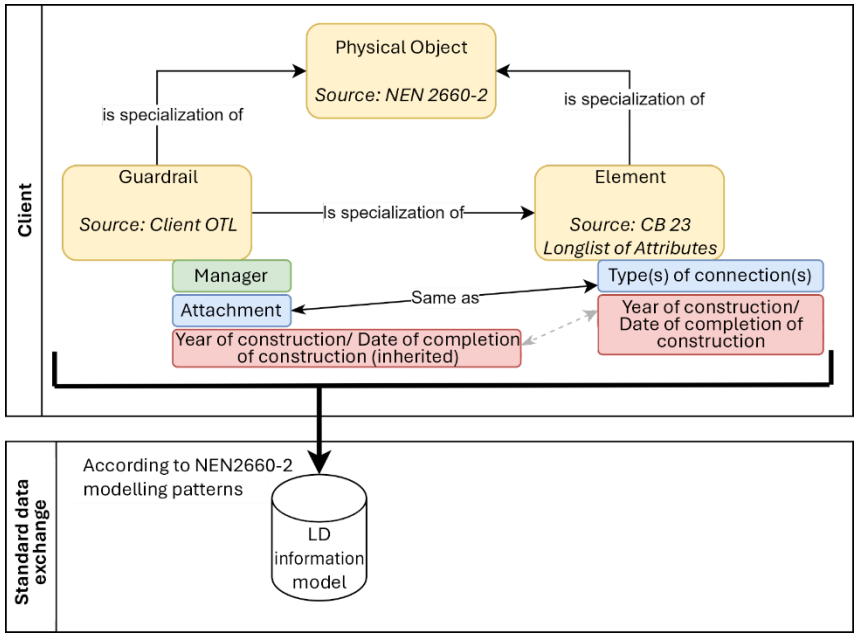

Figure D.2 – Drafting and publishing information requirements in an LD information model

The contractor is given access to the published LD information model. Since this publication is exchanged entirely as standard LD according to NEN 2660-2, there is no dependence on closed formats and vendor lock-in is avoided on both sides. Next, the contractor loads the information model into their **construction project data environment** and collects an entire set of linked data sets during the project. This includes data from manufacturers, geometry from CAD and/or BIM authoring tools, alphanumeric data from the work planner, etc. During the project, 'Guardrail 2' is defined as an individual object in the construction project data environment, linked to geometry from a CAD application and classified according to the 'Guardrail' object type from the client's OTL. The next step consists of filling in the three

attributes required, i.e. 'Manager' (the Ministry of Infrastructure), 'Attachment' (bolted connection) and 'Year of construction/Date of completion of construction', for this individual 'Guardrail 2'. Figure D.3 shows this dataset and how it relates to the information model received. In each phase, the contractor can easily check which information requirements from the ILS have already been met by verifying the dataset against the information model. A materials passport, consisting of the datasets collected, is continually constructed during a construction project as it were.

Upon completion of the structure, the LD dataset is made available to the client. When using LD for the data exchange, the dataset is converted and published in RDF in a standardised manner. The modelling patterns from NEN 2660-2 are used here, similar to when the client's information model is published. However, since it is not possible to efficiently store all the data required, e.g. geometry from CAD/BIM, in the RDF data model (a graph), it makes sense to link individual objects such as 'Guardrail 2' in the LD dataset to the corresponding geometry element from the separate CAD/BIM files in a standard way. This means that, in addition to the LD dataset, non-LD files also have to be delivered to the client, preferably in an open format. In our example, the contractor chooses the ISO standardised IFC-SPFF (Industry Foundation Classes – STEP Physical File Format) for the geometry. Other non-LD formats may be required in the case of photos, videos, etc. The use of LD enables specific relationships between the contents of different datasets to be defined, even if one of the two datasets is not available in RDF. The lower part of Figure D.3 shows this standard data exchange.

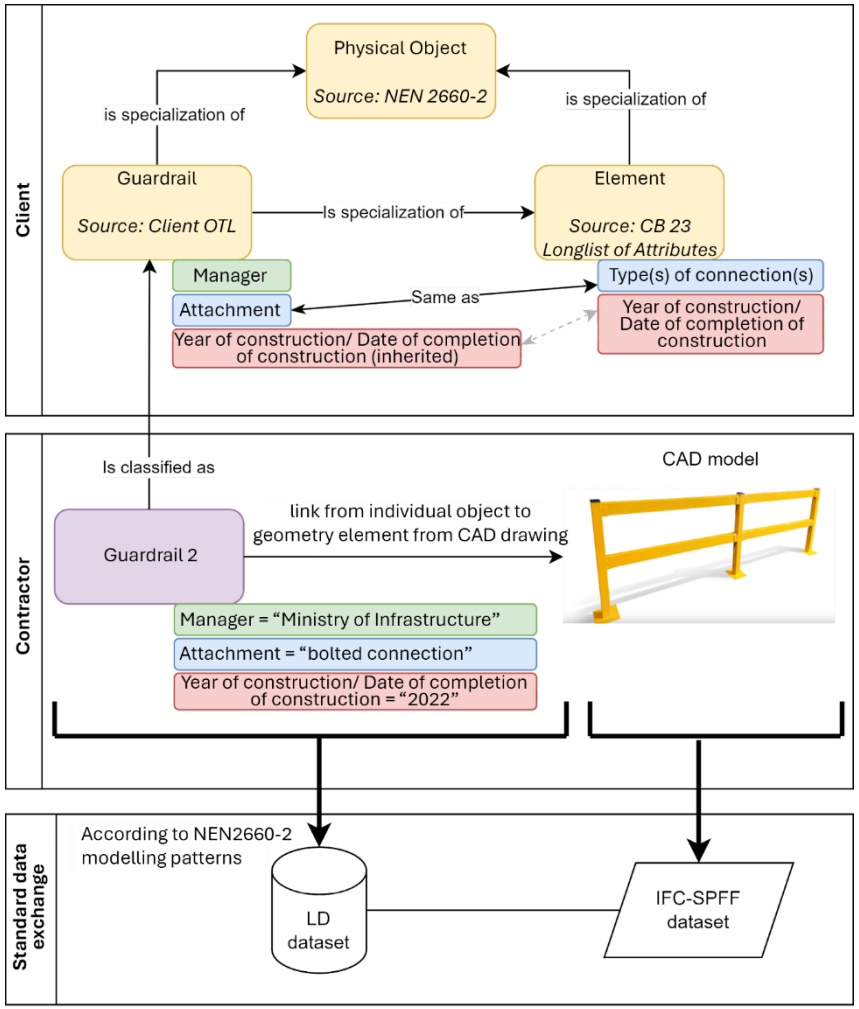

Figure D.3 – Preparing and delivering a construction project dataset according to LD

Although the contractor claims that the LD dataset delivered is complete, the client would like to be able to double-check that this is so. The use of LD for the dataset and specifically the use of the open SHACL standard for LD information requirements means that the client does not have to use exactly the same application for this as the contractor did and a vendor lock-in is avoided yet again. The standard LD relations and corresponding standard logic enable the number of duplicates in the dataset delivered to be avoided. In the 'Guardrail 2' example, SHACL's verification tooling automatically recognises that the 'Attachment' attribute filled in means the same thing as 'Type(s) of connection(s)'. This shows that the dataset complies with both the original information requirements from the client's OTL and the information from the Longlist of Attributes.

After verifying the data sets received which together constitute the materials passport, the client puts the bridge and the accompanying guardrail into use. The client uploads the LD dataset received and the linked IFC file to its **asset management system**. This can be any asset management system thanks to the use of open standards and compliance with the original information requirements. The information obtained upon completion plus the information added during the use phase of the guardrail enables the manager to both plan maintenance tasks for the installed guardrail and to have future studies carried out to determine whether and how the guardrail can be reused in another structure.

D.5 Discussion

None of the tools used in the example construction project (preparing an information model, publishing the information model, collecting data during a project, verifying a dataset against an information model, asset management system, etc.) *must* be able to work entirely on LD internally. The only hard and fast requirement is that these applications make interfaces available (import/export) which can serialise, publish and/or consume LD. This means that there is no strict requirement to apply the modelling patterns of NEN 2660-2 (the standard applied). However, it should always be possible to interpret (receiving party) and/or serialise (sending party) an LD dataset in accordance with NEN 2660-2.

It was a deliberate choice on our part to not mention any software applications in the construction project example. We would like to refer interested readers to https://www.neanex.com/en/cases/establishing-digitally-sustainable-asset-registers-for-construction-data for a possible implementation of the LD principles discussed. Depending on the software applications used, end users need not necessarily have thorough knowledge of LD technologies in order to use them.

The LD technologies are based on a full range of mature and open standards. The general principles can be applied to different sectors. However, further refinement is still possible. For instance, the example deals with two datasets: an LD dataset with the alphanumeric data and an IFC dataset with the geometry of individual objects. If more datasets are exchanged (possibly between several parties at once) and if they are exchanged more frequently, it becomes important to provide **metadata** with each dataset as well. LD can be used again, but now to describe the metadata of datasets. It may be interesting to further expand on the W3C-standardised DCAT information model with concepts relevant to construction-related datasets.

Another unanswered issue is about standardised version management of LD datasets and information models. There are several possibilities, but not yet any shared agreements on this.

Finally, one should realise that not all alphanumeric data from all parties needs to be fully available at once in an open format such as LD. The combined complexity of applications, parties, standards and individual construction projects has been found to make further digitising of the construction sector a gradual process in which

attention should be paid to interoperability in order to enable circularity in the built environment.

D.6 Conclusion

This annex gives a more in-depth account of the technical subject of data interoperability, and more specifically standardised data exchange using LD technologies. Only if sufficiently mature and open standards are chosen will it be possible to have an open market of software applications that can contribute to and/or make use of data from a materials passport.

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