



Creating materials banks
from digital urban mining

D1.3 Standardization and interoperability

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Creating materials banks from digital urban mining

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EXECUTIVE SUMMARY

This report was prepared by the SUM4Re project consortium, led by VTT, with contributions from CONC, TECN and THUAS. It focuses on the important role of standardization in the circular economy, particularly in enhancing resource efficiency and waste prevention. The report highlights the most important information sources for pre-demolition auditing and assessment of materials and components in existing buildings, quality assessment and testing protocols, design standards for retrofitting and reuse, product standards, environmental metrics, data standards, and sustainability assessment rules. Examples of the successful implementation of circular standardisation on the European level are presented for constructional steelwork where the deconstruction and reuse of recovered component is already implemented in a large scale.

The report covers environmental assessment methodologies, focusing on the quantification of impacts of recycled and reused materials and components and data standards related to circular information management, including Building Information Modelling (BIM) and smart CE marking for construction products.

The second part of the report focuses on the interoperability of the standard information carriers such as Digital Building Logbook, Digital Product Passport and Digital Material Passport. The concepts and data structures introduced in the report are linked to the Industry Foundation Class specification, which is widely used in the construction sector, especially for the design of new buildings, but increasingly also for their lifecycle management including maintenance, renovation and deconstruction works.

APPENDIX A of the report introduces a hierarchical glossary of terms and definitions used in the report and in the referenced legal documents and standards. It can serve as a basis for the development of circular taxonomy within SUM4Re project. The general template for the data requirements of the Digital Product Passport is presented in the APPENDIX B of this report and a specific example of data collected for the constructional steelwork according to the existing standards is presented in the APPENDIX C.

GLOSSARY

Terms and definitions

Terms and definitions used in this report are explained in detail in the APPENDIX A of this document.

Abbreviations and acronyms

AHG	Ad-Hoc Group for standardisation
API	Application Programming Interface
BCI	Building Circularity Indicator
BRCW	Basic Requirements for Construction Works
BREEAM	Building Research Establishment Environmental Assessment Methodology
bSDD	buildingSMART Data Dictionary
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CDE	Common Data Environment
CDW	Construction and Demolition Waste
CE	European Conformity
CEN	European Committee for Standardization
CONC	Concular GmbH
CPR	Construction Products Regulation
CWA	European Committee for Standardization Workshop Agreement
C-BIM	Circular Building Information Model
DBL	Digital Building Logbook
DGA	Data Governance Act
DGNB	Deutsche Gesellschaft für Nachhaltiges Bauen
DIN	German Institute for Standardisation
DMP	Digital Material Passport
DoP	Declaration of Performance
DoPC	Declaration of Performance and Conformity
DPP	Digital Product Passport
EAD	European Assessment Document
ECS	Entity Component System

EIF	European Interoperability Framework
EN	European Standard
EPC	Energy Performance Certificate
ESL	Estimated Service Life
ESPR	Ecodesign for Sustainable Products Regulation
EPBD	Energy Performance of Buildings Directive
EPD	Environmental Product Declaration
ETA	European Technical Assessment
EU	European Union
FAIR	Findability, Accessibility, Interoperability, and Reuse of digital assets
FCSA	Finnish Constructional Steelwork Association
FSC	Forest Stewardship Council
GBC	Green Building Council
GPS	Global Positioning System
GWP	Global Warming Potential
ICE	Inventory of Carbon and Energy
IDS	Information Delivery Specification
IFC	Industry Foundation Classes
ILCD	International Life Cycle Data system
IMBOR	Informatiemodel Beheer Openbare Ruimte
ISO	International Organisation for Standardisation
LCA	Life Cycle Assessment
LEED	Leadership in Energy and Environmental Design
LoW	European List of Wastes
MCI	Material Circularity Indicator
MIVES	Integrated Value Model for Sustainable Evaluation
MVR	Swedish National Association of Mechanical Workshops
NEN	Royal Netherlands Standardization Institute
NTA	Dutch Technical Agreement
OTL	Object Type Library
OWL	Web Ontology Language

PCI	Product Circularity Indicator
PEF	Product Environmental Footprint
PEFC	Programme for the Endorsement of Forest Certification
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RSL	Reference Service Life
SC	Sub-Committee for standardisation
SCI	System Circularity Indicator
SDI	Spatial Data Infrastructure
SFI	Sustainable Forestry Initiative
SHACL	Shapes Constraint Language
SIA	Swiss Society of Engineers and Architects
SKOS	Simple Knowledge Organisation System
SPARQL	SPARQL Protocol and RDF Query Language
SRI	Smart Readiness Indicator
STEP	Standard for the Exchange of Product Model Data
STRA	Stress Reduction of Area requirements
SVHC	Substance of Very High Concern
TC	Technical Committee for standardisation (e.g. CEN/TC)
TECN	Tecnia
THUAS	The Hague University of Applied Sciences
TR	Technical Report (e.g. ISO/TR)
TS	Technical Specification (e.g. CEN/TS)
URI	Uniform Resource Identifier
USD	Universal Scene Description
VTT	VTT Technical Research Centre of Finland, Ltd.
WFD	Waste Framework Directive
W3C	World Wide Web Consortium
XML	Extensible Markup Language
XSD	XML Schema Definition

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1. Introduction

1.1. Background

The main objective of Work Package 1 of SUM4Re project is to define the requirements and boundary conditions that allow for efficient and reliable data acquisition, processing, sharing and safekeeping over the lifecycle of buildings and civil infrastructures. This report summarises the outcomes of Task 1.3. This task explores the ecosystem of standards and technical specifications related to circular building construction from the design standards (Eurocodes) auditing and deconstruction protocols, material quality testing standards, harmonized product standards and European Technical Assessment documents for reused building products, including environmental assessment standards and Product Category Rules. The main objectives of Task 1.3 are (1) to develop a specification for information delivery at the deconstruction and reuse stage with respect to the various standards and regulations and (2) to recommend a common data exchange format for this information.

The documents were reviewed with respect to data interoperability and DPP requirements. Focus was on data needs in DPP to support circularity with special attention to the challenging difficulty-to-manage wastes (hazardous materials, multi-component products, insulation materials). Data used in DPP were considered for C-BIM integration throughout lifecycle stages of the building. It is assumed that the data will be stored and handled in Industry Foundation Classes (IFC) format and linked to relevant Information Delivery Specification (IDS) document.

1.2. Goal, scope and focus

The main goal of this report is to systematically review the typology of essential technical standardisation needed to successfully execute a deconstruction and reuse project, including any supporting documents such as technical specifications and industry guides. The review also includes data standards and specifications that can be applied to link the information requirements from the technical standards and Digital Passports. Further elaboration on the possible data structure and interoperability is then provided in the second part of this report.

1.3. Methodology

The report is based on a combination of research methods such as individual data collection, critical review of the collected data, building up a model case based on the most comprehensive standard coverage (structural steelwork) and extracting the basic terminology and hierarchical structure from the reviewed documents. The outcomes of this first phase were then communicated in the workshop, where an agreement was reached about several ambiguities. The review process was then finalized in collaboration with the working groups in Task 1.1 and Task 1.5 of the SUM4Re project and with the support of several other partners involved in the project work. One simplified case study of the material audit information integrated into the IFC STEP file and its validation by IDS was then developed and included in APPENDIX D.

2. Circular standardization

Key messages:

- *Technical standards, protocols and industry guides related to the reuse of building elements were analysed and related to the relevant data specifications*
- *Despite the gaps in the standardisation of many materials and product groups, the example of successful standardisation process could be demonstrated for the constructional steelwork*

Standardisation plays a crucial role in the circular economy and enhances resource efficiency and waste prevention. By setting clear technical specification, products can be designed for easier repair, reuse, remanufacturing, and recycling. They can also be more efficiently recovered during de-installation, deconstruction and demolition of existing buildings and returned into circulation in the construction sector or different industry. Standardisation helps in improving the quality and safety of such recovered materials and components. It ensures that products meet performance criteria equivalent to the new products, which is essential for consumer trust and market acceptance¹

Concerning the circular use of building materials and components, different standard groups cover different life cycle stages (see Figure 2.1). Standardisation supports the development of new business models and market opportunities. It is essential to provide guidance how to obtain and process necessary information for reuse, remanufacturing, and recycling within the context of new Digital Product Passports (DPP). This is crucial for the circular economy as it promotes transparency and traceability.

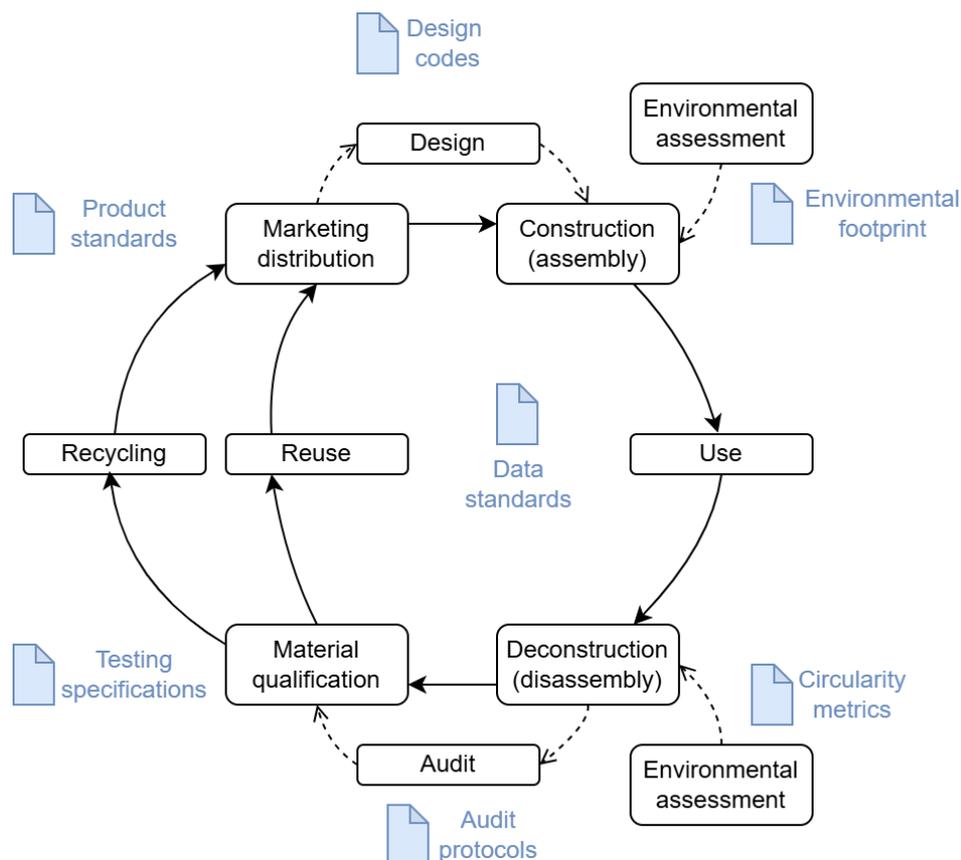


Figure 2.1 Standards and specifications related to the circular use of building materials and components

¹ Circular Economy Principles for buildings design (2020) available online at: <https://ec.europa.eu/docsroom/documents/39984>

In the recent years, several new standards were developed by ISO to provide a framework for measuring and assessing circularity performance. However, due to the large variability of construction products, and their production, processing and recovery chains, there is still a great need for more specific standardisation targeting different materials and component groups. In this context, we can follow the example of structural steel products, which are already almost entirely recovered for recycling and are relatively easy to reuse as well. Therefore, several standards related to the structural steel recovery and reuse are already published or under the development. The comprehensive state-of-the-art report on steel reuse standardisation was published by the EU project ADVANCE in 2024². Examples of the standards, specifications and industry guides collected for this report are listed in this document to show how the circular standardisation is organised around the specific topic of structural steel reuse. The intention is to set a common framework that can be applied all the materials and components covered by the SUM4Re project. As can be seen from Figure 2.1, the circular economy relies on several domains of technical standardisation, and it benefits with the use of data standards implemented across the value chain (see Figure 2.1 in the middle). The focus areas for the technical standardisation are

1. pre-demolition auditing and assessment of the materials and components in the existing buildings
2. quality assessment and testing protocols
3. design standards for retrofitting and reuse of existing materials and components
4. product standards such as execution standards and other harmonised product standards
5. environmental metrics, including product category rules for conducting lifecycle assessment of materials and components in the building during its service life and other sustainability assessment rules such as circularity indicators and different certification schemes

Table 2.1 Relevant data standards for different domains of technical standardisation. The core domain is highlighted in dark green; the other related domains are highlighted in light green.

Data standards related to the circular construction domain	Pre-demolition auditing	Quality assessment and testing	Design standards	Product standards	Environmental metrics
Classification of materials, products and buildings					
Classification of wastes and waste treatments					
Building information management and modelling					
Environmental databases					
Smart CE marking					
Monitoring and testing data					

² Report on the Circular Economy of Steel-Based Components (2024), Deliverable D2.1 of ADVANCE project, available online at <https://www.steelconstruct.com/wp-content/uploads/ADVANCE-D2.1-Circular-Economy-of-Steel-Based-Components.pdf>

The analysed documents are classified into the three levels:

1. international standards and specifications such as CEN or ISO standards and other documents,
2. national standards and specifications applicable to a certain country or region, and
3. other guidance and protocols mostly developed by the national and international industry associations or jointly funded research and innovation projects.

2.1. Pre-demolition auditing and assessment of existing buildings

According to the definition from³, audit is *qualitative and quantitative assessment of materials and components prior to deconstruction, demolition or renovation of buildings and civil engineering works. It includes assessments of what can be reused and stripped out, respectively. It informs the potential to reuse materials and components in subsequent construction and/or fit out (of refurbishment).* It results in the overview of wastes and recoverable materials and components from the inspected building and their amounts, often with the recommendations about their recycling, reuse or other treatment. It may include estimation of their value or environmental loads. Pre-demolition audit is typically part of the larger pre-demolition management plan and in some cases is conducted in several steps by the specialised experts (e.g. assessment of asbestos).

To successfully recover and reuse materials and components, the preliminary assessment of their quality and reusability must be carried out before the demolition or deconstruction including the labelling of the components intended for reuse. It shall be part of the pre-demolition audit. Extraction of the samples for the laboratory testing or on-site non-destructive measurements shall be part of this stage of the process as well. Several examples of the standards, technical specifications and other supporting documents are presented in this section with the focus on the constructional steelwork, where the circular standardisation is at the highest level of the development. It should be noted that some aspects of pre-demolition auditing are also covered in the guides and documents related to the later stages of the material circulation which will be mentioned in the following sections.

2.1.1. European standards and specifications

On the European level, the most notable work was done to answer the Mandate M/515 requirement to extend the design codes to cover existing structures. Working group WG2 of the technical committee TC250 of CEN therefore prepared a guidance how the second generation of the Eurocodes, specifically EN 1990, can handle verifications of the existing structures for retrofitting and in-situ reuse.

CEN/TS 17440 Assessment and retrofitting of existing structures (2020)



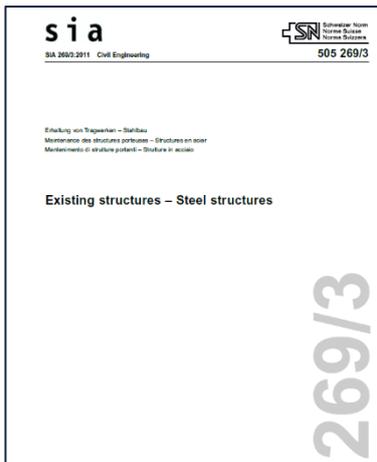
The technical specification by CEN/TC250 lays down the basis for further development of the recommendations for the assessment and design according to the new generation of structural Eurocodes. The Technical Committee may then develop dedicated standard(s) for retrofitting and design of reused components or new parts of the existing Eurocodes specific to a given material.

³ Guidelines for the waste audits before demolition and renovation works of buildings (2018) available online at: <https://ec.europa.eu/docsroom/documents/31521/>

2.1.2. National standards and specifications

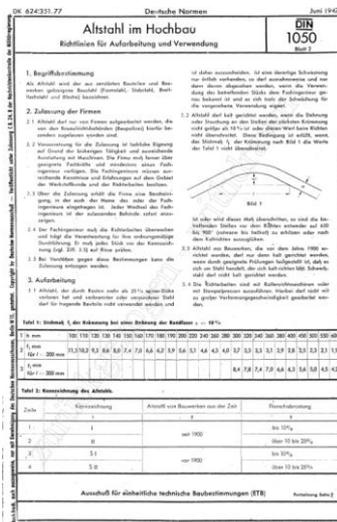
Prior to the development of TS 17440, several standards and specifications were already in use in different countries dealing with the same issues⁴. They were developed for various reasons, such as the need to maintain and extend the life of a large number of bridges (as demonstrated on the following example from Switzerland) or just because of the scarcity of available material after the second world war as illustrated on the German example.

SIA 269 series. Existing structures (2016)



The Swiss Code SIA 269 is a series of standards dealing with the assessment of existing structures. It describes the procedures to be followed in extending the service life of constructional materials. It addresses specialists in the preservation of structures as well as owners of construction works and specialists involved in construction management and the execution of construction works. It focuses on materials and connections and provides guidance for condition survey, interventions, and structural verifications of those. The standards are generally used for verification and extending life of existing heritage structures and bridges, but many parts are applicable for retrofitting or reuse of load-bearing structures in general.

DIN 1050 Sheet 2 Old steel in building construction, guidelines for reconditioning and utilisation (1947)



The scarcity of new constructional steel in Germany in 1947 led to the development of the first rules for the assessment and marking of steel components extracted from the destroyed buildings. The steel could be used in buildings with predominantly static loads and must be marked with a certain label. The marking contains information about

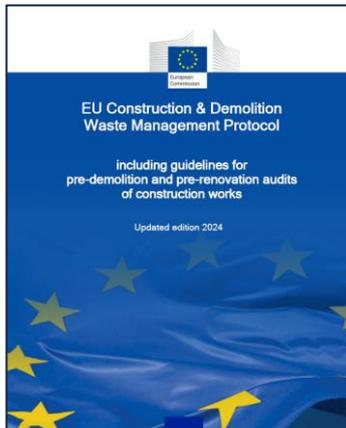
- company
- specialist engineer supervising extraction and processing
- steel class depending on the degree of flange rusting (class I with rusting below 10%, class II 10-25% rusting and cross-section resistance reduced to 80%)
- material age (steel older than 1900 was marked with “S” letter)

⁴ NS 3691:2025 Evaluation of reclaimed timber (3 parts) available online at: <https://online.standard.no/en/ns-3691-1-2025>, <https://online.standard.no/en/ns-3691-2-2025> and <https://online.standard.no/en/ns-3691-3-2025>

2.1.3. Other guidance and protocols

Pre-demolition audits, material assessment and building inspection guides exist in most of the EU Member States (e.g. in Finland⁵, Norway⁶). A thorough review of the implementation process was carried out during the development of the original EU waste audit guidelines³, and therefore we present in this section only selected notable documents intended for the international audience.

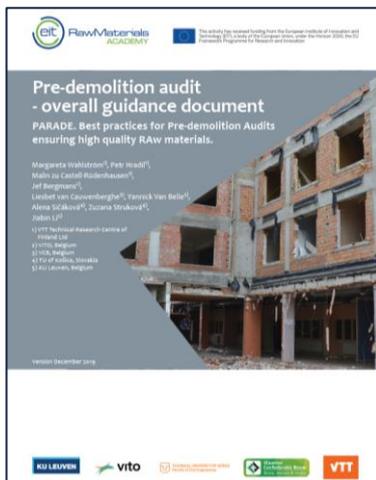
EU Construction & Demolition Waste Management Protocol (2024)⁷



The updated edition of the EU CDW management protocol includes the guidelines for pre-demolition and pre-renovation audits that were previously published separately. These guidelines provide guidance on best practices for the assessment of construction and demolition waste streams prior to demolition or renovation of buildings and infrastructures, called "waste audit". The aim of the guidance is to facilitate and maximize recovery of materials and components from demolition or renovation of buildings and infrastructures for beneficial reuse and recycling, without compromising the safety measures and practices outlined in the Protocol.

It introduces the '*inventory of materials and elements*' as the basic output of the audit based on the duty of the waste holder to gain knowledge about the objects and substances intended to be discarded and their potentially hazardous nature and contamination. The inventory of reusable elements (not to be discarded) is an optional part of the audit, but if applied, it is recommended to have a higher priority than materials recycling and waste management. It should be noted that the revision of this document is under preparation.

Pre-demolition audit – Overall guidance document (2019)⁸



This document extends the guidelines published by the European Commission. It provides information about the best practices for the assessment of Construction and Demolition Waste streams prior to demolition or renovation of buildings or infrastructure. The aim of the document is to facilitate and maximize recovery of materials and components for beneficial reuse and recycling without compromising the safety measures and practices outlined in the EU Construction & Demolition Waste Management Protocol⁷.

The declaration of reusable components is optional, but the content of such declaration is specified in the guidance.

⁵ Finnish pre-demolition audit guide for the auditors, available online at: <https://julkaisut.valtioneuvosto.fi/handle/10024/161883>

⁶ Norwegian guide on Reuse mapping of buildings, available online at https://www.byggforsk.no/dokument/6254/ombrukskartlegging_av_bygninger

⁷ EU Construction & Demolition Waste Management Protocol (2024), available online at: <https://op.europa.eu/en/publication-detail/-/publication/d63d5a8f-64e8-11ef-a8ba-01aa75ed71a1>

⁸ Wahlström M, Hradil P, zu Castell-Rüdenhausen M, Bergmans J, van Cauwenberge L, Van Belle Y, Sičáková A, Struková Z, Li J (2019) Pre-demolition audit – Overall guidance document: PARADE. Best practices for Pre-demolition Audits ensuring high quality RAW materials, available online at: <https://cris.vtt.fi/en/publications/pre-demolition-audit-overall-guidance-document-parade-best-practi>

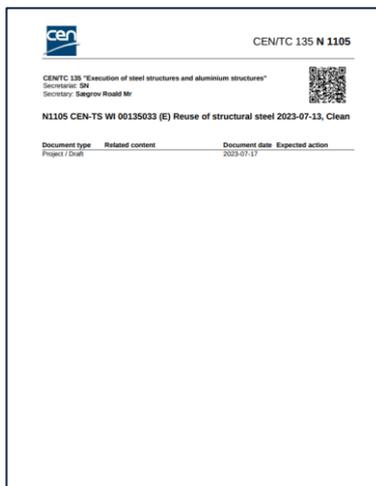
2.2. Quality assessment and testing

It is generally recommended to do the material assessment as early as possible, but the verification of some important aspects the quality of the materials and components might need to be done after deconstruction. Typical examples are destructive tests of the material strength and ductility which are essential for the recovery and reuse of load-bearing structures. These tests are specific for different materials or product groups.

Several examples of the standards, technical specifications and other supporting documents are presented in this section with the focus on the constructional steelwork, where the circular standardisation is at the highest level of the development. It should be noted that some aspects of quality assessment and testing are also covered in the guides and documents related to the later stages of the material circulation which will be mentioned in the following sections.

2.2.1. European standards and specifications

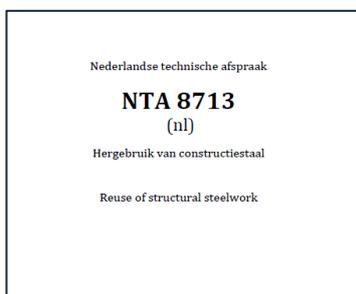
CEN/TS 1090-201: Reuse of structural steel (2024)



The Technical Specification was developed by CEN/TC135 to serve as a supplement to EN 1090-2 “Execution of steel structures and aluminium structures, Part 2: Technical requirements for steel structures” and provides specific guidance for material testing of constituent products to comply with clause 5.1 of the standard. It is in-line with the general recommendations from PROGRESS project⁹ and national guides developed by MVR in Sweden¹⁰ and FCSA in Finland¹¹.

2.2.2. National standards and specifications

NTA 8713: Reuse of structural steel (2023)



The Dutch technical specification NTA 8713 “Hergebruik van constructiestaal” describes the procedure to determine the geometric and material properties of steel profiles that are dismantled from a donor building and reused in another structure. The procedure ensures that the suitability of these profiles can be demonstrated with EN 1993. The purpose is to facilitate the reuse of structural steelwork and reduce the environmental impact of steel structures.

⁹ European Recommendations for Reuse of Steel Products in Single-Storey Buildings (2020) available online at: https://www.steelconstruct.com/wp-content/uploads/PROGRESS_Design_guide_final-version.pdf

¹⁰ MVR (2021). Återbruk av stål i bärande konstruktioner: Krav- & Processbeskrivning, Mekaniska Verkstädernas Riksförbund, available at: <https://mvr.se/wpcontent/uploads/2021/05/mvr-bs04-2021-aterbruk-av-stal-i-barande-konstruktioner-kravprocessbeskrivning-utgava-1-april-2021.pdf>

¹¹ Finnish Constructional Steelwork Association (2023) Reuse of steel structures, unofficial translation of the FCSA Technical publication 3-2023, Helsinki, Finland

The document specifies the information that needs to be documented before dismantling the steel profiles, such as the original documentation of the building, the inspection documents, the assessment of the tolerances, the visual inspection, and the testing of the material properties and weldability in a building with a certain consequence class. The specification provides rules and recommendations for the structural design of reused steel profiles, such as the verification of the resistance, stability, and serviceability, and the design of the connections. It should be noted that national standards and specifications exist also in another countries¹².

2.2.3. Other guidance and protocols

The specific guidelines for testing of reused constructional steel are available in many Member States. Most of them are listed in the constructional steel review report from ADVANCE project². Moreover, the development of similar documents for different materials or product groups is ongoing.

2.3. Design standards

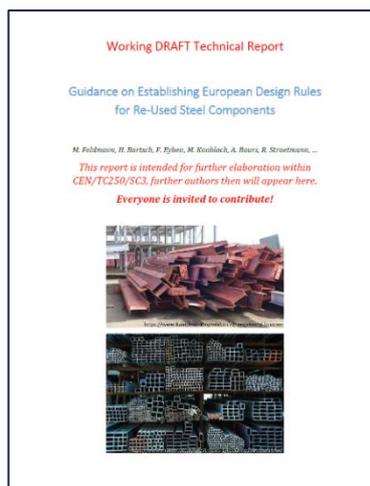
The most important aspect in the implementation of circular economy principles in building design is that the building codes are covering materials and components originating from the previous structures and ready for the deconstruction and future use after the current building's end of life.

2.3.1. European standards and specifications

The first generation of the Eurocodes was developed for the new structural elements produced from the primary or secondary materials, but it does not provide any guidance on the design with the previously used materials and components. Following the mandate M/515 and the new Construction Products Regulation, the codes will have to take into account also reclaimed structural components used in a new design. The development of the particular standards is still in the planning phase as described in the following section.

2.3.2. Other guidance and protocols

CEN Guidance on Establishing European Design Rules for Re-Used Steel Components (2024)



AHG of CEN/250 SC3 is developing a new technical report describing the need for concepts and rules for the evaluation, reclaiming, storing, distribution, design, and installation of reused constructional steel components. The document will propose Eurocode 3 design rules for reused steel components and action plan to foster reuse in construction across European countries. The scope of the AHG work includes pre-deconstruction audit, assessment of the suitability for reuse, testing protocol, and determination of safety factors and characteristic material values based on the available information. The report proposes “key-routes” for the procedure how assessment and design of reused steel components can be done.

¹² Norwegian standard NS 3682:2022 Hollow core slabs for reuse, <https://online.standard.no/en/ns-3682-2022>

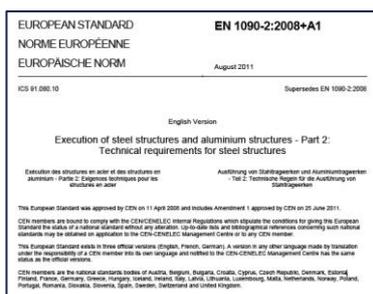
2.4. Product standards

Manufacturers, other economic operators, or conformity assessment bodies typically use harmonized product standards to demonstrate that their products comply with the relevant legislation.

2.4.1. European standards and specifications

In the context of construction products in EU, the Construction Products Regulation (CPR) requires manufacturers to produce a Declaration of Performance and Conformity (DoPC) according to the requirements for the specific product group provided by the harmonized product standard. Alternatively, the declaration can be prepared according to the European Assessment Document (EAD) if the standard is not available. It should be noted that CE marking of reused products was not very clear before the CPR was renewed in 2024, and therefore there are not many good examples of such declarations. The new CPR covers the conformity regulation of reused products, but the product standards will have to be updated accordingly in the following years. Moreover, the Environmental Product Declaration (EPD) must go along with this regulation including a digital construction products database and a digital product passport.

CEN/EN 1090-2 Execution of steel structures and aluminium structures - Part 2: Technical requirements for steel structures (2008-2018)



EN 1090 covers structural steel and aluminium products that are installed in a permanent manner. As a harmonised standards it can be used to prove that the products comply with the technical requirements of the relevant EU law, in this case Construction Products Regulation. Therefore, it is used for obtaining CE certification of the constructional steelwork. Part 2 of EN 1090 introduces a possibility to use reused or generally unknown constituent products in the execution of steel structures in Clause 5.1:

“Generally, constituent products to be used for the execution of steel structures shall be selected from the relevant European Standards listed in the following clauses. If constituent products that are not covered by the standards listed are to be used, their properties shall be specified.” The text was updated in 2018 and the current version of the standard extends the clause with the list of relevant properties to be specified: *strength (yield and tensile), elongation, stress reduction of area requirements (STRA if required), tolerances on dimensions and shape, impact strength or toughness (if required), heat treatment delivery condition, through thickness requirements (Z-quality if required) and limits on internal discontinuities or cracks in zones to be welded (if required)*. Additional information for welds shall be provided such as: *classification in accordance with the materials grouping system defined in CEN ISO/TR 15608 or a maximum limit for the carbon equivalent of the steel, or a declaration of its chemical composition in sufficient detail for its carbon equivalent to be calculated*.

2.4.2. Other guidance and protocols

European Technical Assessment (ETA) for reused bricks

The CE marking of reclaimed bricks is not covered in any harmonized product standard. The harmonized standard for bricks (EN 771-1) does not cover reuse, and the factory production control system is based on the manufacture of new bricks. Therefore, the Danish company Gamle Mursten managed to obtain approved technical certification by following the European Technical Assessment (ETA) and European Assessment Document (EAD) methodologies. These documents allow the reuse of construction products where no harmonized standard exists, therefore enabling CE marking. Their patented vibration technology enables the delivery of reused bricks on a large scale for both larger and smaller construction projects. To achieve CE marking, the bricks must be tested for compression, frost resistance, and water absorption with satisfactory results.

2.5. Environmental metrics

This section focuses on the assessment methodologies to quantify impacts of recycled and reused materials and components. It is essential that the recycling and reuse is acknowledged in the production stage of the new building and as the potential saving in the future project if the current building is designed according to the circular economy principles. In the context of SUM4Re project, the quantification is also considered to be performed at the end-of-life stage of the current building, and therefore its main focus is only the recycling and reuse potential of the materials and components in the future building(s).

2.5.1. International standards and specifications

The rules for the end-of-life environmental potential calculation of products and buildings are established in the series of technical standards developed by CEN/TC350. They divide the life cycle of the building into stages and modules as: product stage (Module A1-A3), construction stage (Module A4-A5), use stage (Module B), end-of-life stage (Module C). The potential benefits or burdens caused by the management of end-of-life materials in the next building's lifecycle are treated separately in the so-called Module D.

CEN/EN 15804+A2 Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products (2019)



Annex D of the standard introduces the calculation of loads and benefits beyond the system boundary (Module D1) when more than one recycling or reuse operations are considered at the end of the product's life. This calculation does not consider yield of the recycling process according to the World Steel Association's method, but otherwise it was demonstrated to be compatible with PEF¹³ and PROGRESS¹⁴ methodologies.

¹³ European Commission (2018). Product environmental footprint category rules guidance, Version 6.3, 2018, available online at

http://ec.europa.eu/environment/eussd/smgp/pdf/PEFCR_guidance_v6.3.pdf

¹⁴ Methodology to declare environmental benefits of reused elements (2019) Deliverable D5.1 of PROGRESS project available online at <https://www.steelconstruct.com/wp-content/uploads/PROGRESS-D5.1-Environmental-benefits.pdf>

CEN/prEN 17662 Execution of steel structures and aluminium structures - Environmental Product Declarations - Product category rules complementary to EN 15804 for Steel, Iron and Aluminium structural products for use in construction works (2023)

Annex F of the proposed standard extends the calculation from Annex D of EN 15804 with the implementation of World Steel Association's yield factor and demonstrates the calculation of simultaneous recycling and reuse. It is in-line with PROGRESS methodology¹⁴, but the recommended allocation procedure for reused products is open-loop. ADVANCE project shows that both approaches are possible and produce the same results¹⁵.

2.5.2. Other guidance and protocols

Product Environmental Footprint (PEF)¹³

The methodology for declaration of Product Environmental Footprint (PEF) can consider multiple recycling options, and therefore it is suitable for expressing benefits of steel reuse, which is often happening together with recycling of the non-reusable material. The disadvantage of PEF methodology is that the loads and benefits of future recycling and reuse are aggregated together with the impacts of the current lifecycle, and therefore it is difficult or even impossible to distinguish between reuse of existing material and the design for the future reuse.

Material Circularity Indicator (MCI)¹⁶

The Material Circularity Indicator (MCI), developed by the Ellen MacArthur Foundation, is a tool designed to measure how well a product or system adheres to the principles of a circular economy. It evaluates the circularity of material flows by assessing inputs (what the product is made of and where those components come from) and outputs (what happens at the end of the product's life). Its extensions cover Product Circularity Indicator (PCI), System Circularity Indicator (SCI) and Building Circularity Indicator (BCI).

2.6. Data standards and classification systems

2.6.1. International standards and specifications

ISO 12006-2:2015 Building construction - Organization of information about construction works, Part 2: Framework for classification

ISO 12006 series of standards provide a framework for organizing information in the building construction sector. Part 2 of this standard group focuses on the classification of information related to construction works. This standard identifies recommended classification table titles for various information object classes based on different views, such as form or function. It aims to facilitate the development of local classification systems and tables, promoting harmonization across different regions. ISO 12006-2 applies to the entire lifecycle of

¹⁵ Environmental assessment of constructional steel reuse: Methodology report (2024) Deliverable D4.1 of ADVANCE project, available online at: <https://www.steelconstruct.com/wp-content/uploads/ADVANCE-D4.1-Methodology-report.pdf>

¹⁶ Ellen MacArthur Foundation (2015) an approach to measuring circularity available online at: <https://www.ellenmacarthurfoundation.org/material-circularity-indicator>

construction works, including briefing, design, documentation, construction, operation, maintenance, and demolition.

ISO 16739-1:2024 Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries¹⁷

Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries is an international standard that defines a data schema for Building Information Modelling (BIM). This standard facilitates the exchange and sharing of information among various software applications used by participants in the construction and facility management sectors. It covers information required for buildings and infrastructure works over their entire lifecycle, including bridges, roads, railways, waterways, and port facilities. The standard includes definitions for project structure, physical components, spatial components, analysis items, processes, resources, controls, actors, their context definition and relation.

CWA 17316 Smart CE marking for construction products

Smart CE marking for construction products is a CEN specification for digitalization of the mandatory information provided in the Declaration of Performance (DoP) for construction products. It facilitates the creation of digital DoP information in XML format, making it accessible through smart devices like mobile phones, tablets, and computers. The goal is to ensure that this information is both human and machine-readable, enhancing the efficiency and accuracy of data sharing in the construction industry.

ISO 22057:2022 Sustainability in buildings and civil engineering works — Data templates for the use of environmental product declarations (EPDs) for construction products in building information modelling (BIM)

ISO 22057 provides data templates for the use of environmental product declarations (EPDs) in building information modelling (BIM). The standard aims to make EPD data machine-interpretable, enabling its integration into various stages of construction, from design to end-of-life.

2.6.2. National standards and specifications

NEN 2660-2¹⁸

The standard aims to ensure consistency and interoperability in the information systems used in the building field. It contains detailed instructions on how to configure information models to meet specific project requirements including setting up the necessary parameters and ensuring that the models are adaptable to different scenarios. The standard also provides guidelines on how to extend the existing models to incorporate additional data or functionalities. This ensures that the models remain flexible and can evolve with changing project needs. Practical steps for implementing the configured and extended models in real-world projects are described in the document, such as the best practices for integrating the models into existing systems and workflow.

¹⁷ IFC 4.3.2 schema documentation available online at <https://ifc43-docs.standards.buildingsmart.org/>

¹⁸ NEN 2660-2: Rules for information modelling of the built environment - Part 2: Practical configuration, extension and implementation of NEN 2660-1

Estonian CCI-EE classification system¹⁹

The CCI-EE classification system includes specification of digital information and its exchange formats for the Building Information Modelling (BIM). It is part of the Construction Classification International (CCI) framework, and it is designed to classify construction components throughout the entire building lifecycle. CCI-EE is based on EN ISO 12006-2 and includes tables divided into key groups. When handling BIM data, the system provides a structured approach to classify and manage information. This involves defining attributes for construction components, technical systems, built spaces, and construction entities. These attributes are integrated into BIM authoring software. The classification system supports the export of data to formats like IFC (Industry Foundation Classes), ensuring that the information is both human and machine-readable. This helps in filtering geometry, transferring data, and viewing general-level information within the BIM environment.

2.6.3. Other guidance and protocols

RDF specification²⁰

The Resource Description Framework (RDF) is a standard model for data interchange on the web. It was originally designed by the World Wide Web Consortium (W3C) as a data model for metadata. RDF is a flexible and powerful way to represent information about resources in the form of a graph, which consists of triples. Each triple is composed of three parts: a subject, a predicate, and an object. This structure allows RDF to express complex relationships and data in a machine-readable format. 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.

IDS specification²¹

The Information Delivery Specification (IDS) is a standard under development for the computer interpretable document that defines the Exchange Requirements of model-based exchange. It defines how objects, classifications, properties, values and units need to be delivered and exchanged. The delivery can be a combination of Industry Foundation Classes (IFC) and additional classifications and properties. It brings automatic validation of IFC to the end user. IDS is a core component that can be used as a contract to deliver the correct information. The standard is captured in an XML Schema (XSD).

European List of Wastes²²

The European List of Wastes (LoW) is a standardized system for classifying waste across the EU. It assigns specific codes to different types of waste, enabling consistent identification and management of various waste streams. This list is important for many activities, including waste transport, installation permits, and waste statistics. LoW is also essential in pre-demolition audits. The classification helps auditors systematically categorize and document

¹⁹ CCI-EE classification system available online at <https://flowbim.ee/cci-ee-context/introduction-cci-ee/>

²⁰ R. Cyganiak, D. Wood, and M. Lanthaler, (2014) RDF 1.1 Concepts and Abstract Syntax, W3C, Available at <https://www.w3.org/TR/rdf11-concepts/>

²¹ Information Delivery Specification technical documentation, Available at <https://www.buildingsmart.org/standards/bsi-standards/information-delivery-specification-ids/#documentation>

²² Commission Decision of 3 May 2000 replacing Decision 94/3/EC establishing a list of wastes pursuant to Article 1(a) of Council Directive 75/442/EEC on waste and Council Decision 94/904/EC establishing a list of hazardous waste pursuant to Article 1(4) of Council Directive 91/689/EEC on hazardous waste (notified under document number C(2000) 1147) (Text with EEA relevance) (2000/532/EC) available online at <https://eur-lex.europa.eu/eli/dec/2000/532/2015-06-01/eng>

all waste types in a building renovation or demolition site, ensuring proper management and compliance with EU waste regulations.

ILCD + EPD

International Life Cycle Data (ILCD) format with Environmental Product Declaration (EPD) extensions, is a standardized data format used to transport information associated with EPDs in a structured way. This format is based on the ILCD data format developed by the European Commission, with additional extensions to include EPD-specific information such as scenarios, modules, and data types. The standardization of ILCD + EPD is managed by the InData Working Group, which defines the rules and compliance requirements for the data format. Their goal is to ensure that the data is both human and machine-readable, facilitating its use in various applications, including Building Information Modelling (BIM) and other digital tools.

2.7. Summary

There are many standards and technical specifications already developed or under the development, many of them are aimed at certain materials or product groups. Some of the materials are clearly ahead of the others in terms of coverage of the different aspects in these documents because of their easy identification, separation and recovery and/or high market value. This is the case of constructional steel (see APPENDIX B of this report) which can serve as a benchmark for the future developments and harmonization of other product standards.

The list of reviewed documents and their links to different domains of circular economy in construction is presented in Table 2.2.

Table 2.2 Overview of the technical standards, specifications, guidelines and methodologies analysed in Task 1.3. Their relevant scope domains are marked in green.

Reviewed documents	Pre-demolition auditing	Quality assessment and testing	Design standards	Product standards	Environmental metrics	Data and classification
CCI-EE classification system						
CEN/EN 1090-2						
CEN/EN 15804+A2						
CEN/EN 15978						
CEN Guidance on Establishing European Design Rules for Re-Used Steel Components						
CEN/prEN 17662						
CEN/TS 1090-201						
CEN/TS 17440						
CEN/WA 17316						
DIN 1050						
Ellen MacArthur Foundation MCI methodology						
EU CDW Management Protocol (2016)						
EU CDW Management Protocol (2024)						
EU Guidelines for the waste audits						
EU List of Wastes						
IDS specification						
ILCD + EPD data standard						
ISO 12006-2						
ISO 16739-1						
ISO 22057						
NEN 2660-2						
NTA 8713						
Pre-demolition audit – Overall guidance						
Product Environmental Footprint methodology						
RDF specification						
SIA 269						
World Steel Association LCI methodology						

3. Workshop on definitions and data structures

Key messages:

- VTT, CONC and THUAS organised a workshop to clarify the basic concepts in the data structure and interoperability of the Digital Passports
- The outcomes of the workshop were implemented in this document

The workshop on standardization and data interoperability has been organized 4.12.2024 in The Hague together with the project partners and invited audience. It covered the following topics: (1) Description of Task 1.3 of SUM4Re project, (2) Basic definitions, (3) Data architecture and (4) Data templates.

3.1. Definitions

3.1.1. Products and materials

One of the agreements between the partners was about the definition of the term “product” which has a different meaning in the regulatory documents and common BIM usage in IFC schema.

- **Product** is formed or formless physical item or a kit designed for or utilized with a purpose and placed on the market or put into service.^{23 24}
- **IfcProduct** is an abstract representation of any object that relates to a geometric or spatial context.¹⁷

We agreed to align with the standard terminology of CPR²³ and ESPR²⁴ and therefore distinguish between formed and formless product using the terms “component” and “material”.

Material is defined as:

- **Material** means any substance, excluding waste, with specific properties that is embedded in the products in a permanent manner.²
- **IfcMaterial** is a homogeneous or inhomogeneous substance that can be used to form elements (physical products or their components).¹⁷

Component is defined as:

- **Component** is a product manufactured as a distinct unit to serve a specific function or functions and intended to be incorporated into another product or structure, which may itself be an assembly of several smaller components.^{24 25}

Kit is defined as:

- **Kit** is a product placed on the market by a single economic operator as a set of at least two separate items, none of which needs to be a product itself, intended to be incorporated together in construction works.

After the workshop, we identified another disagreement in the definition of the constituents in the standards use and in the IFC schema. It is included in this section as it naturally belongs to the possible sub-categories of the term “product”.

- **Constituent product** is a product used in manufacturing with properties which enter structural calculations or otherwise relate to the mechanical resistance and stability of construction works.²⁶

²³ Regulation (EU) 2024/3110 of the European Parliament and of the Council of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011

²⁴ Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC

²⁵ ISO 6707-1 Buildings and civil engineering works — Vocabulary, Part 1: General terms

²⁶ EN 1990 Eurocode - Basis of structural design

- **IfcMaterialConstituent** is a single and identifiable part of an element which is constructed of a number of part (one or more) each having an individual material.¹⁷

In the structural design, constituents are typically elements without defined major dimensions (e.g. a structural profile with specified cross-section where the length is defined at the higher level of fabricated component) while in the IFC schema they form the subclass of the IfcMaterialDefinition. The scope of both terms is only partly overlapping, and therefore we recommend using them with caution in the SUM4Re project.

3.1.2. Digital Passports

It was agreed that the umbrella term for the Digital Material Passport, Digital Product Passport and Digital Building Logbook will be “Digital Passport”. The proposed definition is not based on any standard or regulation, but contains the main aspect of all three digital data repositories:

- **Digital Passport** is a repository of machine-readable information about a physical entity or process in open data format according to the dedicated specification. The data may be open or with restricted access.

Digital Passports can be described as the instruments that offer a platform and repository for storing, linking and providing relevant information actors along the value chain²⁷. They can be created with different levels of data, resulting in different types of passports, from material and products, up to building-level passports. Essentially, they have the possibility to store information of materials, carbon and environmental impact, material health and safety, demountability, and warranty and certifications in one place. The particular definitions of the Digital Passports are:

- **Material Passport** (or Digital Material Passport, DMP) is a set of data describing defined characteristics of the material in the product that give it the value for recovery and reuse.
- **Product Passport** (or Digital Product Passport, DPP) is a set of data specific to a product that includes the information specified in the applicable delegated act adopted pursuant to Article 4 of ESPR²⁴ and that is accessible via electronic means through a data carrier in accordance with Chapter III of ESPR.
- **Building Logbook** (or Digital Building Logbook, DBL) is a common repository for all relevant building data, including data related to energy performance such as energy performance certificates, renovation passports and smart readiness indicators, as well as data related to the life cycle GWP, which facilitates informed decision making and information sharing within the construction sector, and among building owners and occupants, financial institutions and public bodies.

Additionally, there is a possibility to create a digital bill of materials (and sometimes products), which is often called Materials Passport. This is practical especially in the pre-demolition audits of the buildings where the main output is list of materials and constituents.

- **Materials Passport** (or Resource Passport) is a repository of information about all materials in a specific building, product or product instance²⁷. It can be seen as extracted list of Digital Material Passports of all the materials contained in the building, component or kit.

²⁷ Building as Material Banks project webpage available online at <https://www.bamb2020.eu/>

3.2. Suggested data structure

The basic relationship between the “product”, “material” and “component” was drafted in the workshop. The clarification of these basic concepts is essential for the modelling of interoperability between different Digital Passports such as DMP, DPP or DBL. As there is not any official position from the Commission on this interoperability yet, we present our own view on the possible data structures in this section. The relationship was later extended to contain also the term “kit” and “constituent” (see Figure 3.1) identified in various legal documents, standards and specifications.

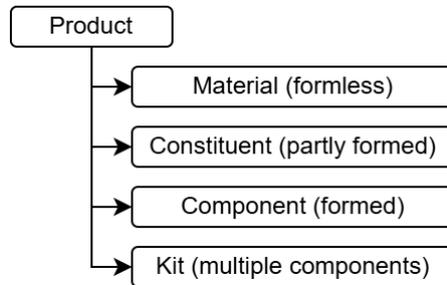


Figure 3.1 Product and its sub-categories

In the context of linked data architecture (e.g. as part of BIM), the relationship between materials, constituents, components and kits will be more complex as the kit may contain one or more components, the component may contain one or more materials or constituents and the constituent should contain exactly one material, but the same material may be contained in one or more components or constituents. This is illustrated on the example in Figure 3.2 that was presented in a simplified form during the workshop.

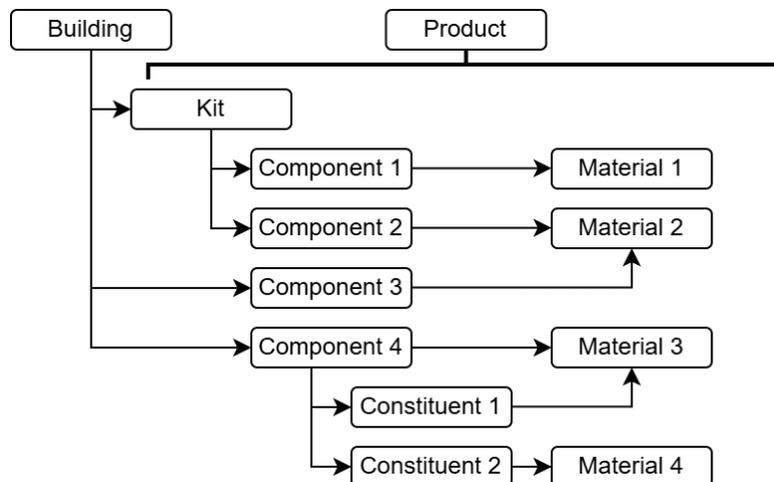


Figure 3.2 Relations between kits, components, constituents and materials in the building information model

For the Digital Passports related to the building (DBL), products (DPP) and materials (DMP), the general structure can be based on the premise that the Building Logbook will contain the Materials Passport for the building and other building-specific data and the Product Passport will contain the Materials Passport for the product (or its instance) and other product-specific data. This is demonstrated in the example data structure in Figure 3.3, which is based on a similar diagram discussed in the workshop.

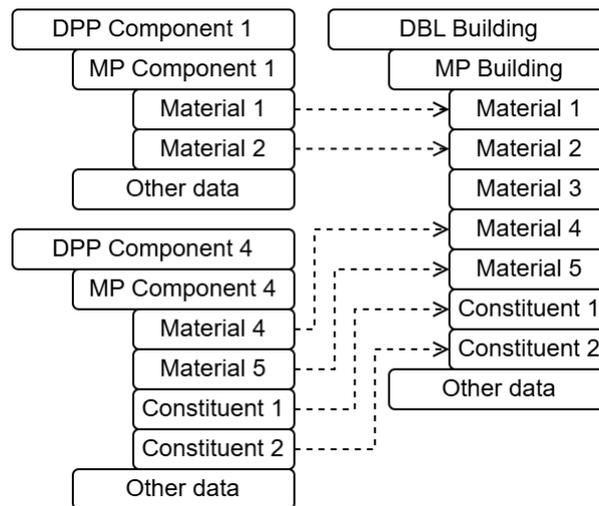


Figure 3.3 Example of linked information from the Digital Passports of two products (Components 1 and 4) from Figure 3.2.

3.3. Summary of the workshop

The discussion about the basic concepts in the data architecture suggested for SUM4Re project was very important for the consequent work and development of the recommendations for the data interoperability. In the workshop, only the terms “component” and “materials” were discussed as possible sub-categories of “product” and the terms “kit” and “constituent” were added to the diagrams later as they are covered by the standard definitions and IFC schema. The data architecture from the workshop is then further developed in the following sections.

4. Data interoperability

Key messages:

- *The outcomes from the workshop were used for the development of a more comprehensive data architecture.*
- *Based on several additional meetings with the project team, a basic structure of the activities and their relation to the Digital Passports was included in the architecture.*

Interoperability is the enabling technology for efficient cooperation in the construction chain. According to the Platform CB'23²⁸ the commonly used 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. 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 Digital Passports.

This section will focus on the basic architecture of three Digital Passport types (DMP, DPP and DBL) discussed in this report. Then, in the following section, the linked data technology will be described in more detail. The aspect of data management is not covered in this report but can be found in the literature²⁹.

4.1. Overview of developments

The Digital Product Passport (DPP) is an innovative system designed to enhance transparency, traceability, and sustainability throughout the lifecycle of products. By providing detailed information about a product's origin, materials, manufacturing processes, and compliance with regulations, the DPP aims to foster a more sustainable and circular economy. This system allows stakeholders, including manufacturers, suppliers, and consumers, to access and share critical product data, thereby promoting informed decision-making and responsible consumption. The DPP includes various essential elements such as a unique product identifier (UID), global trade identification numbers, and relevant commodity codes. It also encompasses compliance documentation, including declarations of conformity, technical documentation, and certificates. Additionally, the DPP provides information on substances of concern, user manuals, safety information, and details about the manufacturer, operators, and importers. It offers guidance for consumers on the installation, use, maintenance, repair, and end-of-life disposal of products. Furthermore, it includes information for treatment facilities on disassembly, recycling, or disposal, and other relevant details that may influence product handling by different parties. To address concerns about traceability, it is important to note that the DPP does not "pull" information from multiple dataspace. Instead, the economic operator placing the product on the market is responsible for collecting the mandatory DPP information and exposing this data in the proper format. The data included in the product passport is stored by the economic operator responsible for its creation or by certified independent third-party product passport service providers authorized to act on their behalf. This ensures that the DPP system remains practical and affordable, especially for SMEs, by being open source and compatible with existing databases in the EU. Data will be stored in a decentralized form and presented through knowledge graphs, reducing the need for companies to input data into multiple databases. The DPP acts as a comprehensive logbook over the product's lifecycle, covering its journey, composition, and impacts. It provides detailed data about a product's

²⁸ Platform CB'23 website available at: <https://platformcb23.nl/>

²⁹ The Passports for the Construction Sector action team of Platform CB'23 (2022) Guide to Passports for the Construction Sector Parts 1 + 2 Working agreements and substantiation for passports in a circular construction sector available at: https://platformcb23.nl/wp-content/uploads/PlatformCB23_Guide_Passports-for-the-construction-sector.pdf

origin, materials used, environmental impact, and end-of-life disposal recommendations. This structured collection of product-related data is accessible electronically, providing insights across supply chains and helping answer questions like: What materials are used? Where do they come from? How can the product be repaired or reused? The DPP is aligned with the Ecodesign Regulation²⁴, which outlines design parameters to guide what product information should be included. This regulation applies to most physical products placed on the EU market and will become mandatory between 2026 and 2030, with enforcement starting in 2024.

Unlike DPP, the introduction of Digital Building Logbook (DBL) is not mandated by any EU Regulation or Directive, but the concept is mentioned in several places, for example in the new Construction Products Regulation²³ and its formal definition is provided in the new Energy Performance of Buildings Directive³⁰. It states that DBL has three principal functions: (1) a data repository, (2) a decision aid, and (3) an instrument for information-sharing. According to Demo-Blog project³¹, *“Digital Building Logbooks are common digital data repositories capturing, integrating and storing building data from across the construction market value chain. This all-in-one information tool is meant to encourage data transparency and availability and simplify decision-making for stakeholders across the buildings value chain.”*

4.2. Suggested data structure

To develop a specific Digital Passport, it is important to define its position among the other Digital Passports and different building information tools that have already been implemented in various policy documents or parts of different voluntary schemes. From the analysis of existing examples of DMPs, DPPs and DBLs, it can be generalized that the Digital Passport contains three basic parts: (1) a repository of data describing the object of interest (including instructions, declarations, certificates, indicators and technical documentation), (2) its traceability information (logbook) and (3) links to the parent or child data repositories, or another data sources.

General information includes identification and classification of the material, product or building, location, information about the owner, manufacturer, fabricator or contractor.

Instructions for use and safety are mandatory part of DPP, but similar documents are often available for materials and buildings. The documents should cover also repair instructions and end-of-life management (e.g. recovery and recycling).

Declarations:

- Environmental Product Declarations (EPDs),
- Declarations of Performance and Conformity (DoPCs),
- Declarations of chemical compliance of materials (REACH³², RoHS³³).

Indicators:

- Smart Readiness Indicators (SRIs) are a voluntary scheme intended as a way of measuring a building’s capacity to adapt aspects of its operations. They are listed as another example of relevant building data in the EPBD definition of DBLs.
- Circularity Indicators (e.g. material MCI¹⁶, product PCI, building BCI) measure the degree of circular material use.

³⁰ Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings.

³¹ Demo-BLog project website available at: <https://demo-blog.eu/>.

³² Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

³³ Directive 2011/65/EU of the European Parliament and of the Council of 8 June 2011 on the restriction of the use of certain hazardous substances in electrical and electronic equipment

Certification:

- Energy performance certificates (EPCs) indicate building energy class on scale from A to G shall include annual whole-life carbon assessment of the building expressed as Global Warming Potential (GWP).
- Certification of sustainable production refers to a voluntary scheme (e.g. SFI³⁴, FSC³⁵, PEFC³⁶ or ResponsibleSteel³⁷) for declaring standardised good practice in material extraction, production and product manufacturing.
- Certification of sustainable building refers to a voluntary scheme (e.g. BREEAM³⁸, LEED³⁹, DGNB⁴⁰, CASBEE⁴¹) for declaring sustainable design practice in building or renovation projects.

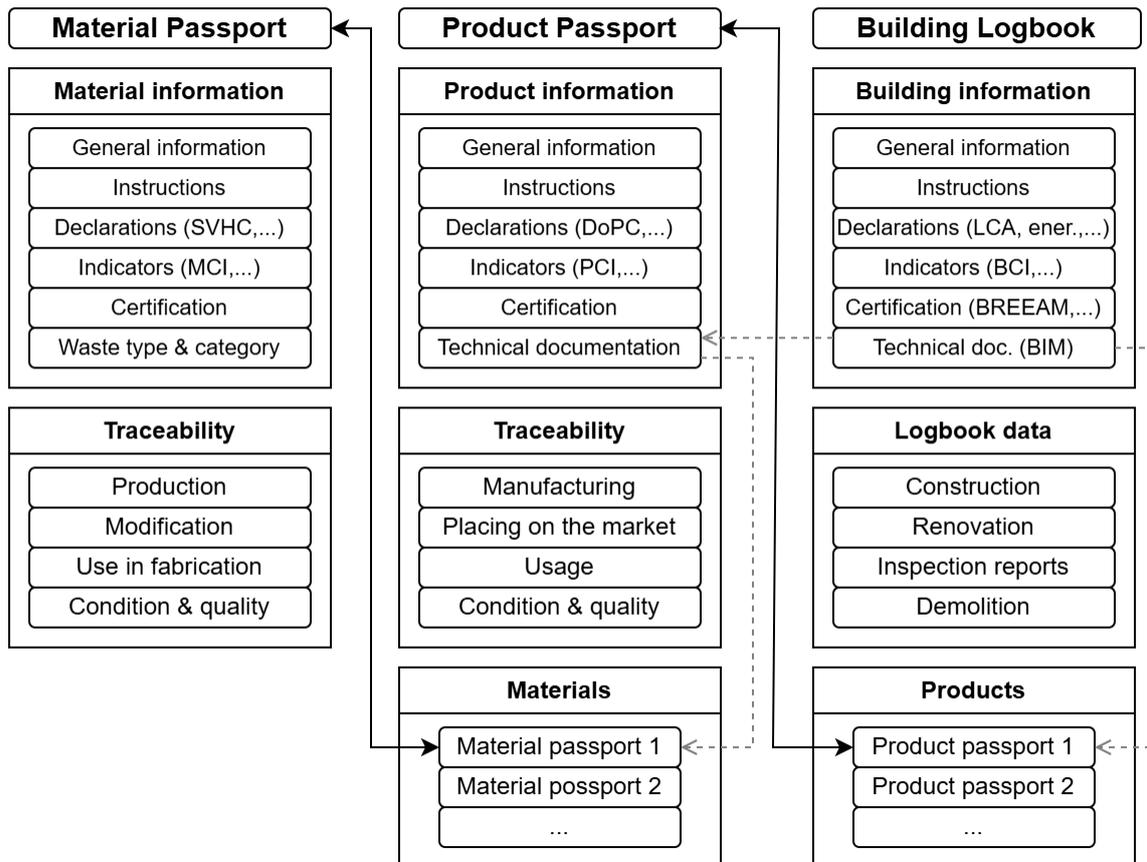


Figure 4.1 Information domains of DMP, DPP and DBL

Technical documentation is a repository of all relevant technical data, datasheets, drawings and technical reports. This data can also be machine-readable (e.g., BIM or BIM objects).

Traceability/Logbook is the “live” part of the Digital Passport, where all the inspection documents, consolidated monitoring data and records of interventions are stored.

³⁴ Sustainable Forestry Initiative, available at: <https://forests.org/standards/>

³⁵ Forest Stewardship Council, available at: <https://fsc.org/en>

³⁶ Programme for the Endorsement of Forest Certification, available at: <https://pefc.org/>

³⁷ ResponsibleSteel programme, available at: <https://www.responsiblesteel.org/>

³⁸ Building Research Establishment Environmental Assessment Method available at: <https://breeam.com/>

³⁹ Leadership in Energy and Environmental Design scheme available at: <https://www.usgbc.org/leed>

⁴⁰ German Sustainable Building Council certification available at: <https://www.dgnb.de/>

⁴¹ Comprehensive Assessment System for Built Environment Efficiency scheme available at: <https://www.ibecs.or.jp/CASBEE/>

Considering the data categories mentioned in this overview, the possible structure of the Digital Passport data can be described as in Figure 4.1 based on the workshop schema from Figure 3.2.

For the spatial arrangement of building kits, components, constituents and materials, the Digital Passports are going to contain nested information as described in Figure 4.2 based on Figure 3.3 from the workshop. This figure was then extended to contain also typical activities (such as audit, deconstruction, recycling, transport) that are recorded in the “traceability” part of the Digital Passports.

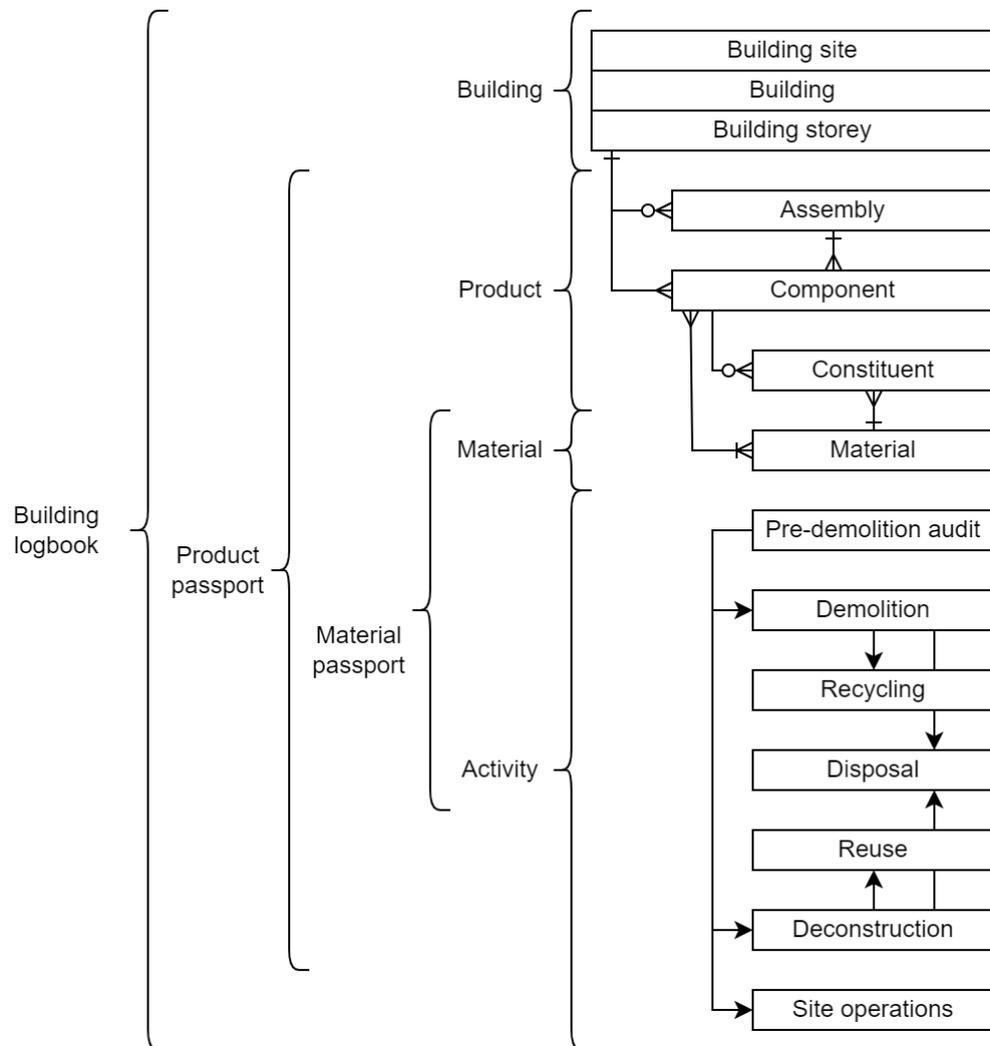


Figure 4.2 Information domains of DMP, DPP and DBL

This schema is just illustrative description of the logical relations between different elements of the Building Information Model without any intention to suggest the final data architecture for SUM4Re project in this report. It should be noted that the C-BIM development is organized in the Work Package 4 separately.

4.3. User Perspectives

User perspectives on the Digital Passports highlight several key aspects that are crucial for their successful implementation and utilization. Users, including owners, manufacturers, regulators, consumers, and other stakeholders, emphasize the importance of having a standardized and interoperable framework to enhance transparency, traceability, and sustainability throughout the building, product or material lifecycle.

From the perspective of manufacturers and responsible economic operators, the Digital Passport provides a comprehensive solution for tracking and managing information. It includes a wide range of data, such as unique identifiers, compliance documentation, substances of concern, user manuals, and details about manufacturers and operators. This information must be structured in a way that allows different systems and technologies to access, interpret, and utilize it effectively. Manufacturers appreciate the cross-sectoral product data model that defines a standardized format for the data included in the Digital Passport, ensuring that the information can be easily shared and understood by various stakeholders.

Regulators view the Digital Passport as a tool to facilitate international trade and compliance by incorporating global trade identification numbers and commodity codes. This ensures that the information is interoperable not only within a specific region or industry but also on a global scale. The use of knowledge graphs for integrating Digital Passport data into value chains and track-and-trace solutions is also highlighted, offering better analytics and interoperability by representing data in a structured and interconnected manner.

Consumers benefit from the Digital Passport by gaining access to extensive information about a product's makeup and environmental footprint during its production, usage, and end-of-life stages. This encourages sustainable production, design, reusability, repairability, and waste reduction. The Digital Passport system architecture includes considerations for data repositories, ERP systems, SQL databases, and RDF data stores, addressing the transformation risks for data quality and energy costs, and emphasizing the need for social agreements and standards.

User stories developed for the Digital Passport system highlight the needs of various stakeholders, such as recyclers, refurbishes, and responsible economic operators. These stories guide the development of the Digital Passport system to ensure it meets the practical requirements of its users. By adopting standardized data models, open data exchange protocols, and advanced technologies like knowledge graphs and decentralized identifiers (DIDs), the Digital Passport can provide a comprehensive and interoperable solution for tracking and managing product information. This enhances the ability of stakeholders to make informed decisions, improve product sustainability, and ensure regulatory compliance throughout the entire lifecycle.

5. Linked data specifications

Key messages:

- This section inspects the relevant features of EU Inspire Directive and Industry Foundation Classes (IFC) standard
- IFC classification is mapped over the terminology used in the previous chapters.

The Digital Passports bring together data from different digital systems. It should be possible to transfer them (or their parts) between different stakeholders and make them accessible via different digital portals. Efficiently linking various datasets is therefore crucial for the development of the Digital Passports.

One of the most advanced interoperability technologies available is called linked data. It facilitates the connection of different data points within conceptual information structures or datasets. As linked data standards are established at the web level, they are applicable across diverse application domains and geographic regions. In recent years, the construction sector has increasingly adopted linked data, leading to the development of new specifications that extend international web standards.

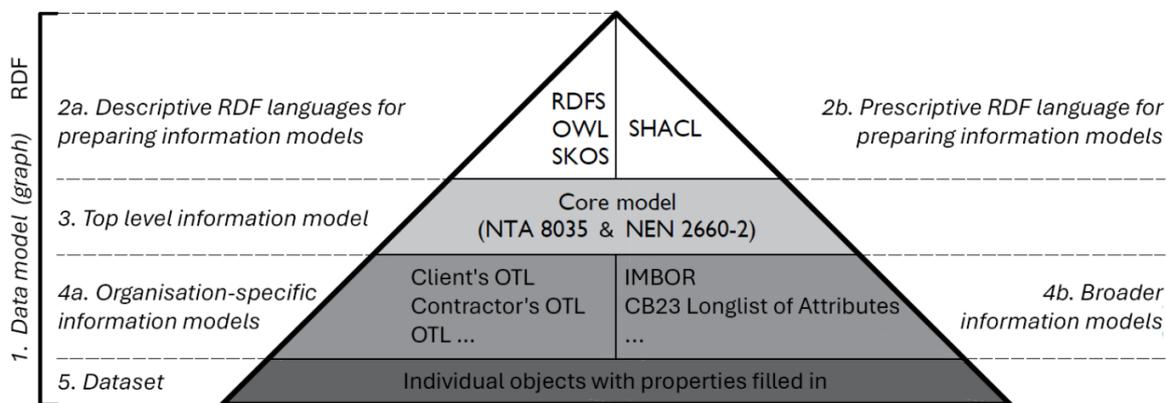


Figure 5.1 Standardisation layers for linked data²⁹

RDF data model was introduced in the previous section. It is represented as triples, which consist of a subject, a predicate, and an object. The model forms a directed graph where nodes represent resources and edges represent the relationships between them. This graph-based structure is particularly useful for representing interconnected data. The data model supports various syntax notations and formats, with Turtle (Terse RDF Triple Language) being one of the most widely used. RDF Schema (RDFS), Web Ontology Language (OWL), Simple Knowledge Organisation System (SKOS) and Shapes Constraint Language (SHACL) are used to describe RDF data and define semantic characteristics. SPARQL is the standard query language for querying RDF data. It allows users to retrieve and manipulate RDF data stored in a graph format.

5.1. Inspire Directive

The INSPIRE Directive establishes a framework for a European Union Spatial Data Infrastructure (SDI) designed to support the implementation of EU environmental policies, as well as other initiatives with potential environmental implications. This infrastructure facilitates the interoperability and exchange of spatial environmental data among public authorities, enhances public access to geospatial information across Europe, and promotes more effective cross-border environmental governance and decision-making⁴²

⁴² INSPIRE Knowledge Base available online at https://knowledge-base.inspire.ec.europa.eu/overview_en

The INSPIRE principles describe a method in which buildings can be uniquely identified by a code shared, interpreted and maintained across all levels of users of the DBL. Since municipalities and countries have different methods of numbering buildings, and buildings can receive different codes even on a regional municipal level, the need for a consistent coding scheme is evident. Should a building's ID change over time, for example, if the type of building is included in the code and its use changes, data associated with the building might be lost⁴³. The basis of the INSPIRE principles is that every identification unit, even on municipal level, can assign building numbers, and that aggregate administrative units, such as countries, include codes to identify all previous numbering systems used.

INSPIRE principles also describe how large amounts of data pertaining to a building can be organized in a document. This is done by building up a URI link to a document in components, under which various data related to the component topic is accessible. These components appear in the URI in order of decreasing importance.

Furthermore, the INSPIRE principles require that buildings be identifiable by geographical coordinates, and that the worldwide GPS coordinate system be used for this. It also outlines a method for writing addresses that eliminate confusion with regards to, for example, building and floor numbers.

These principles not only decrease the risk of building duplication or data loss but also make the DBL more user-friendly and provide clear methods for structuring information.

5.1.1. The DBL Semantic Data Model

The DBL Semantic Data Model contains both a dictionary that defines building-related terms and an ontology, which uses these terms as names for concepts, attributes, relations and other constraints. The ontology controls all DBL data sets.

According to the INSPIRE specification, data is classified according to three key concepts: Building, BuildingUnit, and CadastralParcel. Each of these concepts have pre-defined attributes and relations and operates under a bi-temporal logic. This bi-temporal logic interprets their various lifespan states in time and adds information about the transaction time to the metadata.

The DBL dictionary/ontology can be extended by users by importing the common core DBL Framework and following a set of steps outlined by the framework and using either a text editor or commercial semantic development tool.

The semantic interoperability architecture for European and national DBLs follows the FAIR principles⁴⁴ which include several key elements. These are data specification (in the DBL Framework, this is the DBL Ontology), data dictionary, metadata, and data technology elements, which includes, for example, identification schemes, data formats and data languages.

5.1.2. Data sharing and Interaction

The technical interoperability of Digital Building Logbooks (DBLs) allows data sharing for a single source of truth, as long as the data ownership remains unchanged. This allows for data to be governed, updated, extended, and clarity of source and responsibility to be maintained. In this method of working, data is published to a common data environment (CDE), and access is provided through a link or interface which is enabled with an API or query. Additionally, a national DBL validates source data and integrates data from various sources to enrich the DBL.

⁴³ Ecorys, TNO, Arcadis, & Contecht. (2023). Technical guidelines for digital building logbooks. DG Grow, European Commission.

⁴⁴ Wilkinson, M., Dumontier, M., Aalbersberg, I. et al. The FAIR Guiding Principles for scientific data management and stewardship. *Sci Data* 3, 160018 (2016). <https://doi.org/10.1038/sdata.2016.18>

The seven aspects of the DBL Framework include Identification, General (such as relations between entities, types, dates of construction etc.), Legal & Finance, Dimensions, Performance, Structure & Material, and Building Services.

5.1.3. Interoperability

To strengthen cross-border interoperability between public authorities, the Interoperable Europe Act was established and the purpose of interoperability outlined in the European Interoperability Framework (EIF).

In addition, the Data Governance Act (DGA) outlines the requirements to ensure interoperability for data intermediary services. A DBL, where data is uploaded by various parties, as well as collected from third parties, is considered a data intermediary service. Therefore, EU laws related to interoperability apply. While the DGA does not define interoperability, it does require the use of open standards in the arenas where data intermediary services are used.

5.2. IFC

IFC is the most recognized data schema for BIM. It is based on semantic representations of different concepts and relations between specific entities, and therefore it can be expressed in OWL as any other RDF data. This makes it extremely useful for combining with different ontologies to facilitate data interoperability across the whole building lifecycle. Ontologies then serve as the representation of domain knowledge, an enrichment tool for IFC model semantics, and a linkage between IFC data and other heterogeneous data. The possibility of integration of IFC with Linked Data technology, such as RDF and SPARQL, allows for the creation of a web of interconnected data. This enhances the ability to link and query data from different sources, improving data sharing and collaboration among stakeholders. Ontologies that enrich IFC models with additional semantics make the data more meaningful and easier to interpret. This supports various applications, including automated compliance checking and lifecycle management.

On the other hand, IFC schema is also very flexible and able to directly accommodate most of the common data types. Their additional classifications can be stored in the buildingSMART Data Dictionary (bSDD)⁴⁵. This section will focus on the possibility to integrate the new data in the IFC schema rather than linking external ontologies. Such links will be explored in the later stages of the SUM4Re project.

5.2.1. Mapping the data structure to IFC4 standard

This report covers just the high-level concepts of the Digital Passports, and therefore it should be mostly possible to link the terminology discussed in the workshop and in the later parts of the Task 1.3 development to the relevant core entities and their properties from the IFC schema. For this demonstration, we used IFC4.3.2 as the latest valid IFC standard.

The basic spatial and temporal terminology described in Figure 4.2 is then mapped to the entities and their predefined types in Figure 5.2. The mapping also includes links between the activities (IfcTask) and their respective objects (IfcSite, IfcBuilding, IfcProduct, IfcMaterial, ...). The most important terms are also mapped in Table 5.1.

⁴⁵ buildingSMART Data Dictionary available at: <https://www.buildingsmart.org/users/services/buildingsmart-data-dictionary/>

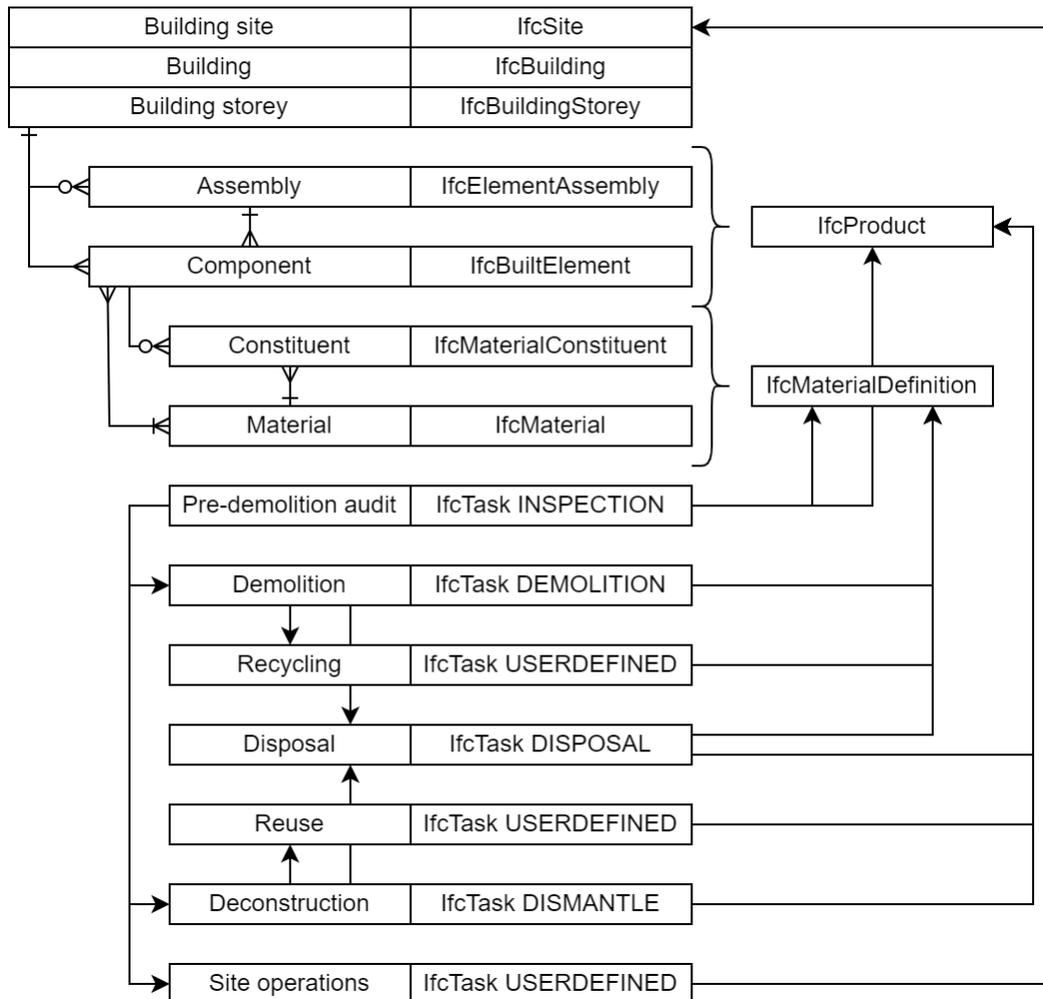


Figure 5.2 General domains of DMP, DPP and DBL represented in IFC4.3.2 schema

Table 5.1 Mapping of common terminology used in Task 1.3 to IFC4.3.2

	IFC 4.3.2 mapping
Building site	IfcSite
Building	IfcBuilding
Product - Kit	IfcElementAssembly
Product - Component	IfcBuiltElement
Product - Constituent	IfcMaterialConstituent
Product classification	IfcRelAssociatesClassification
Material	IfcMaterial
Material classification	IfcMaterialClassificationRelationship (deprecated)

Activity (pre-demolition audit, deconstruction, demolition, transport, quality assessment, ...)	IfcTask IfcTask.PrefedinedType = INSPECTION, DISMANTLE, DEMOLITION, LOGISTIC, TESTING, ...
Activity schedule	IfcTask.TaskTime
Activity sequencing	IfcTask.IsPredecessorTo, IfcTask.IsSuccessorFrom
Impacts and resources related to the activity	subclasses of IfcResource

5.2.2. Opportunities in the implementation of IFC5

The IFC schema up to version IFC4 was primarily developed to be represented in the STEP format which provides optimized exchange and storage of data in files. Managing data in files has become obsolete in recent years. Moreover, the current IFC schema also faces many other limitations related to the STEP data format such as increasing complexity to manage and further extend the schema. In the context of circular economy, the most fundamental drawback of the current IFC standard is the complicated breakdown of the project into sub-assemblies and separate objects that would be recovered, recycled or reused separately. In practice, this means mostly re-creating of the component or kit in the new model. Any data structured according to different ontologies (such as ILCD+EPD) or represented in different formats (for example scanning, monitoring and imaging data) would need to be linked to the IFC model as external resources.

Therefore, buildingSMART International decided that the future schema will be language independent enabling the building data to be represented in multiple formats such as XML, JSON, RDF and even binary formats like HDF5. The new concept was tested in 2020 on the Entity Component System (ECS) where the information is represented as Entities (unique identifiers that represent objects in the model), Components (sets of data that describe specific aspects of an entity) or Systems (logic that operates on entities with specific components). This system provides more flexibility and granularity than the current schema and allows distributed collaboration of different disciplines without conflicts. Another promising technology for representing (mostly) 3D data is Universal Scene Description (USD) which was tested as IFC5 candidate in 2024. With USD, the geometry is represented as triangular meshes, abandoning complex procedural geometric definitions. This allows better performance and optimization of the geometric data. This is, of course, convenient for the pre-demolition inspections, where the spatial data is mostly obtained from point clouds, but many existing modelling and parametrization concepts used in new designs won't be compatible with this geometric simplification.

It can be concluded that IFC5 brings many opportunities for the circular economy applications in buildings, namely: (1) distributed datasets across different platforms, (2) integration of scanning, monitoring and imaging binary data, (4) better granularity and efficient decomposition of existing models, and (3) optimized performance of point-cloud based geometry. However, at the current state it does not have solutions for many modelling concepts from IFC4 that will have to be abandoned. This means that the adoption of IFC5 will be rather slow, and it is expected that several new versions of IFC4 will be still released in parallel. Considering the limitations on the modelling of new buildings, it may be possible for the demolition industry to be one of the first adopters of IFC5.

6. Information flows in existing platforms

Key messages

- As a background information for the discussion in the workshop organized within Task 1.3 of SUM4Re project, CONC, BLOCKM and TECN provided a description of the essential information flows in their platforms.
- The flowcharts and description of the data standards and interoperability is described in this section.

This section introduces the data flows in the three platforms used in SUM4Re project. The description focuses on the input and output formats as well as the internal exchange between specific modules of the platforms.

6.1. Concular

Figure 6.1 illustrates the structured flow of data between different entities in an extended LCA (Life-Cycle-Assessment) tool. The process begins with the IFC file, which provides fundamental building information such as object name, material properties (length, height, width, area, volume, and possibly mass). This data acts as the foundational input for further processing. The data from IFC is parsed and imported to the main Concular Platform, where the Mapping Process takes place. This step ensures compatibility by mapping IFC data with relevant lifespan considerations, DIN standards, and certification requirements. It is still only half-automated, since the heterogeneity of construction projects stops easy automation. During this stage, materials are identified and linked with external datasets, ensuring accurate classification and alignment with environmental impact assessments.

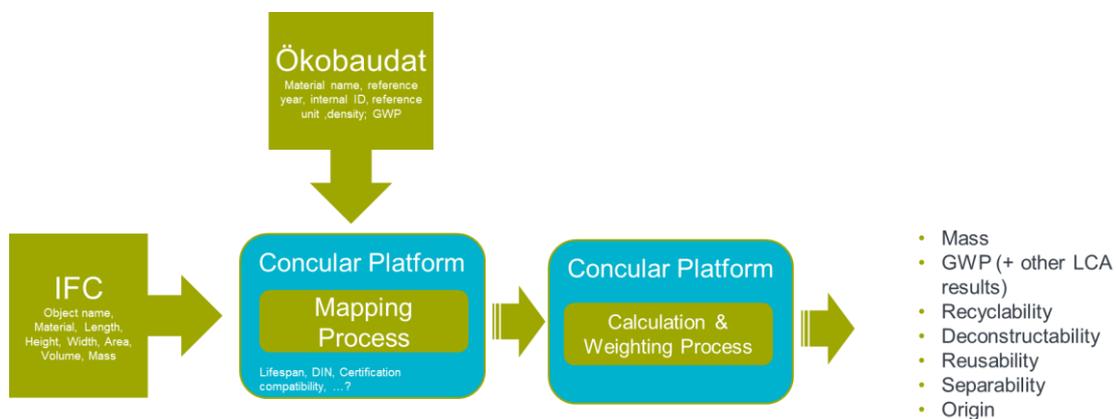


Figure 6.1 Data flows in CONCLULAR platform

One key external dataset integrated into this system is Ökobaudat, which contains essential material information such as reference year, reference unit, density, and environmental impact indicators like Global Warming Potential (GWP). This database builds the base for most certifications used in Germany but is extended by international databases for specific EPDs (Environment Product Declarations). These datasets provide crucial environmental impact metrics, enriching the lifecycle assessment process.

The LCA data from different sources is aggregated by Concular with information about the lifespan, overwriting reference unit and circularity information. This provides a one-of-a-kind dataset which is based on Concular's extensive experience in the reuse of building products. Following the mapping, the data progresses within the Concular Platform to the Calculation & Weighting Process. Here, a comprehensive analysis is conducted, considering factors like

mass, GWP (and other Life Cycle Assessment results), recyclability, deconstructability, reusability, separability, and origin. These metrics help in assessing the sustainability and circular economy potential of the materials used in construction. The outcome of this structured data flow is an enriched dataset, calculated per material and aggregated to the whole project, that allows for better decision-making in material selection, focusing on sustainability, environmental impact reduction, and efficient resource utilization.

6.2. Cirdax

Figure 6.2 illustrates the information flow entered into Cirdax, which enables the extraction of various datasets and documents. The process, as depicted, begins with the collection of existing information in different formats, including physical and digital drawings, reports, financial documents, and written architectural descriptions. Once all relevant data has been gathered, an assessor enters the information into Cirdax, populating the database with all available content. There are two methods for entering data into Cirdax: directly through the web-based platform or tablet application, and via an Excel import sheet, which can be filled in manually or supplemented using an IFC export.

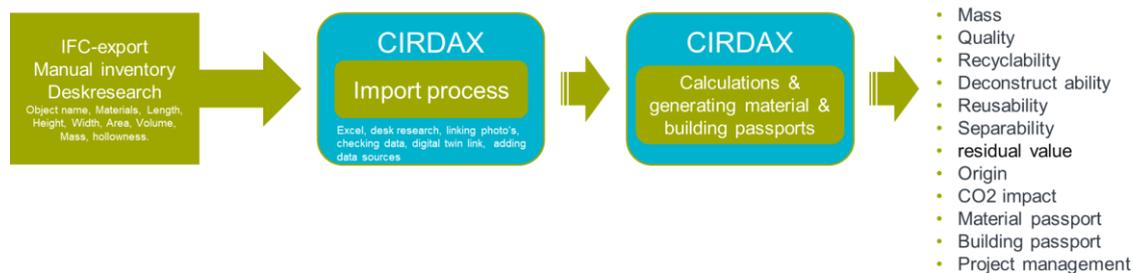


Figure 6.2 Data flows in CIRDAX platform

Each data point entering Cirdax is enriched with additional classification parameters, including the Ladder van Lansink, NEN 2767 (material condition assessment), technical service life, photographs, density, the 10R-model, and the disassembly index. These enrichments serve to structure and enhance the input data. Once processed, all data is automatically converted into cubic meters and tonnage, and the CO₂ factor for each material is calculated based on the ICE database (other databases can be implemented). Within the Cirdax database, the CO₂ costs and treatment methods (recycling, reuse, or incineration) for materials are summarized to generate material passports. All this information is structured according to the NL-SfB classification system, offering a clear and organized overview of all materials, their applications, and handling or processing methods.

This process results in a unique dataset created by and within Cirdax, consisting of material passports which, together with building information, generate a building passport. All passports and building-related data can be linked to a digital twin within Cirdax, allowing for the integration of material passports into the 3D model by linking them to the corresponding material or product.

Additionally, Cirdax includes a project management module that supports the full range of project-related activities, including inventory, demolition, and other relevant processes. This module provides a comprehensive overview accessible to all stakeholders, enabling transparent registration and trade, while ensuring consistent communication across parties. The outcome of this structured information flow is an enriched dataset, calculated per material and aggregated at the project level, providing users with a complete overview of their building.

6.3. Genia

Figure 6.3 illustrates the flow of information and processes within the Genia platform to obtain the condition index of the structure and its elements according to their loss of functionality due to damage, and the maintenance to be performed accordingly.

The process starts with the BIM model or point cloud of the structure as a geometric and visualisation base. In the case of the BIM model, information can be added to the elements/sub-elements defined in it, and in the case of the point cloud, to points in 3D space. This information comes from visual inspections or from sensors installed in the structure. The platform's 3D viewer allows all this information and models to be visualised and interacted with.

In an internal analysis process, MIVES (Integrated Value Model for Sustainable Evaluation) is used to weight and evaluate the available data, resulting in a condition index for each of the analysed elements and a global one for the whole structure. It also lists and proposes maintenance or repair work to be carried out on the damaged elements.

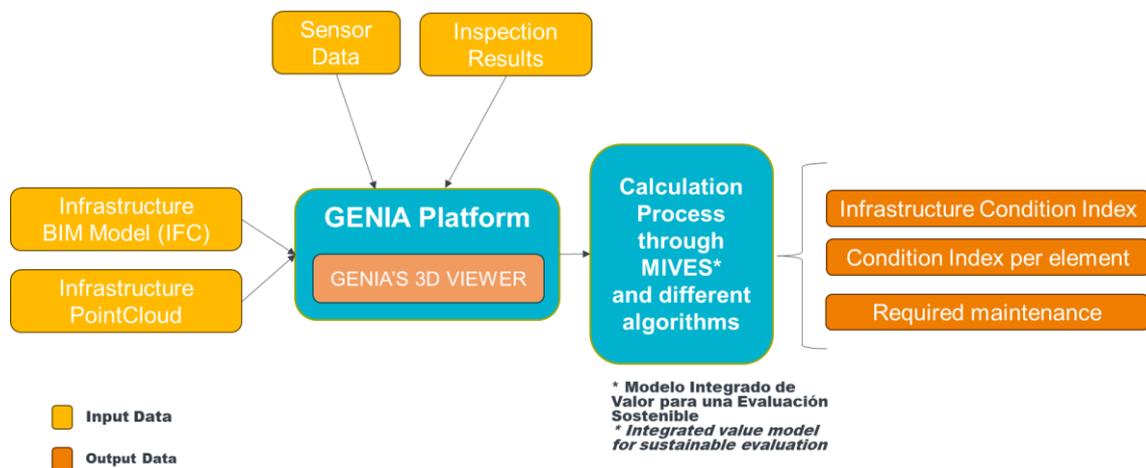


Figure 6.3 Data flows in GENIA platform

7. Conclusions and recommendations

7.1. Standardisation gaps

There are many standards and technical specifications already developed or under the development, many of them are aimed at certain materials or product groups. Some of the materials are clearly ahead of the others in terms of coverage of the different aspects in these documents because of their easy identification, separation and recovery and/or high market value. For instance, CE marking is now clarified for reused constructional steel (using harmonized product standard) and bricks (using ETA), but the remaining materials will need to receive updated harmonize standards according to the new CPR or develop their own EAD. Concerning the data standards, the situation is much better, as the whole industry relies on the IFC schema which is being continuously improved. Building product classification systems are rather scattered across Europe, and it can be expected that the regional construction practices will make harmonization of this data rather difficult.

7.2. Interoperability gaps

The Digital Passports bring together data from different digital systems. It should be possible to transfer them (or their parts) between different stakeholders and make them accessible via different digital portals. Efficiently linking various datasets is therefore crucial for the development of the Digital Passports. Unfortunately, the current IFC4 schema is not very suitable for the management of data linked across different platforms and standards. Although, it is possible to provide external links to the models or convert STEP files into RDF, the efficiency of such process is very low. One of the opportunities for the seamless integration of Digital Passports in the Building Information Modelling could be the newly developed IFC5.

7.3. Future development

The information collected in this report will be provided to the partners of the SUM4Re project with the hope that it will support the development of the C-BIM concept for the circular use of building products and materials.



Creating materials banks
from digital urban mining

APPENDICES

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Table 7.3. Simplified example of the material inventory

APPENDIX A Terms and definitions

The following glossary is based on the guidelines, standards and regulations summarised in this report and in Deliverable D1.2 of SUM4Re project. The terms and definitions are listed hierarchically to enable development of circular taxonomy and implementation of the definitions in C-BIM concept.

Activity is action, process or operation performed on *construction*, *product* or *waste* during its life cycle.

Accreditation is an attestation by a national accreditation body that a conformity assessment body meets the requirements set by harmonised standards and, where applicable, any additional requirements including those set out in relevant sectoral schemes, to carry out a specific conformity assessment activity.⁴⁶

Alteration is a transformative process of a *product* or *component*.

Minor alteration means transformation caused by checking, cleaning and repairing, which results in a product or component that retains most of its original material (by weight) and does not change its major dimensions by more than 10%.⁴⁷

Major alteration is going beyond checking, cleaning or repairing recovery operations by which the product or components of products are prepared.⁴⁸

Audit (or pre-development audit) is qualitative and quantitative assessment of materials and products prior to deconstruction, demolition or renovation of buildings and infrastructures. It includes demolition and refurbishment assessments of what can be reused from deconstruction and stripped out, respectively. It informs the potential to reuse products and materials in subsequent construction and/or fit out (of refurbishment)^{49 50}

Material audit (or resource audit) is the audit focusing on the materials, their characterisation, recycling and recovery.

Waste audit is the material audit focusing on different waste streams, their characterisation and management.³

Pre-demolition audit means a preparatory activity with the purpose of (1) collecting and assessing information about the qualities and quantities of construction products for re-use, CDW materials with the potential for preparing for re-use and recycling as well as other types of CDW materials that will be released during the demolition works; and (2) giving general and site-specific recommendations regarding the demolition process. An important part of the pre-demolition audit is also the identification of materials containing hazardous substances or mixtures and those that might hinder re-use or recycling.⁵¹

Pre-deconstruction audit is the reclamation audit before building deconstruction. Its main purpose is to prevent the reusable products becoming waste.⁴⁷

⁴⁶ Regulation (EC) No 765/2008 of the European Parliament and of the Council of 9 July 2008 setting out the requirements for accreditation.

⁴⁷ Based on PROGRESS project, Deliverable D9.1 Comprehensive Overview of the Project

⁴⁸ Based on the adapted text of the new Construction Products Regulation (CPR)

⁴⁹ Based on the European Commission's Waste Audit Guidelines

⁵⁰ Based on BAMB project <https://www.bamb2020.eu/wp-content/uploads/2017/07/Reuse-of-building-products-and-materials-barriers-and-opportunities.pdf>

⁵¹ Based on the new EU Construction & Demolition Waste Management Protocol (2024)

Pre-renovation audit is the activity similar to pre-demolition audit but focused on the materials and components released during the renovation works.⁵¹

Reclamation audit is the pre-development audit focusing specifically on building products before refurbishment or deconstruction, their characterisation and planning of their reuse. It results in the reclamation inventory.⁵²

Cascading is a repeated use of a resource usually starting at a level of high value with decreasing quantity and quality at each subsequent stage or cycle, depending on the processes used.

Certification is a procedure by which a third party gives written assurance that a product, process or service is in conformity with certain standards.⁵¹

Deconstruction (or disassembly) is the process of selectively and systematically dismantling construction works to reduce the amount of waste created and generate a supply of secondary materials that are suitable for reuse and recycling. It differs from demolition where a site is cleared of its building by the most expedient means.⁴⁷

Decontamination is reduction or removal of hazardous materials.⁴⁷

Deep renovation is a renovation, which focuses on essential building elements, and which transforms a building or building unit into a zero-emission building.⁵³

Demolition is the tearing down of buildings and other structures typically resulting in their destruction. It contrasts with deconstruction, which involves taking a building apart while carefully preserving valuable components for reuse purposes.⁴⁷

Selective demolition means removal of materials from a demolition site in a pre-defined sequence in order to maximise recovery and recycling performance. It involves sequencing the demolition activities to allow the separation and sorting of building materials and products. Selective demolition ensures the removal and safe handling of hazardous substances and mixtures and facilitates re-use and high-quality recycling by selective removal of materials and products in a pre-defined sequence.⁵¹

Destruction is the intentional damaging or discarding of a product as waste with the exception of discarding for the only purpose of delivering a product for preparing for re-use or remanufacturing operations.⁵⁴

Distance selling is offer for sale, hire or hire purchase of products, online or through other means of distance sales, whereby the potential customer cannot physically access the product displayed.⁵⁴

Execution means all activities carried out for the physical completion of the construction works including procurement, the inspection and documentation, such as work on site or fabrication of components off site and their subsequent erection on site.^{55 56}

Labelling means affixation of a label or symbol indicating that compliance with standards has been verified. Use of the label is usually controlled by the standard-setting body. Where certification bodies certify against their own specific standards, the label can be owned by the certification body.⁵¹

⁵² Based on FCRBE project https://opalis.eu/sites/default/files/2022-02/FCRBE-Reclamation_Audit-v12.pdf

⁵³ Based on the Energy Performance of Buildings Directive (EPBD)

⁵⁴ Based on the Ecodesign for Sustainable Products Regulation (ESPR)

⁵⁵ Based on EN 1990 (Eurocode 0)

⁵⁶ Based on EN 1090-2

Maintenance is an action (or series of actions) carried out during the working life of the structure or product to retain it in a condition where it can function as specified. It includes set of activities to enable it to fulfil the requirements for reliability.^{48 54 56}

Manufacturing is an activity required to produce and deliver the component, which may encompass fabrication, welding, mechanical fastenings, assembly, testing and documentation of the performance characteristics declared.^{56 57}

Material recovery means any recovery operation, other than energy recovery and the reprocessing into materials that are to be used as fuels or other means to generate energy.⁵¹

Backfilling is a material recovery operation where suitable non-hazardous waste is used for purposes of reclamation in excavated areas or for engineering purposes in landscaping. Waste used for backfilling must substitute non-waste materials, be suitable for the aforementioned purposes, and be limited to the amount strictly necessary to achieve those purposes.⁵⁸

Preparing for reuse means checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing.⁵⁸

Recycling is a process where the waste materials are collected, broken down and processed to be converted into raw materials for new products. The process is typically energy intensive, requires a special facility and differs from reuse where the components do not enter the material stage.⁵⁸

Closed-loop recycling is a process in which products are recycled into materials aimed to manufacturing products with the same function. An example of closed-loop recycling is recycling steel into steel by re-melting.⁴⁷

Open loop recycling is a process where the material gained from recycling is used in a different product system than the original product. It comprises both upcycling and downcycling.⁴⁷

Downcycling is a recycling process when the product created from recycled material is of lower commercial value, quality or functionality than the original product. One example is the crushing of concrete for use as road fill or aggregate.⁴⁷

Upcycling is a recycling process when resulting product or material is of a higher commercial value, quality or functionality than the original item.⁴⁷

Preparing for assembly is an activity performed on the constituent products to produce the parts ready for assembly and inclusion in components, such as identification, handling and storage, cutting, shaping and holing.⁵⁶

Quality assessment means the collection and analysis of data to determine the degree of conformity with predefined criteria or objectives.⁵¹

Refurbishment (or reconditioning) means preparing or modifying an object that is waste or a product to restore its performance or functionality within the intended use, range of performance and maintenance originally conceived at the design stage, or to

⁵⁷ Based on EN 1090-1

⁵⁸ Based on the Waste Framework Directive (WFD)

meet applicable technical standards or regulatory requirements, with the result of making a fully functional product.⁷

Remanufacturing is an industrial process in which a product is produced from objects that are waste, products or components and in which at least one change is made to the product that affects the safety, performance, purpose or type of the product.⁷

Renovation means modification and improvements to an existing plant, building, or civil engineering works in order to bring it up to an acceptable condition.⁵¹

Repair means returning a defective product or structure (fixing or replacing its defective components) to a condition where it fulfils its intended use. This activity falls outside the definition of maintenance.^{2 7 8}

Repurposing is any operation that changes the function or purpose of a component.¹

Reuse is any operation by which the building components are used again. They may be reused for the original function (a conventional reuse scenario), or repurposed, but the components will only have minor alterations, retaining a similar (or the same) form. The operation includes checking, cleaning or repairing, by which the components are prepared so they can be used without any other pre-processing. Components can be reused in closed-loop system without repurposing or open-loop system resulting in lower or higher value of the reused products.^{1 11}

Adaptive reuse (of buildings or building sites) is the process when the buildings or sites are repurposed for use other than the original design. Adaptive reuse is not the focus of the ADVANCE project.¹

In-situ reuse means that the component is reused locally in the same or neighbouring building site without the need to organize its transport.¹

Relocated reuse requires transport of the component over longer distances.¹

Scavenging is the activity of identifying usable materials that takes place after demolition, in this context, particularly re-usable products and recyclable materials.⁵¹

Stripping-out is the activity of removing all materials from construction works that takes place before demolition.⁵¹

Upgrading means enhancing the functionality, performance, capacity or aesthetics of a product.⁷

Urban mining is the recovery of raw materials from products, buildings, and waste found within urban settings. It involves reclaiming valuable materials from existing goods and structures, which can include building materials and items that would otherwise end up in landfills.

Waste management is the collection, transport, recovery (including sorting), and disposal of waste, including the supervision of such operations and the aftercare of disposal sites, and including actions taken as a dealer or broker.¹¹

Waste prevention means measures taken before a substance, material or product has become waste, that reduce: (a) the quantity of waste, including through the re-use of products or the extension of the life span of products; (b) the adverse impacts of the generated waste on the environment and human health; or (c) the content of hazardous substances in materials and products.¹¹

Waste recovery is any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II sets out a non-exhaustive list of recovery operations.¹¹

Waste treatment means recovery or disposal operations, including preparation prior to recovery or disposal.¹¹

Actor is a natural or legal person/organisation responsible for carrying out any activity or in possession of the materials, products or components at any stage of the building's life cycle.

Auditor is the expert or the team of experts (auditors' team) performing the audit. The auditor or the team of auditors can be appointed by the owner of the construction works or consultant (e.g. an architect or structure engineer) acting on behalf of the owner.⁵¹

Authority means the national or regional administration responsible for granting the demolition or renovation permits and supervision of the demolition or renovation process.⁵¹

Constructor is any natural or legal person executing the construction works.⁹

Contractor is any natural or legal person acting on behalf of the owner of the construction, products, material or waste with the responsibilities specified in the contract.

Dealer is a retailer or any other natural or legal person who offers products for sale, hire or hire purchase, or displays products to customers in the course of a commercial activity, whether or not in return for payment.⁷

Distributor is any natural or legal person in the supply chain, other than the manufacturer or the importer, who makes a product available on the market, including by offering products for sale, hire or hire purchase, or displaying products to customers or installers during a commercial activity, and including through distance selling, whether or not in return for payment.^{2,7}

Economic operator is the manufacturer, the authorised representative, the importer, the distributor, the fulfilment service provider or any other natural or legal person in relation to the manufacturing or remanufacturing of products, including reused products, or to making those products available on the market in accordance with CPR.^{2,7}

Holder is any natural or legal person that possesses, carries or legally owns the object of consideration.

Waste holder means the waste producer or the natural or legal person who is in possession of the waste.¹¹

Manufacturer is any natural or legal person who manufactures a product or who has such a product designed or manufactured and markets that product under its name or trademark or, in the absence of such person or an importer, any natural or legal person who places on the market or puts into service a product.^{5,12}

Owner of the construction works means the owner of the buildings or civil engineering works, the developer or the party identified by the national legislation as the original waste holder.⁵¹

Service provider is any natural or legal person providing a service to a manufacturer or to a supplier of a key part, provided that the service is relevant for the manufacturing of products, including to their design, or to their deinstallation in the case of reused products.²

Supplier is any natural or legal person providing raw materials, interim products, or used products to manufacturers or to other persons providing raw materials, interim products, or used products to manufacturers.²

User is any natural or legal person using a solution for commercial, private or public purposes.

End user is any user, to whom a product has been made available either as a consumer outside of any trade, business, craft or profession or as a professional end user during its industrial or professional activities.⁵⁹

Waste producer is anyone whose activities produce waste or anyone who carries out pre-processing, mixing or other operations resulting in a change in the nature or composition of this waste.¹¹

Building element is a technical building system or an element of the building envelope.⁶

Building envelope means the integrated elements of a building which separate its interior from the outdoor environment.⁶

CE marking is a marking by which the manufacturer indicates that the relevant product is in conformity with the applicable requirements set out in Union harmonisation legislation providing for its affixing.⁷

Construction (or construction works) is everything that is constructed or results from construction operations whether over or in the ground or water. This term covers both building and civil engineering works comprising both structural and non-structural components.^{2 8 9 14}

Building is a roofed construction having walls, that provide shelter for its occupants or contents as one of its main purposes, usually partially or totally enclosed and designed to stay in one place permanently.^{6 60}

Civil engineering works means construction works including, but not limited to roads, bridges, tunnels, pylons and other facilities for transport of electricity, communication cables, pipelines, aqueducts, dams, airports, ports, waterways, and installations which is the bases for the rails of railways.

Structure (or structural assembly) is the assembled and organised system of connected structural components designed to carry loads and provide adequate rigidity.^{8 10}

Degradation is loss of item performance due to changes in its material, geometry or connection to the system.

Design strategy is a set of rules and requirements for the design process to achieve optimal solution with respect to the specific set of goals.

Design for deconstruction (design for disassembly, DfD) is a design strategy considering how a building can be taken apart allowing for effective recovery of building materials and components.¹

Design for circularity (DfC) is a design strategy based on the circular economy principles.

Design for end-of-life (DfEOL) is a design strategy considering one or more end-of-life scenarios including the communication of the relevant design information to the end-of-life industry.¹

Design for reuse is a specific DfEOL approach considering deconstruction and reuse of building components as one of the basic requirements. The design documentation should take into account also reuse process.¹

Design life (or design working life) is assumed period for which the component or structure is to be used for its intended purpose with anticipated maintenance but without major repair being necessary.¹⁰

⁵⁹ Based on the European Regulation (EU) 2019/1020.

⁶⁰ Based on ISO 6707-1:2017

Digital passport is a repository of machine-readable information about a physical entity or process in open data format according to the dedicated specification. The data may be open or with restricted access.

Building logbook (or Digital Building Logbook, DBL) is a common repository for all relevant building data, including data related to energy performance such as energy performance certificates, renovation passports and smart readiness indicators, as well as data related to the life cycle GWP, which facilitates informed decision making and information sharing within the construction sector, and among building owners and occupants, financial institutions and public bodies.⁶

Material passport (or Digital Material Passport, DMP) is a set of data describing defined characteristics of the material in the product that give it the value for recovery and reuse.

Materials passport (or Resource Passport) is a repository of information about all materials in a specific building, product or product instance⁶¹. It can be seen as extracted list of Digital Material Passports of all the materials contained in the building, component or kit.

Materials passport for building is a set of material information related to a specific building/project.

Materials passport for product is a dataset describing a product type based on the manufacturer's information.

Materials passport for product instance is a dataset specific to a certain product instance. It contains instance data, such as the product condition.

Product passport (or Digital Product Passport, DPP) is a set of data specific to a product that includes the information specified in the applicable delegated act adopted pursuant to Article 4 of ESPR and that is accessible via electronic means through a data carrier in accordance with Chapter III of ESPR.⁷

Product passport for construction product is the Digital Product Passport of construction products according to the new Construction Products Regulation.²

Renovation passport is a tailored roadmap for the deep renovation of a specific building in a maximum number of steps that will significantly improve its energy performance.⁶

End-of-waste status is achieved when waste which has undergone a recycling or other recovery operation complies with the conditions laid out in the Waste Framework Directive.

Environment means surroundings in which an actor operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelationships.

Biosphere is part of the environmental system that is capable of supporting life.

Technosphere is the realm of human technological activity which results in a technologically modified environment.

Environmental impact means any change to the environment, whether adverse or beneficial, wholly or partially resulting from a product system during its life cycle or beyond the system boundary directly related to the product.⁷

Environmental footprint is a quantification of a product's environmental impacts, whether in relation to a single environmental impact category or an aggregated set of impact categories occurring in one or more life cycle stages.⁷

⁶¹ Buildings as Material Banks (BAMB) project

Carbon footprint is the sum of greenhouse gas emissions and their removals in a product system, expressed as CO₂ equivalents and based on a life cycle assessment using the single impact category of climate change.⁷

Whole-life-cycle greenhouse gas emissions are greenhouse gas emissions that occur over the whole life cycle of a building, including the production and transport of construction products, construction-site activities, the use of energy in the building and replacement of construction products, as well as demolition, transport and management of waste materials and their reuse, recycling and final disposal.⁶

Life-cycle global warming potential is an indicator which quantifies the global warming potential contributions of a building along its full life cycle.⁶

Essential characteristics are those characteristics of the product which relate to the basic requirements for construction works set out in Annex I of CPR, and those which are listed as predetermined environmental essential characteristics in Annex II of CPR.²

Inventory means the list of types and quantities of materials, construction products with potential for re-use, and CDW materials.⁵¹

Life cycle means the consecutive and interlinked stages of a product's life, from raw material acquisition or generation from natural resources, or in the case of products which have previously been incorporated in a construction work, from the latest de-installation from the construction work to final disposal.^{2,7}

End-of-life is the life cycle stage that begins when a product is discarded and ends when the product is returned to nature as a waste product or enters another product's life cycle.⁷

Obsolescence is loss of product performance due to changes in the performance requirements.⁶²

Performance is the degree to which a product or system has certain scalable characteristics.²

Adaptability is the possibility to change or modify a product, system or module to make it suitable for a particular purpose.¹³

Circularity is the degree of alignment with the principles for a circular economy.

Durability is the ability of a product to function as required, under specified conditions of use, maintenance and repair, until a limiting event prevents its functioning.⁷

Load bearing capacity is value or set of values for the loads that can be carried by the component referring respectively to either a single type and direction of loading or to a set of loads in various directions and referring to a defined level of resistance in accordance with EN 1990 and the relevant parts of EN 1993, EN 1994 or EN 1999. For kits the load bearing capacity refers to loads and load combinations the kit can carry that are relevant to the structure for its intended purpose.¹⁰

Recyclability is the susceptibility of a material or product to be effectively and efficiently separated, collected, sorted and aggregated in specific waste streams for the purpose of being recycled into secondary raw materials while minimising the loss of quality or functionality compared to the relevant primary raw material.²

Reliability is the ability of a structure or a structural member to fulfil the specified requirements, including the design working life, for which it has been designed. Reliability is usually expressed the probability that a product functions as required

⁶² Based on ISO 15686-1:2011.

under given conditions for a given duration without a limiting event. It covers safety, serviceability and durability of a structure.^{5 10}

Resilience is the ability of a system to endure, resist, adapt to or recover from disruptive events or conditions, whether natural or anthropogenic.

Reusability is the ability of a product, component or system to be used in its original form more than once and maintain its value and functional qualities during recovery to accommodate reapplication for the same or any purpose.⁶³

Traceability means the tracking and documentation of the movement and management of (waste) materials. To ensure compliance with rules and encourage transparency, it requires tracking information about origin, transit, treatment and final disposal.⁵¹

Weldability is quality of a material for which a qualified welding procedure can be developed.¹⁰

Product is formed (component) or formless (material) physical item or a kit designed for or utilized with a purpose and placed on the market or put into service.⁷

Component is a product manufactured as a distinct unit to serve a specific function or functions and intended to be incorporated into another product or structure, which may itself be an assembly of several smaller components.^{7 9 13}

Constituent product is a product used in manufacturing with properties which enter structural calculations or otherwise relate to the mechanical resistance and stability of construction works.^{9 10}

Construction product is a product that is placed on the market, including by means of supply to the construction site, for incorporation in a permanent manner into construction works or parts thereof with the exception of items that need first to be integrated into a kit or another construction product prior to being incorporated in a permanent manner into construction works.²

Custom-made product is a product that, due to the specifications of the client, has a variation in terms of size or material when compared with all other products produced for other clients by the economic operator in question.²

Intermediate product is a product that requires further manufacturing or transformation such as mixing, coating or assembling to make it suitable for end-users.⁷

Permanent product is a product intended to remain in the construction work, or in parts thereof, after the completion of the construction or renovation process.²

Remanufactured product is a product that is not waste or has ceased to be waste in accordance with Directive 2008/98/EC, which has been installed at least once into a construction work, and that has been subject to major alteration which is qualified as essential to the product's performance.²

Structural component (or structural member) is a component to be used as load-bearing parts of works designed to provide required performance which can be used directly as delivered or can be incorporated into a construction work.^{9 10}

Used product is a product that is not waste or has ceased to be waste in accordance with WFD, and which has been installed at least once into a construction work, and that: (a) has not undergone major alteration so that it can be used for construction purposes without any other pre-processing; or (b) has

⁶³ Based on Level(s) <https://ec.europa.eu/jrc/en/publication/levels-common-eu-framework-core-sustainability-indicators-office-and-residential-buildings-part-3>

been subject to a major alteration which, according to the applicable harmonised technical specification, is qualified as non-essential to the product's performance.²

Reused product is a used product installed for at least second time into a construction work.

Kit is a product placed on the market by a single economic operator as a set of at least two separate items, none of which needs to be a product itself, intended to be incorporated together in construction works.²

Structural kit means set of structural components to be assembled and installed on site.¹⁰

Material means any substance, excluding waste, with specific properties that is embedded in the products in a permanent manner.

Constructional material is a material used in the construction works.

Structural material is a constructional material used in the load bearing (structural) components.

Resource is an asset (material, component, waste) from which a solution is created or implemented.

Natural resource is a resource occurring in nature.

Virgin resource (or primary resource) is natural resource that is used as the resource for the first time as input in a process or for creating a solution. Virgin resources can be renewable or non-renewable.

Renewable resource is a resource that can be naturally or artificially grown or replenished within a foreseeable time frame by processes found in nature.

Secondary resource (or recovered resource) is resource that is obtained from one that has already been processed or used.

Service life is the cumulative time during which the component is in use.¹

Estimated service life (ESL) is the estimated service life of a component.⁶⁴

Reference service life (RSL) is a service life of a component, which is known to be expected under a particular set (e.g. a reference set) of in-use conditions and which may form the basis of estimating the service life under other in-use conditions.¹⁷

Sustainable development is a development that meets the environmental, social and economic needs of the present without compromising the ability of future generations to meet their own needs.

System is a set of interrelated or interacting elements

Closed loop system is a system by which products or resources are used and the recovered and turned into new products or resources without losing their inherent properties.

Economic system is a system by which a society organizes and allocates resources.

Circular economy is an economic system that uses a systemic approach to maintain circular flow of resources by recovering, retaining or adding to their value, while contributing to their sustainable development. It involves sharing,

⁶⁴ Based on EN 15804

leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible.⁶⁵

Linear economy is an economic system where resources typically follow the pattern of extraction, production, use and disposal.

Environmental system is a set of systems of the natural environment that interact, encompassing biotic and abiotic components.

Ecosystem is a dynamic complex of communities of plants, animals and microorganisms and their non-living environment interacting as a functional entity.

Social system is a system by which human beings are expected to undertake different types of tasks to achieve common goals within a society.

Structural system is load-bearing members of a building or civil engineering works and the way in which these members function together.⁸

Use

Intended use is the purpose of a product as set out in the applicable harmonised technical specifications or European assessment documents.²

Declared use is the use intended by the manufacturer, including the conditions for usage, as laid out in technical documentation, on labels, in instructions for use, in safety information, or in publicity material.²

Value is gain or benefit from satisfying needs and expectations, in relation to the use and conservation of resources.

Waste (e.g. steel scrap) means any substance or object which is no longer considered to be an asset as it, at the time, provides insufficient value to the holder, or which the holder intends or is required to discard.¹¹

Construction and demolition waste (CDW) is waste generated by construction and demolition activities¹¹ with the following exceptions: (a) uncontaminated soil and other naturally occurring material excavated in the course of construction activities where it is guaranteed that the material will be used for the purposes of construction in its natural state on the site from which it was excavated and (b) waste waters (such as trade effluent disposed of via tankers, foul sewers, surface water drains, water courses, etc.).⁵¹

Hazardous waste is waste that poses substantial or potential threats to public health or the environment. Waste classification is based on the European List of Waste or based on its hazardous properties.¹¹

Inert waste means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise react physically or chemically, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm human health.⁵¹

⁶⁵ Based on European Parliament's definition

<https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits>

APPENDIX B General data requirements for the Digital Product Passport

Table 7.1. Data collection for the Digital Product Passport

Data requirement		Related standard or regulation
General product information		
Product identification		
	Unique identifier at the level indicated in the applicable delegated act	Annex IV(1) of CPR
	Other identification (if available)	
	GTIN (Global Trade Item Number)	ISO/IEC 15459-6 or equivalent
	Relevant commodity codes, such as a TARIC code	Council Regulation (EEC) No 2658/87
	Type, batch or serial number of the product or other element allowing its unequivocal identification, product model identifier	Article 22 of CPR
Product description		
	Declared uses, intended users, conditions of uses, durability	Annex IV(1) of CPR
	Product family	Annex VII of CPR
Product location within the building		
	Manufacturer or the authorised representative	Annex IV(1) of CPR
	Other manufacturers or authorised representatives dealing with information on installation, maintenance, use, deconstruction and demolition, information on risks, information on the event of product failure	Annex IV(1) of CPR
	Product contact point for construction in the Member State in which the product is made available	Annex IV(1) of CPR
	Importer	Annex IV(1) of CPR
Instructions for use and safety		
	Safety during transport, installation, deinstallation, maintenance, deconstruction and demolition	Annex IV(2) of CPR
	Compatibility and integration into systems or kits	Annex IV(2) of CPR
	Maintenance needs with a view to maintaining the performance of the product during its service life span	Annex IV(2) of CPR
	Safety during use	Annex IV(2) of CPR
	Training and other requirements necessarily to be fulfilled for safe use	Annex IV(2) of CPR
	Risk mitigation possibilities going beyond the previous points	Annex IV(2) of CPR
	Recommendations for a product's: (a) repair; (b) de-installation; (c) reuse; (d) remanufacturing; (e) recycling; (f) safe deposit.	Annex IV(2) of CPR
	Information on the performance of the product as measured in terms of its climate change effects	Annex II(a) and (p) of CPR
Declaration of Performance and Conformity		
	Declaration code, version according to Annex V of CPR	Article 15 and 76(2) of CPR
	Safety data sheets and other information	Article 31 and 33 of REACH (required by CPR)
	Other information	Annex V of CPR
Declared performances and sustainability characteristics		
	Reaction to fire	CWA 17316
	Resistance to fire	CWA 17316
	External fire performance	CWA 17316
	Noise absorption	CWA 17316
	Release and content of dangerous substances	CWA 17316
	Environmental sustainability	Annex II of CPR ISO 22057, ILCD + EPD, French INIES database format, OpenEPD, Ökobaudat
	Declaration of Conformity	CPR
	Information requirements	CPR
Technical documentation		
	BIM object/entity	ISO 16739-1:2024
	Calculation of environmental essential characteristics	Article 22(3) of CPR

	Other technical documentation required by CPR	Article 22(3) and 59-61 of CPR
Material & composition information		
For each material in the product		
	Material identification	
	Material location within the product	
	Material quantity	
	Material indicators	
	Origin	
	Separability	
	Recyclability	
	Material certification	
	Responsible supply chain certifications (FSC, responsible steel, ...)	
	Certified labels	
	Instructions, service information	
	Waste type and category	European List of Wastes
For each substance of concern in the product		
	Substance identification	
	Substance location within the product	
	Concentration at the level of the product, main components or spare parts	
Critical raw material contained in the product		
	Recycled content	
	Renewable content	
Traceability		
	Date of manufacture	
	Placing on the market	
	Economic operators	
	State of health, condition, quality	
	Classification	
	Information about the audit (date, inspector, laboratory, etc.)	
	Condition monitoring/scanning data	
Usage		
	Exposure	
	Extreme events	
	Usage data (purchase date, use cycles, etc.)	
	Repair, reuse history	
Product indicators		
	Reusability	
	Deconstructability	
Product certification		

APPENDIX C Example of data requirements for the reused steelwork

Table 7.2. Data collection for the reused constructional steelwork

Data requirement		Related standard
Description of the donor structure		TS 1090-201, 5.2.1 a)
Geographical location of the donor structure		TS 1090-201, 5.2.1 a)
Use of the donor structure		TS 1090-201, 5.2.1 a)
Age of the donor structure		TS 1090-201, 5.2.1 b)
If the following information is available		
	Drawings, models, photographic evidence for the as built structure	TS 1090-201, 5.2.1 c)
	Inspection documents	TS 1090-201, 5.2.1 d) EN 10204 or similar standard in use at the time
	Information about the design such as calculation notes, loading history	TS 1090-201, 5.2.1 e)
	Building Owner's manual	TS 1090-201, 5.2.1 f)
	Operation and maintenance manual	TS 1090-201, 5.2.1 g)
	Inspection and maintenance records	TS 1090-201, 5.2.1 h)
	Records of interventions (e.g. expansions, modifications)	TS 1090-201, 5.2.1 i)
	Records from any possible incident (e.g. fire, earthquake)	TS 1090-201, 5.2.1 j)
	Information on designer	TS 1090-201, 5.2.1 b)
	Information on fabricator	TS 1090-201, 5.2.1 b)
	Information on erector/assembler	TS 1090-201, 5.2.1 b)
	Information on other actors	TS 1090-201, 5.2.1 b)
If the donor structure originates from the building		
	Date of construction of the original building	TS 1090-201, 5.2.1 a)
	Place of construction of the original building	TS 1090-201, 5.2.1 a)
	Information on architect	TS 1090-201, 5.2.1 b)
	Else	
	Description of the origin of the donor structure and related specific actors	
For each structural component		TS 1090-201, 5.2.1 c)
	Location of the component within the donor structure	TS 1090-201, 5.2.1 c)
	Function of the structural component	TS 1090-201, 5.2.1 c)
	Global deformation indicating plastification	TS 1090-201, 5.2.2 a)
	Signs of direct exposure to high temperatures (e.g. soot, burnt or blistered paint)	TS 1090-201, 5.2.2 b)
	Local damages, inclusive plastic deformations, and reduced cross sections (e.g. through holes, openings, cracks or excessive corrosion)	TS 1090-201, 5.2.2 c)
If the component is a constituent product and is covered by the standard listed in EN 1090-2		EN 1090-2, 5.1
	DoPC of the constituent product	
	Else	EN 1090-2, 5.1
	yield strength	EN 1090-2, 5.1 a)
	tensile strength	EN 1090-2, 5.1 a)
	elongation	EN 1090-2, 5.1 b)
	tolerances on dimensions and shape	EN 1090-2, 5.1 d)
	heat treatment delivery condition	EN 1090-2, 5.1 f)
If the following information is required		EN 1090-2, 5.1
	stress reduction of area requirements (STRA)	EN 1090-2, 5.1 c)
	impact strength or toughness	EN 1090-2, 5.1 e)
	through thickness requirements (Z-quality), if required	EN 1090-2, 5.1 g)
	limits on internal discontinuities or cracks in zones to be welded	EN 1090-2, 5.1 h)
If the steel is going to be welded (one of the following)		EN 1090-2, 5.1
	classification in accordance with the materials grouping system	EN 1090-2, 5.1 i) CEN ISO/TR 15608
	maximum limit for the carbon equivalent of the steel	EN 1090-2, 5.1 j)
	declaration of its chemical composition in sufficient detail for its carbon equivalent to be calculated	EN 1090-2, 5.1 k)


```

#26=IFCRELAGGREGATES('0D$FwBrkzlRQjhJ97DaL6y',,$,$,$,#22,(#24));
#27=IFCMATERIAL('Wood',,$,'waste');
#28=IFCMATERIAL('Windows',,$,'waste');
#29=IFCMATERIAL('Concrete',,$,'waste');
#30=IFCMATERIAL('Steel',,$,'waste');
#31=IFCMATERIAL('Sandwich panels',,$,'waste');
#32=IFCMATERIAL('Bricks',,$,'waste');
#33=IFCMATERIALPROPERTIES('Pset_MaterialAudit',,$,(#34),#29);
#34=IFCPROPERTYSINGLEVALUE('GrossWeight (kg)',,$,IFCREAL(150000.),$);
#35=IFCMATERIALPROPERTIES('Pset_MaterialAudit',,$,(#36),#31);
#36=IFCPROPERTYSINGLEVALUE('GrossArea (m2)',,$,IFCREAL(200.),$);
#37=IFCMATERIALPROPERTIES('Pset_MaterialAudit',,$,(#38),#32);
#38=IFCPROPERTYSINGLEVALUE('GrossWeight (kg)',,$,IFCREAL(10000.),$);
#39=IFCBUILDINGELEMENTPROXY('3N8uZsG5v2axTPaejWdnjY',,$,'Boards',,$,$,$,$,$);
#40=IFCRELASSOCIATESMATERIAL('0HmEuefIP2JQCkJzfvZwte',,$,$,$,(#39),#27);
#41=IFCWINDOW('2VqcbDevDBt82KVxzBvRip',,$,'Windows',,$,$,$,$,$,$,$);
#42=IFCRELASSOCIATESMATERIAL('3XgRsX0mv5s0BdIJxRKSaw',,$,$,$,(#41),#28);
#43=IFCSLAB('0QrR7gHbX01OV587M73U2U',,$,'Concrete',,$,$,$,$,$);
#44=IFCRELASSOCIATESMATERIAL('0bcucmThb6T9OGBTNq1EqM',,$,$,$,(#43),#29);
#45=IFCBEAM('39VgX4Wfr5qArgdE1YcNoS',,$,'IPE profiles',,$,$,$,$,$);
#46=IFCRELASSOCIATESMATERIAL('0Nk3Cg$zb6BPL_t27zbcRa',,$,$,$,(#45,#51),#30);
#47=IFCWALL('2g17Q14sn5uOzWuvsenu5r',,$,'Sandwich panels',,$,$,$,$,$);
#48=IFCRELASSOCIATESMATERIAL('3nbK_0tBn7hek5d$PpGilo',,$,$,$,(#47),#31);
#49=IFCWALL('1ipLtSwlXAoAZwT$w4u$57',,$,'Bricks',,$,$,$,$,$);
#50=IFCRELASSOCIATESMATERIAL('3uQsFEyUb9Wf_Dmnh82Y4f',,$,$,$,(#49),#32);
#51=IFCCOLUMN('2sjh6jNvr8nvDaOmdt5AZL',,$,'HEA profiles',,$,$,$,$,$);
#52=IFCRELCONTAINEDINSPATIALSTRUCTURE('1zqdsVAfr0EweAxDdPKFF',,$,$,$,(#39),#24);
#53=IFCRELCONTAINEDINSPATIALSTRUCTURE('0BvXd$B096_PqI5QE8dXuk',,$,$,$,(#41),#22);
#54=IFCRELCONTAINEDINSPATIALSTRUCTURE('2ri6tNahf7aBUDhpburAo',,$,$,$,(#51),#9);
#55=IFCRELCONTAINEDINSPATIALSTRUCTURE('3qmXoWkAjFVBvr84BGVApz',,$,$,$,(#47),#25);
#56=IFCELEMENTQUANTITY('3u_4BQZ2r3Ae7GhZ4gyAhR',,$,'Qto_SlabBaseQuantities',,$,$,(#58));
#57=IFCRELDEFINESBYPROPERTIES('1W0hTvHW56re8CkuBTbOAw',,$,$,$,(#43),#56);
#58=IFCQUANTITYWEIGHT('GrossWeight',,$,$,150000.,$);
#59=IFCELEMENTQUANTITY('1kqxIQcE1AsRXwZ91$Jrs8',,$,'Qto_BeamBaseQuantities',,$,$,(#61));
#60=IFCRELDEFINESBYPROPERTIES('0LNAV9n29ATwxtsy8CnNkq',,$,$,$,(#45),#59);
#61=IFCQUANTITYLENGTH('Length',,$,$,20.,$);
#62=IFCPROPERTYSET('1qRADJwDL3XOc_zfaDKf5r',,$,'Pset_ReusedSteel',,$,(#64,#65,#66));
#63=IFCRELDEFINESBYPROPERTIES('0zfCjkQsJAhe2pMny2XVe5',,$,$,$,(#45),#62);
#64=IFCPROPERTYSINGLEVALUE('GlobalDeformation',,$,IFCLABEL('No deformations'),$);
#65=IFCPROPERTYSINGLEVALUE('LocalDamages',,$,IFCLABEL('n/a'),$);
#66=IFCPROPERTYSINGLEVALUE('SignsOfHeatExposure',,$,IFCLABEL('n/a'),$);
#67=IFCELEMENTQUANTITY('2CenJo37X328Ka_gBShA9w',,$,'Qto_WallBaseQuantities',,$,$,(#69));
#68=IFCRELDEFINESBYPROPERTIES('36na1CFzzDp9GqXNxQ2VWS',,$,$,$,(#49),#67);
#69=IFCQUANTITYWEIGHT('GrossWeight',,$,$,10000.,$);
#70=IFCELEMENTQUANTITY('2D05FUksn75RC5G07sU2dn',,$,'Qto_ColumnBaseQuantities',,$,$,(#72));
#71=IFCRELDEFINESBYPROPERTIES('3NQXQVdsHCqAuuzKAPQnoL',,$,$,$,(#51),#70);
#72=IFCQUANTITYLENGTH('Length',,$,$,10.,$);
#73=IFCPROPERTYSET('07qU150bXD5ROo2gxXLsM8',,$,'Pset_ReusedSteel',,$,(#75,#76,#77));
#74=IFCRELDEFINESBYPROPERTIES('0IBcfUVozDExBnjcok0sAG',,$,$,$,(#51),#73);
#75=IFCPROPERTYSINGLEVALUE('GlobalDeformation',,$,IFCLABEL('Small deformations'),$);
#76=IFCPROPERTYSINGLEVALUE('LocalDamages',,$,IFCLABEL('No damage'),$);
#77=IFCPROPERTYSINGLEVALUE('SignsOfHeatExposure',,$,IFCLABEL('n/a'),$);
ENDSEC;
END-ISO-10303-21;
    
```

The information delivery specification for the reused constructional steelwork (see Table 7.2) in XML format is in Box 7.2.

Box 7.2 IDS specification of the basic information about reused constructional steel

```
<?xml version='1.0' encoding='utf-8'?>
<ids xmlns="http://standards.buildingsmart.org/IDS"
xmlns:xs="http://www.w3.org/2001/XMLSchema" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://standards.buildingsmart.org/IDS/ids_09.xsd">
  <info>
    <title>IDS EXAMPLE FOR TASK 1.3 OF SUM4RE PROJECT</title>
    <copyright>VTT TECHNICAL RESEARCH CENTRE OF FINLAND</copyright>
    <version>1.0</version>
    <author>petr.hradil@vtt.fi</author>
    <date>2025-05-05</date>
  </info>
  <specifications>
    <specification ifcVersion="IFC4X3_ADD2" name="Reused structure" instructions="">
      <applicability minOccurs="1" maxOccurs="unbounded">
        <entity>
          <name>
            <simpleValue>IFCBUILDING</simpleValue>
          </name>
        </entity>
      </applicability>
      <requirements>
        <property dataType="IFCLABEL">
          <propertySet>
            <simpleValue>Pset_DonorStructure</simpleValue>
          </propertySet>
          <baseName>
            <simpleValue>YearOfConstruction</simpleValue>
          </baseName>
        </property>
        <property dataType="IFCLABEL">
          <propertySet>
            <simpleValue>Pset_DonorStructure</simpleValue>
          </propertySet>
          <baseName>
            <simpleValue>AddressLines</simpleValue>
          </baseName>
        </property>
      </requirements>
    </specification>
    <specification ifcVersion="IFC4X3_ADD2" name="Reused element" instructions="">
      <applicability minOccurs="1" maxOccurs="unbounded">
        <entity>
          <name>
            <xs:restriction base="xs:string">
              <xs:enumeration value="IFCBEAM" />
              <xs:enumeration value="IFCCOLUMN" />
              <xs:enumeration value="IFCMEMBER" />
            </xs:restriction>
          </name>
        </entity>
        <material>
          <value>
            <simpleValue>Steel</simpleValue>
          </value>
        </material>
      </applicability>
      <requirements>
        <property dataType="IFCLABEL">
          <propertySet>
            <simpleValue>Pset_ReusedSteel</simpleValue>
          </propertySet>
          <baseName>
            <simpleValue>GlobalDeformation</simpleValue>
          </baseName>
        </property>
      </requirements>
    </specification>
  </specifications>
</ids>
```

```

        </property>
        <property dataType="IFCLABEL">
          <propertySet>
            <simpleValue>Pset_ReusedSteel</simpleValue>
          </propertySet>
          <baseName>
            <simpleValue>SignsOfHeatExposure</simpleValue>
          </baseName>
        </property>
        <property dataType="IFCLABEL">
          <propertySet>
            <simpleValue>Pset_ReusedSteel</simpleValue>
          </propertySet>
          <baseName>
            <simpleValue>LocalDamages</simpleValue>
          </baseName>
        </property>
      </requirements>
    </specification>
  </specifications>
</ids>

```

Using IDS validation tool such as IfcTester Python module, we can demonstrate that the STEP file is valid and contains the required information (see Box 7.3).

Box 7.3 Results of IDS validation

IDS EXAMPLE FOR TASK 1.3 OF SUM4RE PROJECT

[PASS] (1/1) *Reused structure

Applies to:

All **IFCBUILDING** data

Requirements:

YearOfConstruction data shall be provided in the dataset **Pset_DonorStructure**

AddressLines data shall be provided in the dataset **Pset_DonorStructure**

[PASS] (2/2) *Reused steel element

Applies to:

All {'enumeration': ['**IFCBEAM**', '**IFCCOLUMN**', '**IFCMEMBER**']} data

All data with a Steel material

Requirements:

GlobalDeformation data shall be provided in the dataset **Pset_ReusedSteel**

SignsOfHeatExposure data shall be provided in the dataset **Pset_ReusedSteel**

LocalDamages data shall be provided in the dataset **Pset_ReusedSteel**

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