European Commission

JRC SCIENCE FOR POLICY REPORT

Developing EU-wide End-of-Waste criteria for mineral construction and demolition waste

Background paper for the first stakeholder workshop

EGLE, L.
MILIOS, L.
SAVEYN, H. G. M.

26 September 2024

EUR XXXXX XX

Contact information
Name: European Commission – Joint Research Centre, Fair and Sustainable Economy, Circular Economy and Sustainable Industry
Address: Edificio EXPO, Calle Inca Garcilaso 3, 41092 Seville, Spain
Email: JRC-END-OF-WASTE@ec.europa.eu

EU Science Hub
https://joint-research-centre.ec.europa.eu

Luxembourg: Publications Office of the European Union, 2024

Contents

1 Introduction

1.1 Definition

The Waste Framework Directive (WFD[1]; (EC) No 2008/98) Article 3(2c)) defines *'construction and demolition waste'* (CDW) as *'waste generated by construction and demolition activities'.* Article 3(2b) WFD excludes CDW from the scope of municipal waste.

CDW contains a wide variety of materials such as concrete, bricks, wood, glass, metals and plastic, including excavated soil. The different materials from CDW are listed under certain waste codes in the European List of Waste (LoW; (EU) No 2011/753) (see Annex 1, **Table 12**).

CDW includes all the waste produced by the construction and demolition of buildings and other infrastructure (see section 3.1), as well as road planning and maintenance (renovation and repair), whether on the surface or underground (EEA, 2002).

This work focuses on the **mineral fractions of CDW**. Mineral CDW refers to the waste generated from construction and demolition activities, which primarily consists of concrete, bricks, tiles, ceramics, and stones (see WFD, Article 11(1)).

1.2 EU regulatory framework on construction and demolition waste

The following sections provide an overview of the EU regulatory frameworks for waste in general and specifically for CDW. Waste legislation applies to CDW when it is still considered part of the waste regime. Particularly relevant for the development of EoW criteria are the classification of waste as non-hazardous or hazardous, provisions on waste shipment the sound management of CDW under the WFD and a potential disposal under the Landfill Directive.

Furthermore, in this section the updated 'EU Construction & Demolition Waste Management Protocol including guidelines for pre-demolition and pre-renovation audits of construction works', REACH and the Best Available Techniques Reference Document (BREF) are briefly discussed.

1.2.1 Waste Framework Directive

The WFD laid down in Article 11, that '*Member States shall take measures to **promote selective demolition** in order to enable removal and safe handling of hazardous substances and facilitate re-use and high-quality recycling by selective removal of materials, and to ensure the establishment of sorting systems for construction and demolition waste at least for wood, **mineral fractions (concrete, bricks, tiles and ceramics, stones),** metal, glass, plastic and plaster'.*

The WFD established targets by which a **minimum of 70 % (by weight)** of non-hazardous construction and demolition waste, excluding naturally occurring material, need to be prepared for re-use, recycling and other material recovery by 2020 (Article 11(2b)).

Article 11(6) of the WFD provides that 'b*y 31 December 2024, the Commission shall consider the setting of preparing for re-use and recycling targets for construction and demolition waste and its material-specific fractions'.*

1.2.2 Landfill Directive

One essential aim of the Landfill Directive (EC) No 1999/31 (latest amendment by (EU) No 2018/850) is to ensure a progressive reduction of landfilling of waste in particular of waste that is suitable for recycling or other recovery. Article 5(3a) defines that as of 2030 all waste suitable for recycling or other recovery, in

[1] Directive (EC) No 2008/98 of the European Parliament and of the Council of 19 November 2008 on waste amended by Directive (EU) No 2018/851

particular in municipal waste, shall not be accepted in a landfill with the exception of waste for which landfilling delivers the best environmental outcome in accordance with Article 4 of the WFD Directive.

Due to its characteristic, mineral CDW under scope in this work can most likely be categorised as inert waste and the Landfill Directive provides a definition for inert waste[2]. The Landfill Directives defines three classes of landfills, one class for landfilling of inert waste. Inert waste landfill sites shall be used only for inert waste.

Furthermore, in Article 3(2) this Directive lays down that the use of inert waste which is suitable, in redevelopment/restoration and filling-in work, or for construction purposes, in landfills, shall be excluded from the scope of the Landfill Directive.

1.2.3 Basel Convention and Waste Shipment Regulation

The Basel Convention is an international treaty aiming at reducing the transboundary movements of hazardous waste, and specifically at preventing shipment of hazardous waste from developed to less developed countries. The convention also seeks to minimise the amount and toxicity of hazardous waste generated and to ensure its environmentally sound management (UNEP, 2019). Article 1 of the Basel Convention defines the wastes that shall be classified as hazardous waste and refers to Annex I, including the list the hazardous CDW waste.

Waste gypsum wallboard or plasterboard arising from the demolition of buildings and broken concrete are listed in Annex IX of the Basel convention under B2040 (Other wastes containing principally inorganic constituents). Wastes that are contained in Annex IX will not be hazardous wastes covered by Article 1, paragraph 1 (a), of Basel Convention unless they contain Annex I material to an extent causing them to exhibit an Annex III characteristic.

The Waste Shipment Regulation (WSR) (EC) No 1013/2006 controls the shipment of waste within EU Member States, from third countries to the EU, from the EU to third countries and in transit intra-EU. It lays down shipment rules, depending on the origin, destination and route, the type of waste the type of treatment.

1.2.4 Legislation on hazardousness classification of waste

Hazardous substances and mixtures are defined as substances or mixtures fulfilling the criteria relating to physical hazards, health hazards or environmental hazards laid down in Regulation (EC) No 1272/2008 on classification, labelling and packaging of substances and mixtures (CLP Regulation).

The classification of waste as hazardous or non-hazardous is regulated in Annex III of the WFD (15 properties (HP 1 to HP 15) of waste which renders it hazardous), and the classification laid down in the Annex of Commission Decision (EC) No 2000/532 on the European List of Waste.

The Commission Notice 2018/C 124/01 on the classification of waste provides technical guidance on the correct interpretation of the provisions on waste classification. Although some criteria of Annex III to the WFD make reference to CLP Regulation's hazard classes and statements, the CLP Regulation is only applicable to substances and mixtures, not to waste.

1.2.5 EU Construction and Demolition Waste Management Protocol including guidelines for pre-demolition and pre-renovation audits of construction works

The Commission introduced non-binding guidelines as a proposal to the industry (EC, 2024c). The 'EU Construction & Demolition Waste Management Protocol' (EC, 2016) and the 'Guidelines for waste audits before demolition and renovation works of buildings' (EC, 2018) were initially published separately. The revision of the Protocol now incorporates the revised 'guidelines for pre-demolition audits, which also apply to all construction works (infrastructure as well as buildings) (EC, 2024c).

---

[2] Landfill Directive, Article 2(e) *'inert waste' means waste that does not undergo any significant physical, chemical or biological transformations. Inert waste will not dissolve, burn or otherwise physically or chemically react, 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. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater;*

The protocol fits within the Construction 2020 strategy[3], as well as the Communication on Resource Efficiency Opportunities in the Building Sector[4]. It's also part of the European Commission's Circular Economy Action Plan (CEAP). Its overall aim is to enhance confidence in CDW management processes and increase trust in re-used products and recycled materials. It covers the full CDW management process, providing guidance on

a. Waste identification through pre-demolition and pre-renovation audits
b. Selective Demolition
c. Waste logistics
d. Waste processing and treatment
e. Quality management (ensuring quality at all stages, this involves monitoring, documentation, certification schemes, product standards and end-of-waste criteria where applicable);
f. Policy framework (recommendations for authorities on developing conducive regulations, strategies and enforcement mechanisms).

Overcoming regulatory, economic, technical and social barriers requires concerted efforts and cooperation between industry, authorities and society. The Protocol emphasises shared responsibility, from identifying re-use opportunities to ensuring quality recycled materials, to facilitate circularity in construction and demolition activities across the EU.

Guidelines for audits before demolition of building

The Guidelines provides guidance on best practices for the assessment of CDW streams prior to demolition or renovation of buildings and infrastructures. The aim of the guidance is to facilitate and maximise recovery of materials and components from demolition or renovation of buildings and infrastructures for beneficial re-use and recycling, without compromising the safety measures and practices outlined in the European Demolition Protocol. This protocol states that:

— any demolition, renovation or construction project needs to be well planned and managed;

— waste audits (or pre-demolition audit as defined in the European Demolition Protocol) are to be carried out before any renovation or demolition project, for any materials to be re-used or recycled, as well as for hazardous waste;

— public authorities should decide upon the threshold for pre-demolition audits;

— waste audits take full account of local markets for CDW and re-used and recycled materials;

— a waste audit must be carried out by a qualified expert.

1.2.6 REACH

Regulation (EC) No 1907/2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (**REACH**) applies to all chemicals, including those used in the construction industry. This includes construction materials such as cement, treated wood, insulation, paints, and adhesives. However, certain construction materials such as natural aggregates from mineral sources are exempted from REACH (see section 4.2.2.5). As long as the materials from CDW are in the waste regime, REACH does not apply.

1.2.7 Best Available Techniques (BAT) Reference Document (BREF)

The minimisation of environmental impacts of manufacturing processes for cement is addressed in the following **Best Available Techniques (BAT) Reference Document (BREF)** for the Production of Cement, Lime and Magnesium Oxide[2] as a part of the revision of the Industrial Emission Directive (EU) No 2010/75.

[3] Communication from the Commission to European Parliament and the Council Strategy for the sustainable competitiveness of the construction sector and its enterprises. COM(2012) 433; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52012DC0433

[4] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Region on Resource Efficiency Opportunities in the Building Sector. COM(2014) 445; https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52014DC0445

1.3 EU regulatory framework on End-of-Waste

One of the barriers to an EU circular economy is the lack of harmonisation of End-of-Waste (EoW) criteria across Member States, which creates legal uncertainty for waste operators as well as for entities trading or using secondary raw materials. As announced in the Circular Economy Action Plan [5], the Commission introduced a mandate to assess the scope to develop further EU-wide EoW criteria for relevant waste streams to encourage recycling in the EU and promote a well-functioning internal market for secondary raw materials. The implementation of EoW criteria can contribute to a reduction of administrative and economic burdens, especially when dealing with shipment. EoW criteria for CDW will define when certain CDW ceases to be waste and can be considered and shipped as a product. EoW criteria can thus contribute to addressing the mentioned legal uncertainties for waste operators and traders within the EU.

The **WFD** defines in Article 6(1) the general conditions that a waste material has to fulfil to cease to be waste: *"Member States shall take appropriate measures to ensure that waste which has undergone a recycling or other recovery operation is considered to have ceased to be waste if it complies with the following conditions:*

(a) the substance or object is to be used for specific purposes;
(b) a market or demand exists for such a substance or object;
(c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and
(d) the use of the substance or object will not lead to overall adverse environmental or human health impacts."

In 2009, the Joint Research Centre (JRC) published a methodology analysing the principles according to which the criteria should be set up and providing the related methodological framework required to determine EoW criteria (Delgado et al., 2009). This methodology was incorporated into the WFD (Article 6(2)) as follows:

"The Commission shall monitor the development of national EoW criteria in Member States, and assess the need to develop Union-wide criteria on this basis. To that end, and where appropriate, the Commission shall adopt implementing acts in order to establish detailed criteria on the uniform application of the conditions laid down in paragraph 1 to certain types of waste.

Those detailed criteria shall ensure a high level of protection of the environment and human health and facilitate the prudent and rational utilisation of natural resources. They shall include:

(a) permissible waste input material for the recovery operation;
(b) allowed treatment processes and techniques;
(c) quality criteria for end-of-waste materials resulting from the recovery operation in line with the applicable product standards, including limit values for pollutants where necessary;
(d) requirements for management systems to demonstrate compliance with the end-of-waste criteria, including for quality control and self-monitoring, and accreditation, where appropriate; and
(e) a requirement for a statement of conformity."

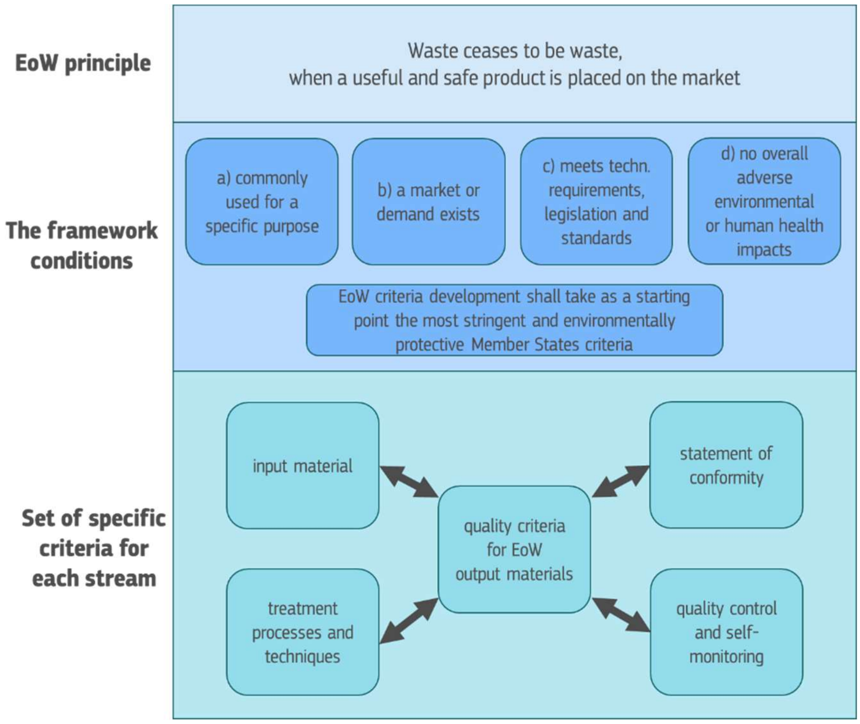
A relevant point introduced in the latest amendment of the WFD is that the Commission shall take as starting point the most stringent and environmentally protective EoW criteria established in Member States:

"When adopting those implementing acts, the Commission shall take account of the relevant criteria established by Member States in accordance with paragraph 3 and shall take as ***a starting point the most stringent and environmentally protective*** *of those criteria".*

Figure 1 shows the conceptual approach and framework conditions for the development of EoW criteria, taking into account the JRC methodology and the new condition introduced in the last amendment.

[5] COM/2020/98: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

Figure 1. Conceptual approach of the EoW mechanism, framework conditions and elements of EoW criteria



EoW criteria have been already successfully laid down for iron, steel and aluminium scrap (Commission Regulation (EC) No 333/2011)), glass cullet (Commission Regulation (EU) No 1179/2012)) and copper scrap (Commission Regulation (EU) No 715/2013)). In addition, the Commission adopted Component Material Criteria (CMC)[6] for waste materials that can cease to be waste pursuant to Article 19 of the Fertilising Products Regulation (EU) No 2019/1009[7]. Furthermore, EoW criteria for plastic- and textile waste are currently under development by the JRC.

1.4 Identify candidate streams

1.4.1 Scoping exercise

Further to the commitment to assess the scope to develop EU-wide EoW or by-product criteria for certain waste streams[8], the Commission carried out a scoping exercise to identify candidate streams (Orveillon et al., 2022). The potential of 11 categories of waste and by-products for the development of EU-wide EoW was appraised by using ranking criteria such as the level of support from stakeholders to develop further EU-wide EoW criteria, evidence of demand, existence of relevant international or national product standards, and existence of national or regional EoW criteria.

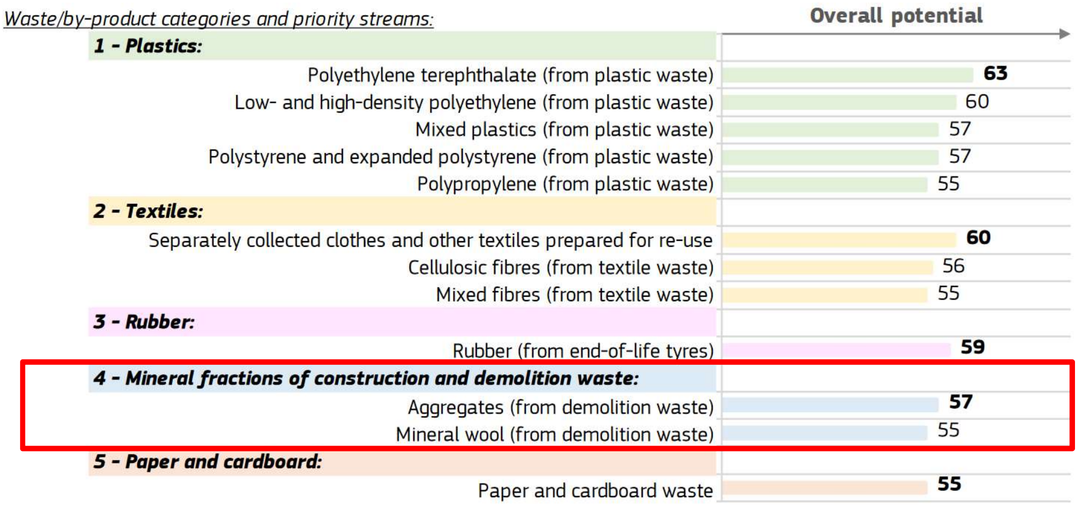
Figure 2 presents the results of the scoping study, grouped by category of waste. **Mineral fractions of CDW** were ranked as **forth priority stream** for the development of **EoW criteria** and the two CDW streams (1) '*Aggregates (from demolition waste)'* and (2) '*Mineral wool (from demolition waste)'* were included in the priority list (highlighted in red). Annex 2 (Figure 11) presents the final ranking of the 12 streams that were scored as top candidates for the development of EoW or by-product criteria. The ranking includes another CDW stream, *'Gypsum (from demolition waste)',* but this waste stream is listed as a non-priority stream.

[6] CMC 3 (Compost) and CMC 5 (Digestate other than fresh crop digestate) under Regulation (EU) No 2019/1009; CMC 12 (Precipitated phosphate salts and derivates) under the Commission Delegated Regulation (EU) No 2021/2086); CMC 13 (Thermal oxidation materials and derivates) under the Commission Delegated Regulation (EU) No 2021/2087; CMC 14 (Pyrolysis and gasification materials) under the Commission Delegated Regulation (EU) No 2021/2088; CMC 15 (Recovered high purity materials) under the Commission Delegated Regulation (EU) No 2022/1171.

[7] Regulation (EU) No 2019/1009: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02019R1009-20230316#M2-2

[8] COM No 2020/98 final: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1583933814386&uri=COM:2020:98:FIN

Figure 2. List of priority streams grouped per category, and ranked based on their overall potential, according to the scoring system (Orveillon et al., 2022)



1.4.2 Background data collection for future EU EoW criteria of CDW

Apart from the JRC scoping study, DG GROW launched a study in 2023 to collect background data for the future development of EoW criteria for ten different CDW streams (TAUW, 2024). The objective of the project was to collect and analyse data and background information on these CDW streams. 15 parameters such as evidence of demand, intra- and extra EU shipment, expected environmental and human health impacts and estimates in market evolution were analysed as part of a stakeholder consultation. The data and information collected was then used to propose a list of high, average and low potential CDW streams:.

- The **higher potential CDW streams** (those within the third tertile of all CDW streams) were *aggregates, concrete, fired clay bricks* and *gypsum*[9] in alphabetical order.
- The CDW streams with **average potential** (those within the second tertile) were *asphalt*, *inert insulation*, *plastic foam insulation, rigid plastics* and *wood* in alphabetical order.
- The **lower potential CDW stream** (that within the first tertile) was *building products for reuse*.

1.5 Timeline and objectives of the written stakeholder consultation

As a subsequent step after the scoping study and the priority list defined especially for CDW, the Commission announced a new line of work on the **development of technical proposals for EoW criteria for mineral construction and demolition waste**. A stakeholder kick-off meeting to be held on 26 September 2024 constitutes the start of this project.

According to the envisaged timeline, the JRC plans to finalise the technical proposals by **end of Q2/2026**. The process towards the potential adoption of an implementing act (handled by DG ENV) will follow after the submission of the JRC proposals..

The development of technical proposals is data-driven and is supported by **written stakeholder consultations**, with the aim of gathering relevant data and information on CDW in a first phase and feedback on the proposed EoW criteria at a later stage.

The first written stakeholder consultation will be opened after this stakeholder kick-off meeting. The consultation consists of an EU Survey with a total of 39 questions, targeted to different types of organisations. Through the questionnaire the JRC aims at:

- gathering feedback on the consolidated scope and criteria presented in this document;

[9] The sensitivity analysis reveals, that gypsum is more pronounced to changes in the ranking compared to the other 'high potential CDW streams'

- validating available information on CDW management, e.g. practices for collection, sorting, re-use and recycling and re-conversion;
- gathering additional data and information to support the development of technical proposals for EoW criteria for CDW.

1.6 Structure of the document

This document is structured as follows:

- Section 2 provides a brief overview on mineral raw materials and the construction material value chain and includes relevant definitions.
- Section 3 contains relevant background information on CDW, including definitions, CDW generation in the EU and an overview of the CDW management chain.
- Section 4 is focused on the four conditions to be fulfilled for EoW status, complemented by a mapping of existing EoW criteria in Member States and other existing EoW guidelines.
- Section 5 presents the consolidated scope for the development of EoW criteria and some preliminary proposals for EoW criteria.

2 Background information on mineral construction materials

This section provides a brief overview on raw materials that are used for the production, but also on the production process, of man-made mineral construction materials. Furthermore, this section elaborates briefly about the market, use and transboundary trade flows of the man-made construction materials (based on available data). The construction materials considered correspond with the CDW materials under scope for developing EoW-criteria (see Section 5.1), namely aggregates, concrete, fired clay bricks as well as tiles and ceramics.

2.1 Mineral raw materials

The raw materials for the production of mineral construction materials can be subdivided into naturally occurring raw materials, manufactured aggregates and recycled aggregates (RA). Naturally occurring mineral raw materials are for example clay, sand, stones, gravel, limestone/chalk (calcium carbonate or dolomite), gypsum (hydrated calcium sulphate), quartz (silica), clay, loam, silica or iron ore. Manufactured aggregates may include output from the iron and steel industry such as blast furnace- and steel slags. Recycled aggregates recovered from CDW will be further described in detail in section 3.3.4.

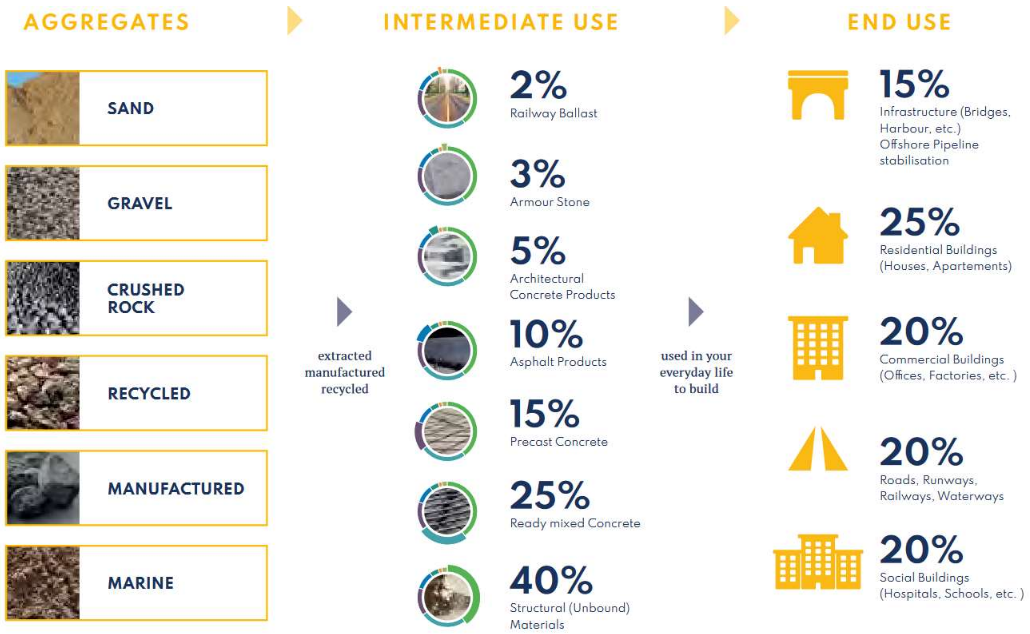
2.2 Construction materials and their market and (transboundary) trade flows

2.2.1 Aggregates

According to (CEN, 2024) (CEN/TC 154) aggregates are defined as granular material used in construction. Aggregates may be natural, manufactured or recycled. Natural aggregates are produced from mineral deposits, manufactured aggregates from industrial thermal or other processes (e.g. slags) and recycled aggregates from former construction material (e.g. concrete). The processes involved to produce aggregates are usually crushing, screening for different particle sizes (sand, gravel, rock) and in some cases washing to remove impurities or contaminants. Aggregates are the basis for many applications that are either unbound (e.g. armour stones, railway ballast, road pavement, fillings) or bound (concrete and asphalt) (**Figure 3**).

Aggregates Europe (UEPG, 2022b) published data showing that in 2021 in the EU-27, UK and EFTA, the demand for aggregates was 3.14 billion tonnes (= 6 tonnes per capita and year). With its share of 45 % of all aggregates, crushed rock constitutes the largest portion, followed by sand & gravel with about 40 %. With about 9 %, the share of recycled aggregates on the annual total aggregates demand is low. A small share of aggregates are produced from marine sources or manufacturing. Figure 3 offers a detailed insight into the intermediate and end use of aggregates. Two-third of final use of aggregates accounts for buildings, and the other one-third is used for transport infrastructure such as roads, railways but also harbours and bridges (UEPG, 2021).

Figure 3. Overview on aggregates and their intermediate use and end use (UEPG, 2021)



2.2.2 Cement

In a first step, raw materials such as calcium carbonate and clay, shale, silica sand, bauxite and iron ore are crushed and grinded into a fine powder. After preheating and pre-calcination, the raw materials are sent to a kiln with a processing temperature of up to 2,000°C to ensure material temperatures of up to 1,450°C. This temperature causes the material to fuse and form small, marble-sized balls known as clinker. Once cooled, gypsum is added to the grounded clinker to produce ordinary Portland cement, ready for use in construction (Cembureau, 2021).

In the EU-27, around 180 million tonnes of cement were produced and 170 million tonnes of cement were consumed in 2021 (Cembureau, 2024). The remaining 10 million tonnes are exported.

2.2.3 Concrete

The main ingredients of concrete are aggregates such as sand and gravel with different particle size, cement, and water. Additional materials, such as admixtures and additives, may also be included to enhance specific properties of the concrete. The ingredients are then mixed to ensure that the materials are thoroughly combined to form a homogenous mixture. Mixing time and method are critical to achieving the desired consistency and strength of the concrete. As highlighted in **Figure 3**, concrete represents with 45 % one of the main intermediate uses of aggregates. The aggregates are used for various concrete application such as architectural concrete products, precast concrete, or ready mixed concrete.

Considering around 15 % of cement per kg of concrete and an annual use of 170 million tonnes of cement a total of around 1,100 million tonnes of concrete are produced in the EU-27.

Concrete is a locally produced material and according to (MPA, 2020), the average delivery distance for all types of concrete is about 30 km. For ready-mixed concrete, the average transport distance is less than 10 km, which is significantly shorter than the transport distance for precast concrete or blocks, exceeding 100 km.

2.2.4 Bricks and tiles

Clay from natural deposits is crushed, grinded and screened to achieve the desired particle size and consistency. The prepared clay is mixed with water to create a plastic clay mixture, which is then shaped into individual bricks or tiles using a moulding process. Drying removes excess moisture and allows the bricks and tiles to achieve the necessary strength and reduce the risk of cracking during the high temperatures in a kiln. During firing the bricks and tiles are hardened and transformed to a durable product. During the firing process, the clay undergoes chemical and physical changes, resulting in the formation of a strong ceramic material (TPE, 2024).

For the EU, no numbers are available on the volume of produced bricks and tile industry, but according to (TPE, 2024), the generated production value is around €5.5 billion in Europe.

Due to the relatively high unit transport costs, for both the raw materials from their source and finished products to consumers, the market for bricks, blocks and roof tiles is mostly regional. Bricks and roof tiles with high weight and low price have local or regional markets (GROW, 2014). With regard to transboundary shipment, (CEPS, 2014) shows, that 80 % of bricks and roof tiles are not further transported than 200 km away from their production sites. Eurostat data show trade both inside and outside the EU, whereas intra-EU trade accounts for almost 85% of the total trade value in 2016 (GROW, 2018)..

2.2.5 Ceramics

The main raw materials used in ceramics production are clay, silica, quartz, feldspar, and various other minerals and additives. The ingredients are processed to achieve the desired particle size, consistency, and chemical composition. The prepared raw materials are then shaped into the desired shape and are dried to remove excess moisture. Many ceramic products are glazed to provide a decorative and protective surface. The dried and glazed ceramic products are fired in kilns at high temperatures. This firing process causes the raw materials to undergo chemical and physical changes, resulting in the formation of a hard and durable ceramic material.

Ceramics are often used as wall & floor tiles (31 %), bricks & roof tiles (20 %), and refractories (17 %). In comparison a small portion is used for table & ornamental ware (7 %) and sanitary ware (6 %) (Jaganmohan, 2024). For the EU, no numbers are available on the volume of produced ceramics, but the ceramics sector accounts for €27.8 billion in production value (EC, 2024b). In comparison to clay bricks and clay rooftop tiles, tableware and tiles are traded over long distances. Around 30 % of is exported outside the EU (Cerame-Unie, 2024).

3 Background information on mineral construction and demolition waste

This section provides in-depth background information on construction and demolition waste, their sources, composition and suitability for re-use or recycling. The different phases of the waste value chain, with the relevant definitions, are presented. Key aspects related to intra-EU shipping and exports of CDW are also briefly introduced.

3.1 Source

The two sources of CDW are **buildings** and other **infrastructure.** CDW from these two sources arises during construction, maintenance, renovation, refurbishment, and demolition. Examples for the two sources of CDW are presented in the following (non-exhaustive list):

- Buildings: residential-, commercial-, and industrial buildings, schools, hospitals as well as associated underground structures such as foundations, basements, and underground car parks.
- Infrastructure:
  - above ground infrastructure such as roads, bridges, (air-)ports, energy supply infrastructure (e.g. wind turbines, dams).
  - underground infrastructure for the transport of people and goods (e.g. tunnels) and to transport and dispose materials (e.g. pipes, channels and pipelines) as well as structures for their maintenance (e.g. manholes).

3.2 Generation

According to EUROSTAT, CDW accounts for more than one third **(37.5 %)** of the total waste generated in the EU-27 (800 Mt out of a total of 2 135 Mt per year; (Eurostat, 2023)). According to (Damgaard et al., 2022), the generation of CDW in the EU in 2018 amounted to **848 Mt** when including soil, track ballast, dredging spoils, and asphalt (**Table 1**). Considering only the mineral waste from CDW, **305 Mt** are generated annually. When excluding soil, or other waste materials from the total CDW generation, such as track ballast, dredging spoils, and asphalt, the information in the literature differs significantly. The quantity ranges from **276 Mt** (Damgaard et al., 2022) **to 461 Mt** (GROW, 2016) (**Table 1**)**.**

Table 1. Construction and demolition waste generation in the EU (Mt per year)

Reference	**Volume (Mt)**		**Year**	**Additional information**
(Eurostat, 2023)	800 Mt	EU-27	2020	Total CDW generation; CDW represents 37.5 % of total waste generation of 2 135 Mt per year
(Damgaard et al., 2022)	848 Mt[10]	EU-27	2018	Total CDW generation including soil, track ballast, dredging spoils, and asphalt
(Eurostat, 2023)	305 Mt	EU-27	2020	Mineral waste from construction and demolition (hazardous and non-hazardous)
(Damgaard et al., 2022)	276 Mt	EU-27	2018	Total CDW excluding soil, track ballast, dredging spoils, and asphalt
(EEA, 2020)	374 Mt	EU-28	2016	Total CDW excluding excavated soil
(GROW, 2016)	461 Mt	EU-28	2016	Total CDW excluding excavated material

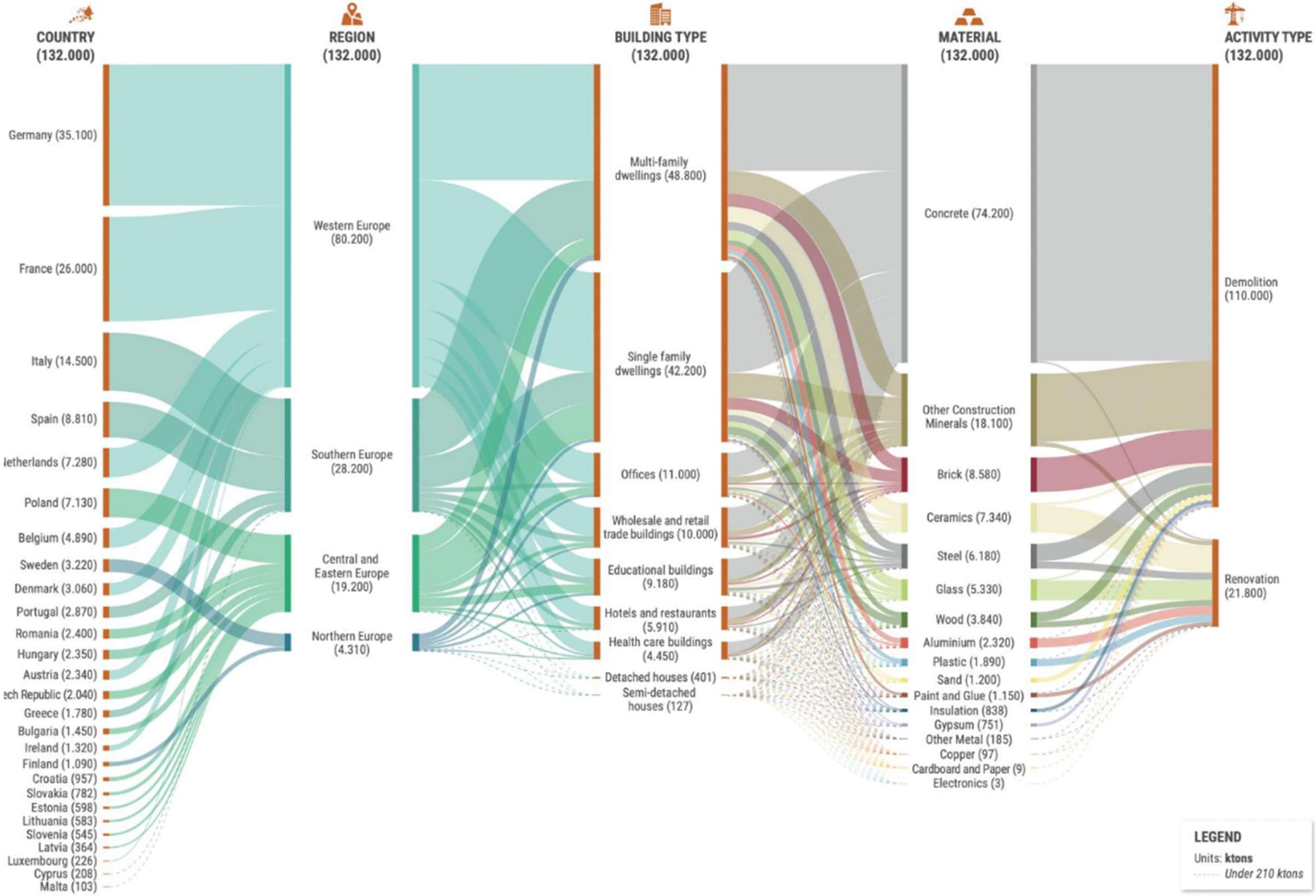
[10] Data source: comprising Eurostat sources, techno-scientific literature, and country-specific data obtained via stakeholders and environment agencies

(Cristóbal García et al., 2024b) provide a detailed breakdown of the CDW material fraction composition at the EU level based on the data provided by (Damgaard et al., 2022). When excluding excavated soil waste, the largest material fraction on average in CDW is the mineral fraction (77 %). It consists mainly of concrete (24.0 %) and bricks (5 %), followed by tiles and ceramics (1.2 %) and mixes thereof (46.9 %). Other fractions such as gypsum or glass account for only a small proportion of the CDW (see Annex 1, **Table 13**).

The data reported to EU or national authorities from which the EU average is reported is highly affected by the demolition, separation and management practices applied by the Member States. A consequence is, that almost 50 % of the mineral fraction material is reported as mixed (see Annex 3, **Table 13**). This implies, that in 2020 in total about **132 million tonnes of mixed mineral waste** were generated in the EU-27. Demolition is responsible for 83 % of this material flow, while renovation is responsible for 17 % (Damgaard et al., 2022). **Figure 4** highlights that this mixed mineral waste from demolition activities predominantly consists of concrete, other construction minerals and bricks. Waste from renovation activities predominantly consists of ceramics and glass, and less of concrete or bricks.

The volume of this mixed mineral waste fraction is staggering and growing. (Damgaard et al., 2022) calculated projections until 2050 and assumed that the waste generated through demolition and renovation activities will **increase to 326 million tonnes of CDW** per year in the EU-27. With regard to the composition, there are no major changes expected compared to 2020, with concrete, other construction minerals and bricks as dominating materials from demolition waste.

Figure 4. Material Flow Analysis showing the total material mass grouped by material fraction [kt] in 2020 for EU-27 (Damgaard et al., 2022).



3.3 Management of mineral CDW

The recycling value chain includes a series of steps, from demolition, separate collection / source separation on site, to sorting, up to recycling and re-conversion to construction materials for new buildings or infrastructure. Furthermore, it is also possible to directly re-use parts of buildings or infrastructure (which have not become waste) or prepare certain CDW parts for re-use (after they have become waste). In the following sections, the different phases and the key aspects are qualitatively described. Emphasis is given to the mineral CDW fractions. A summary of management options reported in the literature for the different mineral CDW fractions is presented in Annex 4 (**Table 14**).

3.3.1 Separate collection and selective demolition

As per the definition in Article 3(11) of the WFD, *'Separate collection' means the collection where a waste stream is kept separately by type and nature so as to facilitate a specific treatment.*

Especially with regard to CDW Article 11(1) of the WFD defines, that '*Member States shall take measures to promote selective demolition in order to enable removal and safe handling of hazardous substances and facilitate re-use and high-quality recycling by selective removal of materials, and to ensure the establishment of sorting systems for construction and demolition waste at least for wood, mineral fractions (concrete, bricks, tiles and ceramics, stones), metal, glass, plastic and plaster.'*

According to the 'EU Construction & Demolition Waste Management Protocol including guidelines for pre-demolition and pre-renovation audits of construction works' (EC, 2024c), the better the mineral CDW is separated at source, the more effective re-use and recycling will be and the higher the quality of recycled aggregates and materials. When not separated at source, CDW can contain unwanted and hazardous substances and materials (e.g. solvents and asbestos) that can pose particular risks to the environment, human health and/or impede recycling (see also section 4.3).

According to the 'EU Construction & Demolition Waste Management Protocol' (EC, 2024c) source separation involves the following types of operation:

- hazardous waste separation;
- deconstruction (dismantling including separation of side streams and fixation materials);
- separation of fixation materials;
- structural or mechanical demolition.

Most Member States apply source separation of hazardous materials and a limited number of Member States have implemented source separation obligations for other materials (Deloitte, 2017). The on-site separation can encourage on-site re-use. It also facilitates the distinction of different treatment solutions according to each material, which may improve recycling. **Figure 5** presents the Member States that have introduced in national/regional legislation the obligation of sorting and separate collection on-site or at a sorting facility. **Figure 6** presents the Member States that have introduced separate collections obligations for specific materials. There is a variety to material types that are included in the separation at source obligations by each Member State. For instance, in Sweden there is a statutory obligation to separate on-site at least six distinct material types such as wood, gypsum, glass, mineral materials (such as concrete, tiles, ceramics, and stone), metals, and plastics. These will be segregated and transported for further treatment separately from other waste streams, according to the Swedish Waste Ordinance (2020:614).

Figure 5. Member States with a national/regional sorting obligation (Deloitte, 2017)

Figure 6. Member States with a national/regional separate collection obligation for specific materials (Deloitte, 2017)

3.3.2 Re-use and preparation for re-use

As per the definition in Article 3(13) of the WFD, *'Re-use' means any operation by which products or components that are **not waste** are used again for the same purpose for which they were conceived.*

As per the definition in Article 3(16) of the WFD, *'Preparing for re-use' 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.*

Re-using building materials at the end of life of built structures results in higher preserved value of materials, and at the same time waste reduction. For demolition, the process is usually that the project is mapped for what material is available, and the demolishing starts with dismantling all the materials and products that can be re-used. These can be e.g., doors and windows, all kinds of interior elements, panels, bricks, beams, and even whole elements of buildings. However, re-using building elements and materials from demolished buildings must fulfil certain technical requirements. The eligibility of a construction product is generally indicated by the CE mark inside the EU if the construction product falls within the scope of the harmonized product standard or has a European Technical Assessment (ETA) (see section 4.2.2). Materials usually re-used are fittings (e.g. doors, windows), tiles, bricks and steel structures/elements.

Considering the mineral fraction of CDW, tiles and bricks have the highest potential for re-use. According to (Iacovidou & Purnell, 2016), clay bricks bonded with cement mortar cannot be re-used with the application of current processes, while those bonded with lime mortar have a high re-use potential (>50 %). However, there have been examples of innovative technologies that can overcome the barrier of cement mortars and succeeding to clean the bricks in preparation for re-use (Svedmyr et al., 2024). When cleaned, the brick can be re-used for the same purpose, even for load bearing purposes. If a brick is not fit for load bearing purposes any more, it can still be re-used, for non-load-bearing uses such as pavement, cladding or aesthetic purposes.

Based on a literature review, (Cristóbal García et al., 2024a) indicate that only precast concrete can be re-used, provided that it has been handled appropriately during the dismantling/demolition phase of a structure, while any other source of concrete results in material that cannot be re-used as is but must be treated through appropriate recycling techniques. For ceramics and tiles, there is a distinction between roof and floor tiles. Roof tiles generally have a higher re-use potential (>50 % according to (Iacovidou & Purnell, 2016)), while ceramic floor tiles have a lower re-use potential.

3.3.3 Sorting

Typically, a preliminary sorting of CDW happens on-site, especially in the case of obligatory source separation as discussed in the previous section (see **Figure 5** and **Figure 6**). Further sorting for recycling purposes might happen also at a later stage, when the collected CDW reaches a dedicated recycling facility. In the case of mineral CDW the processes of sorting and recycling might not be as clearly distinguished as in other materials (e.g. plastics, metals), especially when the recycled aggregates do not have high quality requirements for its end use. However, the most common practice is to separate non-mineral fractions on site. Transportation of mixed fractions to a recycling facility for sorting and recycling is often un-economical and environmentally disadvantageous due to the sheer quantity of the mineral CDW fraction that would need to be transported – often with non-zero emission transportation – for medium/long distances, depending on the location of the demolition site. Mobile units typically consume diesel, while fixed sorting plants are usually electrified (Pacheco et al., 2023).

For sorting on-site, typically mobile units are used. Mobile sorting units are temporarily installed in the construction and/or demolition site and are equipped with some basic equipment, usually a single crusher and single sieving equipment. Thus, mobile units are usually not as effective and precise at sorting as stationary plants. However, since mobile plants process waste coming from a single site, the quality of recycled aggregates may be controlled better and high-quality recycled aggregates may be produced (Dhir & Paine, 2007).

The level of sorting in dedicated recycling facilities is usually much higher since a combination of traditional and advanced sorting techniques can be used in the incoming mineral CDW fraction. In mechanical sorting, equipment such as conveyors, screens, multi-level diameter and magnets are used to separate different types of materials. Increasingly, new technologies are starting to be deployed for the separation of construction waste, such as robotic equipment (Wahlström et al., 2020). For a summary of the different actions taking place in the production of recycled aggregates, see **Figure 7**.

3.3.4 Recycling

A material classified as waste can only cease to be waste after it has undergone and concluded a recycling process, given it fulfils the requirements in Article 6(1) of the WFD.

As per the definition in Article 3(17) of the WFD, *'Recycling' means any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes. It includes the reprocessing of organic material but does not include energy recovery and the reprocessing into materials that are to be used as fuels or for backfilling operations.*

The recycling process to obtain recycled aggregates can vary according to the anticipated quality and end-use of the RA. There is a variety of techniques that can be used commercially today in facilities across the EU, but a typical process of conventional recycling of CDW includes the following (Pacheco et al., 2023):

- CDW is preliminarily sorted at the construction site using conventional equipment and is then sent to a CDW management plant, or treated on-site (in case of mono-material streams);
- The CDW recycling facility receives and stores the CDW according to composition (e.g. unsorted/mixed CDW, concrete waste, ceramics, plastics, wood, metals, and asbestos);
- The CDW intended for the production of RA, which is either composed of concrete waste or of mixed CDW after removal of contaminants (therefore, composed mostly of concrete and masonry waste), is sent to the production line;
- At entry of the production line, preliminary screening by size removes soils and other smaller elements and magnetic separators are used to remove metals;

— Subsequently, the CDW is crushed, sieved, undergoes additional magnetic separation stages and lightweight materials (such as paper and plastics) are removed, typically with air sifters. Manual separation is usually carried out to remove other contaminants, such as wood and glass;

— A final sieving stage is carried out and recycled aggregates are sent to stockpiles ready for sale and in conformity with a declared grading. Some types of recycled aggregates (e.g. those intended for backfilling) may not be sieved.

— Preferably, the storage of recycled aggregates should be sheltered to minimize their water content.

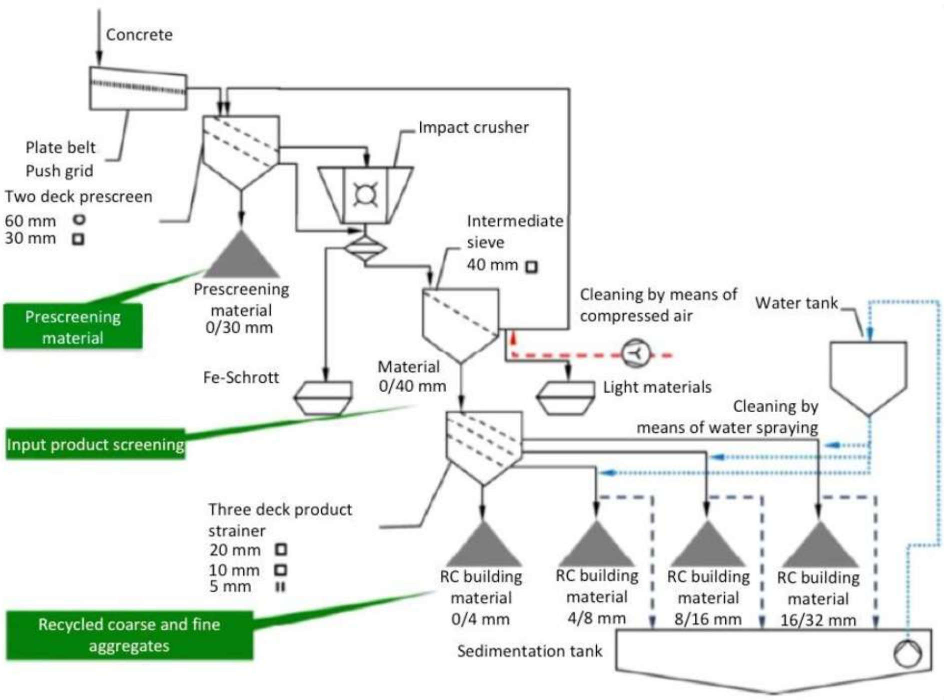
An overview of the characteristics of the most common recycling technologies is presented in **Table 2**.

Table 2. Summary of technical characteristics of common recycling systems for mineral CDW (C. Zhang et al., 2022)

Features	**Wet process**	**Stationary/ semi-mobile advanced dry recovery**	**Mobile advanced dry recovery**	**Heating air classification system**	**Smart crushing system**
Transportability	-	-	+	+	+
Producing recycled clean gravel	+	+	+	+	+
Producing recycled clean sand	-	-	-	+	+
Producing recycled cementitious material	-	-	-	+	+
Generating by-product: sieve sand	+	+	+	-	+
Generating waste: sludge	+	-		-	-
Energy source	Electricity	Diesel, Electricity	Diesel, Electricity	Diesel	Electricity
Capacity	150 t/h	130 t/h	50 t/h	3 t/h	20 t/h

In Figure 7, the process of recycling aggregates from concrete is illustrated step-by-step from the moment the sorted fraction of mineral CDW (in this case concrete debris) enters the conveyor belt of the plant.

Figure 7. Process steps for aggregates recycling from concrete waste (Gühlstorf & Dörner Kies, 2023)



A list of the available recycling technologies (TRL>5) that are relevant and applied in CDW recycling is presented in **Table 3**.

Table 3. Processing technologies for advanced recovery of CDW (Cinderela, 2021)

Type	Technology	Function	Application
Mechanical sorting technologies	Magnetic separators	Magnetic separators for removal of ferrous metals by means of last generation magnets and for the separation of non-ferrous metals by means of Eddy currents, including more efficient detection sensors.	All types of mineral streams.
	Advanced dry recovery sorting technology	Advanced Dry Recovery sorting technology that allows, through the application of kinetic energy from the blades of a rotor and subsequent injection of air, the breaking of capillary bridges in wet granular materials and the separation of fine particles.	Coarse recycled concrete aggregates RCA.
	High frequency sieves	Dry high energy efficiency sorting of fine products with Particle Size Distributions up to 45 μm. They can be linear or circular vibrating screens.	Any type of dry aggregate.
Hydraulic sorting technologies	Gravimetric sorting using densimetric tables	Density tables are used for efficient sorting of dry materials due to density. Separation is achieved by vibrating movement on the surface of an inclined treatment table. The rising air flows from below through this surface together with the vibration causes the separation of the particles.	Coarse particles: RCA, RBA, RP
	Gravimetric sorting by differential acceleration (JIG)	Differential acceleration equipment works with currents of water or air in turbulent regime and differential action. According to this principle and for very short cycles, the solid particles are subjected to upward and downward currents, motivated by alternating pulsations given to the fluid, either by a piston or a diaphragm. In this way, a separation of the particles by density is achieved, with stratification of the different materials, so that the lightest ones go to the surface, while the heaviest ones go through the bottom of the screen.	Coarse particles: RCA, RBA, RP
	Gravimetric separation by concentrating spirals	The spiral concentrator consists of a helical chute. Its operation can be compared to that of a conical pan, where the light particles are moved by the action of the water towards the edge and the heavy particles are concentrated in the centre. Especially suitable for CDW fine fractions by optimizing the separation	Fine particles: RCA, RBA, RP
	Cyclonic classifiers	Classification of products with granulometry between 10 and 300 μm using hydraulic cyclones. A cyclone separator is an equipment used to separate solid particles suspended in air, gas or liquid flow, without the use of an air filter, using a vortex for separation.	Any type of dry fine aggregate <300 μm.
	Hydrocyclone Technologies	Hydrocyclone technologies to separate plasterboard from plasterboard.	RP
Optical sorting technologies	Optical sorting using VIS + NIR	Optical sorting that allows to automatically identify and separate different types of materials, by composition (NIR), colour (VIS) and / or shape (deep learning). Identification of the different fractions using optical sensors and separation of the identified fractions by air pulses.	Coarse particles: RCA, RBA, RMA, RP

Drying and Thermal Activation Technologies	Rotary dryers	They consist of slightly inclined rotating cylinders into which hot air is injected and circulated through the moving cylinder	Any type of aggregate.
	Fluidized bed dryers	The HAS (Heating Air System) technology consists of a vertical cylinder fed from the top in such a way that the particles pass through the cylinder by gravity. The burner, which reaches temperatures of up to 700 °C, is located in the central part of the cylinder. The novelty of the HAS technology is the incorporation of a grid that hinders the passage of the particles, increasing the residence time and the interaction with the heated air in the fluidized bed.	Any type of fine aggregate.
	HAS technology	Spouted bed technologies consist in very high efficiency gas-solid contact systems (greater than 90 % efficiency) that achieves optimized conditions for the transfer of mass and energy with the aim of drying fine and ultrafine mineral fractions.	Any type of fine aggregate.
	Spouted bed technologies	Spouted bed technologies consist in very high efficiency gas-solid contact systems (greater than 90 % efficiency) that achieves optimized conditions for the transfer of mass and energy with the aim of drying fine and ultrafine mineral fractions.	Any type of fine aggregate.
Transformation technologies	Milling technology	Particle size reduction employing mechanical comminution processes using bar or ball mills.	Any type of dry aggregate.
Digital technologies	BIM-based technologies	Technologies based on Building Information Modelling (BIM) oriented to improve pre-demolition audits, plan selective demolition and improve the management of generated waste.	All waste streams
	Traceability technologies Digital	Digital tools for the traceability of resources throughout the entire value chain.	All waste streams
	Quality analysis technologies	Use of optical sensors combined with Deep Learning for the automatic identification of mineral resource typologies and quality analysis.	All waste streams

Depending on the final output of each of the various recycling processes, there is a variety of potential recycled aggregates that can be obtained for different uses according to quality requirements and specifications. In the scope of this study, assessing the EoW status of mineral CDW the recycled aggregates fractions of relevance are the following:

- Recycled Concrete Aggregates (RCA): recycled aggregates composed mostly of concrete (>80 %) from CDW;
- Recycled Mixed Aggregates (RMA): recycled aggregates composed of concrete and brick/ceramic from CDW;
- Recycled Brick/Ceramic Aggregates (RBA): recycled aggregates obtained by processing predominantly ceramic type material from CDW.

Depending on the country and the local regulations, the recycled aggregates are classified according to different parameters (Cinderela, 2021):

a) According to weight:

Recycled aggregates can be classified based on their particle density:

- Normal weight aggregates: aggregate with a particle density not less than 2,000 kg/m^3 (in some case 1,700 or even 1,500 kg/m^3) and not more than 3,000 kg/m^3;
- Light weight aggregates: aggregate with a particle density less than 2,000 kg/m^3 (in some cases 1,700 or 1,500 kg/m^3).

b) According to size:

The Particle Size Distribution (PSD) is expressed as mass percentages passing through a specified set of sieves. The recycled aggregates can be classified as a function of the sizes of the lower (d) and upper (D) sieves, expressed as d/D (size range depending on the country):

- Coarse recycled aggregates: designation given to the aggregate sizes with d equal to or greater than 2 mm and D equal to or greater than 4 mm;
- Fine recycled aggregates: designation given to the aggregate sizes with D equal to or less than 4 mm;
- All-in aggregate: aggregates composed of a mixture of fine and coarse aggregates with a continuous PSD;
- Fines: particle size fraction of an aggregate which passes the 0.063 mm sieve;
- Ballast (in some countries): designation given to the coarser aggregate sizes with d equal to or greater than 40 mm and D equal to or greater than 150 mm.

c) According to the composition:

Recycled aggregates are classified according to their physical composition based on the weight percentage of each of the components that make it up, in accordance with the EN 933-11 (2009) standard as presented in Table 6.

Table 4. Classification of recycled aggregates according to their physical composition

Component	Description
Rc	Concrete, concrete products, mortar Concrete masonry units
Ru	Unprocessed aggregates, natural stone Hydraulically bound aggregate
Rb	Clay masonry units (i.e., bricks and shingles) Calcium silicate masonry units Non-floating aerated concrete
Rg	Glass
Ra	Bituminous materials
X	Others: cohesive (i.e., clay and sand) Various: metals (ferrous and non-ferrous), non-floating wood, plastic and rubber Gypsum plaster
FL	Floating Particles

3.3.5 Backfilling

Backfilling is defined in Art. 3(17a) of the WFD as *'any 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'.*

3.3.6 Re-conversion

The use of recycled aggregates in useful applications, thus fulfilling the WFD definition of recycling, can be categorised into bound and unbound application (Cinderela, 2021). Exemplary applications are:

Bound applications:

- Structural concrete
    - ready-mix concrete
    - precast concrete elements: blocks, pavements, barriers, pipes, etc.
    - concrete caissons for docks
    - non-structural concrete:
        - levelling concrete
        - infill concrete
- Concrete for roads and flooring:
    - concrete for pavements
    - vibrated concrete
- Cement treated material for foundation courses: gravel-cement (slag-cement).
- Bituminous mixtures (hot, warm and cold) for the execution of roads surface courses, bicycle paths and pedestrian paths.
- Capping layers
- Masonry products
- Supplementary cementitious materials
- Filler for the manufacture of cement-based products

Unbound applications:

- Engineering embankments
- Surface courses: wearing and binder courses for roads
- Foundation courses: base course and sub-base course for roads, pedestrian paths and cycle paths
- Subgrade courses
- Uncapped pavement or shoulder sublayers
- Engineering embankments associated with road infrastructure or for uncovered shoulders

The different end-use applications of recycled aggregates are also determined by the obtained level of quality at the end of the recycling process. Generally, recycled aggregates for use in bound applications for structural purposes require the highest quality available, while unbound application may lay in the border of recycling/backfilling, meaning that the expected recycled aggregates quality in not critical for the application (C. Zhang et al., 2020).

In terms of recycling concrete and using back the recycled aggregates into concrete, which is considered a high quality recycling application, there are several hindering factors that need to be considered (Pacheco et al., 2023):

- The incorporation of recycled aggregates may not be justifiable due to environmental and technical issues, since the production of concrete with recycled aggregates may be associated with larger environmental impacts and cost than the production with natural aggregates.
- The production of recycled aggregates for road construction and backfilling has smaller environmental impact than the production of recycled aggregates for concrete, due to less sieving and sorting stages needed to produce recycled aggregates for less demanding applications than those needed for the production of recycled aggregates that are fit for concrete.
- The production of high-quality recycled aggregates cannot be made without producing other recycled aggregates (e.g. fine recycled aggregates and recycled aggregates produced with significant portions of masonry waste) since the composition and processing of CDW mean that such materials will always be generated.

4 Conditions for End-of-Waste

As mentioned in Section 1.3, the main conditions to fulfil for End-of-Waste are:

*"(a) the substance or object is to be used for **specific purposes**;*
*(b) a **market or demand** exists for such a substance or object;*
*(c) the substance or object fulfils the **technical requirements** for the specific purposes and meets the **existing legislation** and **standards** applicable to products; and*
*(d) the use of the substance or object will not lead to overall **adverse environmental or human health impacts**."*

Besides the Commission shall take as a **starting point** the most stringent and environmentally protective **EoW criteria established in Member States**.

The following sections provide an overview of market and demand as well as common applications for recovered CDW. Technical requirements, standards and legislative aspects are introduced. Environmental and human health impacts related to the use of recovered CDW are discussed. Finally, a first brief benchmarking of EoW criteria in Member States is presented.

4.1 Market, demand and common applications

Article 6(1) of the WFD defines that *"(a) the substance or object is to be used for specific purposes*; and *(b) a market or demand exists for such a substance or object. "*

According to Eurostat (*env_wastrt*) the overall recovery rate for CDW materials can vary significantly for the different CDW materials and for Member States. Concrete, bricks, ceramics and tiles have currently the highest recovery rates with an average of 89 % (recycling and backfilling) for the EU in 2020 (Cristóbal García et al., 2024b) (see **Table 5**). Significant lesser recovery rates are observed for insulation materials, gypsum or glass, where 70 to 98 % is landfilled.

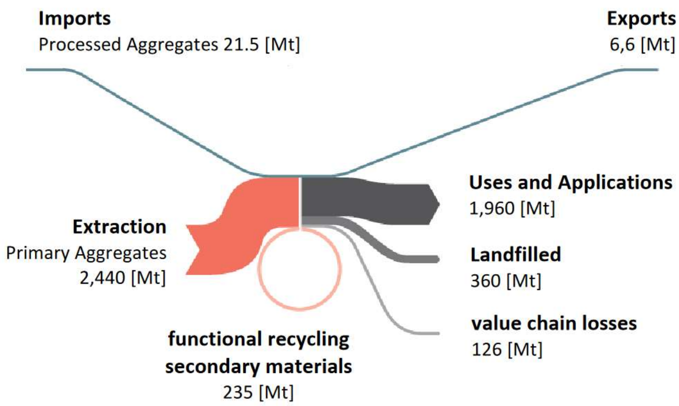
Table 5. Overview of the current treatment pathways for selected CDW materials in the EU (rounded values, expressed in percent)

Material fraction	Preparing for re-use	Recycling	Backfilling	Incineration	Landfilling
Concrete	0	79	10	0	11
Bricks	0	79	10	0	11
Ceramics and tiles	0	79	10	0	11
Insulation material	0	2	0	0	98
Gypsum	0	10	0	0	90
Glass	0	6	24	0	70
Track ballast	N/A	N/A	N/A	N/A	N/A

Even though concrete, bricks and ceramics and tiles are recovered to a great extent, from all aggregates produced in the EU-27 in the year of 2019, recycled and re-used aggregates account for only 8.2 % (UEPG, 2021) (see **Figure 8**). (UEPG, 2021) further estimate that it would be realistic to incorporate 10–20 % of recycled aggregates in current structural concrete production, hereby substituting natural aggregates.

(ANEFA, 2022) predicts, that even in an optimal recycling scenario, 85 % of the aggregates consumed will still need to be extracted from natural resources. Exemplary, Belgium recovered 97 % of CDW in 2018, but this would have only covered less than 30 % of their aggregates demand in 2020.

Figure 8. Sankey Diagram on the aggregates flow for the EU (ANEFA, 2022)



4.2 Technical requirements, standards and legislation

Article 6(1)(c) of the WFD defines that *'the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products'*. The following sections give an overview on technical requirements, standards and product legislation.

4.2.1 Technical requirements and standards

The following **Table 6** gives an overview on national and EU standards that specify the properties of concrete and aggregates obtained by processing natural, manufactured or recycled materials. These standards also define tests on aggregates and characterisation of waste in general.

Table 6. Overview of national and EU standards for natural, manufactured and recycled construction materials (non-exhaustive list)

Standard	**Content**
AT OENORM B 4710-1:2018, concrete standard	Existing standard has been adapted for the application of recycled aggregates in concrete formulations
CEN/TC 154 (SC1 to SC6 and WG 1 to WG13)	Aggregates. Standardization in the field of natural, recycled and manufactured aggregates, by specifying aggregate performance characteristics, sampling and methods of test.
EN 206 (1 to 9)[11]	Concrete
EN 932 (1 to 6)	Tests for general properties of aggregates
EN 933 (1 to 9)	Tests for geometrical properties of aggregates
EN 1097 (1 to 8)	Tests for mechanical and physical properties of aggregates
EN 12457-4:2004	Characterisation of waste - Leaching - Compliance test for leaching of granular waste materials and sludges - Part 4: One stage batch test at a liquid to solid ratio of 10 l/kg for materials with particle size below 10 mm (without or with size reduction).
EN 12620:2002+A1:2008	Aggregates for concrete[12]
EN 13043:2002/AC:2004	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas;
EN 13055-1:2002/AC:2004 (1+2)	Lightweight aggregates

[11] EN 206 (Standard on concrete) allows for recycled concrete aggregates to be used with a maximum replacement percentage of 30 % of the total aggregate by mass for all low demanding exposure classes. With lower recycled aggregates quality, 5–15 % of total aggregates can be substituted by recycled aggregates in concrete with low demanding exposure classes (≤C25/30).

[12] EN 12620:2002+A1:2008 specifies the properties of aggregates and filler aggregates obtained by processing natural, manufactured or recycled materials and mixtures of these aggregates for use in concrete

EN 13108-1 to 5	Bituminous mixtures – Material specifications
EN 13108-8	Bituminous mixtures – Material specifications – Part 8: Reclaimed asphalt.
EN 13139:2002/AC:2004	Aggregates for mortar
EN 13242:2003+A1:2008	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
EN 13285	Unbound mixtures – Specifications
EN 13286	Unbound and hydraulically bound mixtures – Test methods
EN 14227-1 to 5	Hydraulically Bound Mixtures: Specifications

4.2.2 Product legislation

One of the objectives of EoW criteria is to ensure that a shift to the product status will not lead to environmental or human health concerns. Both waste and product legislation address environmental and human health impacts. Once EoW status is granted, the material enters the product regime, hence having to comply with legislation applicable to products. The main concerns to be addressed in EoW criteria for CDW are related to the **performance and safety of construction products** and the **potential negative effects on the environment and human health of the output materials**. The main regulatory references are briefly introduced in the following sections and summarised in **Table 7**.

4.2.2.1 Construction Product Regulation

The aim of the CPR Regulation (EU) No 305/2011[13] is to improve the functioning of the single market and the free movement of construction products in the EU, by laying down uniform rules for the marketing of these products and providing a common technical language to assess the performance of construction products. This regulation also enables EU Member States to ensure the safety of construction works. One key aspect is that this Regulation sets out methods and criteria for assessing and expressing the performance of construction products and the conditions for the use of CE marking. Member States remain responsible for fire safety, for mechanical resistance and stability, as well as for environmental, energy and other requirements applicable to buildings and other construction works.

The CPR regulation is currently under revision and a proposal for revision was adopted on 30 March 2022. The key objectives are to improve the functioning of the internal market, enhance the sustainability of construction products, and introduce product requirements for construction products. Regarding sustainable design and production of construction products, the new product requirements will ensure that the design and manufacture of construction products is based on state of the art to make these more durable, repairable, recyclable and easier to re-manufacture (EC, 2022).

4.2.2.2 European Technical Assessment

The ETA is an alternative for construction products not covered by a harmonised standard. It is a document providing information on their performance assessment. The procedure is established in the construction products regulation and offers a way for manufacturers to draw up the declaration of performance and affix the CE marking. It contributes to the free movement of construction products and the creation of a strong single market (EC, 2024d).

4.2.2.3 CE Marking

CE marking is necessary for the marketing of a product within Europe as it states that the product complies with the applicable legislation. On a construction product, it indicates that the product conforms to a harmonised standard (hEN) or a European Technical Assessment (ETA). The letters 'CE' appear on many products traded on the extended Single Market in the European Economic Area (EEA). They signify that products sold in the EEA have been assessed to meet high safety, health, and environmental protection requirements. CE marking also supports fair competition by holding all companies accountable to the same rules (EC, 2024a). By affixing the CE marking to a product, a manufacturer declares that the product meets all the legal requirements for CE

[13] Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive (EEC) No 89/106

marking and can be sold throughout the EEA. This also applies to products made in other countries that are sold in the EEA.

4.2.2.4 CLP Regulation

Regulation (EC) No 1272/2008 on Classification, Labelling and Packaging of substances and mixtures (CLP) requires those placing substances and mixtures on the market to classify and label according to the rules established therein. It has the purpose of ensuring a high level of protection of human health and the environment as well as the free movement of substances, mixtures and articles. This also applies to the placing on the market of recycled substances and mixtures[14]. Annex I of the CLP sets out the criteria for classification in hazard classes and in their differentiations and sets out additional provisions on how the criteria may be met.

4.2.2.5 REACH Regulation

According to Article 2(2) of **REACH** (Regulation (EC) No 1907/2006), waste as defined in Directive (EC) No 2006/12 is not a substance, mixture or article within the meaning of REACH. Therefore, this regulation does not apply to waste. However, as soon as a waste material ceases to be waste, the product legislation, including REACH apply, including various obligations defined therein for substances on their own, in mixtures and in articles. This includes, for example, registration obligations for manufacturers or importers of substances and substances in mixtures above 1 tonne/year to gain access to the EU market (subject to exemptions). Other relevant obligations include substances of very high concern (SVHC) listed in Annex XIV, for which an authorisation is needed to place them on the market for a use or to use them in the EU. In addition, restrictions pursuant to Article 67 and listed in Annex XVII to REACH may apply to the manufacturing, placing on the market and use of some substances.

Article 3 of the REACH Regulation defines placing on the market as "*supplying or making available, whether in return for payment or free of charge, to a third party. Import shall be deemed to be placing on the market*". No reference is made to the 'first placing on the market', hence under REACH every placing on the market, unless stated otherwise, is to be considered a "placing on the market". This is particularly relevant for second hand goods.

4.2.2.6 POPs Regulation

Persistent Organic Pollutants (POPs) are chemicals that persist in the environment, bio-accumulate and pose a risk of causing significant adverse effects to human health or the environment. The **POPs Regulation** (EU) No 2019/1021) aims at protecting human health and the environment from these chemicals by banning or restricting the use of POPs in both chemical products and articles. Article 3 of the POPs Regulation prohibits the manufacturing, placing on the market and use of substances listed in Annexes I and II, whether on their own, in mixtures or in articles, unless covered by any of the exemptions in Article 4. Recycled aggregates that reach EoW status will have to comply with the POPs Regulation, including the limit values imposed therein.

Table 7. Overview of product legislation for construction materials

Product legislation	**Abbr.**	**Legislation**
Construction Product Regulation	CPR	Regulation (EU) No 305/2011
European Technical Assessment	ETA	-
CE Marking	CE	Part of the EU harmonisation legislation
Classification, Labelling and Packaging of substances and mixtures	CLP	Regulation (EC) No 1272/2008
Registration, Evaluation, Authorisation and Restriction of Chemicals	REACH	Regulation (EC) No 1907/2006
Regulation concerning Persistent Organic Pollutants	POP	Regulation (EC) No 2019/1021

[14] As per Article 1(3) of the CLP Regulation "*Waste as defined in Directive (EC) No 2006/12 of the European Parliament and of the Council of 5 April 2006 on waste (1) is not a substance, mixture or article within the meaning of Article 2 of this Regulation*". To be noted that Directive (EC) No 2006/12 was superseded by Directive (EC) No 2008/98

4.3 Environmental and human health impacts

One of the conditions to be fulfilled for EoW is that the use of the material that has reached EoW shall not lead to adverse environmental or human health impacts. Once waste ceases to be waste, it shall comply with product legislation and the relevant requirements to prevent adverse impacts to human health and the environment. Collection, sorting and recycling of CDW, as well as storage and transport of recovered/recycled materials can lead to environmental and human health impacts, including for instance (Villanueva & Eder, 2014):

- energy and resource use;
- climate relevant air emissions (CO_2, and other greenhouse gases);
- emission of toxic and/or environmentally harmful substances as well as dust into the air;
- leaching or leakage of liquid components to the underground;
- accumulation and/or release of toxic substances;
- accidents at work by operators handling the waste.

In the following two sections a brief overview on hazardous substances in CDW and results from Life Cycle Analysis on different CDW management options are presented.

4.3.1 Hazardous substances in CDW

Waste arising from construction and demolition activities may contain a wide variety of hazardous properties, summarized in **Table 8**.

Table 8. Hazardous substances in constructions (buildings/infrastructure), including limit values for hazardous waste classification (Wahlström et al., 2019).

Hazardous substances	Hazardous waste limit
Asbestos	N/A (total ban)
Chlorofluorocarbons (CFC)	0.1 %
Polychlorinated biphenyls (PCBs)	50 mg/kg
Polycyclic aromatic hydrocarbons (PAH)	1,000 mg/kg
Hydrocarbons C10-C40	limits depend on composition
Chlorophenols (candidate POP substance)	2,500 mg/kg (pentachlorophenol)
Polychlorinated-p-dioxins and furans (PCDD/PCDF)	15 µg/kg
Phthalates (e.g. DEHP)	3,000 mg/kg
Chlorinated paraffins (e.g. SCCP)	2,500 mg/kg
Bisphenol A	3,000 mg/kg
Arsenic	1,000 mg/kg
Lead	2,500 mg/kg
Cadmium	1,000 mg/kg
Chromium	2,500 mg/kg
Copper	2,500 mg/kg
Mercury	2,500 mg/kg
Nickel	1,000 mg/kg
Zinc	2,500 mg/kg

The use of **asbestos** has been banned in the EU since 1 January 2005[15]. Construction works, including renovation and demolition activities, and the management of CDW pose a high risk of exposure to asbestos due to the widespread historical use of asbestos-containing products in the construction sector. Although updated data are not readily available, a 2014 study showed that the use of asbestos was negligible by 2012 in most European countries (Kameda et al., 2014). However, while asbestos may not be actively used and marketed anymore, built-in asbestos in, for example, pipes, insulation, stoves, heating devices, asbestos sheeting and roofing may still put people at risk.

Specifically, for waste consisting of the mineral fraction of CDW, there are a few possibly problematic fractions that need to be considered. Concrete can contain several substances that could classify it as hazardous, while hazardous substances are less frequent in bricks and tiles and their presence is usually due to joint materials (e.g. plaster, mortars etc.) that have been bound to these materials.

Contamination of concrete can occur due to the structure's use and proximity to contaminants. For instance, **mineral oils** are found as secondary contaminants in places where they have been stored or used for technical purposes (e.g. in machinery, workspaces, etc.). Oil components migrate in concrete structures and degrade the concrete with time. If the contaminant can be visually determined to consist of oil from oil tanks, oil boilers, leaking machinery/installations or similar, analysis should be carried out regarding **PCBs**. If the concrete surface consists of a black coating, for example a wear surface on a floor, there is a possibility for **PAHs** detection in the concrete CDW material (Wahlström et al., 2019). Tar products (tar, coke and bitumen) containing PAHs can be found as a waterproofing layer on foundations and bathroom walls (waterproofing), in tar paper (impregnation and surface treatment), etc.

Depending on previous and ongoing activities within a building, a large quantity of contaminants can be found on and potentially having penetrated into the concrete. Examples of such contaminants are **arsenic, chromium and mercury**. In addition to these types of contaminants, there may also be other substances which can affect occupational health and safety of workers, such as mould, decomposition products from adhesives and levelling compounds containing casein (Byggforetagen, 2019).

Tiles and similar materials that have a yellow, orange or red appearance could possibly contain **cadmium**. Cadmium has also been encountered in glazed roof tiles. Moreover, **lead** can be found as a glaze on white-glazed tiles but also in other colour glazes.

Several studies have been performed to analyse the average composition of potential hazardous substances that are present in the mineral fraction of CDW. The studies analysed samples of CDW consisting of concrete waste or mixed mineral waste (incl. concrete, bricks, tiles, and mortar). Moreover, the analyses have measured the leaching behaviour of the sampled CDW and the concentration of potentially hazardous substances. Detailed information are presented in Annex 5 (**Table 15** and **Table 16**).

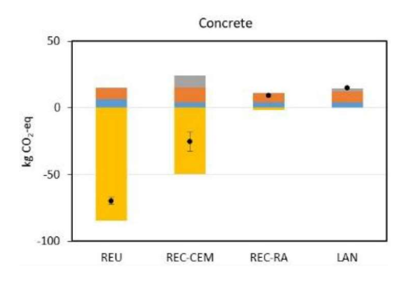
4.3.2 Life Cycle Assessment of CDW management options

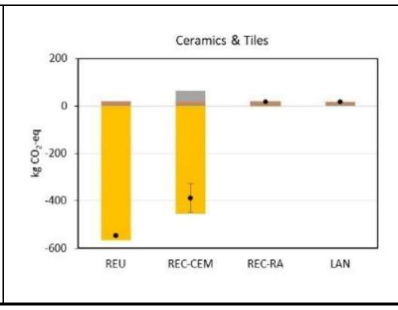
The comprehensive study on the Life Cycle Assessment (LCA) of different management options of CDW, (Cristóbal García et al., 2024) indicates that for the impact category Climate Change preparing for re-use and recycling are the options with the highest greenhouse gas (GHG) savings compared to all others, when assuming the use of best-performing recycling technologies. Landfilling (or incineration when applicable) shows the highest GHG burdens for all individual material fractions, except for wood and mineral wool waste. When assuming the use of recycling processes that produce only recycled aggregates, savings from recycling are often comparable to (or only slightly better than) landfilling. The reason is that the GHG savings connected to avoiding natural material extraction and processing (gravel, sand) are limited. Despite that, the results show that recycling always offers environmental benefits against landfilling. Ultimately, technological progress in sorting and recycling processes could lead to higher recycling yields in the future, increasing the environmental benefits of recycling against landfilling.

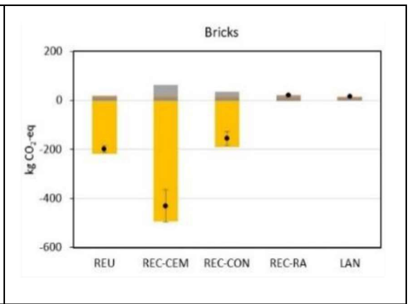
[15] The placing on the market and use of asbestos was banned in the EU by Commission Directive 1999/77/EC of 26 July 1999 adapting to technical progress for the sixth time Annex I to Council Directive 76/769/EEC on the approximation of the laws, regulations and administrative provisions of the Member States relating to restrictions on the marketing and use of certain dangerous substances and preparations (asbestos). This Directive was repealed by the REACH Regulation (Regulation (EC) No 1907/2006 (OJ L 396 , 30.12.2006 , p. 1), see its Annex XVII , entry 6 , on asbestos fibres).

The LCA analysis took into account the following processes: i) waste generation (including demolition, excavation, dredging); ii) conditioning processes; iii) transport; iv) processing; v) material recovery; vi) energy recovery. Across all scenarios investigated, the most important contribution to climate burdens from recycling is the recycling process itself, while the most notable contribution to the savings is the substitution of materials with a substantial difference between substituting natural aggregates (low savings) and substituting cement or materials in a closed loop (high savings). For instance, recycling of concrete waste to cement records a total net GHG saving of 26 kg CO_2 eq. t^{-1} which is substantially higher than the net burden obtained when recycling concrete to recycled aggregates (9 kg CO_2 eq. t^{-1}). However, in scenarios with recycling to recycled aggregates the contribution of the processing is minor and, in many cases, lower than transport (e.g. for concrete, ceramics/tiles, bricks and glass), which becomes the most impacting parameter in CDW management. For bricks, the recycling option performs better than the preparation for re-use, with the latter being the second best performing option. For ceramics/tiles and bricks, recycling to recycled aggregates performs better than landfill and incineration, but results in limited savings relative to them. The results of the LCA studies and the scenario parameters are summarised in **Table 9**.

Table 9. LCA results and the scenario parameters







Fraction	Details of life cycle stage				Substitutability factor	Scenario Code[(1)]
	Generation	Processing	Products & Outputs	Products substituted		
Concrete (CON)	Selective demolition	Preparing for re-use	Concrete	Concrete	1	REU
	Selective demolition	Recycling	Cementitious material Recycled aggregates	Cement Natural aggregates	0.71 0.85	REC-CEM
	Selective demolition	Recycling	Recycled aggregates	Natural aggregates	0.85	REC-RA
	Conventional demolition	Landfill	-	-	-	LAN

Note: re-use (REU), recycling (REC), recovery-backfilling (RCB), landfilling (LAN), and incineration (INC)

The use of recycled aggregates in the concrete mixture, instead of natural aggregates, generally improves the environmental footprint of the produced concrete (Cristóbal García et al., 2024). Several studies have assessed the environmental impact of recycled aggregates in concrete by using a LCA methodology, as presented in a review by (Xing et al., 2021) in **Table 10**. There are several parameters that influence the environmental performance of recycling and use of recycled aggregates, mainly being the source and intensity of energy input of the recycling processing technology and the average distances of transport from the origin of CDW to reprocessing facilities.

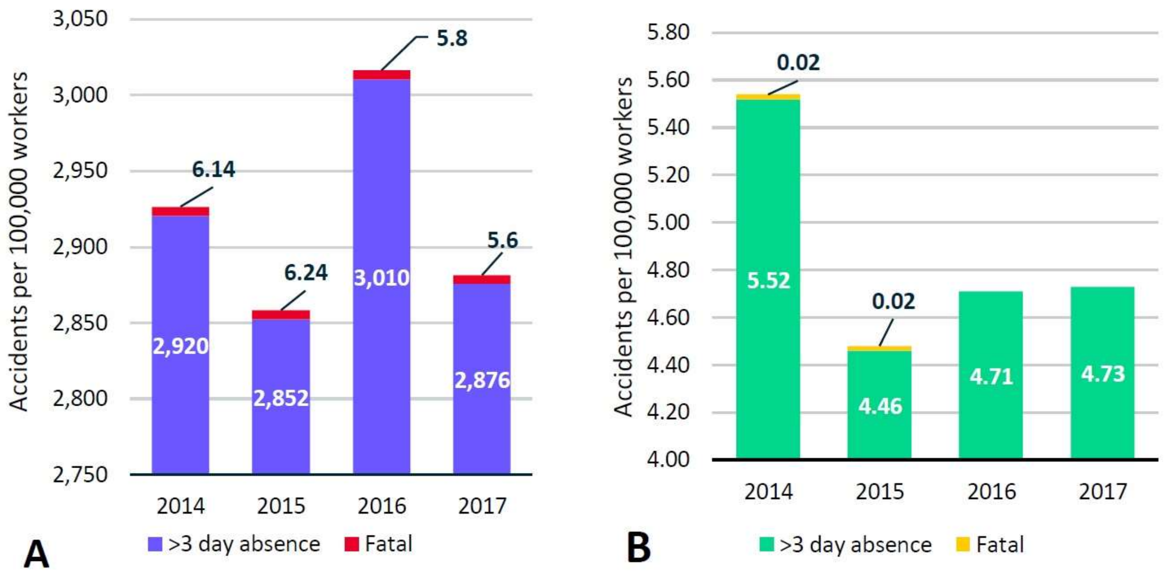
Table 10. Comparative analysis of recycled aggregates against natural aggregates in concrete. Results are presented as a percentage difference (+ increase and – decrease) of the respective environmental impact category.

Global warming potential (GWP)	Abiotic depletion potential (AD)	Acidification potential (AP)	Eutro-phication potential (EP)	Ozone depletion potential (ODP)	Photo-chemical ozone creation potential (POCP)	Energy use	Source
-25 %	-47 %	+42 %	-43 %	-44 %	-50 %	-42 %	(Serres et al., 2016)
-4 %	-13 %	-13 %	-12 %	N/A	-20 %	-11 %	(Turk et al., 2015)
-25 %	N/A	N/A	N/A	N/A	N/A	-30 %	(Braga et al., 2017)
+11 %	N/A	+14 %	+21 %	N/A	+37 %	+22 %	Marinkovic et al. (2010)
+4 %	N/A	-4 %	+3 %	-7 %	N/A	N/A	Yazdanbakhsh et al. (2018)
-5 %	-34 %	N/A	N/A	N/A	N/A	N/A	(Knoeri et al., 2013)
+6 %	N/A	N/A	N/A	N/A	N/A	+3 %	(Ding et al., 2016)

Most studies account for a generally favourable use of recycled aggregates in the production of concrete. The main reason identified for increasing environmental impacts in the study by (Marinković et al., 2010) is the assumption that about 5 % more cement is added to the mixture to offset the assumed inferior quality of the recycled aggregate concrete. However, more recent research proved comparable mechanical performance of normal strength recycled aggregate concrete without adding extra cement, thus strengthening its advantages in its environmental behaviour (Visintin et al., 2020). The difference observed in global warming potential among the studies is clearly attributed to the energy sources and the treatment steps required. Also, transport distance is an important factor which leads to 4–45 % of the environmental burden from concrete (Y. Zhang et al., 2019).

Handling CDW during the construction, maintenance, renovation and demolition stages of the built environment can have detrimental effects in the occupational health and safety of workers. Main sources of concern are the hazards that exist from materials or substances in CDW or the previous use of buildings, and physical accidents that take place during deconstruction (demolition) and/or waste removal activities. Data compiled by (Cook et al., 2022) present the rate of fatality and accidents in EU related to construction and demolition activities (**Figure 9**).

Figure 9. Rate of fatality and accidents in the EU-27 (+UK) resulting in more than three days absence from work by: A) NACE activity: construction; and B) NACE activity: construction; material agent: bulk waste.



However, accurate data on the handling of CDW specifically does not exist. Accidents and fatalities involving CDW are not well reported at EU-level, although some Member States do provide more granular information for “bulk waste” from construction and demolition activities (no definition is provided for this term).

4.4 Mapping existing End-of-Waste criteria

4.4.1 National EoW criteria for CDW re-use and recycling

The mapping of existing EoW criteria at national level is based on JRC in-house research and communication with stakeholders within the JRC scoping study (Orveillon et al., 2022). Six Member States implemented national EoW criteria for several construction and demolition wastes (see overview in Table 11). Ireland as one of these six Member States has one national EoW legislation and four case-by-case decisions in place. Germany has the intention to develop EoW criteria for mineral substitute building materials. The following paragraphs give a short introduction into the respective national EoW legislations (alphabetical order).

Austria: The ‘Recycling Building Materials Ordinance’ in Austria contains obligations for construction or demolition activities, the separation and treatment of waste generated during construction or demolition activities, the production and End-of-Waste of recycled building materials (BML, 2015). This ordinance stipulates that recycled construction materials of the highest quality can lose their **waste status if certain conditions are met** (§ 14 (1) defines, that at the moment the recycling building material complies with quality class U-A and is handed over by the producer to a third party, EoW is achieved). There are a number of waste types permitted for the production of recycled building materials[16].

Depending on the intended use of recycled aggregates different limit values on total content and the eluate are defined. Furthermore, the End-of-Waste criteria typically include parameters such as the absence of hazardous substances, compliance with technical standards for the intended use, and the ability to meet specified product standards. The waste producer or holder must demonstrate that the recovered material meets the EoW criteria through documentation and testing.

Finland: released a **Government Decree on End-of-Waste Criteria for Crushed Concrete (466/2022)** (YM, 2022). This Decree defines the requirements under which concrete waste ceases to be waste. Types of concrete waste that are permitted as input are defined with corresponding List of Waste codes[17]. The input material (concrete waste) has to undergo a recovery operation with defined requirements. The output material (crushed concrete) has to fulfil specific requirements such as maximum permitted solubilities (e.g. heavy metals and salts), total contents of harmful substances (e.g. PAH, PCB) and a maximum quantity of impurities (e.g. fired bricks, plastic, rubber). In addition, the intended use of the crushed concrete is defined and it depends on the origin of the input material (e.g. concrete waste from unused concrete, unused concrete products or used concrete). Intended uses of recycled aggregates are:

- building and earth construction
- landscaping
- the manufacture of ready-mixed concrete and concrete products
- fertiliser, liming material, soil improver or growing medium

Germany: In Germany, the Substitute Building Materials Ordinance (Ersatzbaustoffverordnung; (BMUV, 2021)) is enforced. This Ordinance regulates the recycling of certain mineral waste from CDW in technical structures by specifying requirements for the production, classification and installation of mineral waste substitute building materials. Many of the elements that would be required for an End-of-Waste regulation in accordance with national German Circular Economy Act (KrWG) are already included this Ordinance. However, this Ordinance does not currently provide for End-of-Waste.

[16] 31220: Converter slag, 31407: Ceramic; 31409 Building rubble (no building site waste); 31410: Road demolition; 31411: soil excavation; 31427: Concrete demolition; 31467: track ballast; 31498: Slag-containing reclaimed asphalt; 54912: Bitumen, asphalt; 91501: road sweepings (Austria has not adopted the European List of Waste. The Austrian catalogue is less extensive, has a different (5-digit) numbering system and is not harmonized with the EU catalogue).

[17] Concrete waste from unused concrete (10 13 14, 10 13 14, 10 13 14, 17 01 01, 19 12 12); Concrete waste from unused concrete products (16 03 04, 16 03 04, 19 12 12); Concrete waste from used concrete (17 01 01, 17 01 07, 19 12 12)

In the coalition agreement, the German Federal Government set itself the goal of developing specific criteria for achieving the EoW for certain CDW. In order to realise this goal, the BMUV[18] has decided to define corresponding criteria for mineral substitute building materials that originate from the processing of mineral waste and whose further intended use can exclude their waste status. A key point paper on the End-of-Waste Ordinance for certain mineral substitute has been formulated (BMUV, 2023). It is proposed to establish End-of-Waste criteria for the following waste materials:

- Soil and stones: According to the Substitute Building Materials Ordinance, the material classes for soil material (BM-0, BM-0, and BM-F0) and track ballast (GS-0);
- Recycling building materials: According to the Substitute Building Materials Ordinance, material class RC-1;
- Brick material: According to the Substitute Building Materials Ordinance, material class ZM.

Italy: The Ministry of the Ecological Transition established a regulation governing the EoW status of inert waste from construction and demolition and other mineral waste (Legislative Decree No 152 of 27 September 2022; (MASA, 2022)). The wastes allowed for the production of recovered aggregate are defined by EU LoW and are without any exception non-hazardous[19]. In addition to the allowed input materials, the regulation defines for example minimum processing and storage criteria, criteria on the quality of recovered aggregate and specify usability purposes. The quality requirements of the recycled aggregates must be analysed for each batch and in addition to that, a quality management system must be in place and a monitoring system needs to be installed. Furthermore, a 'Declaration of Conformity' and modalities must be provided with each batch. Quality parameters to be analysed are for example asbestos, various aromatic hydrocarbons, polycyclic aromatic hydrocarbons, heavy metals, salts, floating materials and foreign fractions.

The recycled aggregates shall be in accordance with defined technical standards and the use shall be limited to

- the realisation of the body of detections of civil engineering works on the ground;
- the construction of road, rail, airport and civil and industrial sub-basins;
- the construction of building blocks of transport infrastructure and civil and industrial apron;
- the implementation of environmental recoveries and filling;
- the creation of ancillary layers having, but not limited to, counter capillary, anti-frost and drainage functions;
- packaging of concrete and bound mixtures with hydraulic binders (e.g. cemented mixtures, concrete mixtures).

Ireland: developed four case-by-case decisions for aggregates produced from non-hazardous demolition concrete waste and in addition established national EoW criteria determining when recycled aggregate ceases to be waste (EoW-N001/2023) (EPA-IR, 2023). These are briefly explained below. Recycled aggregate shall cease to be waste when all of the following conditions are fulfilled and the recycled aggregate results from a recovery operation undertaken under an appropriate waste authorisation:

[18] Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection

[19] **Inert waste from construction and demolition activities (Chapter 17 of the EU LoW):** 17 01 01 cement; 17 01 02 bricks; 17 01 03 tiles and ceramics; 17 01 07 mixtures or slag of cement, bricks, tiles and ceramics, other than those mentioned in 17 01 06; 17 03 02 bituminous mixtures other than those mentioned in 17 03 01; 17 05 04 excavated earth and rocks, other than those mentioned in 17 05 03; 17 05 08 rail ballast other than that mentioned in 17 05 07; 17 09 04 mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03.

Other inert waste of mineral origin (not covered by Chapter 17 of the EU LoW): 01 04 08 waste gravel and chippings other than those mentioned in 01 04 07; 01 04 09 waste sand and clay; 01 04 10 powders and similar residues, other than those mentioned in 01 04 07; 01 04 13 wastes from cutting and sawing stone other than those mentioned in 01 04 07; 10 12 01 residues of preparation mixture not subjected to heat treatment; 10 12 06 waste moulds consisting exclusively of frictles and scrap of glazed and cooked raw ceramic products or of cooked clay and expanded clay, possibly covered with raw enamel in a concentration < 10 % by weight; 10 12 08 ceramic waste, bricks, bricks and building materials (heat treated); 10 13 11 wastes from the production of composites based on cement, other than those mentioned in 10 13 09 and 10 13 10; 12 01 17 residues of sanding material other than those mentioned in 12 01 16 consisting exclusively of waste abrasive sands; 19 12 09 minerals (e.g. sand, rock).

— the waste used as input for the recovery operation complies with the set criteria (e.g. only non-hazardous waste, no C&D fines, no asbestos and a defined list of waste with List of Waste code);

— the waste used as input for the recovery operation has been treated in accordance with the defined criteria (e.g. all treatment processes needed to prepare the recycled aggregate for direct input into final use shall have been completed);

— the quality of the recycled aggregate complies with the criteria including pollutant limits (e.g. solid and leachate pollutant limit values) and physical contaminant limits (e.g. ferrous and non-ferrous metals, gypsum, glass, no asbestos detected);

— the producer has satisfied sampling and testing requirements;

— the producer has satisfied storage requirements (e.g. separate storage);

— the producer has satisfied requirements set for the specific use and restriction of use, the statement of conformity, and the quality management systems;

— the producer has satisfied requirements within any guidance issued by the Agency in relation to these criteria.

The Netherlands: In 2015 the Dutch Government published Regulation No IENM/BSK-2015/18222, laying down rules for determining the EoW status of recycled granules (SEITV, 2015). The criteria to reach EoW for recycled aggregates mainly relate to the existing EU product standards and to Dutch regulations for aggregates, including the Soil Quality Decree. The NL set requirements on the input material, namely stone like waste to be processed into recycling granules. The input material must not be hazardous waste. At least visual observation of the input material has to be performed, so that the input material does not contain asbestos and asbestos-containing or suspected asbestos-suspected materials, tar asphalt, roofing materials, domestic waste, gypsum, soil, soot and wood to an extent that could endanger the quality of recycling granules.

Regarding the final use, for application to or in soil, ground or surface water the recycled granules have to comply with the compositional values and emission values set out in the Soil Quality Decree. For recycling granules used in asphalt, the composition value of PAHs shall not exceed 75 mg/kg dry substance. Furthermore a maximum level of contaminants defined in the standard EN 13242 shall not be exceeded (for impurities having a similar mass of 1.000 kg/m^3 or less: 10 cm^3/kg; for impurities of a similar mass greater than 1.000 kg/m^3: 1 %). In addition to these criteria, further requirements are defined for sampling, production control, quality management system and statement of conformity.

Table 11. EoW criteria for CDW recycling in Member States (non-exhaustive list)

Member State	**Targeted waste**	**Status**
Austria	Recycled building materials.	**Implemented:** Recycling Building Materials Ordinance BGBl. II Nr. 181/2015)
Germany	Proposal	**Planned:** Ministerial key issues paper on the End-of-Waste Ordinance for certain mineral substitute building materials has been developed.
Finland	Crushed concrete	**Implemented:** Government Decree on End-of-Waste Criteria for Crushed Concrete (466/2022)
France	Aggregates produced from construction and public works to be used in road building	**Implemented:** Order No 2010-1579 of 17 December 2010 based on the WFD definition and supplemented by Decree No 2012-602 of 30 April 2012.
Ireland	Recycled aggregates[20]	**Implemented (national EoW criteria):** Decision EoW-N001/2023 of 12th September 2023 establishing criteria determining when recycled aggregate ceases to be waste
	Concrete (17 01 01 concrete from CDW)	**Implemented (case-by-case decisions):** Art28-0034: Decision on EoW Criteria relating to Recycled Aggregates from Crushed Demolition Concrete (2019)

[20] IE specifies EoW criteria for recycled aggregates not only from CDW but various different mineral wastes from multiple sources

	Various codes[21] Concrete and soil and stone: 17 01 01 concrete (from CDW)) 17 05 04 soil and stone other than those mentioned in 17 05 03, (non-hazardous) 17 01 01 concrete (from CDW)	Art28-0035: Decision on EoW Criteria relating to Recycled Aggregates from Construction and Demolition Waste (2019) Art28-0056: Decision on EoW Criteria relating for recycled aggregate (2022) Art28-0059: Decision on EoW Criteria relating for recycled aggregate (2023)
Italy	Inert CDW and other waste aggregates of mineral origin	**Implemented**: Regulation governing the end of waste status of inert construction and demolition waste and other inert waste of mineral origin. Decree 152 of 27 settembre 2022.
The Netherlands	Recycled aggregates	**Implemented**: Regulation on Recycling Aggregates from stony waste. Regulation No IENM / BSK-2015/18222 of February 5, 2015.

4.4.2 Voluntary industry guidelines for EoW-criteria

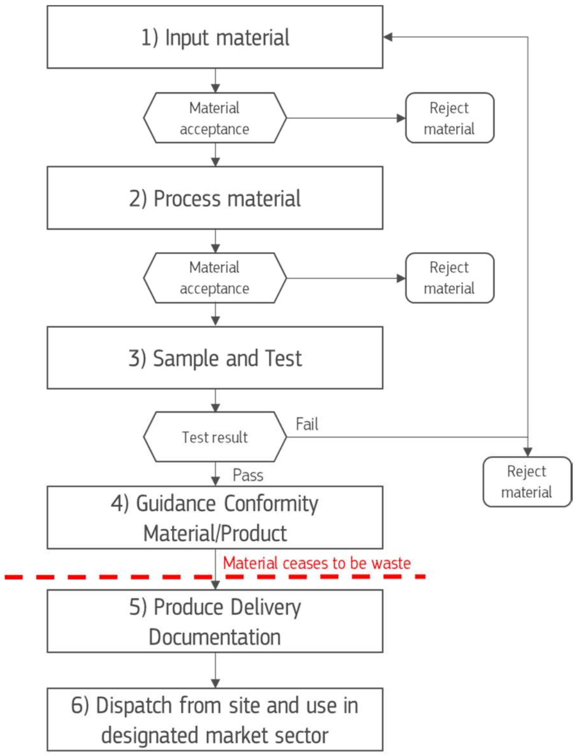
In the absence of EU-wide harmonised EoW criteria, 'Aggregates Europe' (UEPG, 2022a) developed guidance to set out the common requirements that will enable recycled materials (aggregates) to cease to be waste and hence meet the relevant product standards. It is proposed that compliance with these criteria shall ensure that the recovered material will be accepted as 'product'. It is important to notice, that this guidance is voluntary and producers and users are not obliged to conform with the defined criteria. The main stages and control mechanism to reach EoW are (**Figure 10**):

1) Input material: Only non-hazardous CDW materials listed in Annex 6 (**Table 17**) of the guideline. Waste acceptance criteria must be applied;
2) Process Material: In accordance with the permit requirements and Factory Production Control;
3) Sample and test: In accordance with the European standard and the requirements of the Member States where the materials is intended to be placed on the market;
4) Guidance Conformity Material/Product;
5) Produce Delivery Documentation;
6) Dispatch from site of production for storage and uses in designated market sector.

For all steps, a record management is required.

[21] Inputs shall be restricted to the non-hazardous list of waste codes as outlined below: 17 01 01: concrete; 17 01 02: brick; 17 01 03: tiles and ceramics; 17 01 07: mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06; 17 05 04: soil and stone; 17 09 04: mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03; 19 12 12: other wastes (including mixtures of materials) from mechanical treatment of waste other than those mentioned in 19 12 11; 19 12 12 wastes shall be restricted to those originating from the processing of 17 01 01, 17 01 02, 17 01 03, 17 01 07, 17 05 04 or 17 09 04.

Figure 10. The main stages and control mechanism to reach EoW according to Aggregates Europe' (UEPG, 2022a)



5 First JRC proposals for EU wide End-of-Waste criteria for mineral CDW

In the following, preconditions, a consolidated scope and first preliminary proposals for allowed and restricted input materials as well as the point of EoW and the intended use of output materials are presented. No further proposals are made at this stage for the other sets of criteria such as treatment processes and techniques, quality criteria for EoW materials, quality control and self-monitoring and statement of conformity (see also section **Figure 1**). The proposals for these specific criteria and further requirements for the allowed input material will be developed following the stakeholder consultation phase, once additional information becomes available.

5.1 One set of criteria

Following the approach of the previously developed EoW criteria, the aim of this work is to develop **one single set of criteria** that can be applied to determine when mineral CDW is no longer considered waste.

5.2 EoW status exclusively for recycling and recycled aggregates

The EoW criteria shall **exclusively be developed for recycling of mineral CDW.** The rationale behind this is that recycling covers currently the largest mass flow, while the (preparing for) re-use of building products was ranked in the lowest priority group by the (TAUW, 2024) study (section1.4.2). The main reason for being ranked last is that (preparing for) re-use is mainly limited to fire clay bricks and the amount that is currently (prepared for) re-used is negligible in comparison to the total recycled mineral CDW fractions. Furthermore, the development of EoW criteria for (preparing for) re-use would require a separate set of criteria.

The output materials of mechanical CDW recycling processes are aggregates with different particle sizes. According to (CEN, 2011), aggregates can be classified into fine aggregate (0.063[22]–4 mm; sand) and coarse aggregate (>4–63 mm; gravel). For certain unbound application, aggregates with a particle size up to 90 mmone setof can be used (EN 13285 – unbound mixtures). Therefore, the JRC proposes, that the output material of a recycling process should be **recycled aggregates** with a particle size ranging from 0.063–90 mm (see also section 5.6.1). With this particle size, the most common used grain sizes for bound (e.g. concrete[23]) and unbound purposes (e.g. road pavement, track ballast) are covered.

5.3 Restriction of CDW with hazardous properties and containing POPs

The WFD sets minimum recovery target of 70 % for **non-hazardous CDW** by 2020. As presented in section 4.4.2, the UEPG Guidance does not allow CDW that contains or is contaminated with dangerous substances to reach EoW. In line with the targets of the WFD, the UEPG Guidance and existing national EoW criteria (e.g. AT, IE, IT, FI, NL), the JRC proposes to exclude any CDW with hazardous properties and containing POP concentrations above the defined limit value in Annex IV of the POP Regulation (EU) No 2019/1021. By not allowing hazardous waste, also **asbestos containing mineral CDW is excluded**.

Annex 3 (**Table 13**) highlights that hazardous waste is only a small part of all CDW. Therefore, the exclusion of this hazardous waste material has only a minor impact on the recycling rate. The advantage of an exclusion of hazardous waste fractions for EoW criteria is that this may lead to less stringent requirements on the output material, as only clean input materials are used for recycling. This can reduce the administrative burden and analytical costs.

5.4 Input materials under scope

Allowed input materials for recycling could be defined with a positive list. Certain CDW show properties that are detrimental to the recycling process, the recycled aggregates, and could pose a risk to human health and the environment. These CDW could be restricted.

Based on the results from the JRC scoping exercise (section 1.4.1), the ranking from the DG GROW study (section 1.4.2) and the analysis presented in this background paper (e.g. existing national EoW criteria, non-governmental

[22] Fines (clays and silts) pass through a 0.063 mm sieve (EN 12620) and are not considered as targeted aggregates in this work.

[23] Common grain groups used in concrete are 0/2; 0/4; 2/8; 5.6/11.2; 8/16; 11.2/22.4; 8/31.5 and 16/31.5 mm.

EoW guidelines, relevance of CDW material streams) the JRC proposes to have the following **source separated non-hazardous mineral CDW and mixtures of these mineral CDW** under scope:

— concrete (pure and reinforced concrete);

— fired clay (e.g. bricks and tiles, also with rests of mortar);

— ceramics (glazed and unglazed, such as wall & floor tiles, bricks & roof tiles, refractories, sanitary ware);

— stones and boulders (e.g. armour stones);

— mixtures of the above mentioned mineral CDW.

With the five selected **mineral CDW fractions, 77 % of the generated CDW in the EU** (excl. soil, track ballast, dredging spoils and asphalt) is under scope (see also Annex 3, **Table 13**).

Based on the current knowledge, the JRC suggests **to exclude the following inert/mineral CDW materials from the scope** and provides a brief explanation for their exclusion:

— **Inert insulation (mineral and rock wool):** has a relatively low proportion in CDW in terms of its weight (see **Table 13**) and currently hardly any infrastructure for recycling, even though the recycling is technically feasible. Only 2 % of the inert insulation is recycled, while 98 % is landfilled (**Table 5**). In practice, mineral or rock wool are recycled into new insulation materials and are not recycled together with the non-hazardous mineral CDW under scope. This means that no recycled aggregates are produced, which is a fundamental requirement of the current JRC proposal.

— **Gypsum plasterboards**: have a low proportion in CDW in terms of its weight (see **Table 13**) and currently hardly any infrastructure for recycling. Currently 90 % of gypsum from CDW is landfilled (**Table 5**). The technical approach of gypsum plasterboard recycling is to separately collect the plasterboards and separate the gypsum from the plasterboard and produce a gypsum that can be used for new gypsum plasterboards but also any other gypsum products. This means that no recycled aggregates are produced, which is a fundamental requirement of the current JRC proposal.

— **Glass:** has a low proportion in CDW in terms of its weight (see **Table 13**), If broken at a construction or demolition site, it cannot be recovered and ends up in the fine fraction of the mineral CDW. Currently 24 % of the glass from CDW is recycled (**Table 5**). For glass cullet, EU-wide EoW criteria have been already been established (Commission Regulation (EU) No 1179/2012) and thus glass is not under scope

Track ballast: This waste stream has a low proportion on the total amount of CDW in terms of its weight (see **Table 13**). But for track ballast the assessment is challenging as there are information constraints due to missing reporting. The JRC is aware that track ballast is currently already processed either directly on site or in external plants. The processed stones can be reinstalled as recycled gravel or re-used as gravel for other purposes such as road construction, for example. However, usually over the decades of use, the track bed is inevitably exposed to certain sources of contamination (Bassey et al., 2020; Bukowiecki et al., 2007; Burkhardt et al., 2008; EAWAG, 2005; Rak et al., 2022) such as:

  - metals and heavy metals from abrasion of breaks, tracks, wheels and overhead contact lines;
  - hydrocarbons from impregnated wooden railway sleepers and lubricants;
  - herbicides (residues) from vegetation control;
  - organics (e.g. plants, soil) from the surrounding environment.

Due to the potential contamination, the JRC currently refrains from including this waste fraction as an allowed input material as a precautionary principle. At the same time, the JRC requests additional information on track ballast to be provided in order to carry out a more in-depth analysis of this waste stream.

— **Asphalt:** Although asphalt is not a mineral CDW due to the bitumen content, it is listed here for the sake of completeness. According to **Table 13**, the share of asphalt waste in terms of its weight in total CDW is very low (1 %). A likely reason is that asphalt is re-used/recycled in-situ and does not even become waste in practice.

The JRC also proposes to exclude **mixed CDW** (mineral fractions with non-mineral fractions) as allowed input material. As described in section 3.3.4, certain sorting and recycling technologies are already on the market and capable to treat mixed CDW by removing waste materials such as metals, light fractions (e.g. plastics), and wood during the recycling process and to produce mineral recycled aggregates (Deloitte, 2017). However, mixed CDW should not be an allowed input material. The rationale behind this is that mixed CDW contradicts the measure defined by the WFD Article 11 (see also section 1.1) to ***promote selective demolition*** *in order to enable removal and safe handling of hazardous substances and facilitate re-use and high-quality recycling by selective removal of materials, and to ensure the establishment of sorting systems for construction and demolition waste at least for wood, mineral fractions (concrete, bricks, tiles and ceramics, stones), metal, glass, plastic and plaster.'* Allowing mixed CDW as allowed input material would most probably result in the need of additional output material criteria for certain substances, resulting in additional cost to analyse the output material.

Nevertheless, the JRC requests additional information on recycled aggregates from mixed CDW to carry out a more in-depth analysis of this waste stream.

5.5 Sources of mineral CDW under scope

For the development of EU-wide EoW criteria it is proposed to allow **non-hazardous mineral CDW** from **construction works, including buildings and civil engineering works** from all economic activity sectors as input to reach EoW. Furthermore, **mineral CDW generated at every stage of the life cycle of a building and civil engineering works,** including construction, maintenance, renovation, refurbishment, deconstruction and demolition shall be under scope.

The JRC is aware of certain sources of CDW that could be restricted to avoid negative impacts on recycling process and output material. The list below is non-exhaustive and should be considered as examples for restricted source for input material:

- Selected CDW from the (petro-)chemical - or extractive industry (e.g. building and infrastructure parts that are in contact with potentially hazardous substances such as reactors, reservoirs, or pipes);
- Selected CDW from power plants (e.g. exclude any CDW from nuclear power plants due to radioactive concerns, exclude buildings parts that were in contact with substances that could affect the quality of the CDW (e.g stacks in contact with flue gas).

In the questionnaire the stakeholders will be asked to elaborate on the sources that should be restricted as allowed input material.

5.6 Point of End-of-Waste and intended use

5.6.1 Point of End-of-Waste

As already highlighted in section 3.3.4, a material classified as waste in principle ceases to be waste following a recycling or other recovery operation, given it fulfils the requirements in Article 6(1) of the WFD. Furthermore, certain allowed treatment processes and techniques have to be defined when developing EoW criteria (Article 6(2b)). Therefore, the JRC proposes that EoW status should be granted after a recycling operation has been completed, at the point at which the output material is in the form of coarse **recycled aggregates** (see section 5.2).

As presented in section 3.3.4, the JRC is aware, that other possible output materials such as recycled concrete sand, (ultrafine) hydrated cement components, waste cement paste or mud from washing process can be produced to for example substitute virgin cement. However, these technologies have a low TRL level (e.g. research or pilot scale level) and are therefore not foreseen as EoW output material at this stage.

5.6.2 Intended use

In the WFD, recycling is clearly defined as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for **the original or other purposes.** It does not include energy recovery and the reprocessing into materials that are to be used as fuels or for **backfilling operations**. Backfilling operations are explicitly excluded as an intended use to reach EoW, as the WFD defines in Article 3(17), that backfilling is not a recycling operation. According to WFD Art 11a(5), EoW materials used for backfilling have to be discounted from recycling and hence a dual possible use output may complicate the accounting of recycling for CDW.

Therefore, the JRC proposes that EoW status can only be achieved if the recycled aggregates are again used **as construction material for buildings and other infrastructure.** Similar to natural aggregates, the recycled aggregates should therefore exclusively be used for unbound and bound applications defined in section 3.3.6.

The use of the recycled aggregates for purposes such as reclamation in excavated areas or for engineering purposes in landscaping (see also definition of backfilling in Annex 7, Glossary) is **not considered as intended use**. If recycled aggregates are used for this purpose, EoW status cannot be achieved.

6 Next steps

The stakeholders who expressed interest to participate in the project are requested to fill in the **EU-Survey (https://ec.europa.eu/eusurvey/runner/CDW_EoW_Consultation; password:** jrc-cdw)**.**

The EU-Survey should be filled out latest by **26 November 2024**.

Feedback specifically related to this **background paper** can be given using the word template, which can be uploaded via the EU-Survey (see Section 6).

Additional documents, that exceed the maximum file size to upload to EU-Survey shall be sent to the JRC at JRC-END-OF-WASTE@ec.europa.eu (please use "**CDW-EOW – Feedback XX**" as e-mail subject, where XX is the name or acronym of your organisation).

References

ANEFA. (2022). *Plan estratégico del sector de los áridos – Áridos 2030. ISBN 978-84-125559-0-5*.

Bassey, D., Ngene, B., Akinwumi, I., Akpan, V., & Bamigboye, G. (2020). *Ballast Contamination Mechanisms : A Criterial Review of Characterisation and Performance Indicators*.

BML. (2015). *Verordnung des Bundesministers für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft über die Pflichten bei Bau- oder Abbruchtätigkeiten, die Trennung und die Behandlung von bei Bau- oder Abbruchtätigkeiten anfallenden Abfällen, die Herstellung und d*.

BMUV. (2021). *Ersatzbaustoffverordnung. Verordnung über Anforderungen an den Einbau von mineralischen Ersatzbaustoffen in technische Bauwerke. 9. Juli 2021 (BGBl. I S. 2598).*

BMUV. (2023). *Eckpunktepapier zur Abfallende-Verordnung für bestimmte mineralische Ersatzbaustoffe. Referate T II 4, T II 2 und T II 1*. 1–17.

Braga, A. M., Silvestre, J. D., & de Brito, J. (2017). Compared environmental and economic impact from cradle to gate of concrete with natural and recycled coarse aggregates. *Journal of Cleaner Production*, *162*, 529–543. https://doi.org/https://doi.org/10.1016/j.jclepro.2017.06.057

Bukowiecki, N., Gehrig, R., Hill, M., Lienemann, P., Zwicky, C. N., Buchmann, B., & Weingartner, E. (2007). *Iron , manganese and copper emitted by cargo and passenger trains in Zu ¨ rich (Switzerland): Size-segregated mass concentrations in ambient air*. *41*, 878–889. https://doi.org/10.1016/j.atmosenv.2006.07.045

Burkhardt, M., Rossi, L., & Boller, M. (2008). *Diffuse release of environmental hazards by railways*. *226*(September 2006), 106–113. https://doi.org/10.1016/j.desal.2007.02.102

Butera, S., Christensen, T. H., & Astrup, T. F. (2014). Composition and leaching of construction and demolition waste: Inorganic elements and organic compounds. *Journal of Hazardous Materials*, *276*, 302–311. https://doi.org/10.1016/j.jhazmat.2014.05.033

Byggforetagen. (2019). *Resource and waste guidelines for construction and demolition*.

Cembureau. (2021). *Fact Sheet: the Story of Cement Manufacture. Cembureau. The European Cement Association*. https://cembureau.eu/media/drylkjo0/manufacturing-process-factsheet_update-jan2021.pdf

Cembureau. (2024). *Key Facts & Figures. The European Cement Association - Cembureau. Access on 22.5.2024*.

CEN. (2011). *Aggregates for concrete. European Standards EN 12620.*

CEN. (2024). *CEN/TC 154 - Aggregates. Standardization in the field of natural, recycled and manufactured aggregates, by specifying aggregate performance characteristics, sampling and methods of test*.

CEPS. (2014). *Study on composition and drivers of energy prices and costs in energy intensive industries: the case of the ceramics industry - bricks and roof tiles. Centre for European Policy Studies (CEPS). Ref. Ares(2014)174452 - 27/01/2014*.

Cerame-Unie. (2024). *Ceramic Industry. Cerame-Unie. The European Ceramic Industry Association. Access on 4.6.2024*. https://www.cerameunie.eu/ceramic-industry/

Cinderela. (2021). End of Waste criteria protocol for waste used as aggregates. *New Circular Economy Business Model for More Sustainalbe Urban Construction*, *May*, 93.

Cook, E., Velis, C. A., & Black, L. (2022). Construction and Demolition Waste Management: A Systematic Scoping Review of Risks to Occupational and Public Health. *Frontiers in Sustainability*, *3*(June). https://doi.org/10.3389/frsus.2022.924926

Cristóbal García, J., Caro, D., Foster, G., Pristerà, G., Gallo, F., & Tonini, D. (2024a). *Techno-economic and environmental assessment of construction and demolition waste management in the European Union. Publications Office of the European Union, Luxembourg, JRC135470*. https://doi.org/10.2760/721895

Cristóbal García, J., Caro, D., Foster, G., Pristerà, G., Gallo, F., & Tonini, D. (2024b). *Techno-economic and environmental assessment of construction and demolition waste management in the European Union Status quo and prospective potential.Publications Office of the European Union, Luxembourg, 2024, doi:10.2760/721895, JRC135470.* https://doi.org/10.2760/721895

Damgaard, A., Lodato, C., Butera, S., Fruergaard Astrup, T., Kamps, M., Corbin, L., Tonini, D., & Astrup, T. F. (2022). *Background data collection and life cycle assessment for construction and demolition waste (CDW)* *management, Publications Office of the European Union, Luxembourg, 2022, doi:10.2760/772724, JRC 130992*. https://doi.org/10.2760/772724

Delgado, L., Catarino, A. S., Eder, P., Litten, D., Luo, Z., & Villanueva, A. (2009). End of waste criteria, final report. In *JRC Scientific and Technical Reports* (Vol. 14, Issue 3). https://doi.org/10.2791/28650

Deloitte. (2017). *Resource efficient use of mixed wastes improving management of construction and demolition waste – Final report. Prepared for the European Commission, DG ENV. (Issue October)*. Publications Office. https://doi.org/doi/10.2779/99903

Dhir, R. K., & Paine, K. A. (2007). *Performance related approach to use of recycled aggregates. WRAP Final Report.*

Ding, T., Xiao, J., & Tam, V. W. Y. (2016). A closed-loop life cycle assessment of recycled aggregate concrete utilization in China. *Waste Management*, *56*, 367–375. https://doi.org/https://doi.org/10.1016/j.wasman.2016.05.031

EAWAG. (2005). *Water protection on railway installations. Substances emitted during normal SBB operations and principles of their environmental behaviour. Eawag.*

EC. (2016). *EU Construction & Demolition Waste Management Protocol. European Comission. Directorate-General for Internal market, Industry, Entrepreneurship and SMEs.*

EC. (2018). *Guidelines for the waste audits before demolition and renovation works of buildings. EU Construction and Demolition Waste Management. European Commission. Directorate-General for Internal market, Industry, Entrepreneurship and SMEs.*

EC. (2022). *Revised Construction Products Regulation. Factsheets. European Commission. March*, 9–10. https://doi.org/10.2873/46052

EC. (2024a). *CE marking. Internal Market, Industry, Entrepreneurship and SMEs. European Commission. Access on 4.6.2024*. https://single-market-economy.ec.europa.eu/single-market/ce-marking_en

EC. (2024b). *Ceramics. Internal Market, Industry, Entrepreneurship and SMEs. European Comission. Access on 4.6.2024*. https://single-market-economy.ec.europa.eu/sectors/raw-materials/related-industries/non-metallic-products-and-industries/ceramics_en

EC. (2024c). *EU Construction & Demolition Waste Management Protocol including guidelines for pre-demolition and pre-renovation audits of construction works. European Comission. Directorate-General for Internal market, Industry, Entrepreneurship and SMEs (DG GROW).*

EC. (2024d). *European assessment documents and European technical assessments. Internal Market, Industry, Entrepreneurship and SMEs. European Commission.* https://single-market-economy.ec.europa.eu/sectors/construction/construction-products-regulation-cpr/european-assessment-documents-and-european-technical-assessments_en

EEA. (2002). *EEA Glossary. Construction and demolition waste.*

EEA. (2020). *Construction and demolition waste: challenges and opportunities in a circular economy. European Environment Agency.* https://www.eea.europa.eu/publications/construction-and-demolition-waste-challenges

EPA-IR. (2023). *National End-of-Waste Decision EoW-N001/2023 of 12th September 2023 establishing criteria determining when recycled aggregate ceases to be waste under Regulation 28 of the European Union (Waste Directive) Regulations 2011 – 2020*. *305*.

Eurostat. (2023). *Waste generation by economic activities and households, 2020. Source: env_wasgen*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Waste_statistics#Total_waste_generation

Fořt, J., & Černý, R. (2020). Transition to circular economy in the construction industry: Environmental aspects of waste brick recycling scenarios. *Waste Management*, *118*, 510–520. https://doi.org/10.1016/j.wasman.2020.09.004

Gebremariam, A. T., Di Maio, F., Vahidi, A., & Rem, P. (2020). Innovative technologies for recycling End-of-Life concrete waste in the built environment. *Resources, Conservation and Recycling*, *163*(April), 104911. https://doi.org/10.1016/j.resconrec.2020.104911

GROW. (2014). *FWC Sector Competitiveness Studies - Competitiveness of the Ceramics Sector. Within the*

Framework Contract of Sectoral Competitiveness Studies – ENTR/06/054. Final report, 13 October. Ref. Ares(2014)75606 - 15/01/2014 2008.

GROW. (2016). *Technical and Economic Study with regard to the Development of Specific Tools and / or Guidelines for Assessment of Construction and Demolition Waste Streams prior to Demolition or Renovation of Buildings and Infrastructures. Specific Contract. 30-CE-0751*.

GROW. (2018). *Composition and Drivers of Energy Prices and Costs: Case Studies in Selected Energy Intensive Industries – 2018. Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs Directorate C — Industrial Transformation and Advanced Value Chai*.

Gühlstorf, S., & Dörner Kies, O. (2023). *THE MUSTERBUDE Recycled Concrete Sample Building*.

Iacovidou, E., & Purnell, P. (2016). Mining the physical infrastructure: Opportunities, barriers and interventions in promoting structural components reuse. *Science of The Total Environment*, *557–558*, 791–807. https://doi.org/https://doi.org/10.1016/j.scitotenv.2016.03.098

Jaganmohan, M. (2024). *Distribution of the production value of ceramics in Europe in 2018, by end use. Statista*. https://www.statista.com/statistics/1248963/distribution-of-european-ceramics-production-value-by-end-use/

Kameda, T., Takahashi, K., Kim, R., Jiang, Y., Movahed, M., & Park, E. K. (2014). Asbestos: use, bans and disease burden in Europe. *Bulletin of the World Health Organization*, *92*(11), 790–797. https://doi.org/10.2471/BLT.13.132118

Knoeri, C., Sanyé-Mengual, E., & Althaus, H.-J. (2013). Comparative LCA of recycled and conventional concrete for structural applications. *The International Journal of Life Cycle Assessment*, *18*(5), 909–918. https://doi.org/10.1007/s11367-012-0544-2

Marinković, S., Radonjanin, V., Malešev, M., & Ignjatović, I. (2010). Comparative environmental assessment of natural and recycled aggregate concrete. *Waste Management*, *30*(11), 2255–2264. https://doi.org/https://doi.org/10.1016/j.wasman.2010.04.012

Marsh, A. T. M., Velenturf, A. P. M., & Bernal, S. A. (2022). Circular Economy strategies for concrete: implementation and integration. *Journal of Cleaner Production*, *362*(May), 132486. https://doi.org/10.1016/j.jclepro.2022.132486

MASA. (2022). *Regolamento che disciplina la cessazione della qualifica di rifiuto dei rifiuti inerti da costruzione e demolizione e di altri rifiuti inerti di origine minerale. DECRETO 27 settembre 2022, n. 152. Ministero dell'Ambiente e della Sicurezza Energetica. MAS*.

MPA. (2020). *Concrete Industry Sustainability Performance Report. 14th report: 2020 performance data*. https://www.sustainableconcrete.org.uk/Sustainable-Concrete/Performance-Indicators-(1)/Transport.aspx

Orveillon, G., Pierri, E., Egle, L., Gerbendahl, A., Wessman, P., Garcia John, E., & Saveyn, H. G. M. (2022). *Scoping possible further EU-wide end-of-waste and by-product criteria* (Issue March). https://doi.org/10.2760/067213

Pacheco, J., de Brito, J., & Lamperti Tornaghi, M. (2023). *Use of recycled aggregates in concrete Opportunities for upscaling in Europe*. https://doi.org/10.2760/144802

Rak, A., Klosok-bazan, I., Zimoch, I., & Machnik-slomka, J. (2022). Analysis of railway ballast contamination in terms of its potential reuse. *Journal of Cleaner Production*, *378*(October), 134440. https://doi.org/10.1016/j.jclepro.2022.134440

REBRICK. (2013). *REBRICK project*.

SEITV. (2015). *Regulation of the State Secretary for Infrastructure and the Environment, of 5 February 2015, No IENM/BSK-2015/18222, laying down rules for determining the end-of-waste status of recycling granules*.

Serres, N., Braymand, S., & Feugeas, F. (2016). Environmental evaluation of concrete made from recycled concrete aggregate implementing life cycle assessment. *Journal of Building Engineering*, *5*, 24–33. https://doi.org/https://doi.org/10.1016/j.jobe.2015.11.004

Svedmyr, K., Weckman, A., Suikkanen, T., Wium Pálmarsdóttir, J., Grønhaug, B., Damsgaard, J., Lund, M., & Jönbrink, A. K. (2024). Reuse, recycling and recovery of construction and demolition waste in the Nordic countries : n inventory of facilities and techniques in the Nordics including an outlook on other European countries. In *TemaNord NV - 2023:544*. Nordisk Ministerråd. https://doi.org/10.6027/temanord2023-544

TAUW. (2024). *Background Data Collection for Future EU End-of-Waste Criteria of Construction and Demolition Waste – GROW/2022/OP/0015. Deliverable 3 'Final Report on background data and information collected (Task 3).*

TPE. (2024). *Bricks and Tiles - European Manufacturing. Tiles & Bricks Europe (TBE)*. http://www.tiles-bricks.eu/industry

Turk, J., Cotič, Z., Mladenovič, A., & Šajna, A. (2015). Environmental evaluation of green concretes versus conventional concrete by means of LCA. *Waste Management*, *45*, 194–205. https://doi.org/https://doi.org/10.1016/j.wasman.2015.06.035

UEPG. (2021). *Annual review 2020-2021. European Aggregates Association.*

UEPG. (2022a). *UEPG Guidance - End of Waste Criteria For Recycled Aggregates From Construction & Demolition Waste. European Aggregates Association.* 1–24.

UEPG. (2022b). *UEPG Roadmap to 2030 - The European Aggregates Industry 2021. UEPG (Aggregates Europe)*.

UNEP. (2019). *Basel Convention on the control of transboundary movements of hazardous waste and their disposal. Protocol on liability and compensation for damage resulting from transboundary movements of hazardous wastes and their disposal. Texts and Annexex. Revised i*.

Villanueva, A., & Eder, P. (2014). End-of-waste criteria for waste plastic for conversion. In *Luxemburg*. https://doi.org/10.2791/13033

Visintin, P., Xie, T., & Bennett, B. (2020). A large-scale life-cycle assessment of recycled aggregate concrete: The influence of functional unit, emissions allocation and carbon dioxide uptake. *Journal of Cleaner Production*, *248*, 119243. https://doi.org/https://doi.org/10.1016/j.jclepro.2019.119243

Wahlström, M., J, B., T, T., J, B., A, S., & A, P. (2020). *Construction and Demolition Waste: Challenges and opportunities in a circular economy; European Enviroment Agency_European Topic Centre Waste and Materials in a Green Economy*. *January*, 53.

Wahlström, M., Teittinen, T., Kaartinen, T., & van Cauwenberghe, L. (2019). *Hazardous substances in construction products and materials*.

Whittaker, M. J., Grigoriadis, K., Soutsos, M., Sha, W., Klinge, A., Paganoni, S., Casado, M., Brander, L., Mousavi, M., Scullin, M., Correia, R., Zerbi, T., Staiano, G., Merli, I., Ingrosso, I., Attanasio, A., & Largo, A. (2021). Novel construction and demolition waste (CDW) treatment and uses to maximize reuse and recycling. *Advances in Building Energy Research*, *15*(2), 253–269. https://doi.org/10.1080/17512549.2019.1702586

Xing, W., Tam, V. W. Y., Le, K. N., & Hao, J. L. (2021). Proceedings of the 25th International Symposium on Advancement of Construction Management and Real Estate. In *Proceedings of the 25th International Symposium on Advancement of Construction Management and Real Estate*. Springer Singapore. https://doi.org/10.1007/978-981-16-3587-8

YM. (2022). *Government Decree on End-of-Waste Criteria for Crushed Concrete (466/2022). Ministry of the Environment, Finland.* 1–16.

Zhang, C., Hu, M., Di, F., Sprecher, B., Yang, X., & Tukker, A. (2022). An overview of the waste hierarchy framework for analyzing the circularity in construction and demolition waste management in Europe. *Science of the Total Environment*, *803*, 149892. https://doi.org/10.1016/j.scitotenv.2021.149892

Zhang, C., Hu, M., Yang, X., Miranda-Xicotencatl, B., Sprecher, B., Di Maio, F., Zhong, X., & Tukker, A. (2020). Upgrading construction and demolition waste management from downcycling to recycling in the Netherlands. *Journal of Cleaner Production*, *266*, 121718. https://doi.org/10.1016/j.jclepro.2020.121718

Zhang, Y., Luo, W., Wang, J., Wang, Y., Xu, Y., & Xiao, J. (2019). A review of life cycle assessment of recycled aggregate concrete. *Construction and Building Materials*, *209*, 115–125. https://doi.org/https://doi.org/10.1016/j.conbuildmat.2019.03.078

List of abbreviations

BAT	Best Available Techniques
BREF	BAT Reference Document
CEAP	Circular Economy Action Plan
CEN	European Committee for Standardization
C&D	Construction and Demolition
CDW	Construction and Demolition Waste
CE	Conformité Européenne meaning European conformity
CLP	Classification, Labelling and Packaging
CMC	Component Material Criteria
CPR	Construction Product Regulation
DG ENV	Directorate General for the Environment
DG GROW	Directorate General for Internal Market, Industry, Entrepreneurship and SMEs
DG JRC	Directorate General of the Joint Research Centre
EC	European Commission
EFTA	European Free Trade Association
EoW	End-of-Waste
ETA	European Technical Assessment
EU	European Union
EUROSTAT	European Statistics
GHG	Greenhouse Gases
HAS	Heating Air System
hEN	Harmonised standards
LCA	Life Cycle Assessment
JIG	Gravimetric sorting by differential acceleration
Kt	Kilo tonnes
Mt	Million tonnes
NIR	Near-infrared
OENORM	Austrian Standard
PAH	Polycyclic Aromatic Hydrocarbons
PSD	Particle Size Distribution
POP	Persistent Organic Pollutants
RA	Recycled aggregates
RBA	Recycled Brick/Ceramic Aggregates
RCA	Recycled Concrete Aggregates
RMA	Recycled Mixed Aggregates
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
RP	Recycled Plasterboard
SME	Small-Medium Enterprises
SVHC	Substances of Very High Concern
TC	Technical Committee
TRL	Technology Readiness Level
UEPG	European Aggregates Association
UNEP	United Nations Environment Programme

VIS	Visible
WFD	Waste Framework Directive
WSR	Waste Shipment Regulation

List of figures

List of tables

Annexes

Annex 1. Waste codes for CDW waste defined in the European List of Waste

Table 12. CDW materials defined in the List of Waste (LoW)

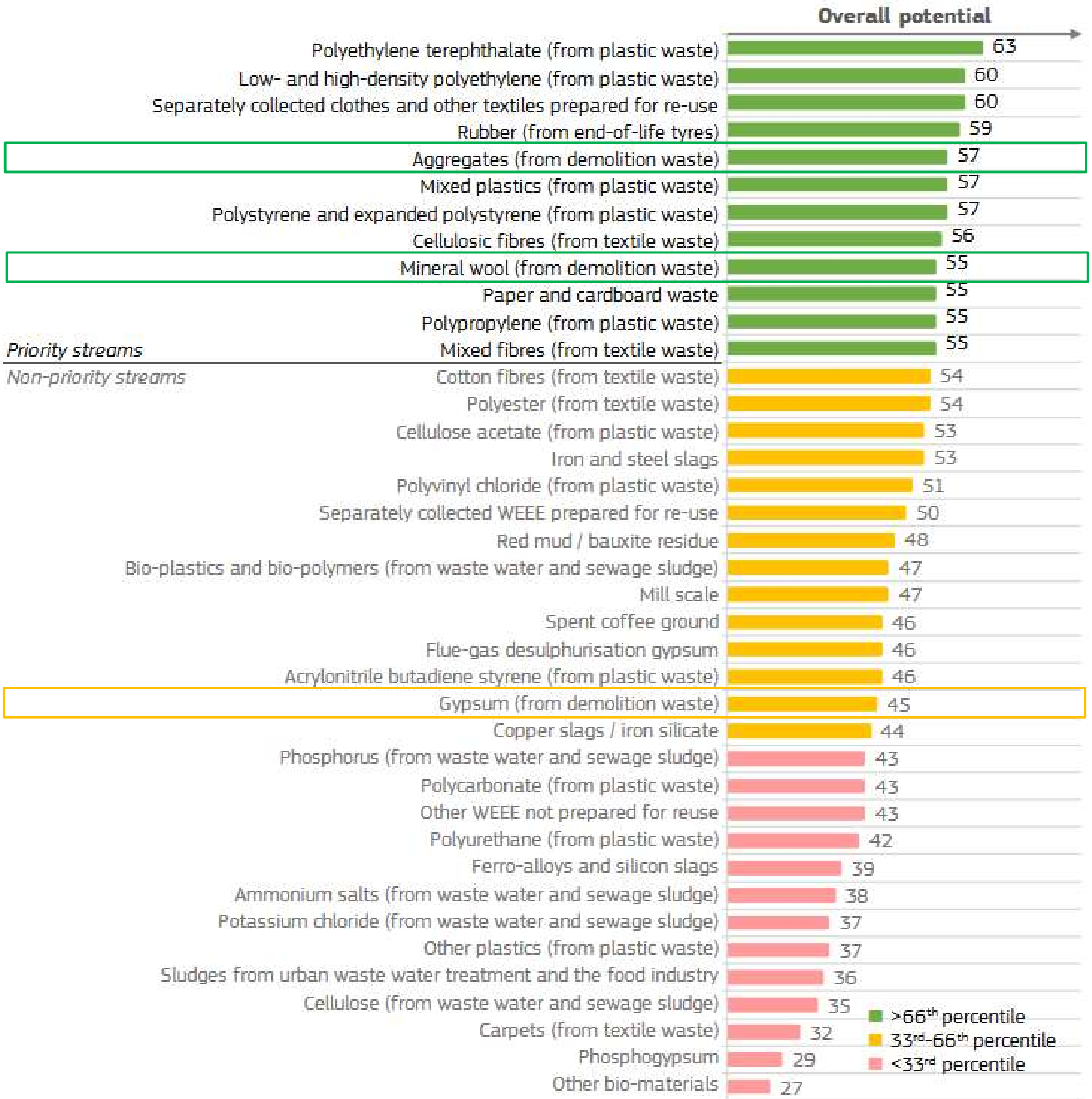
CDW materials	LoW code
Mineral waste	17 01
Concrete	17 01 01
Bricks	17 01 02
Tiles and ceramics	17 01 03
Mixed/other/inert waste	17 01 07
Asphalt waste	17 03 02
Plastic	17 02 03 / 19 12 04
Metal	17 04
Mixed metals, incl. cables	17 04 07, 17 04 1
Ferrous	17 04 05 / 19 12 02
Non-ferrous	17 04 01, 17 04 02, 17 04 03, 17 04 04, 17 04 06 / 19 12 03
Glass	17 02 02 / 19 12 05
Wood	17 02 01 / 19 12 07
Gypsum	17 08 02
Insulation	17 06 04
Paper and cardboard	19 12 01[24]
Mixed waste, generic	17 09 04 / 19 12 09
Mix of non-hazardous, non-inert waste	
Mix of inert and non-hazardous non-inert wastes	
Others	
Soils	
Unpolluted	17 05 04

[24] There is no LoW code for paper and cardboard within the Construction and Demolition waste category

Polluted	17 05 03*
Dredging spoil	
Unpolluted	17 05 06
Polluted	17 05 05*
Track ballast	
Unpolluted	17 05 08
Polluted	17 05 07*
Hazardous waste (excl. hazardous soil, dredging spoil, track ballast)	17 01 06*, 17 02 04*, 17 03 01*, 17 03 03*, 17 04 09*, 17 04 10*, 17 06 01*, 17 06 03*, 17 06 05*, 17 08 01*, 17 09 01*, 17 09 02*, 17 09 03*

Annex 2. Final ranking of candidate streams for developing EU-wide EoW or by-product criteria

Figure 11. Final ranking of the candidate streams for which to develop further EU-wide EoW or by-product criteria based on their overall potential (Orveillon et al., 2022)



Annex 3. Average CDW composition excluding and including soil, track ballast, dredging spoils, and asphalt.

Table 13. Current average CDW composition (expressed as % of current CDW amounts) for EU. CDW data are presented excluding and including soil, track ballast, dredging spoils, and asphalt.

CDW	Total CDW generation excl. soil, track ballast, dredging spoils and asphalt	Total CDW generation incl. soil, track ballast, dredging spoils and asphalt
Mineral waste	**77.0 %**	**27.5 %**
Concrete	*24.0 %*	*8.6 %*
Bricks	*5.0 %*	*1.8 %*
Tiles and ceramics	*1.2 %*	*0.4 %*
Mixed/other mineral/inert waste	*46.9 %*	*16.8 %*
Plastic	**0.2 %**	**0.1 %**
Metal	**4.3 %**	**1.5 %**
Mixed metals	*0.5 %*	*0.2 %*
Ferrous	*3.4 %*	*1.2 %*
Non-ferrous	*0.4 %*	*0.1 %*
Glass	0.2 %	0.1 %
Wood	2.3 %	0.8 %
Gypsum	1.4 %	0.5%
Insulation	0.3 %	0.1 %
Paper and cardboard	0.2 %	0.1 %
Mixed waste, generic	12.3 %	4.4 %
Hazardous waste (total, excluding hazardous soil and dredging spoil)	1.8 %	0.6 %
Soil (hazardous and non-hazardous)	-	54 %
Dredging spoil (hazardous and non-hazardous)	-	9.2 %
Track ballast and asphalt[25]	-	1.0 %
TOTAL	100 %	100 %

[25] Reclaimed asphalt is defined as asphalt paving material, which is milled or scraped off an existing bituminous pavement due to maintenance, reconstruction, resurfacing, or to obtain access to buried utilities. It should be noted that such materials might not necessarily be defined and classified as waste (Damgaard et al., 2022).

Annex 4. Summary of management options reported in the literature for the different mineral CDW fractions

Table 14. Summary of management options reported in the literature for the different mineral CDW fractions. CD: Conventional demolition; DfD: Design for Deconstruction; SD: Selective demolition; TRL: Technology Readiness Levels.

Mineral waste fraction	Enabling process/ measure	Management option	Main output	Potential material substituted	Reference	TRL
Concrete	SD, DfD	Preparing for re-use	Concrete material	Concrete	(Marsh et al., 2022)	9
	CD, SD	Recycling	Cementitious material Recycled aggregates	Cement Sand/Gravel	(Gebremariam et al., 2020; C. Zhang et al., 2020)	7-8
	CD	Recycling[1]	Recycled aggregates	Sand/Gravel	(C. Zhang et al., 2020)	9
	CD	Landfill	-	-	(Data by Ecoinvent)	9
Ceramic & Tiles	SD, DfD	Preparing for re-use	Ceramic material	Ceramic material	(Whittaker et al., 2021)	9
	SD	Recycling	Cementitious material	Cement	(Fořt & Černý, 2020)	6-7
	SD, CD	Recycling[1]	Recycled aggregates	Sand/Gravel	(Fořt & Černý, 2020)	9
	CD	Landfill	-	-	(Data by Ecoinvent)	9
Bricks	SD, DfD	Preparing for re-use	Brick	Brick	(REBRICK, 2013)	7-9
	SD	Recycling	Cementitious material	Cement	(Fořt & Černý, 2020)	6-7
	CD	Recycling[1]	Recycled aggregates	Sand/Gravel	(Fořt & Černý, 2020)	9
	SD	Recycling	Alkali activated blocks	Concrete	(Fořt & Černý, 2020)	6-7
	CD	Landfill	-	-	(Data by Ecoinvent)	9

(1) This can also be considered as recovery – backfilling depending on final use.

Source: Adapted from Cristóbal García et al. (2024).

Annex 5. Summary of content of major and minor elements and characteristics of leachate from batch tests of various mineral CDW media

Table 15. Summary of the content of major and minor elements in various mineral CDW media: total carbon, trace elements and organic compounds of 33 samples (TS: total solid; LOD: limit of detection). (Butera et al., 2014)

	Mean	Inter-sample variation	LOD
Aluminium (g kg^{-1} TS)	42	±19%	0.001
Calcium (g kg^{-1} TS)	85	±21%	0.14
Iron (g kg^{-1} TS)	13	±24%	0.001
Potassium (g kg^{-1} TS)	16	±25%	0.03
Sodium (g kg^{-1} TS)	11	±26%	0.004
Silicon (g kg^{-1} TS)	270	±7%	0.27
Magnesium (g kg^{-1} TS)	3.7	±21%	0.003
S as sulphate (g kg^{-1} TS)	5.3	±38%	0.21
TC (%)	1.6	±44%	0.03
TOC (%)	0.37	±132%	0.03
Arsenic (mg kg^{-1} TS)	3.4	±21%	1.33
Barium (mg kg^{-1} TS)	410	±22%	0.05
Cadmium (mg kg^{-1} TS)	0.21	±24%	0.03
Chloride (mg kg^{-1} TS)	140	±56%	2.0
Cobalt (mg kg^{-1} TS)	5.7	±24%	0.01
Chromium (mg kg^{-1} TS)	23	±43%	0.04
Copper (mg kg^{-1} TS)	18	±38%	0.16
Lithium (mg kg^{-1} TS)	13	±26%	0.38
Manganese (mg kg^{-1} TS)	370	±28%	0.48
Molybdenum (mg kg^{-1} TS)	0.80	±24%	0.11
Nickel (mg kg^{-1} TS)	13	±26%	0.06
Phosphorous (mg kg^{-1} TS)	460	±41%	119.5
Lead (mg kg^{-1} TS)	33	±126%	0.01
Antimony (mg kg^{-1} TS)	0.53	±55%	0.13
Selenium (mg kg^{-1} TS)	<7	–	7.0
Strontium (mg kg^{-1} TS)	260	±15%	0.41
Vanadium (mg kg^{-1} TS)	32	±24%	0.08
Zinc (mg kg^{-1} TS)	67	±45%	0.42
PCB_{TOTAL} (μg kg^{-1} TS)	17	±87%	2.13
Sum 16 EPA PAHs (mg kg^{-1} TS)	5.9	±406%	0.15

Table 16. Characteristics of leachate from batch tests on various CDW media; units are mg kg^{-1}, except pH and phenol index which are dimensionless. (Cook et al., 2022)

	Concrete 1		Concrete 2		Bricks 1		Bricks 2		Mixture 1		Mixture 2	
	L/S=2	L/S=10	L/S=2	L/S=10	L/S=2	L/S=10	L/S=2	L/S=10	L/S=2	L/S=10	L/S=2	L/S=10
pH	11.82	11.64	8.45	8.53	8.28	8.48	8.04	8.18	11.87	12.02	10.49	10.24
Fluoride	0.2	1	2	5.9	2.1	3.7	2.4	5.9	0.7	1	3.6	9.9
Chloride	4.2	5	4.2	14	85.2	85	27	5	7	5	1	14
Sulfate	344	626	454	543	190	255	462	517	142	375	593	612
Phenol index	2.2	3.7	0.1	1	0.2	1.5	0.2	1	0.7	7.3	1.1	5.9
As	0.06	0.02	0.01	0.05	0.05	0.16	0.01	0.08	0.01	<0.01	0.03	0.16
Ba	0.06	0.25	0.06	0.17	0.06	0.1 1	0.07	0.3	0.114	0.45	0.052	0.2
Cd	0.002	<0.01	<0.002	<0.01	<0.002	<0.01	<0.002	<0.01	<0.002	<0.01	<0.002	0.01
Cr	0.2	0.3	0.004	0.04	0.01	0.03	0.01	0.07	0.2	0.48	0.11	0.2
Cu	0.4	1	0.1	0.7	0.19	0.75	0.27	0.78	0.198	0.95	0.2	0.57
Hg	0.0001	<0.0005	<0.0001	<0.0005	<0.0001	<0.0005	<0.0001	<0.0005	0.00068	0.00002	<0.0001	0.0005
Mo	0.07	0.14	0.04	0.05	0.04	0.08	0.03	0.05	0.05	0.12	0.09	0.12
Ni	0.04	0.08	0.01	0.03	0.03	0.05	0.01	0.03	0.068	0.08	0.02	0.04
Pb	0.004	0.04	0.006	0.02	0.01	0.03	0.01	0.06	0.016	0.02	0.008	0.05
Sb												
Se	0.006	<0.01	<0.002	<0.01	0.01	0.02	<0.002	<0.01	0.014	<0.01	0.008	0.01
Zn	0.06	0.26	0.05	0.34	0.06	0.21	0.08	0.52	0.104	0.39	0.09	0.56

Annex 6. Acceptable inert waste input materials to reach EoW according to the UEPG EoW Guidance

Table 17. Acceptable inert waste input materials according to the UEPG guidelines (UEPG, 2022a)

Waste code	Content	Clarification on potential inert waste fraction
Waste of naturally occurring minerals (non-hazardous)		
01 04 08	Waste gravel and crushed rocks other than those mentioned in 01 04 07	May include excavation from mineral workings.
01 04 09	Waste sand and clay	Waste sand only, must not include contaminated sand
Construction and demolition waste – concrete, bricks, tiles and ceramics		
17 01 01	Concrete	-
17 01 02	Bricks	-
17 01 03	Tiles and ceramics	-
17 01 07	Mixtures of concrete, bricks, tiles and ceramics other than those mentioned in 17 01 06	-
Construction and demolition waste – bituminous mixtures, coal tar and tarred prod		
17 03 02	Bituminous mixtures other than those mentioned in 17 03 01	Allowed only if: - Bituminous mixtures from the repair and refurbishment of the asphalt layers of roads and other paved areas (excluding bituminous mixtures containing coal tar and classified as waste code 17 03 01). - Must not include coal tar or tarred products. - Must not include freshly mixed bituminous mixture.
Construction and demolition waste – soil (including excavated soil from contaminated sites), stones and dredging spoil		
17 05 04	Soil and stones other than those mentioned in 17 05 03	Must not contain any soil or stone from contaminated site
17 05 06	Dredging spoil other than those mentioned in 17 05 05	Only allowed if: - Inert aggregate from dredgings. - Must not contain contaminated dredgings. Must not contain fin
17 05 08	Track ballast other than those mentioned in 17 05 07	Only allowed if: - Does not contain soil and stones from contaminated site
Construction and demolition waste – other construction and demolition was		
17 09 04	Mixed construction and demolition wastes other than those mentioned in 17 09 01, 17 09 02 and 17 09 03	Only allowed if: - The waste is generated from utilities trenchings - The waste consists of sub base aggregates i.e. granular material - The waste contains only materials that would be described by entries 17 01 01, 17 03 02 and 17 05 04 in this appendix if the waste was not mixed
Wastes from the mechanical treatment of waste not otherwise specified (for example sorting, crushing, compacting, pelletising)		
19 12 09	Minerals (for example sand, stones)	Must not contain concrete, bricks, tiles, sand, stone or gypsum from recovered plasterboard.
Municipal wastes (household waste and similar commercial, industrial and institutional wastes) including separately collected fractions		
20 02 02	Garden and park wastes (including cemetery waste) – soil and stones	Must not contain contaminated stones from garden and parks waste.

Annex 7. Glossary

Aggregate: granular material used in construction. Aggregates may be natural, manufactured or recycled (Definition in CEN/TC 154; (CEN, 2024)).

Backfilling: is defined in Art. 3(17a) as '*any 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*'

Collection (follows the (EC) No 2008/98 definition): the gathering of waste, including the preliminary sorting and preliminary storage of waste for the purposes of transport to a waste treatment facility.

Collection rate: percentage of CDW collection compared to the total CDW generation. CDW collected in a country but exported for recycling to another country is included. CDW imported from other countries and recycled in the country in question is not included.

Construction materials: are the raw materials or products used in the construction, renovation, or repair of buildings, infrastructure, and other structures. These materials include a wide range of substances such as aggregates, concrete, steel, wood, bricks, glass, plastic, insulation, wiring, piping, and roofing materials, among others.

Construction and demolition waste (follows the (EC) No 2008/98 definition): means waste generated by construction and demolition activities.

Construction waste: can be generated at every stage of a construction project, from site preparation and foundation work to finishing and landscaping.

Construction works: means buildings and civil engineering works that may both be over or in the ground or water, 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 are the basis for rails of railways.

Contaminants: substances or materials present in CDW waste that are not targeted for its further recycling and which could pose a risk for human health and the environment (e.g. hazardous substances, persistent organic pollutants).

Demolition waste: refers to the debris and materials that are generated during the process of tearing down or dismantling a building or infrastructure. This can include materials such as concrete, bricks, wood, metal, glass, and other construction materials. Demolition waste also includes hazardous materials such as asbestos, lead, and other substances that may require special handling and disposal methods.

Disposal (follows the 2008/98/EC definition): any operation which is not recovery even where the operation has as a secondary consequence the reclamation of substances or energy. Annex I of the Directive sets out a non-exhaustive list of disposal operations.

Energy recovery: it refers to the use of waste principally as a fuel (e.g. refused-derived fuel (RDF)) or other means to generate energy.

Hazardous waste (follows the (EC) No 2008/98 definition): waste which displays one or more of the hazardous properties listed in Annex III of the WFD (e.g. explosive, acute toxic).

Mineral waste: means waste that does not undergo any significant physical, chemical or biological transformations. Mineral waste will not dissolve, burn or otherwise physically or chemically react, 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. The total leachability and pollutant content of the waste and the ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.

Input material: construction and demolition waste used as input to a sorting or recycling facility.

Material recovery (follows the (EC) No 2008/98 definition): 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. It includes, inter alia, preparing for re-use, recycling and backfilling.

Manufactured aggregate: aggregate of mineral origin resulting from an industrial process involving thermal or other modification (Definition in CEN/TC 154; (CEN, 2024)).

Municipal solid waste: non-sorted, mixed waste from households and commercial activities. This waste flow excludes the flows of recyclables collected and kept separately, be it one-material flows or multi-material (commingled) flows.

Natural aggregate: aggregate from mineral sources which has been subjected to nothing more than mechanical processing (Definition in CEN/TC 154; (CEN, 2024)).

Output material: materials obtained in the form of recycled aggregates from a recycling operation

Primary raw material (virgin material): material which has never been processed into any form of end use product.

Recovery (follows the (EC) No 2008/98/EC definition): any operation generating waste serving a useful purpose by replacing other materials which would have been otherwise used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II of the Directive sets out a non-exhaustive list of recovery operations.

Recycled aggregate: aggregate resulting from the processing of inorganic material previously used in construction (Definition in CEN/TC 154; (CEN, 2024)).

Recycling rate: percentage of CDW which is re-used and recycled for making new construction materials, compared to the total construction material consumption.

Treatment (follows the 2008/98/EC definition): recovery or disposal operations, including preparation prior to recovery or disposal.

Visual inspection: means inspection of consignments using either one or all human senses such as vision, touch and smell and any non-specialised equipment. Visual inspection shall be carried out in such a way that all representative parts of a consignment are covered. This may often best be achieved in the delivery area during loading or unloading and before packing. It may involve manual manipulations such as the opening of containers, other sensorial controls (feel, smell) or the use of appropriate portable sensors.

Science for policy

The Joint Research Centre (JRC) provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society

EU Science Hub
joint-research-centre.ec.europa.eu

@EU_ScienceHub

EU Science Hub - Joint Research Centre

EU Science, Research and Innovation

EU Science Hub

@eu_science