Comparative Assessment of CDW Management and Disaster Response: Background Analysis for Material Passports

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Abstract. Construction and demolition waste (CDW) has been globally recognized as one of the most challenging waste streams, while simultaneously offering significant potential for valorization as secondary material resource. To effectively utilize these sources in their end-of-life stage, systematic characterization and robust management strategies are essential. In this context, this study comparatively evaluates the current state of CDW management approaches across the selected EU member states (Cyprus, Estonia, Greece, Latvia, Romania, and Slovenia), Switzerland, and Türkiye, with the objective of supporting the development of CDW material passport systems. The study includes characterization of the CDW streams, analysis of waste statistics and identification of good management practices within these countries, to develop realistic baselines for secondary material indicators at an international level. Furthermore, emergency action plans

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implemented during uncontrolled demolition scenarios, including natural disasters, are benchmarked to identify the operational gaps between standard waste management procedures and crisis response mechanisms. Consequently, the study highlights the urgent need to develop specialized management frameworks that prioritize each component of CDW, even when present in a mixed state, enabling their treatment as valuable secondary resources rather than a burden.

Keywords: Construction and Demolition Waste (CDW) · Material Passport · Disaster Waste Management · Circular Economy · Secondary Raw Materials

1 Introduction

Construction and demolition waste (CDW) is a challenging waste stream due to its mixed composition, difficulty of processing, and large volumes, which can be generated by controlled demolition or renovation work, as well as by natural disasters. This waste stream, the generation of which is largely unavoidable, consists primarily of a mineral waste fraction composed of concrete, bricks, tiles, and ceramic components; plastics; metals; glass; wood; plaster; and insulation materials. These wastes are classified under section 17 of the Waste Code List, defined in 1994 as the European Waste Catalogue (EWC) and renamed the List of Waste (LoW) in 2000 with the updated EU legislation. Regulation (EC) No 2150/2002, published by the European Union in 2002 [1], requires member states to maintain and report waste statistics in EWC-Stat format. However, there are discrepancies in the reporting of CDW statistics among many member states. Despite the data inconsistencies, a report published by the Joint Research Centre (JRC) in 2024 states that nearly 40% of the waste produced in the EU is CDW and the largest share of this waste, excluding excavated soil, belongs to the mineral fraction, with a rate of 77% [2]. The 2008 EU Waste Framework Directive (WFD) [3] sets a 70%-by-weight target by 2020 for reuse, recycling, and other material recovery — including backfilling — of non-hazardous CDW, excluding naturally occurring material under LoW 17 05 04, thereby defining both the quantitative target and the hierarchy in scope. According to Eurostat statistics, the overall recovery rate in the EU was reported at 89% in 2020, but this rate is largely due to member states including backfilling practices in their recovery rate calculations, despite varying definitions and scopes [2].

To eliminate this dependence on low-value recovery and align with the Circular Economy Action Plan (2020), the EU policy framework is shifting its focus from quantity to the quality of recycling. The aim is to keep materials in the loop for as long as possible at their highest value and to promote the secondary raw materials market. However, the biggest obstacle to high-quality recycling is the lack of reliable data on the composition and quality of CDW. In this context, Material Passports (MP) have emerged as critical tools for ensuring traceability, quality assurance, and the separation of hazardous substances at source, and this study aims to assess whether selected countries are ready for MP implementation by comparatively evaluating their CDW management baseline criteria, while also addressing operational gaps in managing these flows under uncontrolled disaster conditions.

2 Methodology

This study adopts a comparative analysis approach covering eight countries with different economic and geographical characteristics. Six of these countries are EU members (Cyprus, Estonia, Greece, Latvia, Romania, and Slovenia), while Switzerland and Türkiye, which are outside the EU, are also included in the analysis. Data on CDW production, composition, and recovery rates were collected from national databases, agency reports, and expert inputs; where source statistics permitted, excavated-soil flows (LoW 17 05 04) were reported separately from the structural mineral fraction to improve cross-country comparability. The collected data were synthesised against four comparative indicators — data availability, EoW circularity, sorting-technology readiness, and disaster-response maturity — to score each region's readiness for Material Passport (MP) adoption.

3 Results and Current State Assessment

3.1 Quantitative Analysis of CDW

Analysis of data collected from partner countries and the relevant literature reveals significant heterogeneity in CDW generation rates. This heterogeneity is largely due to differences in construction intensity and the geological classification of excavated materials. In line with the European average, the mineral fraction (concrete, bricks, tiles, and ceramics; LoW Section 17 01) constitutes the dominant waste stream in all regions studied, excluding soil. However, a significant data comparability issue arises from the reporting of "excavated soil and stones" (LoW-17 05 04). For example, data from Cyprus shows that excavated materials constitute a large proportion of the total waste stream (~1.83 million tons out of 2.39 million tons in 2023) and overshadow data on structural construction materials [4]. Similarly, Greece reports that "soil" constitutes 55.96% of non-hazardous waste [5, 6]. In contrast, Estonia reports a total of 2.5–3 million tons of waste, with mineral waste predominating, but emphasizes that the distinction between "waste" and "by-product" for soil is often based on immediate reuse potential, creating areas with statistical uncertainty [7]. In Slovenia, 8.5 million tons of CDW were generated in 2023 and 7.4 million tons were used for backfilling [8]. According to Eurostat statistics, 390,530 tons and 1,584,229 tons of CDW, of which 1,2% and 39.1% are excavated soil, were generated in Latvia and Romania, respectively, in 2018 [2]. The European Environment Agency reported that 82% of Switzerland's total waste volume came from construction and civil engineering activities [9]. In Türkiye, CDW statistics are not officially reported, so the breakdowns required for MP entries are unavailable. This statistical gap, alongside Greece's high backfilling share, directly blocks the baseline inventory that any digital MP requires, making it the first obstacle to a unified tracking system.

Among the EU countries examined, recycling rates for mineral CDW vary, with some Member States reporting figures below the EU average while maintaining overall recovery rates close to or above the 70% WFD target. This variation partly reflects differences in how Member States classify recovery operations following the 2018 revision of the Waste Framework Directive [2]. Despite around 95% of CDW being reported

as recycled in 2022 [2], in Switzerland, there is no segregated data reporting on CDW treatment, unlike in EU member countries, which makes comparisons difficult. On the other hand, there is no data available on CDW treatment in Türkiye, but backfilling is currently widely used and has been encouraged at the policy level for many years.

3.2 Data Granularity and Metadata Availability

When examining additional metadata collection criteria such as geographic location, building category, or material source -which are significant for the Material Passport concept beyond the basic waste codes of the countries under review- the responses revealed a lack of standardized data protocols necessary for functional Material Passports.

Estonia and Latvia are in the early stages of metadata collection. Currently, data collected on transported waste includes waste producer and recipient, waste type (EWC code), quantity (tonnage), and date of transfer. The focus is on the logistics chain, not on material characterization. However, in Estonia, some companies are developing more detailed digital tools as part of pre-demolition audits [10]. Basic information, such as coordinates, quantity, waste code, designation, and waste recipients, is collected on a mandatory basis in Switzerland, while material origin, geometry, description, various circular and environmental indicators can be collected voluntarily in line with the activities of various sector stakeholders. In Cyprus, the regulations in force require data collection at a very detailed level, demanding the collection and presentation of certain data that, in a sense, make circularity mandatory, such as projected recovery options and management methods. In Romania, no metadata is collected beyond the basic descriptive information required for reporting on CDW in EU member countries. This deficiency causes the material's history and potential contamination risks to be lost as soon as it leaves the site. In Türkiye, the absence of a central registration system worsens the situation; even basic geographic location data is often missing in uncontrolled dumping scenarios. In Slovenia, a digital platform for the Digital Product Passport has been introduced, enabling end-to-end traceability of materials from demolition to recycling and reuse. Metadata includes information such as waste producer, waste type (EWC code), status (hazardous, non-hazardous), transport, processing, treatment, treated mass, etc. [11].

3.3 CDW Separation and Processing Techniques

A comparative analysis of separation and processing technologies reveals a significant "technological divide" between practices in the countries under review. This difference significantly impacts the quality of secondary raw materials (SRM) and the efficiency of disaster waste management. In most of the countries studied (Estonia, Romania, Cyprus, Greece), the processing of CDW is characterized by standard mechanical process chains supported by predominantly manual separation [2, 7, 12]. The typical process involves separating large fractions, mechanical crushing with jaw or impact crushers, screening, and magnetic separation for ferrous metals. While the basic technology is similar, operational differences may exist among the countries. Slovenia emphasizes the use of mobile crushing units directly on construction sites, prioritizing logistical flexibility over advanced stationary processing. In Türkiye, field observations show that advanced

separation is often skipped in favour of rapid rubble removal, and heavy machinery is mostly used to extract high-value steel (rebar), while other potential resources are not recovered [13]. Switzerland exhibits a high level of industrial maturity and automation, based on sensor-based separation and the integration of Artificial Intelligence (AI). Additionally, wet mechanical processing (washing) is used to ensure the high purity of recycled aggregates. A critical finding is that most countries under consideration lack advanced quality-control technologies such as X-ray Fluorescence (XRF) and Hyperspectral Imaging (HSI); this stems primarily from the absence of standardised regulatory requirements rather than from capital cost alone, since such tools remain optional under current EoW regimes.

3.4 End-of-Waste (EoW) Status and Circular Economy Implementation

Most of the countries examined in this study operate at the lower levels of the waste hierarchy. The end-of-life process of CDW is largely limited to mechanical crushing for low-quality applications. In Estonia, Cyprus, Latvia, Greece, and Slovenia, the primary application of the 5Rs of Waste Management (Refuse, Reduce, Reuse, Repurpose, Recycle) principle involves the aggregate conversion of concrete and/or masonry materials to be used in road construction and/or as filler material in concrete blocks. Apart from copper scrap, metal, and glass cullet, there are no specific EoW criteria for other fractions of CDW as defined by the EU [14–16]. Switzerland is an exception, reporting that the active application of the reuse and recycling principles for mineral wastes to be utilized as aggregate is a standardized practice. In Türkiye, however, there is no specific national regulation defining waste classification criteria for materials obtained from CDW. This legal gap often leads to even uncontaminated, crushed concrete being legally considered waste, preventing the development of a secondary raw material market.

3.5 Disaster Waste Management Protocols

Analysis of country-specific data reveals a significant gap in the development of regulatory frameworks for disaster waste management. Several parameters, primarily the country's location, can change the scope of "disaster waste". In the case of disasters, the balance between rapid recovery and material circularity is critical. Most countries lack a separate legal definition or statistical category for disaster waste. In Switzerland, Estonia, Romania, and Cyprus, the waste generated by sudden building collapses or emergency demolitions is considered disaster waste and not recorded separately; instead, emergency plans are activated, and the resulting waste is included in general CDW streams [17]. In Türkiye, earthquakes are a serious reality, causing sudden, massive waste generation. Latvia has an active national disaster management system, but it lacks a dedicated disaster debris management plan comparable to those adopted in high-risk countries [18]. In contrast, Slovenia adopted the "Response Act" to prioritize disaster debris after the 2023 floods, marking a shift towards event-based legislation [19]. Greece prioritizes restoring access to infrastructure, often skipping detailed separation processes during disaster demolitions. This situation reflects conditions in Türkiye, where emergency demolitions and the urgency of debris removal have led to the mixing of hazardous and

non-hazardous waste, severely limiting the potential for high-value recycling and providing an example of how standard regulations in force are insufficient and may pose operational challenges.

4 Conclusion

This comparative analysis reveals that while most of the countries under investigation have aligned their legal frameworks with EU Circular Economy principles, a significant "operational gap" remains in technological infrastructure development and data generation (see Table 1).

On the one hand, Central European models (e.g., Switzerland) demonstrate that high-value circularity can be achieved by aligning strict End-of-Waste regulations with advanced automation. Conversely, the Balkans and Mediterranean regions (e.g., Turkey, Greece, Romania) face a technological readiness gap, in which reliance on manual sorting and visual inspection limits the potential to produce high-quality secondary raw materials. In countries like Turkey, the loss of material metadata during rapid demolition undermines the current post-disaster management approach, making it unsustainable. This gap becomes more critical when considering the implementation of Material Passports (MPs).

Based on the findings, several policy implications emerge: (i) national waste monitoring systems should evolve from tonnage tracking to quality metrics (metadata) tracking to support the creation of valid Material Passports, (ii) legal targets for recycling rates should be accompanied by incentives for improving sorting infrastructure with sensor-based technologies and (iii) for disaster-prone regions, it is proposed that the concept of Material Passports be separated from the demolition phase and integrated into the design and use phases as a preventive disaster management tool.

Ultimately, achieving a resilient circular economy requires a fundamental shift towards data-driven material characterization, enabling buildings to function as material banks even under post-disaster conditions.

Table 1. Summary of the current state of countries under consideration

Country	Data Availability	EoW Status and Circularity	Sorting & Processing Technologies	Disaster Response Protocol
Cyprus	Advanced metadata collected.	Circularity is limited to low-quality road backfilling.	Standard conventional facilities.	Crisis management through event-based Cabinet decisions.
Estonia	Early stages of metadata collection.	More than 90% of the material used was recovered.	Standard conventional facilities.	Framework of the general "Emergency Response Plan".
Greece	Collects only basic EU-required data.	Reports a high backfilling rate.	Basic mechanical processes.	Focuses on rapid infrastructure restoration.
Latvia	Early stages of metadata collection.	Circularity is limited to low-quality backfilling.	Basic mechanical processes.	Currently lacks an active disaster management plan.
Romania	Collects only basic EU-required data.	Recycling rates remain below the EU average.	Basic mechanical processes.	No separate legal definition for disaster waste.
Slovenia	Provides clear statistical breakdowns. DPP practice is available.	Landfill taxes encourage circularity.	Mobile processing units are common.	A special "Intervention Law" was enacted after the 2023 floods.
Switzerland	Integrated digital records and detailed statistics are available.	The EoW criteria are clear. Reusing concrete is standard practice.	AI-based robotic sorting, sensors, and wet processing.	The General Waste Management Act (VVEA) covers disaster situations.
Türkiye	CDW statistics are not reported.	No national regulation for waste classification.	Basic mechanical processes.	Massive waste scale causes bottlenecks.

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References

1. European Parliament and Council: Regulation (EC) no 2150/2002 of the European Parliament and of the Council of 25 November 2002 on Waste Statistics. Official Journal of the European Communities, L 332/1, pp. 1–36 (2002)
2. Cristobal García, J., Caro, D., Foster, G., Pristerà, G., Gallo, F., Tonini, D.: Techno-Economic and Environmental Assessment of Construction and Demolition Waste Management in the European Union. Publications Office of the European Union, Luxembourg (2024). https://doi.org/10.2760/721895
3. European Commission: Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives. Official Journal of the European Union, L 312, pp. 3–30 (2008)
4. Cyprus Recycling Authority (OAK): Απόσπασμα Ετήσιας Έκθεσης 2023 Excerpt from Annual Report 2023. Cyprus Recycling Authority, Nicosia (2023). https://www.oak.org.cy/yearly-reports. Accessed 15 May 2026
5. Collective CDW Management System: Report on Construction and Demolition Waste 2023–2024 (in Greek). Collective CDW Management System, Athens (2024)
6. Hellenic Statistical Authority: Waste statistics (2025). https://www.statistics.gr/el/statistics/-/publication/SOP06/-. Accessed 15 May 2026
7. Estonian Environmental Agency: Waste indicators (2025). https://keskkonnaagentuur.ee/en/estonian-environmental-indicators/estonian-environmental-indicators/waste. Accessed 2026/05/15
8. Statistical Office of the Republic of Slovenia: Construction and demolition waste statistics (2024). https://www.stat.si/StatWeb/news/Index/12770. Accessed 15 May 2026
9. European Environment Agency: Total waste generation – Switzerland (2025). https://www.eea.europa.eu/en/europe-environment-2025/countries/switzerland/waste-generation. Accessed 15 May 2026
10. Ministry of Climate of the Republic of Estonia: Digital construction (2025). https://kliimaministeerium.ee/en/living-environment-circular-economy/construction-and-living-environment/digital-construction. Accessed 15 May 2026
11. REBUILT Project: REBUILT — Digital product passport for the built environment (2026). https://rebuilt.infordata.eu/. Accessed 15 May 2026
12. Ministry of Climate of the Republic of Estonia: Waste (2025). https://kliimaministeerium.ee/en/living-environment-circular-economy/circular-economy/waste. Accessed 15 May 2026
13. Mavroulis, S., Mavrouli, M., Vassilakis, E., Argyropoulos, I., Carydis, P., Lekkas, E.: Debris management in Turkey provinces affected by the 6 February 2023 earthquakes: challenges during recovery and potential health and environmental risks. Appl. Sci. **13**(15), 8823 (2023). https://doi.org/10.3390/app13158823
14. Council of the European Union: Council Regulation (EU) no 333/2011 of 31 March 2011 Establishing Criteria Determining when Certain Types of Scrap Metal Cease to Be Waste under Directive 2008/98/EC. Official Journal of the European Union, L 94, pp. 2–11 (2011)
15. European Commission: Commission Regulation (EU) no 1179/2012 of 10 December 2012 Establishing Criteria Determining when Glass Cullet Ceases to Be Waste under Directive 2008/98/EC. Official Journal of the European Union, L 337, pp. 31–36 (2012)
16. European Commission: Commission Regulation (EU) no 715/2013 of 25 July 2013 Establishing Criteria Determining when Copper Scrap Ceases to Be Waste under Directive 2008/98/EC. Official Journal of the European Union, L 201, pp. 14–20 (2013)
17. Government of Romania: Legea nr. 481/2004 privind protecţia civilă Law No. 481/2004 on civil protection (2004). https://legislatie.just.ro/Public/DetaliiDocument/56923. Accessed 15 May 2026

18. Republic of Latvia: Par valsts civilās aizsardzības plānu On the State Civil Protection Plan (2020). https://likumi.lv/ta/id/317006-par-valsts-civilas-aizsardzibas-planu. Accessed 15 May 2026
19. Government of Slovenia: Draft Act determining intervention measures for flood and landslide recovery of August 2023 (2023). https://www.gov.si/en/news/2023-08-24-draft-act-determining-intervention-measures-for-flood-and-landslide-recovery-of-august-2023/. Accessed 15 May 2026

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