REPORT:
CONSTRUCTION MATERIALS RECOVERY
Opportunities and Challenges

APRIL 2024

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SAINT-GOBAIN

The circular economy paradigm must become the new reality. The time has come when it is essential to build with disassembly and reuse in mind, to treat buildings as banks of raw materials ready for easy deconstruction, and to use recovered materials. We need to look at the construction sector in a whole new way. The change in the status quo of the sector is already supported by new regulations, such as the CSRD and EPBD, the revised CPR, or national regulations that will soon make sorting construction waste compulsory. Unfortunately, it is still all too often the case that we have to follow the beaten track and manage waste according to a linear model. In a circular transformation, we need the involvement not only of decision-makers, but of all stakeholders, including above all investors, architects, contractors and manufacturers. We want to encourage you to see construction waste as a valuable raw material that can be reused in many ways. Please take a look at our publication, in which we provide many tips and good examples of how to carry out the recovery of building materials. We also discuss upcoming regulations that will significantly change the activities of construction sector companies and provide a practical step-by-step guide to recovering value from waste.

Agnieszka Sznyk, President of the INNOWO Institute for Innovation and Responsible Development

We are now living in an incredibly rapidly changing world. Fortunately for us and our surroundings, there has been an increasing emphasis on changes regarding the reduction of human impact on the environment. We want to breathe clean air and have unlimited access to clean water. No one wants to live in a polluted and littered environment or see excessive emissions irreversibly alter our climate. We have already realised that household waste can and should be sorted. However, not everyone is aware that around 30% of waste in the EU comes from construction and demolition activities and that such waste should also be sorted, recycled and reused as a raw material. With this in mind, we are truly proud to present to you Poland's first Report on the Recovery of Construction Materials. Thanks to it, contractors and architects will learn more about how to design and build in order to reduce and manage construction waste wisely. I am really happy that we have been able to describe in the report the good practices that we ourselves have implemented and continue to implement at Saint-Gobain. Enjoy the reading!

Joanna Czynsz-Piechowiak, CEO of Saint-Gobain Poland and Ukraine

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The publication

„CONSTRUCTION MATERIALS RECOVERY: Opportunities and Challenges” has been commissioned by the Saint-Gobain Group in Poland and prepared by the INNOWO Institute for Innovation and Responsible Development.

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The report „CONSTRUCTION MATERIALS RECOVERY - Opportunities and Challenges" is a valuable source of information on the recovery of construction materials for key industry stakeholders including construction companies and policy makers responsible for construction sector regulation. The report focuses on critical aspects related to materials recovery, presenting a comprehensive overview of the related opportunities and strategies.

One of the main strengths of the report is its cross-cutting nature, covering both regulatory requirements and practical aspects of optimising the recovery process. The authors thoroughly analyse the various steps of the recovery process, from planning and potential analysis to the management of recovered materials.

The report is also distinguished by its clear presentation of selected technical aspects of the recovery of various construction materials, which is essential knowledge for industry practitioners. In addition, the practical examples and management strategies for recovered materials can provide inspiration for companies operating in the construction sector.

Also of value is the information on barriers to the recovery of construction materials and the proposed methods to overcome them. Hence, the report not only provides information, but also hands-on solutions that can be applied in daily practice.

The report's comprehensive approach to the subject, transparent presentation of the information and practical tips make it a valuable resource for the further development of a sustainable economy in the construction sector.

prof. dr hab. inż. Krzysztof Pikoń, Head of the Department of Waste Management Technologies and Equipment, Silesian University of Technology

The recovery of building materials is one of the important steps in the transition to a climate-neutral construction industry. This aspect of implementing the principles of a circular economy has a significant impact on decreasing the burden of waste on the environment, while also providing an opportunity to reuse materials recovered from buildings, thereby reducing the sector's consumption of primary raw materials. Statistics from the European Commission make it clear: 50 per cent of the natural raw materials consumed in Europe are used in the construction industry, and around 30 per cent of waste is generated by the industry. Therefore, the systematic implementation of recovery processes at construction sites, both during the construction of new buildings and demolition of existing ones, is a very important development not only for the construction sector, but also for the economy as a whole. The next step is to enforce these regulations effectively and to control the quality of their execution.

Alicja Kuczera, Managing Director of the Polish Green Building Council (PLGBC)

INTRODUCTION

In the face of the global challenges posed by the 21st century, such as climate change, pollution and population growth and continued urbanisation, optimising resource use is becoming essential to our civilisation. The construction sector consumes more than 30% of non-renewable natural resources, so it can play a key role in reducing the negative impact on the environment. In Poland alone, the construction sector consumes 228.6 million tonnes of materials annually, which accounts for 37% of the country's total material footprint.[1]

An effective way to counteract these challenges is to implement the concept of a circular economy (CE). First and foremost, we need to reduce landfill waste and limit the consumption of new raw materials by recovering and reusing construction waste.

Construction and demolition waste is among the largest man-made wastes by volume and weight. They account for approximately 25%-30% of all waste generated in the EU[2] and include a wide variety of materials, such as concrete, glass, bricks, plaster, wood, metals, plastics, panels, mineral wool, sand and many others[3]. The vast majority of them can be recycled and reused.

In our report, we present current and upcoming legal regulations for the recovery of building materials and a practical guide presenting the process and technical aspects of recovering selected construction materials. In addition, we showcase best practices and interesting examples from all over the world regarding the dismantling and effective use of secondary building materials and intersectoral cooperation. We have complimented the report with insights and comments from recognised construction industry experts.

We hope you find our report interesting and useful.

1. Material footprint - the total amount of raw materials extracted to meet the country's final consumption needs. Source: https://unstats.un.org/sdgs/report/2019/goal-12/
2. JRC technical Report, Level(s) – Indicator 2.2: Construction and demolition waste and materials, European Commission, Shane Donatello, Nicholas Dodd, Mauro Cordella, 2021
3. http://www.vipskills.pb.edu.pl/images/download/results/polish/presentations/P27-PL_2.pdf

01
SUMMARY

UPCOMING REGULATIONS

- From 2025, construction and demolition waste will have to be separated into at least 6 fractions: wood, metals, glass, plastics, gypsum and mineral waste (concrete, bricks, tiles, ceramics, stones wools).
- The revision of the CPR will accelerate the circular transformation of the construction industry through changes to the Declaration of Performance and Environmental Product Declaration, and the implementation of a digital passport system for construction products.
- The CSRD obliges some construction companies (from 2024-2026) to non-financial reporting on environmental and social impacts, including, inter alia, carbon footprint and recovery and waste management methods.

DECONSTRUCTION

Through deconstruction, as much as 90-95% of the building materials from a building can be recovered and recycled, of which up to 25% can be reused without processing.

STEP-BY-STEP GUIDE:
How to carry out the recovery of construction materials?

STEP 1.
Identify and evaluate technical options for recovery of materials

Carry out a detailed audit, divide materials into categories and take stock of them.

STEP 2.
Evaluate options for managing recovered materials

Management methods in order from most beneficial to least beneficial: 1) Reuse of the whole building; 2) Reuse of components in other buildings; 3) Regeneration of materials; 4) Recycling of materials.

STEP 3.
Select materials for recovery and decide on their use

Purpose of recovery: 1) For personal use; 2) For use in another construction project; 3) Waste collection company; 4) Internet waste exchange; 5) Waste collection points (for households only).

STEP 4.
Inform the market of your demolition plans and select recipients of materials

Disseminate information about planned recovery to all stakeholders as early as possible to ensure selection of the most favourable recipient.

STEP 5.
Establish a schedule for the recovery and disposal of materials

Key aspects: staged planning, flexible scheduling, limited storage time, alignment of schedule with suppliers, monitoring.

STEP 6.
Prepare site and containers for recovered materials

Providing suitable containers, a clear labelling system, adequate accessibility from the logistics and security perspective.

STEP 7.
Ensure health and safety when recovering materials

Before starting work, carry out a hazard analysis and take all measures to minimise the risk of an accident.

STEP 8.
Take care to preserve the economic value of recovered materials

Key actions: cleaning and repair, appropriate protection against damage, selection of the most cost-effective destination.

TECHNICAL ASPECTS OF THE RECOVERY OF SELECTED MATERIALS

Plasterboards

Recovered boards can be recycled and reused provided several criteria are met. If the board has not been damaged during dismantling, it can be reused through the recycling process.

Suspended ceilings and wall panels

The service life of the ceiling systems is estimated at approximately 50 years. The key technical properties, i.e. sound absorption, reaction to fire and mechanical strength of the panels, do not change over time. The only change is in the visual appearance of the panels and this can be significantly minimised through correct use.

Screeds and flooring

After recovery and processing, concrete can be successfully used to produce new building materials (e.g. new binders, concrete blocks, foundation slabs, road paving), to fill in concrete defects, to reinforce existing structures, to build drainage systems or street furniture.

Glass and stone wool

It is important to dismantle the material in an intact state and to separate the material during demolition in order to prevent contamination of the wool with other construction waste. Recovered material can be processed using the wet recycling method.

Flat glass

Architectural and window glass can be recycled by crushing the raw material using the:
1) implosion method;
2) manual breaking;
3) grinding with a concrete mixer.

Properly sorted and uncontaminated cullet can and should be reused for flat glass production. However, it is usually used as an abrasive or grit for concrete and plaster, aggregate for asphalt, or decorative aggregate.

MANAGEMENT OF RECOVERED MATERIALS

- Key aspects of recovered waste management:
- Supply-driven design.
- Early involvement of the construction contractor.
- Release of budget in advance.
- Temporary storage.

METHODS TO OVERCOME THE MAIN BARRIERS TO MATERIALS RECOVERY

SOLUTIONS for economic barriers:

- Reducing costs through economies of scale.
- Developing innovative business models.
- Creating demand for recycled materials through social campaigns.

SOLUTIONS for social barriers:

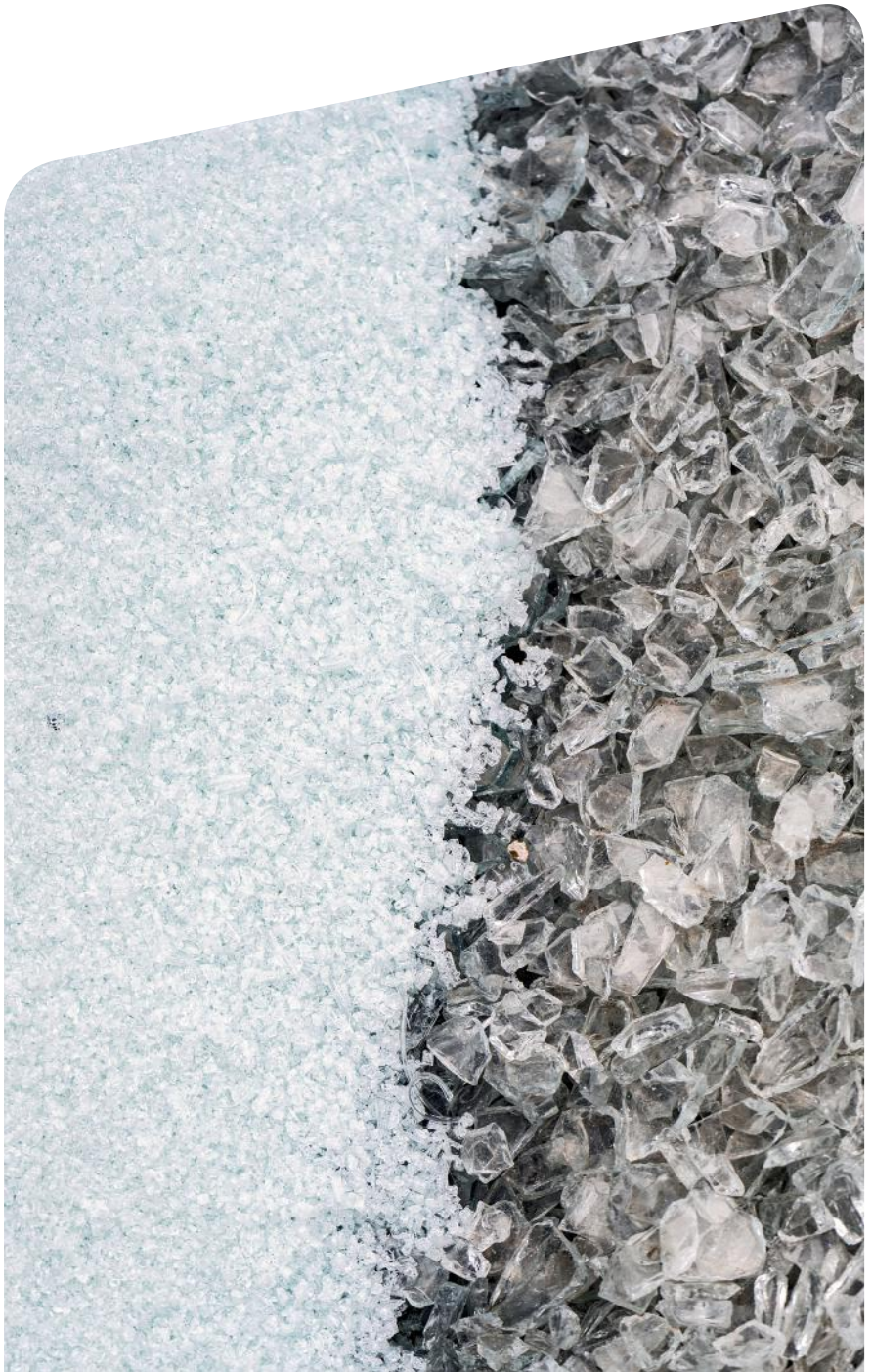
- Raising public awareness of the benefits of the circular model through public education campaigns.
- Training programmes on available recovery methods.
- Laboratory testing for the identification of hazardous substances.

SOLUTIONS for technological barriers:

- Accelerating innovation in the development of construction waste recycling methods.
- Using digital technologies to optimise the recovery process.
- Encouraging knowledge sharing within the sector.
- Increasing the efficiency and compatibility of recycled materials.

SOLUTIONS for regulatory barriers:

- Developing and implementing regulations in favour of circular materials.
- Increasing research and development funding.



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REGULATORY REQUIREMENTS FOR THE RECOVERY OF CONSTRUCTION MATERIALS FOR REUSE

2.1. Current requirements

Construction waste is a special category of waste. The legislator has provided for separate rules for the management and segregation of construction and renovation waste, as well as for its recording in the waste database (BDO). We present all the key regulations governing the current requirements for such waste.

WHAT IS CONSTRUCTION WASTE?

According to the Waste Act[4] construction and demolition waste is ‚waste generated during construction work', i.e. **waste resulting from the construction, alteration, assembly, renovation or demolition of buildings[5].** Construction waste may not be considered household waste.

ARE WE OBLIGED TO RECOVER AND RECYCLE CONSTRUCTION WASTE?[6]

Yes. The Act of 14 December 2012 imposes an obligation on us to **recover and reuse construction waste to the greatest extent possible.**

The Act states that recovery is 'any process whose main outcome is waste serving a useful purpose e.g. by replacing other materials that would otherwise be used for a given purpose, or as a result of which waste is prepared to fulfil such a function in a given facility or in the economy in general'.

Recycling means „recovery whereby waste is reprocessed into products, materials or substances whether for the original purpose or other purposes; this includes the reprocessing of organic material (organic recycling), but does not include energy recovery and reprocessing into materials to be used as fuels or for earthmoving."

4. Art. 3. par. 1 item 6a of the Waste Act
5. https://www.prawo.pl/samorzad/segregacja-odpadow-budowlanych-i-rozbiorkowych,518937.html
6. Waste Act of 14 December, 2012 (Journal of Laws of 2023 item 1587, as amended)

HOW SHOULD WASTE BE HANDLED?

The Waste Act of 14 December 2012[7] introduced the waste hierarchy showing how to make best use of waste:

1. waste prevention;
2. preparing for re-use;
3. recycling;
4. other recovery operations;
5. disposal.

WHO IS RESPONSIBLE FOR WASTE?[8]

According to Directive 2008/98/EC, the ‚polluter pays' principle applies, according to which the **producer of the waste** (construction company or household) **is responsible for its management.**

DOES THE PRODUCER OF CONSTRUCTION WASTE HAVE TO USE THE BDO SYSTEM?

Yes. Companies that produce or own construction waste are obliged to keep records of such waste in the Waste Database (BDO). Exemption from the obligation to keep records applies only to natural persons carrying out construction and renovation work on their own.[9] Such a person may deliver their waste to a waste collection point (PSZOK), provided the limit is not exceeded or to another entity licensed to collect waste.

IMPORTANT!

According to the Regulation of 30 December 2019, small quantities of certain demolition waste (for types and quantity limits see the Regulation) are exempt from the obligation of registration in BDO.[12]

IMPORTANT!

There are separate waste recording rules for construction waste generated in the course of providing off-site construction services.

7. Waste Act of 14 December 2012 Journal of Laws 2023.0.1587, consolidated text, https://lexlege.pl/ustawa-o-odpadach/art-17/
8. Directive 2008/98/EC
9. Art. 66 sec. 4 item D of the Waste Act

ARE THERE SAFETY PRINCIPLES FOR WASTE MANAGEMENT?

YES. Pursuant to Directive 2008/98/EC and Article 16 Journal of Laws 2023.1587 consolidated text[10] "waste management must be carried out in a way that **does not pose a risk** to water, air, soil, plants or animals, **does not cause a nuisance** through noise or odours and does not harm rural areas or places of special significance."[11]

HOW TO STORE CONSTRUCTION WASTE?

Both companies and private individuals are **prohibited from placing construction waste in municipal waste containers**.[12] According to the law, a violation of this provision is punishable by a fine of up to PLN 500. Illegal storage or disposal of debris is subject to a fine of between PLN 20 and PLN 5,000.[13]

HOW LONG CAN WASTE BE STORED?

Pursuant to Article 25 of the Waste Act of 14 December 2012[15]:

- **"Waste, with the exception of waste destined for storage,** may be stored if the need for storage arises from technological or organisational processes for a period not exceeding the time justified by the application of those processes, **but no longer than 3 years."**
- "Waste destined for storage may only be stored for the purpose of collecting sufficient quantities of such waste to be transported to a landfill, **but no longer than for one year.**"

These storage periods are added up for all subsequent waste holders.[16]

ARE MUNICIPALITIES OBLIGED TO RECYCLE CONSTRUCTION WASTE?

Yes. According to Article 3b par. 2 of the Act on Maintaining Cleanliness and Order in Municipalities, municipalities are required to ensure that **at least 70% (by weight) of non-hazardous construction and demolition waste that constitutes municipal waste** is **recycled**, prepared for **reuse** or **recovered** by other methods.[17]

10. Art. 16. - [Protection of human life and health and the environment] - Waste, Journal of Laws 2023.1587, consolidated text.
11. Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (OJ L 312, 22.11.2008, p. 3-30). https://eur-lex.europa.eu/PL/legal-content/summary/eu-waste-management-law.html
12. Waste Act of 14 December 2012
13. Art. 24 § 1 of the Code of Offences
14. https://ekordo.pl/selektywna-zbiorka-odpadow-budowlanych-tak-ale-nie-od-stycznia-2023-roku/
15. Act of 19 July 2019 amending the Act on maintaining cleanliness and order in municipalities
16. https://legalnabudowa.pl/gospodarka-odpadami-na-budowie
17. Act of 13 September 1996 on Maintaining Cleanliness and Order in Municipalities (Journal of Laws 1996, item 662)

2.2. Upcoming regulations

With new regulations planned in the coming years, we will see a huge upheaval in the construction and materials recovery industry. More legislation and regulations are coming into force to motivate the construction sector to take care of the value of building materials even at the end of their life cycle, and to recycle and reuse.

The new regulations, including the most famous one on the compulsory segregation of construction waste, will significantly support the circular transformation of the sector and facilitate the recovery of many types of waste. Separate collection will be a huge challenge for construction, demolition and reassembly companies, so it makes sense to start preparing now to meet future requirements. On the following pages we present the content of the upcoming regulations.

MANDATORY SEPARATION OF CONSTRUCTION WASTE INTO 6 FRACTIONS

ALREADY FROM 2025!

Starting from 1 January 2025, construction and demolition waste will have to be **sorted into at least 6 fractions**.[18]

The wording of the new Article 101a of the Waste Act, which will introduce the abovementioned amendment on mandatory waste sorting, is still under discussion. However, according to the latest version[19] **individuals who are not entrepreneurs will be exempted from the sorting obligation.** In this case, the responsibility for waste sorting will rest with the collector.

The waste generator will be allowed to **hand over the sorting obligation to another entity,** provided that a contract is concluded containing information on further management of the collected waste.

18. The Act of 17 November 2021 amending the Waste Act and certain other acts and the Act of 15 December 2022 on the special protection of certain consumers of gaseous fuels have amended the provisions of the Waste Act
19. https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20130000021/U/D20130021Lj.pdf

CONSTRUCTION PRODUCTS REGULATION /CPR

AMENDMENT OF REGULATION 305/2011 ON CONSTRUCTION PRODUCTS

Work is currently underway to finalise the amendment of one of the most important EU regulations for the construction sector, the Construction Products Regulation (CPR). Among other things, the changes aim to **accelerate circular transformation and support green solutions in the construction industry.**

The amendment is likely to be officially published in 2024 and become effective the following year. The content of the document is nearly final and no further significant changes are envisaged (content as of 1 February, 2024). The regulations will be introduced successively over the period of 15 years.

The main forthcoming changes include:

- extension of the scope of information that the manufacturer of the construction product will have to provide on a mandatory basis in the **Declaration of Performance** (DoP)
- changes to the information provided in the **Environmental Product Declaration** (EPD)
- introduction of **digital passports** for construction products. Such a passport will allow all stakeholders to see the entire journey of a product throughout its life cycle.
- introduction of the **Smart CE Marking** system, which will support and harness the flow of data on construction products throughout the value chain, provide improved, digital access to information on each product.
- The EC will be able to introduce minimum requirements for sustainable development and green solutions in **public procurement** for construction materials.[20]

20. https://data.consilium.europa.eu/doc/document/ST-5762-2024-REV-1/en/pdf; https://bzg.pl/poradnik/artykul/deklaracje-srodowiskowe-typu-iii-czego-dowiem -sie-z-epd/ id/49195

CORPORATE SUSTAINABILITY REPORTING DIRECTIVE/CSRD)

Big changes for the construction industry are also coming in relation to the EU's Corporate Sustainability Reporting Directive (CSRD). Under the new regulations, many companies will be required to **report non-financial information** on a range of environmental and social impact indicators. Mandatory reporting will cover, among other things, the **carbon footprint** in all scopes (Scope 1,2 and 3), **recovery and circularity of materials and waste management.** Operators will be obliged to consider the entire value chain, from the design phase, through operation, up to the end of life of a product or building. The new obligation will have a huge impact on changing the operational activities of construction companies. It is worth preparing for these requirements early on.

The reporting obligation will be introduced gradually for different categories of companies:

1. **from 2024** – companies subject to the NFRD, with > 500 employees, revenues > EUR 50 m ; balance sheet total > EUR 25 m
2. **from 2025** – companies meeting min. 2 out of 3 conditions: employees > 250; revenues > EUR 50 m; balance sheet total > EUR 25 m
3. **from 2026** – Listed SMEs meeting min. 2 out of 3 conditions: employees > 10; balance sheet total > EUR 450k; revenues > EUR 900k.

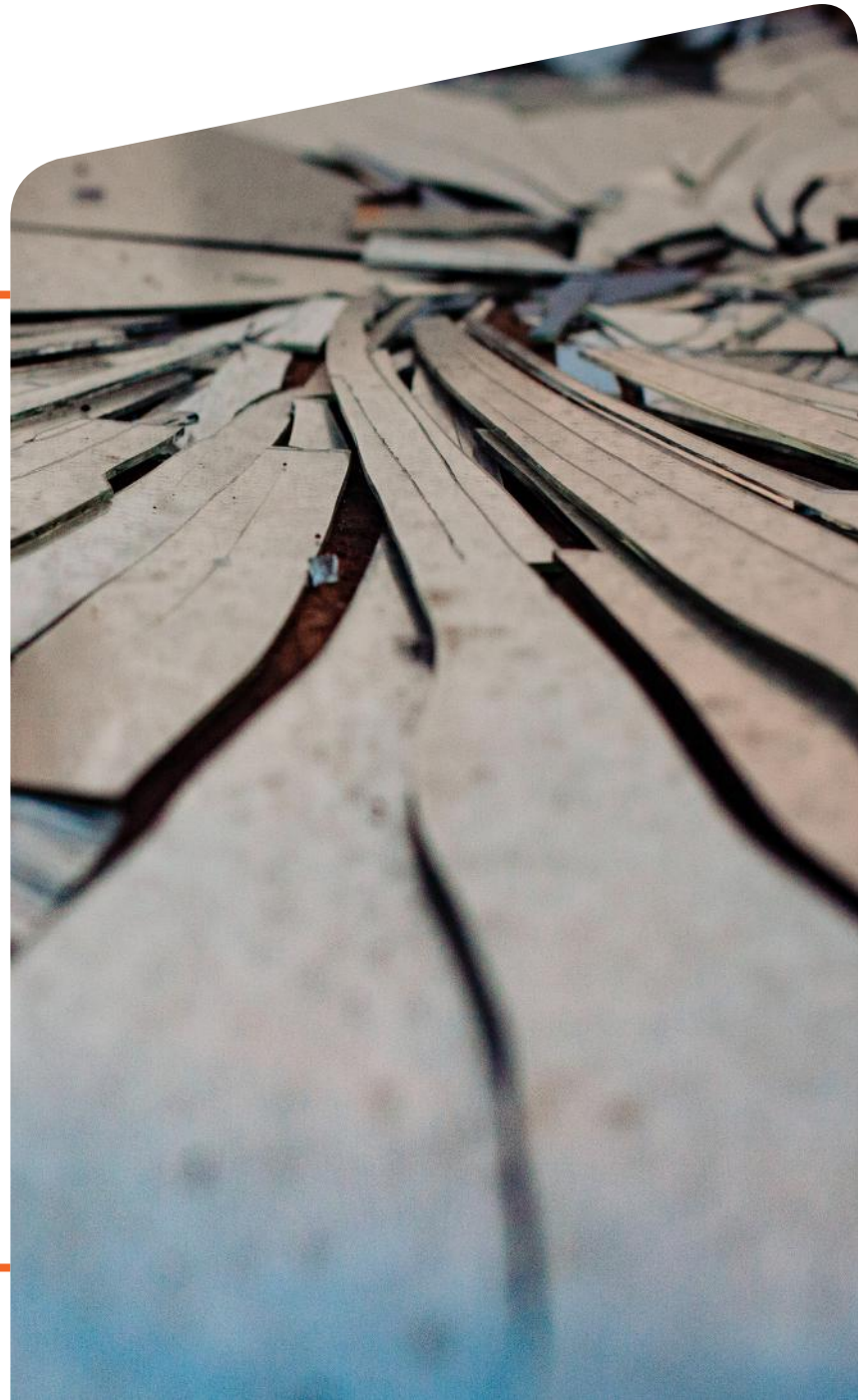
SMEs may defer their reporting obligation until 2028.[21]

21. https://bzg.pl/poradnik/artykul/esg-trend-ktory-zmieni-takze-budownictwo/id/41894#srodtytul-4

The achievement of the EU's environmental objectives has made it necessary to introduce new environmental obligations, without adding disproportionate bureaucracy and costs for economic operators, and to lay the foundations for the development and application of an assessment method for calculating the environmental sustainability of construction products.

On the eve of the entry into force of the revised CPR, it looks all but certain that the harmonised technical specifications and European Assessment Documents will include a list of predetermined essential environmental characteristics related to the life cycle assessment of construction products. For new products, the calculated life cycles will include all stages, from the sourcing of the raw material or its manufacture from natural resources to its final disposal, taking into account the potential benefits and burdens beyond the boundaries of the system. In the case of used and recycled products, the calculated life cycle starts with the dismantling from construction work and includes all subsequent stages up to their final disposal. The calculation should cover the life cycle of the product using methods established through standardisation.

dr Mateusz Kozicki PhD, Head of the Environmental Chemistry Department, Building Research Institute



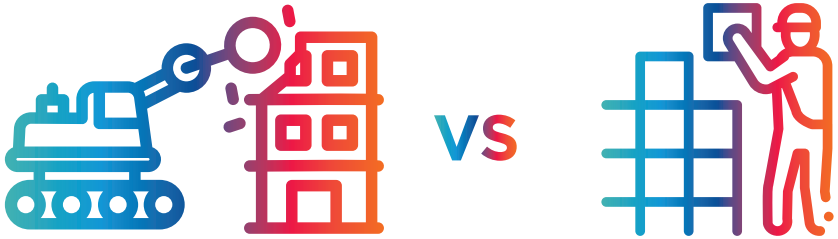
03

OPTIMISING THE RECOVERY OF CONSTRUCTION MATERIALS

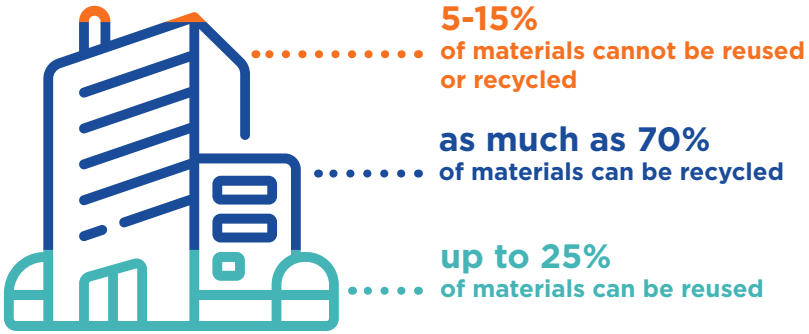
The construction sector is responsible for the largest consumption of raw materials of all sectors of the economy and is on a constant growth wave. Today, the most important aim of the sector should be to counteract the increasing usage of primary materials, to take care of our raw materials and to use them responsibly. In order to achieve this, the priority is to preserve the highest possible value of all materials used in the construction industry for as long as possible. This applies to the design and construction stage, as well as to the modernisation, renovation or complete decommissioning of buildings and infrastructure facilities. This publication focuses on the latter phases of the life cycle of a building, i.e. the preservation of the value of materials during renovation and decommissioning.

There are three main ways to decommission buildings:

- **Deconstruction** which involves careful dismantling of the building, thus preserving the maximum value of the construction materials. This is the most efficient method of recovering construction waste, but requires more manpower.
- **Partial deconstruction** which involves dismantling only selected elements of a building before demolition. Only the most valuable reusable materials are recovered.
- **Demolition** that is, the process of destroying a building completely using heavy equipment, rendering the materials non-reusable and non-recyclable.



Deconstruction is the most time-consuming process which requires more manpower. However, it is only through this approach that we can recover construction materials in their best shape and give them a second life. Using this approach, it is estimated that up to **90-95%** of the construction materials from a building can be **recovered** and **recycled**, of which up to **25%** can be **reused** without the need for processing.[22]



Source: Deconstruction & Building Material Reuse: A Tool For Local Governments & Economic Development Practitioners, May 2018

The transition from traditional demolition to carrying out careful deconstruction is not easy, but necessary. The question is how to properly carry out such deconstruction and how to properly recover building materials. Choosing a deconstruction strategy requires an in-depth knowledge of the characteristics of the building and the demolition procedures that are feasible to carry out, and how these will affect the recyclability of the various elements. We therefore present a practical guide showing how to carry out the process of recovering construction materials during demolition, renovation or retrofitting and how to optimise it.

22. Deconstruction & Building Material Reuse: A Tool For Local Governments & Economic Development Practitioners, May 2018

STEP-BY STEP GUIDE

How to carry out the process of recovering construction materials?

PART 1. Planning and analysis of material recovery potential

The first and crucial step is to identify potential construction materials for recovery. This requires a detailed analysis of the building structure and the type of materials used. For building structures, it is important to identify components that can be safely dismantled or removed from the structure without compromising the integrity of the building. Consider the condition of the materials - components in good condition may be easier to recover and reuse. Here are the next steps to be taken:

- Carry out a **detailed site audit** to identify areas where construction materials can be effectively recovered. Consider all materials, both from the building structure and from supporting infrastructure.
- Divide **identified materials into categories** according to type:
  - construction materials:
    - » concrete
    - » wood
    - » steel
    - » bricks
    - » polystyrene
    - » glass
    - » plasterboards
    - » suspended ceilings
    - » mineral wool: stone and glass
    - » plywood and boards
    - » pipes and insulations
    - » and others;
  - appliances, ornaments and fittings, i.e. light fittings, baths, sinks, toilets, doors, windows, ironmongery, kitchen appliances, worktops, fireplaces, mouldings, floors, furniture.

- **Evaluate and take stock** of each material in terms of:
  - **quantity** (volume, weight, length, area or number)

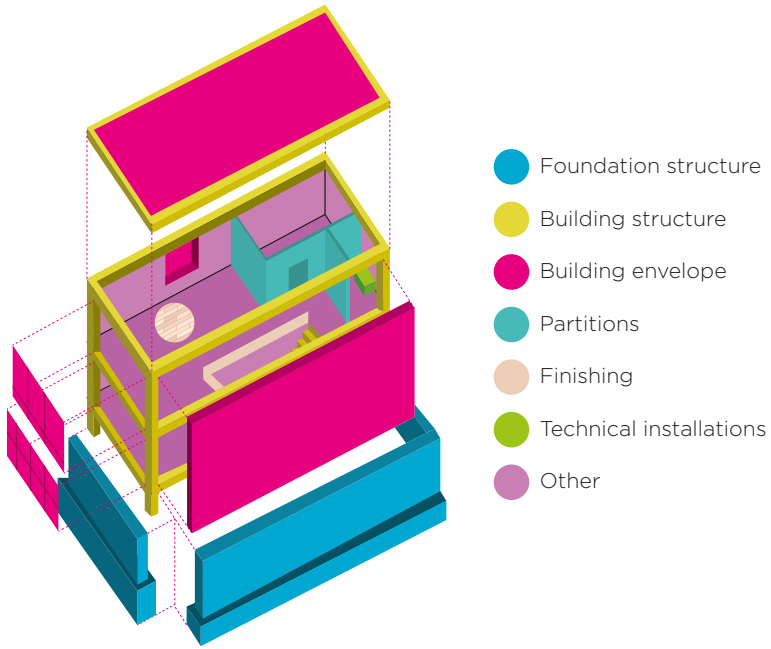
    For example: length of steel pipes; weight of concrete; volume of sand, area of wall cladding; number of internal doors.
  - **how it is connected/attached to the structure**

    For example: dry/wet bonding; type of bond; whether there is a chance of removing the bond without interfering with the condition of the construction material.
  - **quality and technical condition**

    For example: in the case of wooden elements, particular attention should be paid to holes (signs of pests), mould, rot and signs of decay; in the case of plasterboard, attention should be paid to mechanical damage, stains and moisture.

The inventory taking process should be approached in a structured way. Each building, irrespective of its structural system, can be divided into several layers, which should be inventoried and then dismantled in the right order. [Fig. 1].

Figure 1. Deconstruction of a building



Source: Report authors based on Bertino G, Kisser J, Zeilinger J, Langergraber G, Fischer T, Österreicher D. Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials. Applied Sciences. 2021;

The first two layers to be examined and dismantled in the first instance include all **technical installations** (i.e. cabling, plumbing, fire extinguishing systems, air conditioning, heating and ventilation systems) and **finishing elements** (i.e. railings, suspended ceilings and floor tiles).

WORTH KNOWING!

Structures designed according to a flexibility strategy make deconstruction much easier. For example, the use of suspended ceilings allows all installations to be mounted in a visible manner. This allows easy access to installations requiring repair or replacement and allows the ceilings to be easily dismantled.

The third layer consists of **partitions** and **internal doors**. These elements are usually connected to the structure with ‚dry' bonds, so deconstruction is relatively simple and allows these construction materials to be reused unchanged. For example, if the recovered plasterboard is in good condition, it can be reused for partitions or ceilings in new building projects. However, if the material is damaged or worn out, it can be recycled.

The next layer consists of the building envelope and shell - that is, the façade and roof. Depending on the building's structural system, the envelope can have a structural or non-structural function. Elements such as windows and doors are always non-structural regardless of the type of building. They can easily be dismantled and reused.

The fifth and sixth layers consist of structural **components and foundations.** These parts are the most difficult to recover while retaining the full value of the raw materials, but it is not impossible.[23]

23. Bertino G, Kisser J, Zeilinger J, Langergraber G, Fischer T, Österreicher D. Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials. Applied Sciences. 2021; 11(3):939. https://doi.org/10.3390/app11030939

DID YOU KNOW THAT...?

BIM technology greatly facilitates the process of recovering building materials

The use of BIM (Building Information Modelling) technology allows easier access to information about the structure of a building. Creating a database as early as the design and construction stage of a building significantly facilitates the identification of materials and components during deconstruction. By using this tool, digital drawings and photographs of building elements and technical systems can be stored throughout the building's life cycle. This makes it possible to develop a detailed deconstruction plan and plan the best way to reuse or recycle dismantled building components.

02 STEP

ASSESS THE OPTIONS FOR MANAGING THE RECOVERED MATERIAL

Once the building or site has been audited and the materials fully inventoried, their potential use in the next life-cycle step and their value should be determined. In deciding on a new purpose, priority should be given to maximising the preservation of value and minimising negative environmental impact. In order to find the best destination, all options for reuse, refurbishment, remanufacturing and recycling of the material/component should be considered.

It is important to consider both environmental and economic aspects in the assessment process. The economic value of potentially selling the secondary material or using it for own purposes should be estimated. The financial value obtained can be significant, with studies showing that revenues from the sale or reuse of demolished materials cover up to 25% of demolition costs.[24]

There are different ways to manage construction materials:

Reuse of the entire building on a new site: relocating the entire structure to another site. There are two techniques: dismantling the structure and then assembling it at the destination, or transporting the entire, intact structure. This process preserves the highest value of the materials. However, it is expensive and difficult to implement (usually only possible if the building has been designed for dismantling).

Reuse of components in other buildings: parts of the building are dismantled during demolition and reused in new buildings without being processed. Typical elements for this type of process: furniture, other furnishings, appliances, doors, floors, bricks. If these materials are properly dismantled, they do not require any further processing and are ready for use in a new building.

Regeneration of materials: reuse of building components after they have been refurbished or reworked. Compared to the previous case, the remanufacturing of materials requires additional costs and energy. The result of the process is a product that may have exactly the same qualities as originally or different qualities. If its value increases, we are talking about upcycling; if its value decreases, it means a downcycling process.

Recycling of materials: processing construction waste by completely changing its physical form (e.g. by shredding, crushing, soaking or cutting). This process results in a completely new construction product with different physical characteristics. This option should only be chosen if reuse is not possible.

24. Metabolic, Circular Demolition. The Circular Tool Box. Access: https://www.metabolic.nl/publications/circular-demolition/

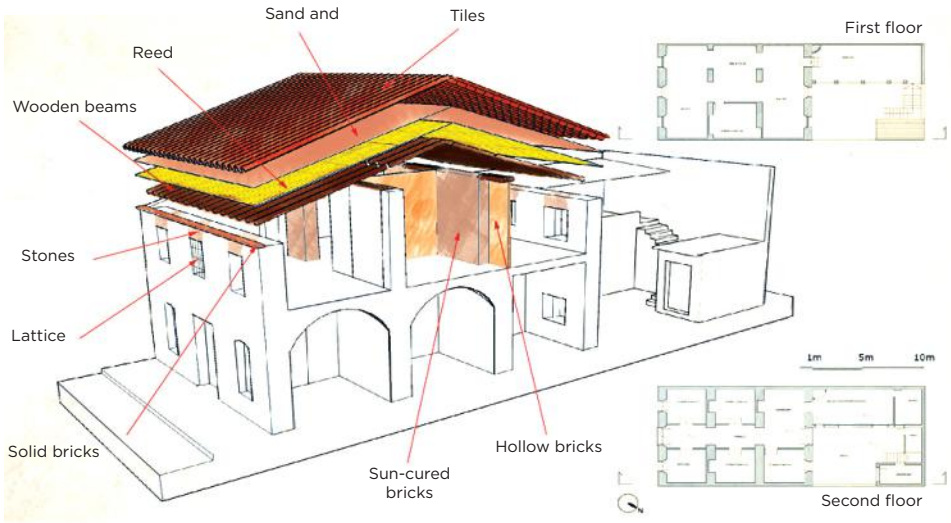
GOOD PRACTICE

DECONSTRUCTION AND REUSE OF ROOF AND WALLS | Castuera, Spain

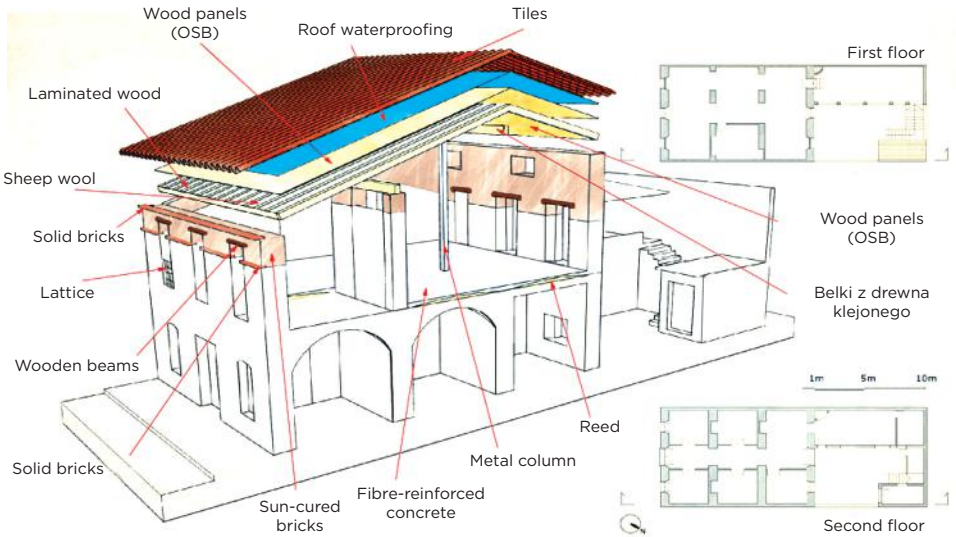
The aim of the project was to dismantle and reuse elements of the roof (tiles, earth, nails and wooden beams) and brick walls. Of the old roof tiles, 70% were in very good condition and were reused for the same purpose, while the remaining 30% were used to fill in the walls or improve the performance of the foundations. Bricks were used to add height to the walls around the building and earth, combined with plaster mortar, was used as infill material in the walls. Beams were used as formwork to create a dome, improving the load distribution in the structural part of the second floor and transferring the load to the walls of the first floor. Timber beams were also used for the windows and door lintels and as supports for the timber elements. Planks and nails were used in the construction of the timber space slabs, where new timber elements and glued laminated beams were used.[25]

25. Milara, Jose & LopezDeAsiain, Maria & Gomez-Azpeitia, Luis Gabriel. (2014). Deconstruction + Reuse = NØ Waste. 10.13140/RG.2.1.3669.9365.

DECONSTRUCTION - COLON 36



REUSE - COLON 36



Source: Milara, Jose & LopezDeAsiain, Maria & Gomez-Azpeitia, Luis Gabriel. (2014). Deconstruction + Reuse = NO Waste. 10.13140/RG.2.1.3669.9365.

03 STEP

SELECT MATERIALS FOR RECOVERY AND DECIDE ON THEIR DESTINATION

The final selection of materials for reuse and the manner in which they are dismantled and possibly processed is closely linked to finding a new use for them. The technical condition of the raw material must be matched to the new use in terms of its chemical and physical properties, quality, quantity, functionality, transportability and storability (in connection with the possible need to store the recovered materials). Generating a supply of materials is important, but the possibilities for reuse are only really worthwhile if supply is linked to demand. All **options for the circular management of waste** should therefore be weighed up, depending on the waste generator.

Options for managing construction waste generated by businesses (e.g. during construction, major renovation, demolition) [Fig. 2.]:

For own use – use in or on your own construction project. Approval must be obtained for the processing of the waste, then all technical properties must be checked. The waste must no longer be classified as waste and, finally, if the material meets all safety and functional requirements, it can be reused.

Examples of use:

Polystyrene foam waste – shredded polystyrene can be used as insulation backfill to fill voids, as a substitute for building aggregates (plasters and mortar) or in the manufacture of other construction products.

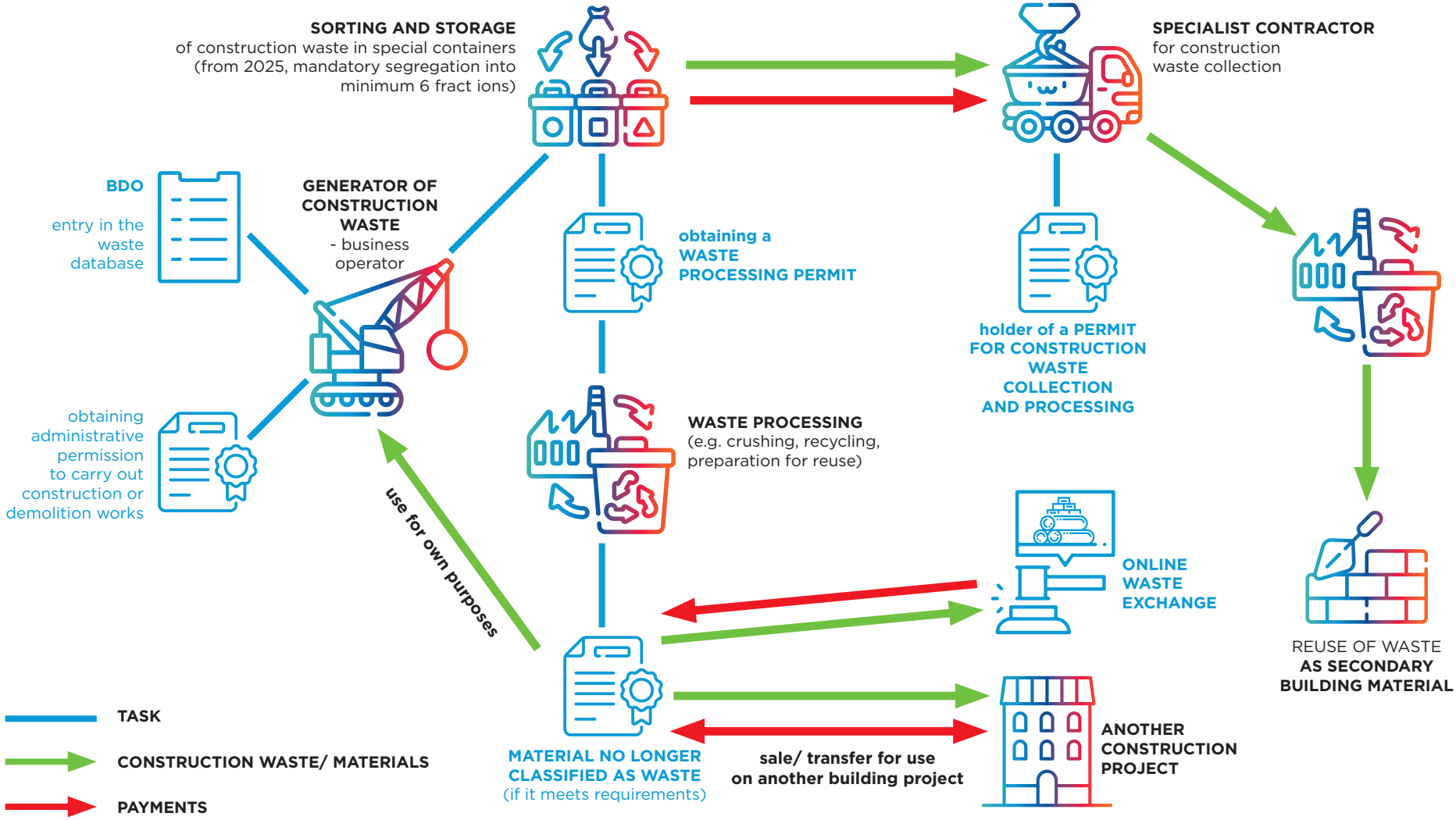
Concrete rubble – can be crushed and then used as construction aggregate or coarse gravel and spread as a car park or road surface.

For use in another construction project – for this purpose, a contractor or builder who needs or is going to need the material on their construction site must be found. The waste generator must obtain a waste treatment permit and the receiver a permit for collection and further use.

Waste collection company – hiring a specialist company is the simplest solution in terms of logistics and does not require any permits. However, it does carry a cost, as you have to pay for waste collection. Waste cannot be handed over to a company that is not authorised to manage waste in a particular area. The company must have all the necessary permits.

Internet waste exchange – selling via online waste sales platforms (e.g. the Cyrkl platform https://cyrkl.com/pl/marketplace) is a great way to make a good profit. With this type of sale, you also need to obtain the relevant waste treatment approvals and bring the material to a point in which it ceases to be classified as waste.

Fig. 2. Reprocessing of construction waste generated by business operators



Source: report authors

Possibilities of managing waste generated by **households** (only applicable if renovation and construction work is carried out by an individual - property owner themselves) [Fig. 3].:

For own use – use in the household or on the property. This is the simplest and most economically viable solution.

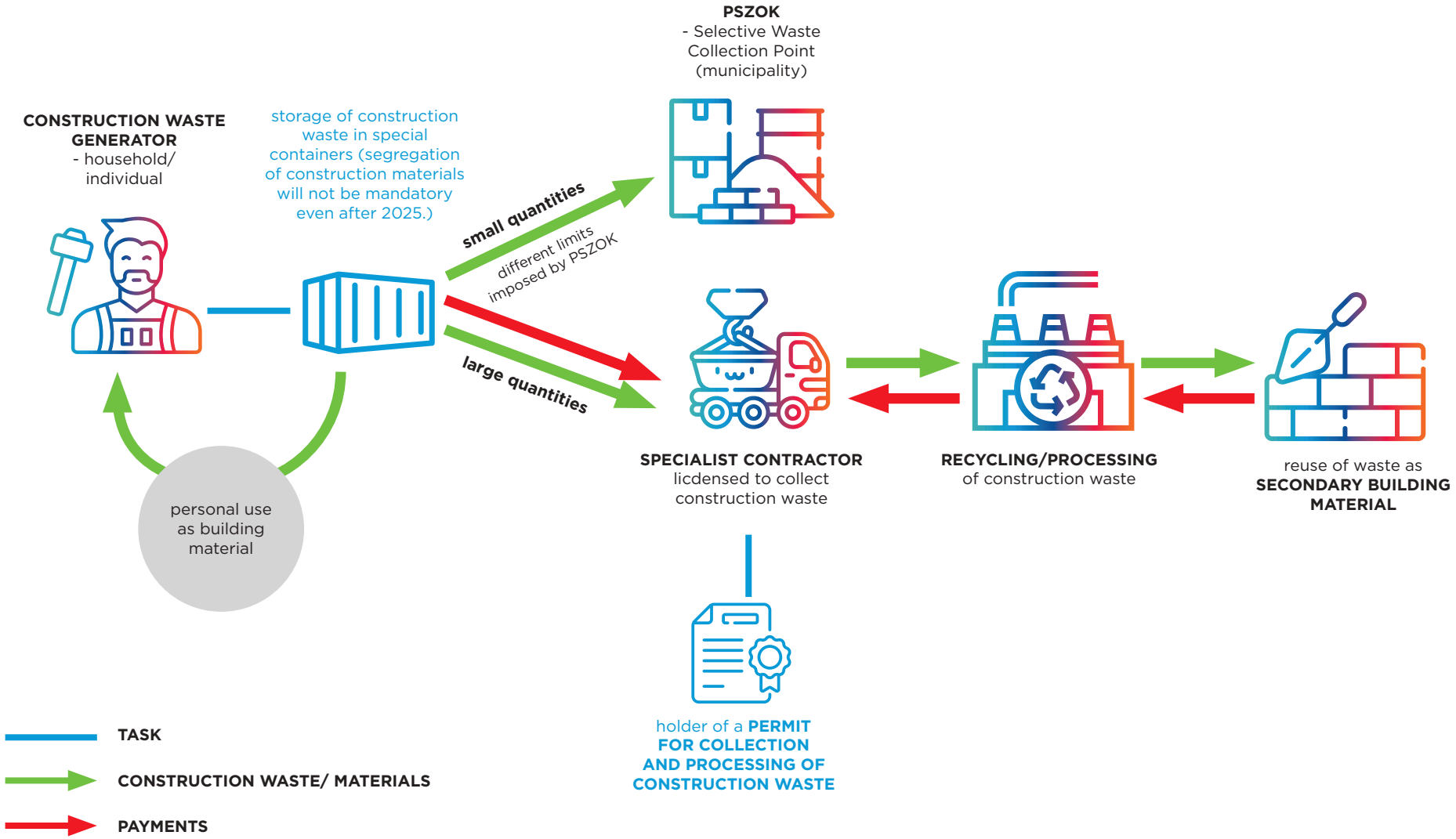
Example of use:

Construction debris – can be used for drainage or landscaping in the garden, as foundations for a terrace or gazebo, or as a road surface around the house.

PSZOK – disposing of the waste at the Municipal Waste Selective Collection Centre (PSZOK) is an option that is worth pursuing when the amount of waste generated is rather small and the owner is able to transport it to the PSZOK themselves. Disposing of the waste is free of charge. Depending on the municipality, PSZOKs set different limits on the maximum amount of waste accepted from one household.

Waste collection company – hiring a specialised company is a good solution when a large amount of waste is generated. Such a company also provides containers for their collection. This solution, however, carries an additional cost, as it is a chargeable service.

Fig. 3. Reuse of construction waste generated by households.



Source: report authors

04 STEP

COMMUNICATE DEMOLITION PLANS AND SELECT RECIPIENTS OF MATERIALS

After assessing the technical condition of the materials and selecting the components to be recovered, it is important to inform the market about one's intentions. Information on the planned collection of construction waste should start to be disseminated at the initial stage of construction/demolition/renovation, as soon as the waste generator is able to identify the materials to be recovered in the future. The earlier the contractor informs the market, the greater the chance of including these materials in the plans of the municipality, investors, construction companies or other contractors operating on nearby projects.

PART 2. Preparation of the construction/demolition site for materials recovery

01 STEP

SCHEDULE FOR RECOVERY AND DISPOSAL OF MATERIALS

Before starting demolition or construction work, it is important to plan well and draw up a schedule for dismantling, sorting and storing the various construction wastes. This is necessary in order to coordinate well in advance with all parties involved, including demolition companies, waste collectors, the municipality or the investor. A precise timetable should be drawn up which specifies when the individual elements will be dismantled, how long they will need to be stored, when they will need to be processed (if necessary) and when they will need to be collected or used on site for one's own purposes.

Commercial developments often require demolition to be carried out at very short notice, and careful dismantling and material selection require more time than with the traditional demolition approach. The plan should therefore be agreed in consultation and with the consent of the investor.

Key aspects in scheduling:

Staged planning: Draw up a detailed recovery schedule taking into account the successive stages of the work and the time limits for disposal of the various materials.

Flexible schedule: Ensure that the schedule is flexible enough to adapt to changing site/demolition conditions, such as weather, material availability or changes in the construction project.

Limiting storage time: When creating a schedule, minimise the time that construction waste is stored on site, thus avoiding additional costs and preventing damage to and contamination of stored materials for reuse.

Adapting the schedule to suit the recipients: Wherever possible, coordinate the timing of dismantling of individual components with the requirements of their users.

Ongoing monitoring: Regularly monitor the progress of the work and update the schedule if necessary.

REMEMBER!

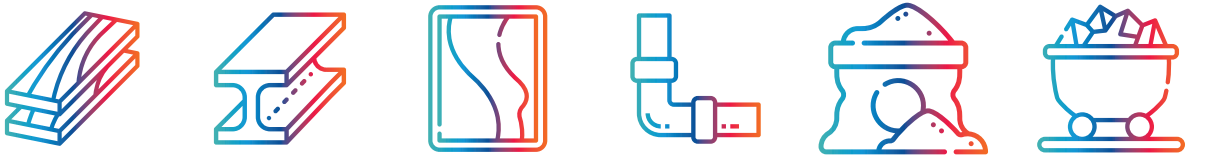
If you anticipate processing any construction/demolition waste on a construction/demolition site (e.g. crushing concrete which causes noise), remember to eliminate in advance from all your contracts any conditions which could prevent you from carrying out your plans.

02 STEP

PREPARE THE SITE AND CONTAINERS FOR RECOVERED MATERIALSWOOD

The first step in preparing the site is to plan a waste collection area on site. This space should be easily accessible to both employees and waste collectors. Next, containers for the various types of waste should be set up at the designated location. In order to ensure careful sorting, it is a good idea to provide separate containers for all types of construction waste that will be generated during the work.

Starting in 2025, waste will have to be sorted into at least 6 fractions:



WOOD **METALS** **GLASS** **PLASTICS** **GYPSUM** **MINERAL WASTE** (including concrete, bricks, tiles and ceramics and stones)

However, we encourage even more thorough segregation, e.g. separate collection of concrete, bricks and other mineral waste - this will make it easier to reuse these raw materials.

IMPORTANT!

The storage of waste on the ground or in plastic bags is not permitted. It is also prohibited to burn waste, whether it is packaging waste, material scraps or, for example, parts of boards or window frames. Failure to observe these rules may result in a fine.

On the construction site, it is also a good idea to introduce a clear system for marking construction waste and to make all employees familiar with it. All areas, materials or construction items that are to be recycled should be marked with visible identifiers. Safety barriers may then be put up to prevent accidental damage to the selected items. Finally, it is also a good idea to draw up a map of the material recovery areas, which will be available to all employees and regularly updated as the work progresses.

PART 3. Separation and collection of materials at construction/demolition sites

ENSURE SAFETY AND HEALTH PROTECTION DURING MATERIAL RECOVERY

Before carrying out demolition and building material recovery work, it is important to carry out a hazard analysis and ensure the safety of workers. It is advisable to draw up a detailed safety plan, taking into account all the potential risks involved in dismantling, sorting and transporting materials.

Examples of risks may include:

Respiratory hazards: Dust and mould accumulated in old buildings can pose a risk to the respiratory system of workers. Particularly in confined spaces, the use of dust masks or respirators is essential.

Toxic substances: Traces of hazardous substances, such as lead or asbestos, may be present in layers of old construction. Careful inspection and identification of such hazards is necessary, paying particular attention to traces of old insulation, black putty and of paint.

Sound management and planning: The plan of demolition activities should be communicated in a clear and concise manner to the whole team in order to minimise the risk of collisions and accidents on the building site. Work with heavy machinery should never take place at the same time as manual work.

Air quality: In some demolition sites, air quality monitoring is required for early detection of potentially harmful substances.

Sharp objects: All sharp objects must be removed from the site or building before starting work.

Overhead hazards: During the demolition process, the environment changes rapidly and new risks emerge on an ongoing basis. A particular risk of accident arises from structural deconstruction. Extra attention and caution must be exercised, constantly looking around and monitoring the surroundings.

REMEMBER!

Protective clothing: Provide workers with appropriate protective clothing and equipment, i.e. helmets, gloves, safety goggles and dust masks.

Equipment maintenance: Regularly inspect and maintain the equipment and tools used to prevent accidents.

02 STEP

RECOVER MATERIALS WITH CAREFUL PRESERVATION OF THEIR ECONOMIC VALUE

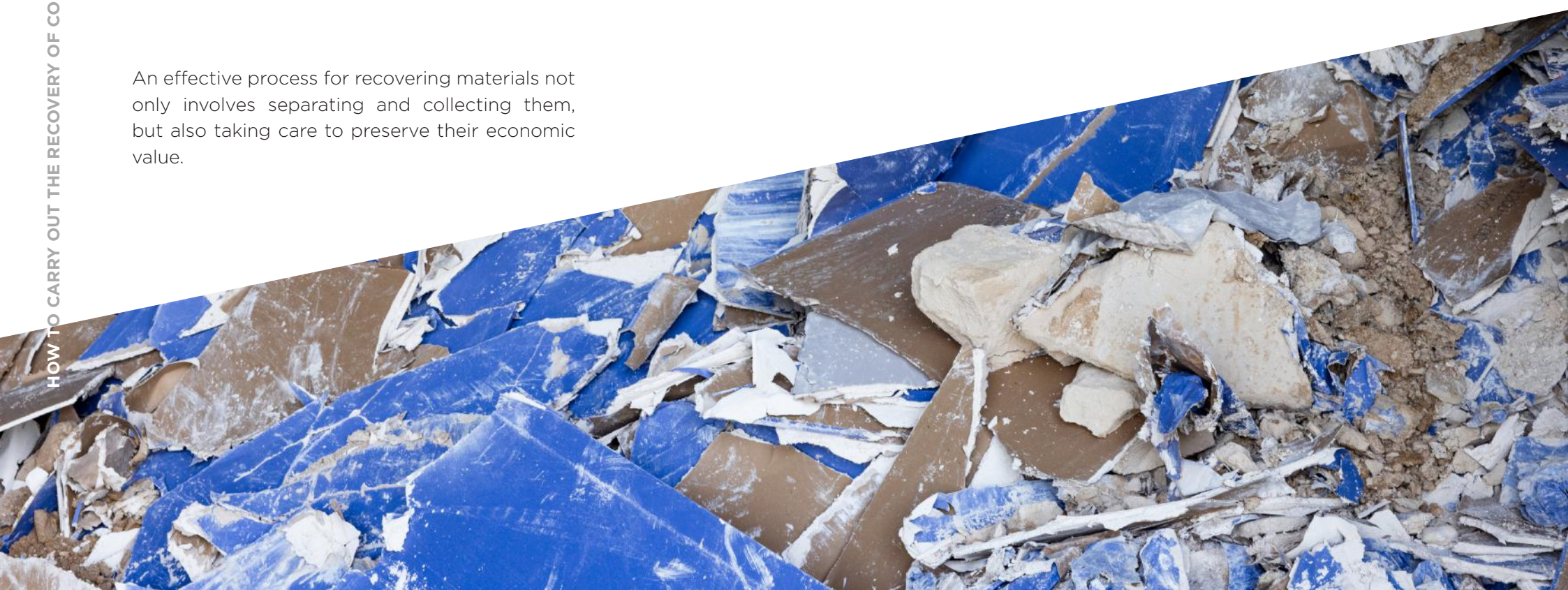
An effective process for recovering materials not only involves separating and collecting them, but also taking care to preserve their economic value.

Actions to be taken to maintain the economic value of the recovered material:

Cleaning and repair: Where materials are damaged or soiled, repair and cleaning measures must be taken to restore their appearance or functionality.

Protection against damage: It is also important to protect the recovered materials from further damage during storage and transport. This can be done through appropriate packaging, protection against moisture and avoiding overloading. In most cases, the protection of the material will need to be tailored to its specific characteristics.

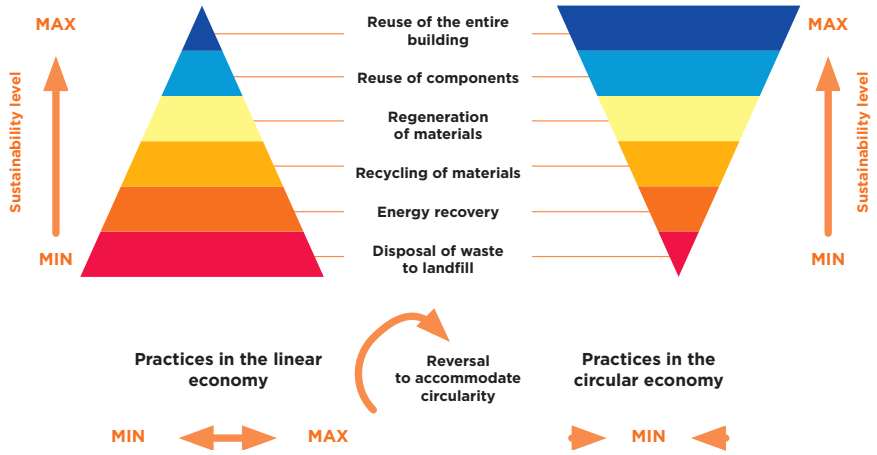
Choosing the most cost-effective use: The decision to reuse recovered material should be made according to the waste hierarchy (see „Did you know...?" box. The higher up in the hierarchy a particular use is, the more viable it is both environmentally and economically.



DID YOU KNOW...?

Hierarchy of sustainable practices for construction waste and end-of-life facilities

The hierarchy of dealing with construction waste or a decommissioned building according to the principles of the circular economy indicates that the most important and best solution is to relocate the entire building or to reuse certain structural elements or materials in another building without interfering with their condition. If these solutions are not possible, it is advisable to rework or refurbish the material. Recycling, i.e. reprocessing the raw material and turning it into another building material (usually of lower value, i.e. downcycling), is another less sustainable method, although still a good one. The least sustainable methods are energy recovery through incineration and composting.

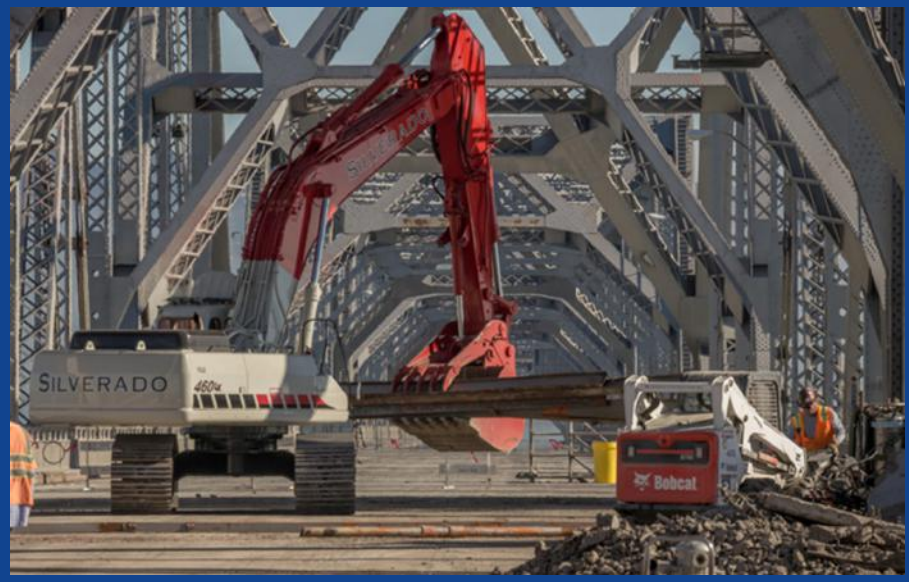


Source: Bertino G, Kisser J, Zeilinger J, Langergraber G, Fischer T, Österreicher D. Fundamentals of Building Deconstruction as a Circular Economy Strategy for the Reuse of Construction Materials. Applied Sciences. 2021

GOOD PRACTICE

DEMOLITION OF THE SAN FRANCISCO BAY BRIDGE | Oakland

When the San Francisco-Oakland Bay Bridge was due to be demolished, the California Department of Transportation opted for careful deconstruction rather than the traditional demolition method. This allowed the recovery of more than 35,000 tonnes of steel, which was sold for scrap and generated more than $100 million in revenue. The project not only resulted in significant financial savings for the investor, but also provided environmental benefits.



Source: https://www.btcalameda.org/journeyman/journeyman-selected-articles-2013/demolition-of-bay-bridge-begins/

How to dismantle a building while preserving the highest economic value of materials?

Dismantling should start with non-structural elements that are not an integral part of the building (i.e. appliances, windows or doors). Their removal is relatively easy and safe and usually takes a few hours or days. Next, it is necessary to proceed to structural dismantling, i.e. the demolition of building elements that are crucial to the building's stability. This dismantling is done from top to bottom - from the roof, to the foundations. If the load-bearing walls are built of bricks bonded with wet adhesives (e.g. mortar, cement), the best way, although the most difficult and time-consuming, is to dismantle the bricks by removing the bond and using them again. If this is not possible, thebricks can be recycled (crushed) and used to make new building materials, for example, for road substructure. In the case of timber-framed buildings, ‚dry' joints are usually used, which to a large extent allow deconstruction and reuse or recycling of materials. In steel-framed buildings, connections are usually made by welding and bolting. With the right tools, it is possible to dismantle and give a second life to steel components. However, the most common structures are those made of reinforced concrete, which are cast-in-place and their elements: beams and columns are fully integrated with each other. Recovering and reusing reinforced concrete elements is very difficult. However, if dismantling is carried out in a controlled and non-destructive manner there is a chance to recover and recycle them (e.g. by straightening the bars and selling them or recycling them as scrap). Structural concrete can be crushed and reused in the production of new binders.[26]

26. J.Żelaziński, Recycling on the construction site, Modern Waste Management 2(2) 2013

04

TECHNICAL ASPECTS OF THE RECOVERY OF SELECTED

4.1. Plasterboards

Plasterboard is a recyclable building material under several conditions (outlined below).

How to recover the material?

When dismantling plasterboards, care should be taken not to damage the material in such a way that it cannot be reused. Before proceeding, it is a good idea to assess the condition of the boards and determine whether they are suitable for reuse or whether they need to be repaired or recycled.

If the panels have been fixed with screws or bolts, they should be gently unscrewed using tools such as an electric screwdriver. If the boards have been glued to a surface, carefully peel them off, starting at the edges and gently separating them from the wall or ceiling. When the boards are loose, they can be safely detached from the frame or structure and the adhesive residue removed with a scraper or suitable solvent. It is important to choose a product that will not damage the boards. Store the boards in a dry place with a flat surface.

If the plasterboard is not reusable, the material can be milled and recycled like any paper or wood product. The gypsum core can be recycled several times without any significant loss of material efficiency.[27] The gypsum waste recycling process involves the elimination of contaminants such as nails, screws, wood and insulation, as well as the removal of paper lining. Specialised equipment allows the raw material to be ground and sifted, which can then go to the gypsum products manufacturer and be reused.[28]

How to reuse the raw material?

If the plasterboards has not been damaged during dismantling, it can be reused in building and renovation work. They can be used to repair existing walls and ceilings, thus saving on material costs, and to build new structures, creating completely new spaces. They can be used to build cabinets and built-in wardrobes, and as wall panels when creating a new layout for a space. Reclaimed plasterboards can also be used as an additional layer of acoustic insulation.

27. https://www.rlabel.org/pl/geri-donusturulebilir-malzemeler/geri-donusturulebilir-malzemeler-yapi-malzemeleri/
28. https://www.utylizacja-odpadow.pl/rodzaj-odpadu/kod-odpadu/17-08-materialy-konstrukcyjne-zawierajace-gips/38-17-08-02-materialy-budowlane-zawierajace-gips-inne-niz--wymienione-w-17-08-01

At present, the main economic use of plasterboard waste is the recycling of gypsum from the binder, carried out in factories. Boards suitable for use in wet rooms can also be recycled, but this requires them to be properly sorted and separated from other boards that are not intended for use in such conditions. The material can be reused after separation of the paper, which accounts for approximately 8% of the total weight of the board. Research has shown that paperless plasterboards contain predominantly calcium sulphate (96-97%) in their composition, of which 92-94% is gypsum dihydrate.

If the proportion of paper in the boards is reduced to 1% of the total weight, in accordance with EU guidelines, the material can be reused in the construction industry, e.g. in cement production, as a cement setting time regulator, thus replacing natural gypsum.[29]

Attempts have also been made to reuse gypsum extracted from the wet lime desulphurisation process as a cement setting time regulator. The results make it possible to assume the suitability of the material even with more paper in the composition. In this case, success is conditional upon adequate grinding of the boards to protect the partitions in the cement mill against clogging.

Due to its content of glass fibres, organic chemicals and paper, plasterboard waste cannot be used for land reclamation.

29. Iwona Kosk, Waste gypsum board for reuse usage limitations in the building materials industry and land reclamation in European Union regulations

DID YOU KNOW...?

The first plant for recycling plasterboard will be built in Austria

The world's first factory for processing plasterboard and other gypsum--to-gypsum components will be up and running in Austria as early as 2025. The initiative is the result of cooperation between construction companies (PORR, Saint-Gobain and Saubermacher) and the association of gypsum producers and the ministry.
As part of this initiative, used plasterboard and other gypsum waste from all over Austria will be transported to a single plant. There, the materials will be processed (crushed and pulverised) and then sold to gypsum product manufacturers as raw material. The new plant is expected to process around 60,000 tonnes of gypsum a year, thus meeting demand in eastern Austria.
The project has been developed in response to the nationwide ban on the landfill of plasterboard, which will come into effect on 1 January, 2026. The plant is scheduled to start operations in 2025.

Source: https://www.greentech.at/en/first-plaster-to-plaster-recycling-plant-in-austria/

4.2. Suspended ceilings and wall panels

The service life of the ceiling systems is estimated to be around 50 years. Research shows that key technical properties such as sound absorption, reaction to fire and mechanical strength of the panels do not change over time. The only change is in the aesthetics of the panels, which can, however, be significantly minimised through proper use.

How to recover the material?

The dismantling of wall panels can be complicated due to the risk of damage to the walls. It is advisable to remove finishing elements such as skirting boards and plinths before starting the dismantling process. In most cases, these are fixed with screws or nails, which must be gently removed. If, on the other hand, the panels are connected by special latches or clips, these should be gently tilted to free the panels from the wall.

Reuse is possible if the material has been dismantled intact. Therefore, cutting should also be avoided. The dismantled parts must be placed in cardboard boxes for safe storage.

How to use the material?

Suspended ceilings and wall panels recovered intact can be reinstalled in another area. If necessary, they can be refurbished or painted beforehand. If a panel is damaged after dismantling, it can be re-used, for example as acoustic insulation. For additional sound absorption, it is a good idea to place the panels, for example, in the ceiling cavity. Products that can no longer be reused can be handed over to a recycling company.

Many construction companies and manufacturers take back used materials such as plasterboard or wall panels free of charge from customers who are renovating their homes. These boards can be recycled and reused, irrespective of their manufacture date. The only prerequisite is not to interfere with the properties of the material, for instance through using paint containing harmful substances.

GOOD PRACTICE

CEILING RECOVERY IN THE NEW OFFICE OF AN ENERGY SECTOR COMPANY | Wrocław, Poland

An innovative ECOPHON acoustic ceiling recovery project was carried out in an office in Wrocław in 2023. The aim of the project was to redesign the office with the maximum possible use of recycled materials. A key element of this transformation was the reuse of acoustic ceilings made of glass wool, which was obtained from recycled glass waste. While the production process for new panels is energy-intensive, the reuse of existing panels significantly minimises energy consumption. The project team successfully used the old ceilings in the new office design. Some of the old modular ceilings and free-hanging acoustic panels were suspended in other areas of the office, while others were printed on to fit even better into the new office space.

Source (photo): https://www.ecophon.com/pl/articles/inspiration/energy-company-office/

4.3. Screeds and flooring

Concrete is the basic building material that makes it possible to create various elements, from foundations to walls, ceilings, terraces and even the roof. Its strength determines the durability of buildings.

In 2015, 6 474.2 thousand tonnes of construction waste accumulated in landfills in Poland alone. Unfortunately, only around 20 per cent of it was recycled. Given that repair and maintenance work on old buildings only prolongs their lifespan, it will soon be necessary to demolish them. This in turn will result in a significant increase in the amount of construction waste in landfills.

How to recover the material?

Depending on the equipment used, concrete can be dismantled using shock or non-aggressive methods. Impact dismantling of reinforced concrete structures is carried out using pneumatic-hydraulic hammers. Concrete removal using this method is effective, safe and economical. Importantly, work does not need to be interrupted to reinforce or protect nearby buildings. In addition, hydraulic hammers are light and compact, making them easy to transport and handle - one person can do the job. This method is effective for dismantling smaller amounts of concrete, but does not work well for large reinforced concrete structures. The disadvantages of this method are that it generates a lot of noise and produces large amounts of dust.

Non-aggressive methods include diamond or wire cutting. They are most commonly used in residential areas because they generate no noise and little dust, and the cutting of the concrete floor is carried out quickly and precisely.[30]

Depending on the type of substrate (acrylic or epoxy resin) and the flooring used, various contaminants such as tile adhesive or carpet adhesive may be present. In this case, recycling of the contaminated flooring with cement products is possible and does not pose any major difficulties. On the other hand, it is problematic to remove contaminants from materials such as polyvinyl acetate-based carpet glue or bituminous material residues.

How to use the material?

After recovery and processing, concrete can be successfully used to produce new building materials (e.g. new binders, concrete blocks, foundation slabs or road paving). Recovered concrete can also be used for refurbishment, e.g. to fill cavities in concrete or to reinforce existing structures. Recycled aggregate can also be used to build drainage systems (e.g. absorption wells, drainage ditches) or to produce street furniture.

Reclaimed aggregate is often used as a substitute for natural coarse aggregate in the concrete mix. Today, coarse aggregate accounts for about 70% of the volume of concrete and has very good strength properties, making it an excellent alternative to traditional raw materials. Recycling of concrete could contribute to a significant reduction in landfill waste and significantly lower the carbon footprint - as cement, as the main component of concrete, has the highest greenhouse gas impact of all building materials.[31]

30. https://diamandbud.pl/demontaz-posadzki-betonowej/
31. Malazdrewicz, S.; Ostrowski, K.A.; Sadowski, Ł. Large Panel System Technology in the Second Half of the Twentieth Century—Literature Review, Recycling Possibilities and Re- search Gaps. Buildings 2022, 12, 1822. https://doi.org/10.3390/buildings12111822

GOOD PRACTICE

SUSTAINABLE RESOURCE CENTRE – RECYCLING PLANT FOR RECLAIMED CONCRETE AND OTHER CONSTRUCTION WASTE | Fairfield, Australia

In 1992, Fairfield City Council initiated the creation of the Sustainable Resource Centre (SRC), dedicated to the efficient conversion of construction and demolition (C&D) waste into new building materials. Since its inception, the facility has been successfully recovering construction waste and giving it new life. SRC processes concrete (with and without steel), bricks, asphalt and roof tiles. It then produces crushed concrete products, asphalt and sand for ballast and road bedding. The concrete and asphalt produced are 100% recycled. All recycled materials are tested and produced in accordance with national regulations. From the very beginning, the centre has been an independent business operation which generates revenue.

4.4. Glass and stone wool

Mineral wool (glass and stone wool) is a popular insulation material that acts as both a thermal and acoustic insulator. Glass wool is mainly made from sand and glass straw. Waste glass wool can be reused in the manufacture of bricks or recycled by the glass wool manufacturer. Technology is being developed that will allow glass wool waste to be reused in the production of the same material.[32]
And stone wool, which is mainly made from basalt and dolomite, can already be reused to produce a new roll of this material, although this process is not yet popular*. Unfortunately, at present stone wool waste still tends to end up in landfill.[33]

How to recover the material?

For the material to be reused, a key element is to dismantle it intact. It is extremely important to use a separation method during demolition to prevent the material from becoming contaminated with other construction waste, which could prevent it from being reused. It is also important to store the material properly so that the wool does not come into contact with moisture and contaminate it.

Wet wool recycling: If the material could not be recovered in an intact state during dismantling so that it can be directly reused, the wool can also be recycled.

This process begins by collecting all the wool scraps, which should then be submerged in water and left in a water bath for some time. This allows the organic glue to soften, facilitating further processing of the material. It is a good idea to mix the soaked wool with paper afterwards, which will help protect the wool fibres from damage. Using a drilling machine, the resulting mass is finely chopped to produce a pulp ready for further processing.

Waste wool is often stored in temporary storage areas without a roof. As a result, precipitation dampens the wool preventing it from dusting. In such systems, it is crucial that the waste storage area has a sealed floor and a separate drainage system for water treatment or reuse. Professional landfills that are authorised to accept mineral wool waste use special compactors that crush the wool and deposit it in the deeper layers of the landfill, eliminating the risk of dusting or blowing away.[34]

How to use the material?

The process waste that is generated during the production of mineral wool, known as ‚offcuts' after the manufacturing process, can be reused in several ways. It can be returned to the production, process, used in the insulation of ventilated ceilings or processed into granulate.

32. Damgaard, A., Lodato, C., Butera, S., Fruergaard Astrup, T., Kamps, M., Corbin, L., Tonini, D. and Astrup, T.F., Background data collection and life cycle assessment for construction and demolition waste (CDW) management, EUR 31323 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-59147-4, doi:10.2760/772724, JRC130992. https://publications.jrc.ec.europa.eu/repository/handle/JRC130992
33. EURIMA, Waste Handling of Mineral Wool Insulation, 2016 https://www.eurima.org/uploads/files/modules/articles/1584367760_SC%20Eurima_waste_handling_Info_Sheet_06_06_2016_final.pdf.
34. Beata Łaźniewska-Piekarczyk1, Monika Czop2, Janusz Mazurkiewicz3, Katarzyna Burchan4, Joanna Englert 4, Natalia Gołba4, Magdalena Grzybek4, Katarzyna Hołomek4, Joanna Jankowiak, Wełna mineralna – perspektywy i bariery ponownego wykorzystania, Współczesne Problemy Ochrony Środowiska i Energetyki 2020, str. 167

Sometimes external waste materials can also be used in production. For example, waste (offcuts) created from a block of mineral wool that has been modified by cutting to a specific shape can be reused in the production process as ‚clean' waste. Wool mats that were once used in horticulture can find a new use as an additive to aggregates, such as expanded clay or cement.[35]

Until recently, I have associated mineral wool, whether glass or stone wool, with excellent acoustic, thermal and fire-protection properties. I am aware, however, that in view of the challenges of today's world, it must have two more important qualities: durability and recyclability. To achieve this, we need not only technology but also planning.

It is necessary to know in advance how the mineral wool insulation will be used after a building has been demolished, and this requires close collaboration between architects and companies such as Saint-Gobain, which has a long tradition in the construction industry.

Henryk Kwapisz, Public Affairs Director,
Saint-Gobain Poland

35. Beata Łaźniewska-Piekarczyk1, Monika Czop2, Janusz Mazurkiewicz3, Katarzyna Burchan4, Joanna Englert4, Natalia Gołba4, Magdalena Grzybek4, Katarzyna Hołomek4, Joanna Jankowiak, Wełna mineralna – perspektywy i bariery ponownego wykorzystania, Współczesne Problemy Ochrony Środowiska i Energetyki 2020, str. 167

4.5. Flat glass

On a construction site, glass is most often found in the form of windows and household chemical packaging. However, for collection companies, glass from construction sites is often an unwanted material as it is not properly segregated, making it difficult to process further and most often ending up in collection containers for construction waste. According to a study carried out in 2019 by the German Flat Glass Association, only around 6 per cent of used flat glass, e.g. from old windows, returns to the furnace and is re-used for the production of new flat glass. It should be borne in mind, however, that up to 90% of the waste glass is used in the production process itself.[36]

Differences in the structure and chemical composition of glass affect not only the processing by recyclers, but also the reusability of the material. Proper sorting already at the demolition stage allows for maximum utilisation of cullet and its appropriate recycling.[37]

How to recover the material?

Hegla New Technology GmbH has introduced an innovative solution that allows double-glazed units to be disassembled into individual components without cutting or breaking the glass. With this approach, it becomes possible to reuse an entire sheet of glass without having to break it. This is a revolutionary solution; however, it still requires the development of a system for carefully removing window panes and other glass components from buildings without the need for demolition companies to break them. Implementing this solution requires the development of new awareness and processes. Currently, the solution is in the research phase.[38]

Architectural glass (e.g. facades, partitions) and window glass can be recycled by crushing the material:

Implosion method: Special crushing machines make it possible to produce granules of uniform size, without sharp edges. The purchase price of such a machine is affordable for many companies.[39]

Manual glass breaking with a hammer on a suitably stiff sieve. The grain size can be regulated by adjusting the mesh of the sieve.

Crushing glass using a concrete mixer equipped with a sealed cover on the drum outlet and a set of fist-sized balls. The whole set acts like a ball mill and the crushed glass is collected in the hopper. This method requires determining the optimum grinding time and angle of the drum.[40] In some cases, this method of glass crushing may render the cullet unusable in an industrial process.

How to use the material?

Properly inventoried and separated glass (cullet), without any contamination, can and should be reused for flat glass production. However, this requires a change in habits and awareness. Currently, recovered material, due to insufficient quality (purity) is not suitable for reuse in the production of glass and is used as abrasive for sandblasting and shotblasting. Another use is as a grit for concrete and plaster, where it serves as the glass equivalent of terrazzo for plastering on concrete slabs and landscaping elements.

36. Expert consultation with Saint-Gobain (one of the largest producers of flat glass in Poland)
37. https://eurobuildcee.com/comments/560-szklo-jako-odpad-budowlany-po-nowemu
38. https://swiat-szkla.pl/article/18633-szklo-plaskie-cykl-zycia-i-recykling
39. http://e-gospodarkaodpadami.pl/aktualnosci/recykling-na-placu-budowy/
40. MODERN WASTE MANAGEMENT - collection, treatment and disposal of waste, municipal management equipment and machinery, landfill sites (e-gospodarkaodpadami.pl) TECHNICAL ASPECTS

The material can also be used as an aggregate for asphalts and concretes, a decorative aggregate for lining pathways and a drainage sub-base in water systems. The coloured glasses can be bonded with chemically hardened resin to create interesting blocks, tops and slabs for use in modern construction.

GOOD PRACTICE

GLASS RECOVERY IN THE REFURBISHMENT OF A 35-YEAR-OLD SAS AIRLINE OFFICE BUILDING | Frösundavik, Szwecja

The renovation of the 35-year-old SAS airline office building, designed by architect Niels Torp, is a shining example of sustainable building practices involving glass recovery. The office building refurbishment project required the replacement of the glass facades. To reduce the environmental impact, façade manufacturer Scandifront partnered with recycling company Ragn-Sells to recover more than 40 tonnes of glass from the old façade. After appropriate processing, the cullet was transported to the Saint-Gobain glassworks, closing the recycling loop. Each tonne of cullet recycled in the float glass production process saves 1,200 kg of natural resources, including 750 kg of sand, and reduces energy consumption by 30%, ultimately reducing carbon dioxide emissions by up to ~300 kg for each tonne of cullet.[41]

Source: https://www.saint-gobain-glass.pl/pl/budynek-sas

41. Świat Szkła, 01/2023, Decarbonisation in practice - implementation of the Grow & Impact strategy by Saint-Gobain, https://swiat-szkla.pl/article/18440-dekarbonizacja-w-praktyce--realizacja-strategii-growaimpact-przez-saint-gobain-glass

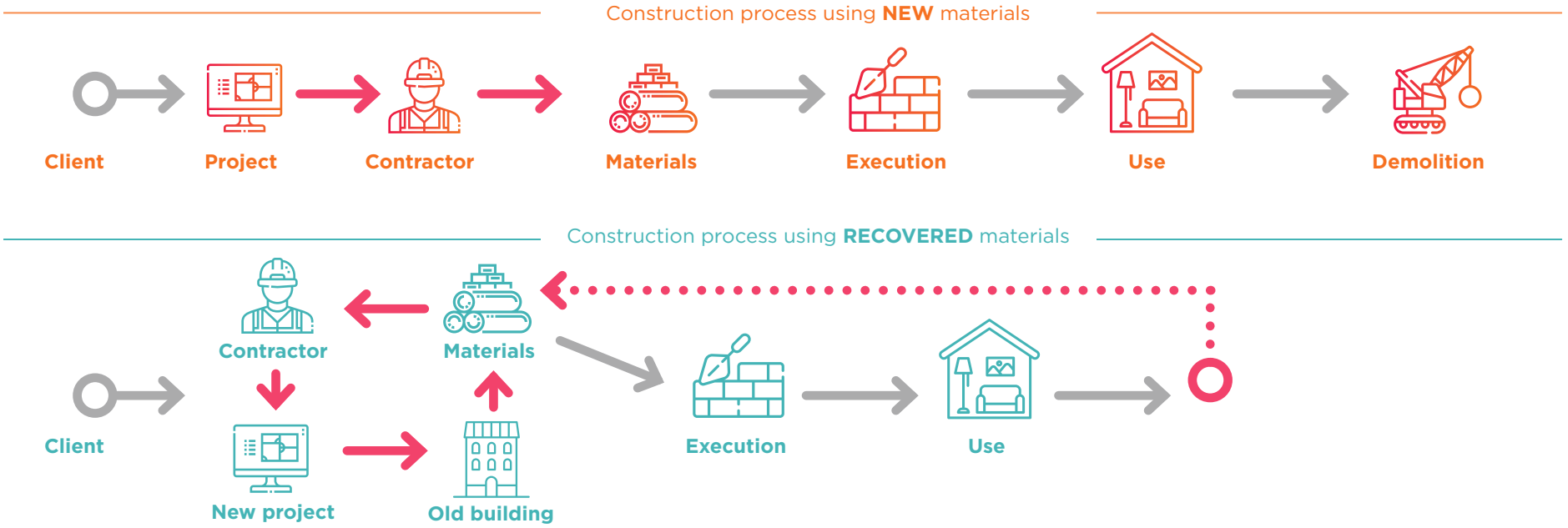
05

MANAGEMENT OF RECOVERED MATERIALS

Once construction waste has been successfully recovered while retaining its highest value, it must be recirculated (see Figure 6). At this stage, it is crucial that investors decide to use secondary building materials rather than primary raw materials in the construction of new buildings.

The use of recycled products or materials differs from traditional materials not only from a technical point of view, but also requires a different process for new facility design and implementation. There are a number of important factors that will help in the successful use of recycled materials.

Fig. 6. The construction process using 1) primary and 2) recycled materials



Source: https://www.metabolic.nl/publications/building-with-recycled-building-materials/

1. Supply-driven design

It is important to change the mindset in the design of new facilities from demand-driven to supply-driven design. When a new building project is created with detailed specifications, there is little likelihood that recycled building materials with exactly the same properties as planned in the specification will be available on the market. Therefore, to increase the use of recycled materials, the project team should base its design on the current supply in the market. The amount of recycled materials used in a project depends solely on the creativity of the architects and designers.

2. Prior involvement of the construction contractor

It is worthwhile to involve a building design contractor at an early stage in the design process; this will significantly facilitate the technical feasibility of using recycled construction products. As a result, materials will not be selected on the basis of specifications (which do not yet exist), but on other quality criteria. Alternatively, it is advisable to implement the project using the integrated tendering method (design and build), whereby the architect and contractor submit a joint bid. In such an approach, the contractor can use their knowledge much earlier than in a standard project and can introduce their ideas already at the design stage.

3. Early release of the budget

Designing based on the supply of secondary building materials on the market often requires their immediate purchase. Usually, these materials are only temporarily available because suppliers do not have the space or do not want to risk storing them for a long time without securing the buyer's interest. It is therefore important for the developer to be able to free up some of the construction budget already at the design stage in order to purchase such materials in advance. Unfortunately, this has the effect of placing the risk of the invested capital on the client. Therefore, when purchasing materials before the design is completed, it is worthwhile to have clear risk allocation agreements in place.

4. Temporary storage

When materials are purchased at an earlier stage in the process, temporary storage must be provided. In order to preserve the quality of the materials, they should be stored in dry areas protected against temperatures below zero.

GOOD PRACTICE

IN FRANCE THERE IS A THRIVING ORGANISATION COLLECTING ECO-CONTRIBUTIONS AND PROVIDING RECYCLING SERVICES FOR CONSTRUCTION MATERIALS

Valobat is a pro-environmental organisation, approved by public authorities and dedicated to the construction industry. Its members include manufacturers, distributors, construction companies, waste managers and local authorities. Its aim is to collect so-called, eco--contributions' - annual fees introduced under the new extended producer responsibility legislation. These funds are then reinvested in recycling projects, reuse promotion and environmental initiatives, including waste upcycling.

Valobat offers companies separate collection solutions for construction waste at local collection points and develops recycling channels. The organisation's mission is to improve resource management and reduce waste by recycling and recovering waste and building products, fixtures and fittings and DIY and garden items.

valobat

06

CURRENT BARRIERS TO RECOVERY OF MATERIALS AND HOW TO OVERCOME THEM

The construction industry faces numerous barriers to efficient material recovery, recycling and reuse, both from the market and from the regulators. Below, we outline the main challenges faced by the sector and suggest ways to overcome them.[42]

42. Geng, Jun & Huang, Yi & Li, Xiang & Zhang, Yun. (2023). Overcoming Barriers to the Adoption of Recycled Construction Materials: A Comprehensive PEST Analysis and Tailored Strategies. Sustainability. 15. 14635. 10.3390/su151914635.

ECONOMIC BARRIERS:

1. Careful dismantling is a more resource-intensive and therefore more costly form of deconstruction than standard demolition. It requires more manpower (employees to carry out the dismantling, experts to make an inventory and technical assessment of the materials and their reuse potential). Labour costs for deconstruction can be up to 6 times higher than for conventional demolition of the same building.[43]
2. Lack of time for stocktaking and deconstruction. There is usually a lot of pressure to complete a project quickly while carrying out an audit and deconstruction is a much more time-consuming process than demolition.
3. Higher production costs for products made from secondary materials compared to traditional materials.
4. Lack of economies of scale in the processing and production of recycled building materials.

SOLUTIONS:

1. **Reducing costs through economies of scale.**
   Governments, industry associations and companies should work together to promote the large-scale recovery of construction waste. Encouraging partnerships between recyclers and construction companies fosters innovation and enables cost sharing, thus reducing financial barriers to market development.
2. **Development of innovative business models.**
   To overcome the barriers of high initial costs, it is worth implementing new business models, i.e. leasing or consumption--based contracts. This would increase the availability of secondary raw materials for construction companies. Changing the business model would also shift the focus from short-term costs to long--term value.
3. **Creating demand for recycled materials through public campaigns.**
   Both the public and private sectors should invest in awareness campaigns to educate potential investors and end-users about the benefits of using recovered materials. By creating demand, these campaigns will help reduce the cost of using circular solutions.

43. André Coelho, Jorge de Brito, Economic analysis of conventional versus selective demolition—A case study, Resources, Conservation and Recycling, Volume 55, Issue 3, 2011, Pages 382-392

SOCIAL BARRIERS:

1. Low level of public awareness and preference regarding the recovery and reuse of construction waste.
2. Resistance of the circular economy and change.
3. Concerns about the safety of recovered materials.
4. Insufficient motivation of the sector for recovery practices.

SOLUTIONS:

1. Raising public awareness of the benefits of the circular approach through public education campaigns. Campaigns can be targeted at construction professionals, clients and end users. They should dispel misconceptions and promote the advantages of using secondary materials.
2. To overcome the sector's resistance to change, it is worthwhile to organise targeted training and education programmes to help industry experts learn about recovery methods and product properties. These programmes should focus on the technical aspects of working with recovered materials.
3. To ensure safety in the recovery of building materials, laboratory tests should be carried out even before demolition to identify potential hazardous substances. This is particularly important in industrial facilities, where there is a high chance of the building material being contaminated with such substances.

TECHNOLOGICAL BARRIERS:

1. Slow pace in the development of construction material recycling technology.
2. Lack of standardised tests, certificates and guidelines for the recovery of construction materials.

SOLUTIONS:

1. **Accelerating innovation in the development of construction waste recycling methods.** To accelerate innovation, government and companies in the sector should promote collaboration between researchers, material suppliers and construction companies. This can be achieved by establishing research centres focused on construction waste treatment or by fostering collaboration between academic institutions and private sector organisations.
2. **Use of digital technologies to optimise the recovery process.** Digital technologies such as Building Information Modelling (BIM) can play a key role in the recovery and reuse of waste from buildings. By integrating materials data (i.e. properties life cycle assessment, cost estimates) with BIM systems, building professionals could gain a better and faster understanding of the functionality and potential benefits of using a given material.
3. **Encouraging knowledge sharing within the sector.** In order to further stimulate circular transformation in the construction sector, it is worth strengthening the exchange of knowledge (sharing of information, research results, good practices) between different industry stakeholders. This can be done through digital platforms, conferences or workshops.
4. **Improving the performance and compatibility of recycled materials.** Emphasis should be placed on research and development to improve the performance and compatibility of secondary materials with current standards. By ensuring that recycled products meet or exceed the standards of traditional materials, we make it more likely that construction companies and customers will use them.

REGULATORY BARRIERS:

1. Law favouring traditional building materials.
2. Uncertainty resulting from inconsistent and changing regulations.
3. Limited funding for research and development of construction materials recovery methods.

SOLUTIONS:)

1. **Development and implementation of regulations favouring circular materials.**
   Public administrations should create policies and incentives that promote material recovery and reuse. Regulations could include tax concessions, subsidies or preferential procurement rules in line with the principles of circularity and recycling.

2. **Increasing funding for research and development.**
   Support for research into methods of processing and recovering construction materials would accelerate their commercialisation. Financial support could include direct investment in research institutions or grants for private R&D initiatives.

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