University of Bologna

School of Engineering and Architecture

ENVIRONMENTAL ENGINEERING RESEARCH (B)

SUSTAINABLE MANAGEMENT AND RECYCLING PROCESSES OF VARIOUS CONSTRUCTION AND DEMOLITION WASTES

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ABBREVATIONS:

C&DW: Construction and demolition waste

EC: European Commission

EU: European Union

MS: Member states

WFD: Waste Framework Directive

VOCs: Volatile Organic compounds

ISPRA: Istituto Superiore per la Protezione e la Ricerca Ambient

BRI: Brutto-Rauminhalt

WRAP: Waste and Resources Action Programme

BRE: Building Research Establishment

GDP: Gross Domestic Product

GPP: Green Public Procurement

FDR: Full Depth Recycling

BIM: Building Information Modelling

DWM: Demolition Waste Management

ABSTRACT

The construction industry has experienced rapid expansion in recent decades as a consequence of population growth, increased IT spending, increased industrialization, and the introduction of new infrastructure projects, all of which have resulted in a dramatic increase in the construction industry. As a result, the demand for building materials for construction operations is high, resulting in a large volume of construction trash. Wasted construction materials resulted in significant financial losses for builders, contractors, regional governments, and the country as a whole. The massive volumes of construction and demolition (C&D) waste created throughout the world, which account for more than 25% of all waste generated, has become a severe environmental concern that must be addressed. This analytical research study examines the many negative environmental effects of the currently utilized conventional waste management approach of landfilling and offers trash recycling as a viable alternative.

Because of the vast volumes created and the tremendous potential for re-use and recycling reflected in these materials, the EC has designated construction and demolition (C&D) waste as a priority stream. Indeed, appropriate management would result in the effective and efficient use of natural resources as well as the reduction of the planet's environmental consequences. As a result, the Waste Framework Directive (WFD) requires Member States (MS) to take all necessary steps by 2020 to obtain the minimum target of 70% (by weight) of C&D waste for re-use, recycling, and other material recovery, including backfilling operational processes using non-hazardous C&D waste to replace other materials.

As a result, this study on C&D waste is an important tool for determining the next stages and trends in the handling of this waste stream in Europe.

1. INTRODUCTION:

Construction and Demolition Waste (CDW) is the EU's biggest waste source, accounting for almost one-third of all waste generated. The proper management of CDW and recycled materials, as well as the proper handling of hazardous waste, can have significant environmental and quality-of-life advantages. CDW recycling can also assist the building and recycling industries in the EU by increasing demand for CDW recovered materials.

Construction and demolition waste (C&D waste) is a combination of inert and non-inert materials generated during construction, excavation, remodeling, refurbishing, demolition, roadwork, and other construction-related operations. Soft inert elements like dirt, earth, and slurry, as well as hard inert materials like boulders and shattered concrete, make up inert materials. Metals, wood, plastics, and packaging debris have all been classified as non-inert materials. The detrimental environmental effects of C&D waste began with its disposal in woods, streams, ravines, and vacant land, causing erosion and contaminating wells, water tables, and surface waterways. They also attracted bugs and posed a risk of causing fire.

All of these large-scale construction projects in many nations have contributed to a rise in waste generation, putting a pressure on landfill capacity, and causing environmental concerns. It should also be noted that due to the presence of hazardous elements such as asbestos, heavy metals, persistent chemical compounds, and volatile organic compounds (VOCs) in building debris, disposal is challenging. These wastes have a variety of negative consequences on human health and the natural/artificial environment. Because the construction industry served as a base and critical variable that was linked to all other sectors, the entire impact of C&D waste had an influence not only on the environment but also on the economic sustainability of the country.

The increase in C&D waste has resulted in major difficulties both internationally and locally. In this setting, C&D waste management has emerged as one of the most pressing environmental concerns in the construction sector. C&D wastes can have a lower environmental and economic impact if they are managed properly. Waste reduction and proper disposal are the goals of construction C&D waste management, both of which contribute to prevent negative environmental consequences. Because C&D wastes are seen as a significant environmental issue in many nations, several restrictions have been enacted. State policy on C&D waste management has been enacted, and standards and guidelines on these topics have been created. There are studies and documentation on establishing objectives for the management and recovery of C&D waste for European Union member states.

2. WHAT ARE CONSTRUCTION AND DEMOLITION MATERIALS:

When new buildings and civil-engineering structures are erected, as well as when existing buildings and civil-engineering structures are rehabilitated or demolished, construction and demolition materials are generated (including deconstruction activities). Streets and roads, bridges, utility facilities, piers, and dams are all examples of civil-engineering constructions.

Bulky, hefty materials are frequently found in C&D materials, such as:

- Concrete
- Wood (from buildings)
- Asphalt (from roads and roofing shingles)
- Gypsum (main component of drywall)
- Metals
- Bricks
- Glass
- Plastics
- Salvaged building components (doors, windows and plumbing fixtures)
- Trees, stumps, earth and rock from clearing sites

3. TYPICAL COMPOSITION OF CONSTRUCTION AND DEMOLITION WASTE:

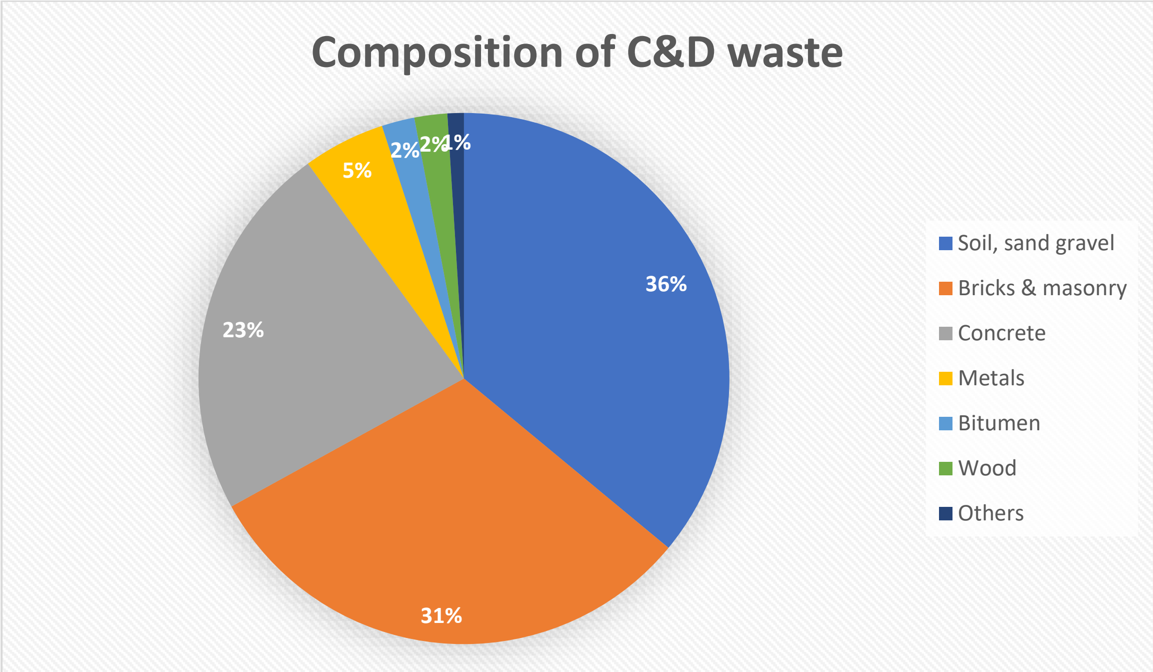

Fig 1: Typical composition of C&D waste

Due to the wide range of CDW created by each activity, these activities confront a variety of issues and may adopt a variety of management methods as a result. The public works sector, which includes road construction, and the construction sector are the two primary sectors. While the public works sector has made significant progress in using recycled aggregates in most states, the building sector is experiencing significant challenges, owing to the wide range of materials involved as well as the diversity of building and construction sites in terms of managed quantities and material characteristics. Indeed, CDW created in the construction industry contains a wide range of waste, particularly when looking at finished work waste and hazardous waste.

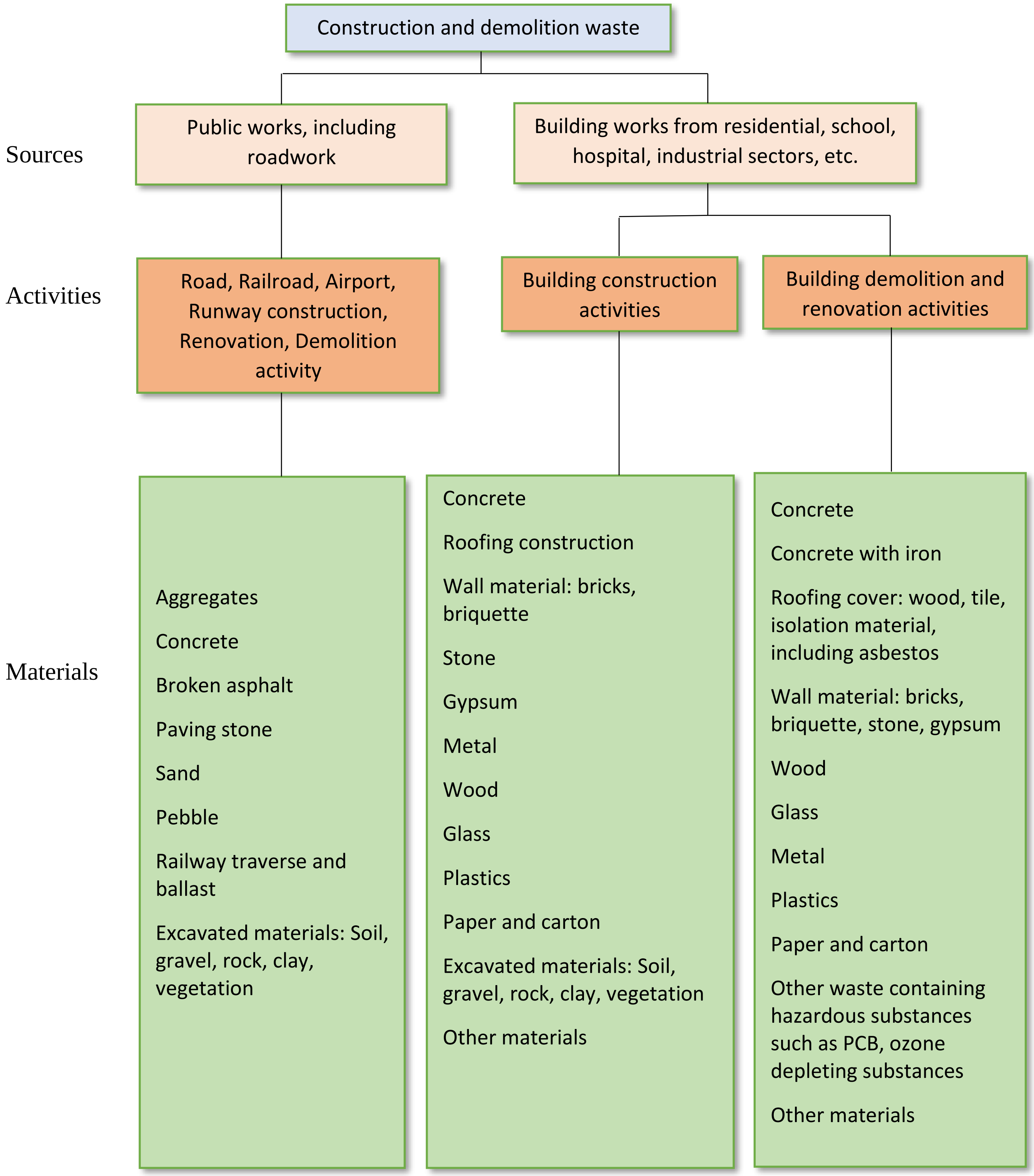

Fig 2: Diversity of C&D waste per activity

4. EVOLUTION OF C&D WASTE IN ITALY:

The produced garbage in the country is divided into two categories: special and municipal waste; C&D waste falls into the special waste category. Hazardous and non-hazardous waste are the two primary subcategories in this category. The C&D group can be hazardous or non-hazardous; in most cases, the high volume falls into the non-hazardous category, which indicates it has a good probability of being re-used. This can be observed in Figure, where the quantity of C&D waste has increased by up to 40%, especially after 2003.

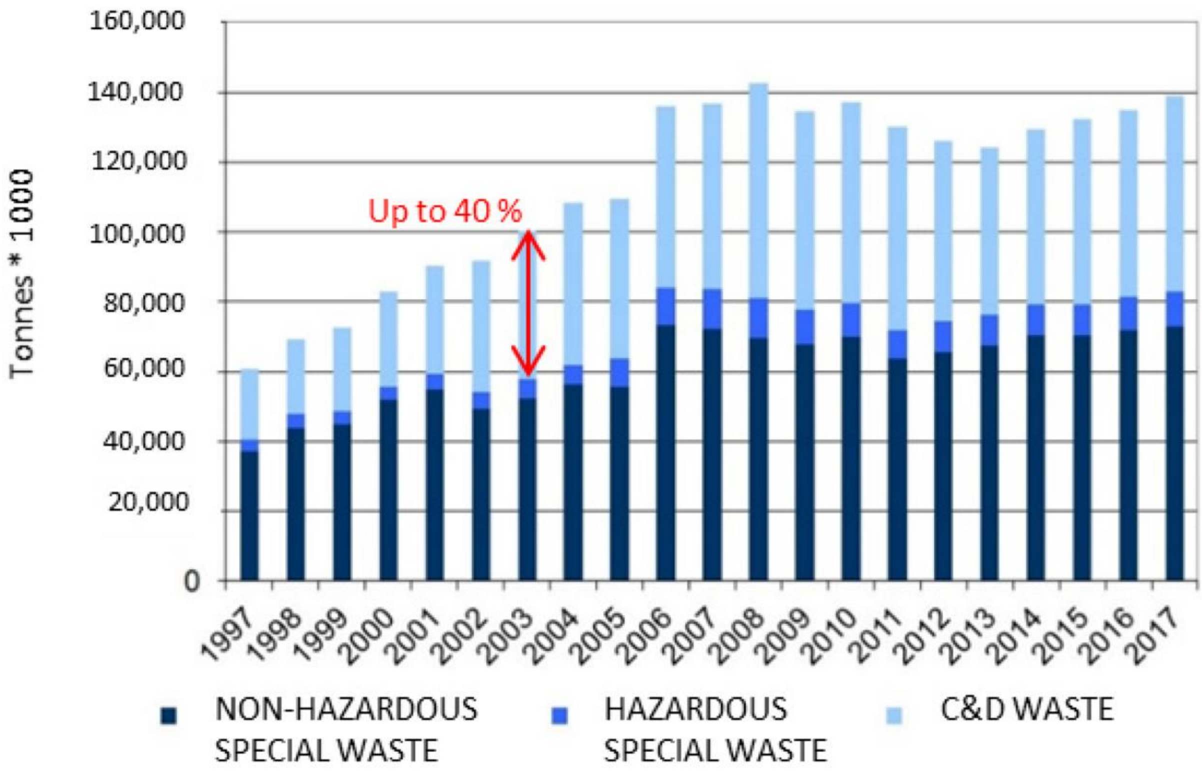

Fig 3: Special waste production in Italy

In 2017, the volume of non-dangerous C&D garbage was 56 million tons, while the generation of special waste was about 140 million tons. It is considerably simpler to grasp the behavior of waste creation over time when looking over a longer period of time. Between 1997 and 2006, the output of special waste increased dramatically, followed by a more gradual increase. As indicated in Figure 3, the country's special waste output decreased by 5.7 percent between 2008 and 2009 as a result of the country's economic crisis. Production increased by 1.8 percent in 2010 as a result of improved economic conditions, but then deflected by 4.3 percent in 2011 as a result of decreased building activity.

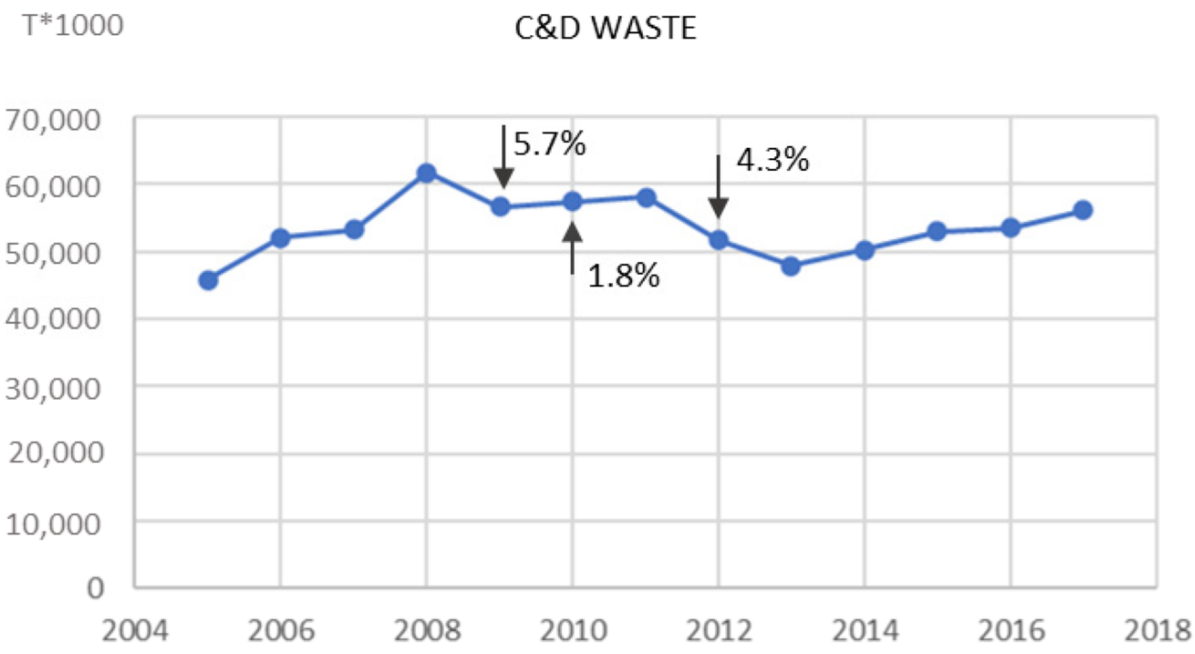

Fig 4: C&D waste production in Italy

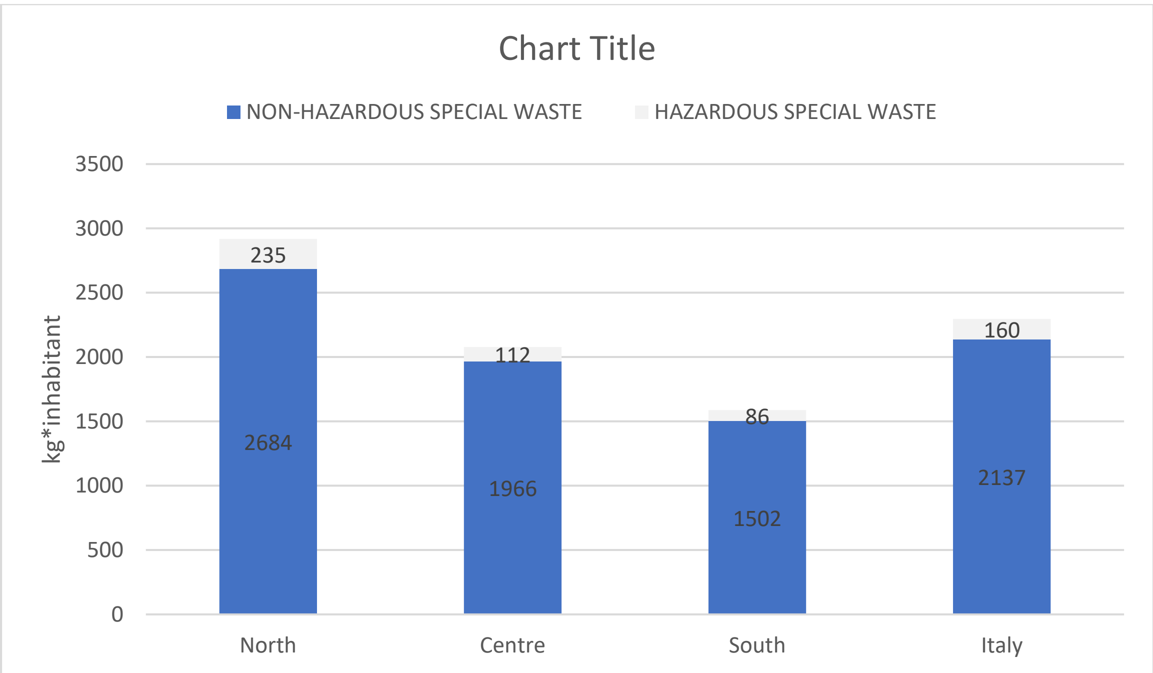

Fig 5: Special waste production in the main parts of Italy

5. CHALLENGES IN ITALY REGARDING SUSTAINABLE WASTE MANAGEMENT:

The current issues within the sector undermine the field's ability to become a productive component of the economy. The following are some of the challenges that can be summarised:

- There is skepticism about the usage of waste-derived goods.
- There is a scarcity of credible information on the production of inert waste.
- There aren't enough updated technological tools.
- Waste separation at the source is poor, and selective demolition procedures are used.
- Lack of mining taxation.
- There is no prohibition or requirement to contribute to inert waste landfilling.
- Analysis of waste sent for recovery/recycling is required.
- Criteria End of Waste.
- CE marking.

In Italy, the usage of materials derived from C&D operations is frowned upon due to prior illegal practices. The waste material is typically employed in road building, where its qualities are similar to those of materials obtained from a new source, but if not properly handled before to use, it can cause major legal and technical issues for the construction business. It is critical to correctly finish the recycling process in order to obtain high-quality material. In light of this, ISPRA's official numbers on waste output from C&D are simply estimates, and it's possible that illegal activities continue to exist today.

6. IDENTIFICATION OF ROOT CAUSES OF C&D WASTES:

There are 34 factors that causes C&D wastes generation. These factors were then divided into seven categories, which are as follows:

1. **Factors relating to design and contract documentation:**

   Contract document flaws, design and construction detail errors, design and detailing complexity, frequent design modifications and change orders, and the use of low-quality materials are all factors to consider.

2. **Considerations relating to procurement:**

   Acquiring supplies that do not meet requirements, supplier and/or shipping issues, quantity take-off errors, and allowances that are too large (i.e., difficulties to order small quantities).

3. **Factors relating to handling:**

   Damage during transit to/on site, materials delivered in a loose state, and on-site material handling that is unnecessary.

4. **Factors relating to storage:**

   Damage and/or degradation due to ineffective storage techniques and an insufficient storage area on site

5. **Factors affecting workers:**

   Worker's inexperience, blunders during construction (i.e., bad craftsmanship), and excessive overtime for workers have all resulted in damage (i.e., time pressure).

6. **Factors relating to site management and supervision:**

   Incorrect materials usage resulting in their disposal, unused/leftover materials and products on site, waste from cutting uneconomical shapes, scarcity of equipment, inappropriate construction methods, site congestion, poor lighting, delays in passing information on types and sizes of materials to be used, poor supervision, lack of on-site material handling, lack of waste management strategies, lack of environmental awareness.

7. **External factors:**

   Weather conditions, unpredictably changing local circumstances, third-party damage, and theft and/or vandalism are all factors to consider.

7. CAUSES OF CONSTRUCTION AND DEMOLITION WASTE:

Design, bidding and contract, and construction are the three primary steps of a construction project. Design encompasses the design/preparation stage; Tenders and Contracts comprise the pre-construction stage; and Construction, of course, includes the building stage.

C&D Waste causes related to design:

- Changes to the design (during construction period).
- Low-quality materials and products selection (unclear specifications).
- Errors in the drawings, lack of information in the drawings, and the difficulty of understanding the drawings.
- Standard sizes available on the market are given little consideration.
- Alternative items are unfamiliar to designers.
- Design and dimensional coordination and communication were not given enough consideration.
- Client requirements necessitated last-minute modifications.
- Designers lack familiarity with construction methods and sequences.
- Lack of influence of contractors.
- Delays caused by the editing and dissemination of drawings.
- Long project duration and inaccuracies in the blueprints.

C&D Waste causes related to tendering and contract:

- Incompletion of contract document at the commencement of construction.
- Contract/tender document errors.
- Type of contract (i.e., cost plus- client bears full cost of materials supply to the site).
- Tendering procedure (allowance being made for waste in the tender).

8. APPROACHES TO C&D WASTE MANAGEMENT:

The existing research methods in the CDW field are divided into various sections. They are:

- Quantification and assessment of construction waste sources.
- Methods and techniques for sorting construction waste on-site.
- Development of waste data collection techniques, including waste flows and waste management mapping, to aid in the treatment of on-site waste and building waste eco-costing.
- On-site trash auditing and evaluation tools are being developed.
- Impact of legislation on waste management practices.
- On-site waste management techniques are being improved.
- In construction, reuse and recycle.
- Benefits and factors of waste management.
- Manuals on waste management, including design guidelines.
- Attitudes towards waste.
- Studies on trash management in comparison.
- Reduction of construction waste by proper design.

9. WASTE MANAGEMENT OPTIONS AND SUSTAINABILITY:

The waste hierarchy is a set of priorities that ranks waste management choices in order of environmental benefit. The primary aim is waste prevention, which entails utilizing less resources in design and manufacturing, less hazardous elements, and storing things for longer periods of time. When garbage is generated, the following are the best options: First and foremost, waste minimization. Second, garbage may be reused (referring to the use of a waste product without further transformation and without changing its shape or original nature). The third point is waste recycling (means reprocessing the waste to turn it into a new substance or product). Waste recovery is ranked fourth, and waste disposal is ranked fifth (e.g., landfill).

The following diagram depicts the relationship between waste hierarchy and sustainability, with prevention being the most sustainable choice and disposal being the least.

Fig 6: C&D waste management hierarchy

9.1. WASTE PREVENTION:

Waste prevention, according to the Waste Framework Directive (WFD), is defined as actions done before a substance, material, or product becomes waste that reduce:

i. The amount of waste produced, especially through the re-use of items or the extending of product life spans,

ii. The negative effects of waste production on the environment and human health,

iii. Harmful substance content in materials and goods.

prevention is frequently the best option for the environment, because resources are not wasted, and negative environmental consequences connected with waste management are avoided. Prevention also refers to actions done to lessen the negative effects of created waste on the environment and human health, such as reducing the number of dangerous compounds in materials and goods. Waste prevention opportunities exist throughout the building or demolition project's life cycle, not only at the conclusion. Through material selection and 'lean design' methodologies, the design stage, for example, provides several options to reduce the environmental effect of both resources and waste.

- The Waste and Resources Action Programme (WRAP) Design Guide offers several suggestions for waste avoidance and other effective building and demolition management practices.

- The Building Research Establishment (BRE) has created a True Cost of Waste Calculator that calculates the environmental benefits of lowering waste rates and material usage.

9.2. PREPARING FOR REDUCTION AND RE-USE:

Generally, re-use implies that a product, its components, or complete building structures are reused instead of being demolished and sent for recycling, recovery, or disposal. 'Preparing for re-use' refers to the act of inspecting, cleaning, or repairing waste materials so that they can be reused without further processing.

- If the product is not reused by the same organization, a separate collection and return mechanism is necessary.

- After salvaging building components before demolition, a cleaning or reconditioning stage is required.

- If the reusable product is heavier or has a bigger capacity than the disposable one, or if reconditioning infrastructure is limited and must be carried further distances, there will be more transportation emissions.

- Higher energy consumption may arise throughout the use phase compared to new and more efficient items, for example, for electrical equipment that requires more energy.

9.3. RECYCLING:

Recycling into 'secondary' materials may be particularly helpful to the environment because the original, or 'primary', creation of materials can demand considerable quantities of energy and raw resources. Separating metals from C&D waste and recycling them into other metal products, for example, has been found to save the environment. The EU's waste strategy strives to guarantee that waste is utilised as a raw material to create new goods whenever feasible. Recycling also saves energy: recycling an aluminium can, for example, saves 95% of the energy required to manufacture a new one from raw materials.

Various elements, on the other hand, might have a substantial impact on the environmental comparison of recycling and alternative management alternatives. These are some of them:

- The distance to the reprocessing factory as well as the mode of conveyance.
- The recycling process's energy intensity.
- Efficiency in recycling.
- The secondary product's quality.
- The product(s) that will be replaced by recycled material.

Fig 7: C&D waste recycling plant in Italy

9.4. <u>RECOVERY:</u> The management and recovery of C&D waste will allow:

- Reducing the environmental impact of procuring more raw materials, as well as their transportation and processing,
- Reducing reliance on natural resources,
- Reducing emissions from the production and transportation of building materials,
- Reducing the expenses of purchasing new materials,
- Reducing the requirement for C&D waste disposal locations,
- By removing and disposing of waste, we can reduce the harmful impacts on the environment,

- Recycling C&D materials to secondary recovered resources to provide a supply for the sector,
- Creating new job opportunities.

9.4.1. MATERIAL RECOVERY: Backfilling is one method of repurposing non-hazardous CDW in public and earthmoving projects. It can assist increased awareness about garbage collection, transportation, and processing. It can be beneficial in specific cases where re-use or recycling into a higher-quality application isn't conceivable, and it can be used in the waste hierarchy.

One approach of reusing non-hazardous CDW in public and earthmoving operations is backfilling. It can help raise awareness regarding waste collection, transportation, and disposal. It can be useful in situations when re-use or recycling into a higher-quality application isn't possible, as well as in the waste hierarchy.

9.4.2. ENERGY RECOVERY: Any method that transforms waste material into energy is considered energy recovery. Some non-recycling waste, which may have a higher energy value than coal, can be transformed into energy in the form of electricity or other fuels like synthetic gas. Waste-to-energy solutions, for example, complement recycling by reducing waste that would otherwise be disposed of in landfills.

Energy recovery through incineration is not always the most efficient method of treating spent materials, especially those that are difficult to burn or release toxins at high temperatures. When selecting whether or not to incinerate waste, Member States are advised to utilize lifecycle thinking to balance the potential environmental advantages and costs.

9.5. DISPOSAL:

There are times when landfill disposal of C&D wastes is inevitable at the bottom of the waste hierarchy. There may be times when this is the most ecologically sound option. Take, for example, low-grade inert materials. They may need to be reprocessed and transported to a distant location of usage before being recycled as aggregate. The consequences might outweigh both the "avoided burdens" of generating primary aggregates and the inert waste material's disposal in a landfill. The WRAP aggregates model and other life cycle tools can help you figure out whether this is the case.

Fig 8: Disposal of C&D waste into open area

9.6. STORAGE OF C&D MATERIALS:

Construction wastes should be kept in a regulated manner if recovery of C&D wastes is not possible. Storage facilities should not be built on main farmland or in locations with a strong potential for agricultural output. These fields should also be kept away from drinking water, irrigation systems, and water reservoirs such as ponds. The distance between settlement regions is an essential consideration (at least 200 meters). The storage field should be divided by an appropriate divider and should include equipment to accept arriving C&D wastes, an operating building, and a weighbridge.

To enable segregated storage of distinct waste products, an efficient management, monitoring, and tracking system should be established in the storage area.

Vehicles should be coated with suitable materials to avoid environmental contamination during transportation of C&D wastes to the storage location. Vehicles should not be overloaded, and they should only function once they have cleaned mud or other debris from their wheels. Vehicles should also be equipped with signs that indicate the type of C&D garbage being transported.

10. ESTIMATION OF CDW GENERATION DURING CONSTRUCTION AND DEMOLITION:

10.1. MIXED SITE RUBBLE:

Soil excavation is usually the first step in the construction of a structure. The waste from scrap and leftover materials, auxiliary supplies, unclean packaging that cannot be returned, and other components then gather on the construction site. The amount of mixed site rubble produced is determined by the following variables:

- Size of the building
- type of building, such as: residential, office, commercial, or industrial use
- type of construction, such as: concrete or masonry, prefabricated concrete, or frame construction.

The amount of mixed site rubble is obviously proportional to the size of the structure. The relationship between gross building volume (BRI, from Bruttorauminhalt) and cubic meters of mixed rubble generated has a particular value ranging from 0.03 to 0.05 m3 / m3 BRI. The volume of a building contained by the bottom surface and the structure's outer surfaces is known as the BRI. It must be computed in accordance with particular guidelines.

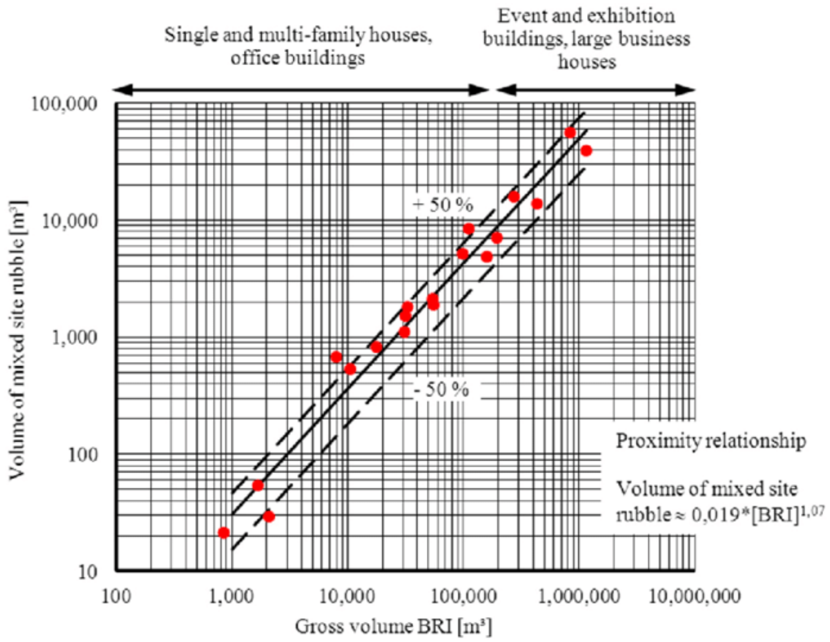

Fig 9: Dependence of mixed site rubble volumes resulting from the erection of buildings on building size

Throughout the building process, mixed site rubble is produced. The building of the load-bearing structure accounts for roughly 25% of this material; finishing accounting for the remaining 75% of the overall volume. The following groups of substances make up mixed site rubble:

- Mineral materials: concrete, brick, sand-limestone, mortar, ceramics, natural stone
- Metals: Reinforcement scraps, installation material for heating, plumbing, roof drainage, electrical installations
- Wood: wood from formwork, timber, pallets, laminated wood, chipboard
- Paper and cardboard
- Plastics

The composition of mixed-site rubble varies significantly. The look of the mixed rubble is dominated by light components. The volumes generated must be considered while planning transportation capacity.

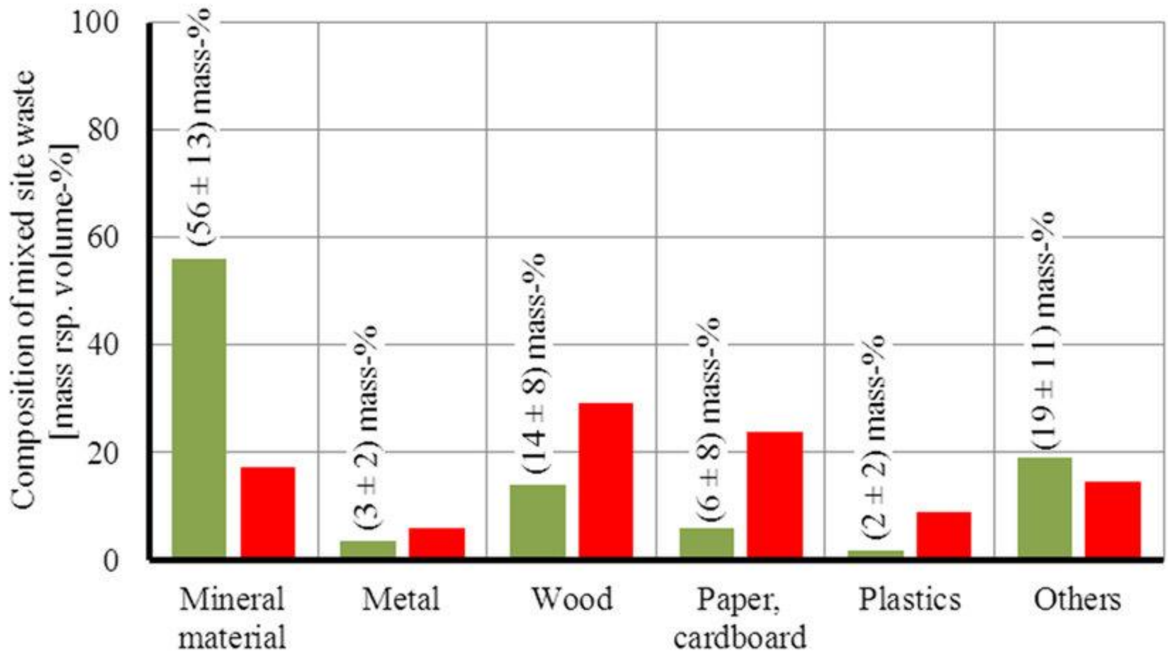

Fig 10: Composition of mixed site rubble

10.2. DEMOLITION DEBRIS:

Before a building is demolished, detachable equipment and appliances, non-structural components, and other items are usually removed. As a result, the structure is simplified to a "skeleton-like" condition. The structure is subsequently dismantled using specially equipped machinery. Concrete and masonry rubble make up the majority of the debris generated in this stage. It should be fed to a processing plant so that it may be utilized as construction material.

An estimate of the quantity and kind of material produced at the demolition site is required in order to prepare for processing and reuse. This computation is based on the relationship between the volume of debris and the size of the structure once again. With a basic cube model, it can be demonstrated that shrinking the cube improves the "specific surface." The compactness of a building may be represented in a simpler fashion if the thickness of the walls and the number of inner walls is also considered. Cooling towers, for example, have very thin walls, resulting in very low specific volumes of material. Extremely dense structures, such as bunkers, have extremely large specific volumes of material. Buildings with no inner hollow space, such as foundations, are the extreme.

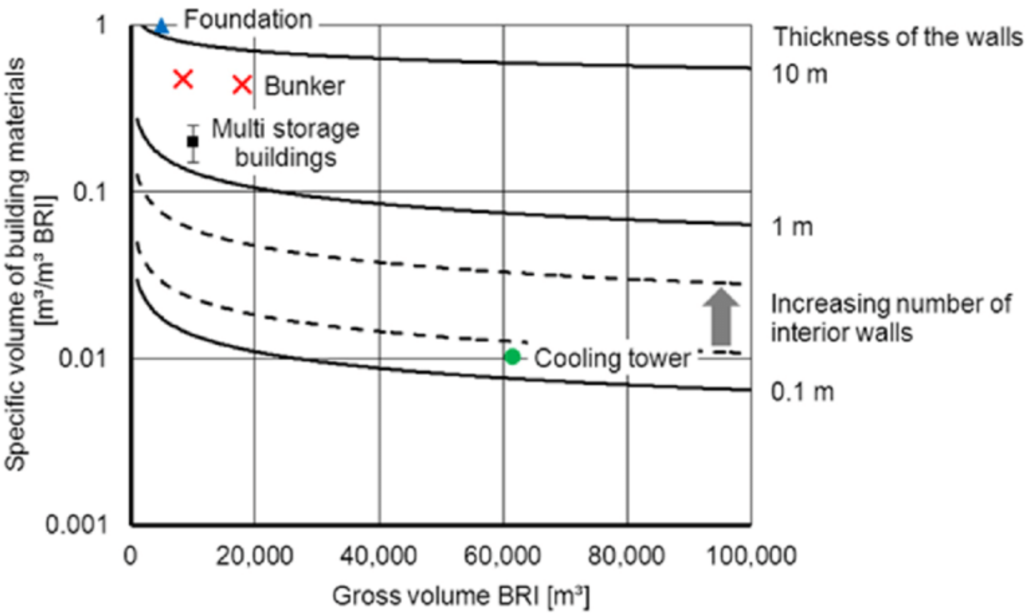

Fig 11: Influence of building size on the volume of construction materials, calculated by the cube model

The quantity of construction debris created during the demolition of residential and non-residential structures is depicted in Figure 12 as a function of gross volume (BRI). The information was compiled from a variety of sources. It can be proved using data from real buildings that the impact of the building's size follows a hyperbolic function. There is, however, a lot of variation. Because of this fluctuation, the ratio of debris created to BRI for extremely big structures may, in certain cases, be larger than the ratio for tiny, single-family residences, despite the theoretical trend. There are two simplified building size ranges to consider: The influence of the quantity of debris on the overall volume of the structure should be taken into consideration up to a gross volume of 6,000 m^3. A constant value of 0.4 tons per m^3 can be assumed above a volume of 6,000 m^3. Only rough estimates may be calculated from these statistics due to the enormous diversity inherent in building construction. A first-hand assessment of the structure yields more precise figures.

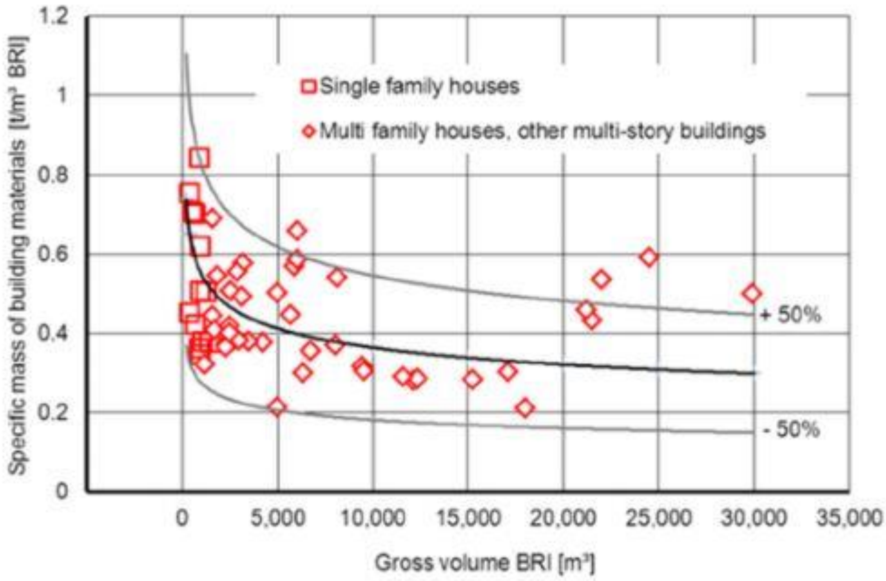

Fig 12: Dependence of specific construction debris on structure size and construction for residential and non-residential structures from the literature

11. WASTE MINIMIZATION STRATEGIES:

According to the conclusions of this study, roughly 4–6% of the concrete utilized will end up in the waste stream. In certain projects, dry concrete was segregated from other trash and recycled as aggregate for road sub-bases. Falsework and formwork for concrete buildings, as well as site borders and bamboo scaffolding, are all done with wooden boards. Some wooden boards were reused on the job site several times until the quality of the boards degraded to the point that they could no longer be used. Wood boards should be reused at least five times before being discarded, resulting in a waste rate of roughly 20%.

Waste management strategies	Mean	Rank
Reusing or recycling some of the waste materials on site	0.908	1
Proper storage and handling of materials on-site	0.874	2
Prepare a list of each waste material to be salvaged, reduce, reused, or recycled	0.857	3
Issuing guidelines for waste segregation	0.829	4
Minimizing design changes	0.752	5
Analyzing site waste to be generated	0.749	6
Minimizing Waste at the source of origin	0.728	7
Organizing waste management meetings	0.723	8
Training of construction personnel	0.723	9
Designating waste disposal operators	0.689	10

Table 1: C&D waste management strategies

12. ANALYSIS OF THE C&D WASTE RECYCLING OPTION:

Waste recycling ranks fourth in the waste management hierarchy. Its goal is to create secondary materials from waste by reprocessing it to change its physical–chemical characteristics and create new products that may be utilized for the same or other uses. Landfilling, incineration, and recycling are the three primary ways for dealing with C&D waste. Crushing of bricks and concrete to substitute gravel as ‘filler’ in new construction projects or as ‘filling’ under new construction is part of the C&D waste recycling process.

By redirecting C&D waste from landfilling to recycling, certain environmental concerns can be minimized. One danger connected with C&D waste landfilling is the pollution of groundwater by leachate, which occurs when rainfall comes into contact with the landfilled C&D waste. The development of hydrogen sulfide, which is caused by naturally existing microorganisms converting the sulfate recovered from drywall gypsum to hydrogen sulfide, is another concern. This can not only give out a terrible odor, but it can also have long-term health effects at low quantities and be fatal at high concentrations.

The quality of recycled concrete aggregate is worse than that of natural aggregate, according to research. This is due to the associated mortar and cement paste fractions that remain after crushing the C&D waste. These residual fragments reduce the density of recycled aggregate by up to 10% compared to natural aggregate and increase its water absorbability, making quality monitoring more difficult. While the presence of polluting metals in waste continues to be a major concern for recycling, a study into the environmental impact assessment of metals in C&D waste found that total metal concentrations in recycled C&D waste products were relatively low when compared to demolition waste, renovation waste, or C&D waste in a landfill site.

13. WHY TO RECYCLE CONSTRUCTION AND DEMOLITION WASTE:

Recycling One of the most crucial parts of this movement is construction and demolition detritus. Construction and demolition recycling is one of the most apparent commitments a developer can make to environmentally friendly construction, since it is visible to every worker on the site as well as passers-by.

i. **Reduce costs:** Waste disposal costs and material expenses are reduced through recycling, reusing salvaged building materials, and limiting materials and packaging.

ii. **Marketing opportunity:** The company's waste avoidance and recycling skills may be a valuable marketing asset for the rising number of potential clients interested in LEED and BUILT GREEN construction initiatives.

iii. **Employment:** According to Ecocycle.org, for every employment at a landfill, ten people are engaged elsewhere in the recycling industry, and another 25 are employed in the manufacture of recovered items.

iv. **Reduce the environmental impact:** Preventing and recycling wastes

- Natural resources like as trees, oil, and minerals are less likely to be depleted.
- Reduces pollution through lowering emissions from production and transportation.
- When compared to many virgin material product production methods, it uses less energy and water.
- By utilizing less energy for manufacturing and transportation, greenhouse gas emissions are reduced.

14. TOWARDS THE 70% TARGET:

Due to a lack of consistent data and reporting throughout MS, assessing the current situation in Europe is extremely challenging. However, it seems expected that the amount of C&D waste generated will continue to rise, at least at the same rate as the economy. Despite having excellent recycling rates, the situation of Flanders demonstrates that there may even be a negative decoupling, in which the volume of C&D waste grows faster than the GDP. However, because to the ambiguity of the decoupling research, a definite trend for the next several years cannot be defined. According to some experts, the priority given to waste prevention in European and national policy, as well as an increasing number of voluntary industry initiatives toward material efficiency, could create the conditions for a reduction in the amount of C&D waste generated, but concrete measures are only beginning to be implemented, and it appears unlikely that a reduction will be observed before 2015.

14.1. BARRIERS AND DRIVERS TOWARDS THE 70% TARGET:

Without a major economic event, it appears that the volumes and composition of C&D waste will continue to follow the current patterns. Existing barriers, and drivers to overcome them, will thus still be significant in the foreseeable future.

i. Economic barriers: High availability and low cost of raw materials

Concrete, masonry, asphalt, and other mineral waste, such as stones, sand, or gravel, make up the majority of C&D trash. The greatest impediment to this mineral fraction’s recycling is that virgin materials that would be substituted by the recycled fraction (such as natural aggregates) are frequently readily accessible and inexpensive to generate. As a result, secondary raw materials from mineral C&D waste may have a lower economic appeal than virgin raw materials; recycling of the mineral part of C&D waste has been largely effective in high-density areas, where virgin raw materials recovered from quarries are scarce.

ii. Cultural barriers: Misconception of the quality of recycled products

Consumers continue to have misconceptions regarding the quality of recycled aggregates made from the mineral component of C&D waste, particularly when used in structural applications. The following are the primary corresponding drivers to overcome this:

- Quality certification of secondary raw material from C&D waste can be used to turn trash into a profitable raw material.

- Communicating the advantages of secondary raw materials: It has been demonstrated that up to 20% recycled aggregates may be utilized in structural concrete without affecting the product's quality. In some uses, such as road construction, recycled materials outperform virgin aggregates.

- The development of end-of-waste requirements for materials, as envisioned in the Waste Framework Directive, might also help to improve the recyclates image and minimize market uncertainty.

- Green Public Procurement (GPP) can play an important role in promoting recyclates and the use of recyclable materials, given the considerable percentage of public-funded building. This voluntary instrument can assist to create a critical mass of demand for more environmentally friendly construction materials that would otherwise be difficult to get.

iii. Technical barriers: contamination of the waste flow due to ineffective sorting

The fact that the waste collected is "clean," that is, free of pollutants and other impurities, is critical to the successful recycling of the mineral component of C&D. The following are the key drivers for overcoming this:

- Encourage "at-source" sorting of C&D waste: efforts should be made to separate out the various materials that make up C&D waste; clear identification of materials and potential contaminants should be carried out to avoid contamination of the inert portion and assure high quality recycled material.

- Selective demolition / controlled deconstruction: “controlled deconstruction" procedures, which include the methodical removal of pollutants prior to demolition as well as the sorting of various building elements, should be promoted and widely implemented.

14.2. IS THE 70% TARGET ACHIEVABLE:

Given that 5MS now have recycling rates of 70% or higher, with some exceeding 80%, it appears that this goal is achievable. Countries with low recycling rates (less than 40%) will, however, have significant challenges in meeting this goal, since they will need to build sufficient infrastructure as well as markets for recovered products. With a current reported recycling rate of less than 15%, Spain, for example, will need to make significant efforts to control the enforcement of existing regulations at the national level; however, some experts are optimistic, as local case studies in Spain have shown that recycling rates of more than 90% are possible.

Furthermore, because mineral waste recovery necessitates selective demolition and proper sorting of C&D waste, this is expected to encourage the recycling of smaller fractions and contribute to the separation and better management of hazardous C&D waste fractions.

The market's ability to absorb recyclates will also determine if the 70 percent objective can be met. This is especially true during economic downturns, when building operations may suffer as a result of an economic or sectoral crisis, making recyclates absorption more difficult.

14.3. BEYOND THE CURRENT DIRECTIVE’S TARGETS:

The WFD calls for 70 percent of C&D waste to be prepared for re-use, recycling, or other kinds of material recovery, including backfilling. According to the findings of this study, most MS should be able to achieve this goal. As a result, the question of how to go beyond this goal arises.

i. Increasing the target.

ii. Creating a hierarchy among the various solutions available to attain the goal.

iii. Specifically addressing "small" portions of C&D waste.

iv. Quantitative objectives for the reduction of C&D waste are being set.

v. Avoiding distortions.

vi. End-of-Waste criteria are being developed.

15. RECYCLING RATES OF CONSTRUCTION AND DEMOLITION WASTE IN THE EUROPEAN UNION:

For the use of secondary raw resources, each country in the European Union (EU) has its own set of rules. Figure 13 depicts the recovery rate of construction and demolition mineral waste in EU nations. In terms of accessible primary raw resources, there are diverse areas in the EU. Due to the extensive availability and low cost of main raw materials, locations with abundant natural resources are not driven to employ secondary raw materials in construction production; the only motive would be landfilling expenses. Regions with a scarcity of primary raw resources, on the other hand, are already highly driven to prepare materials from building and demolition waste for effective use as secondary raw materials. As a result, other communities may be inspired to begin the demolition and recycling process. However, in order to maximize the effectiveness of recycled material consumption in a specific site, the proper strategy must be found. The Czech Republic has a plentiful supply of natural resources at low prices, which contributes to the employment of low-quality demolition and recycling processes, as well as downcycling of building and demolition waste.

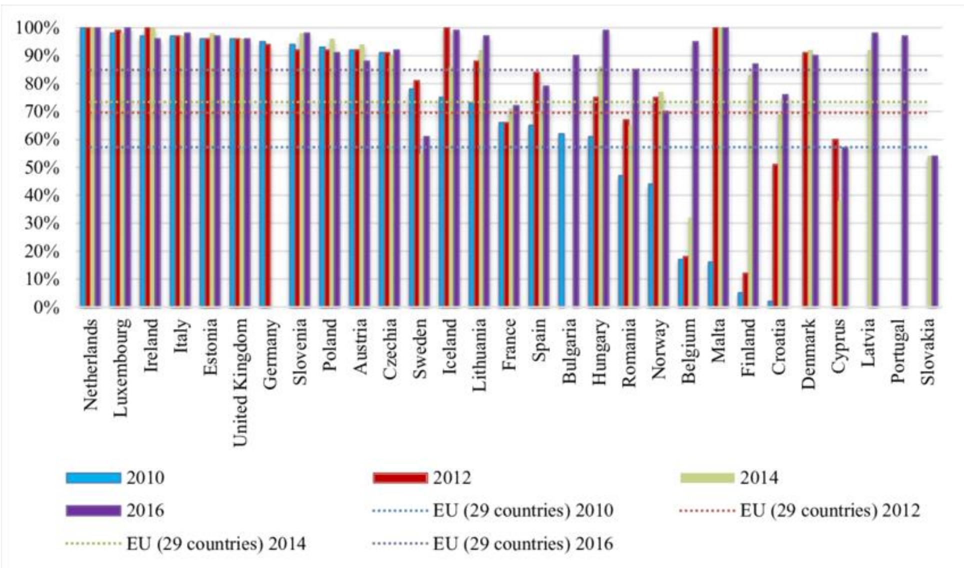

Fig 13: Recovery rates of C&D mineral waste in EU

16.C&D WASTE RECYCLING PROCESS:

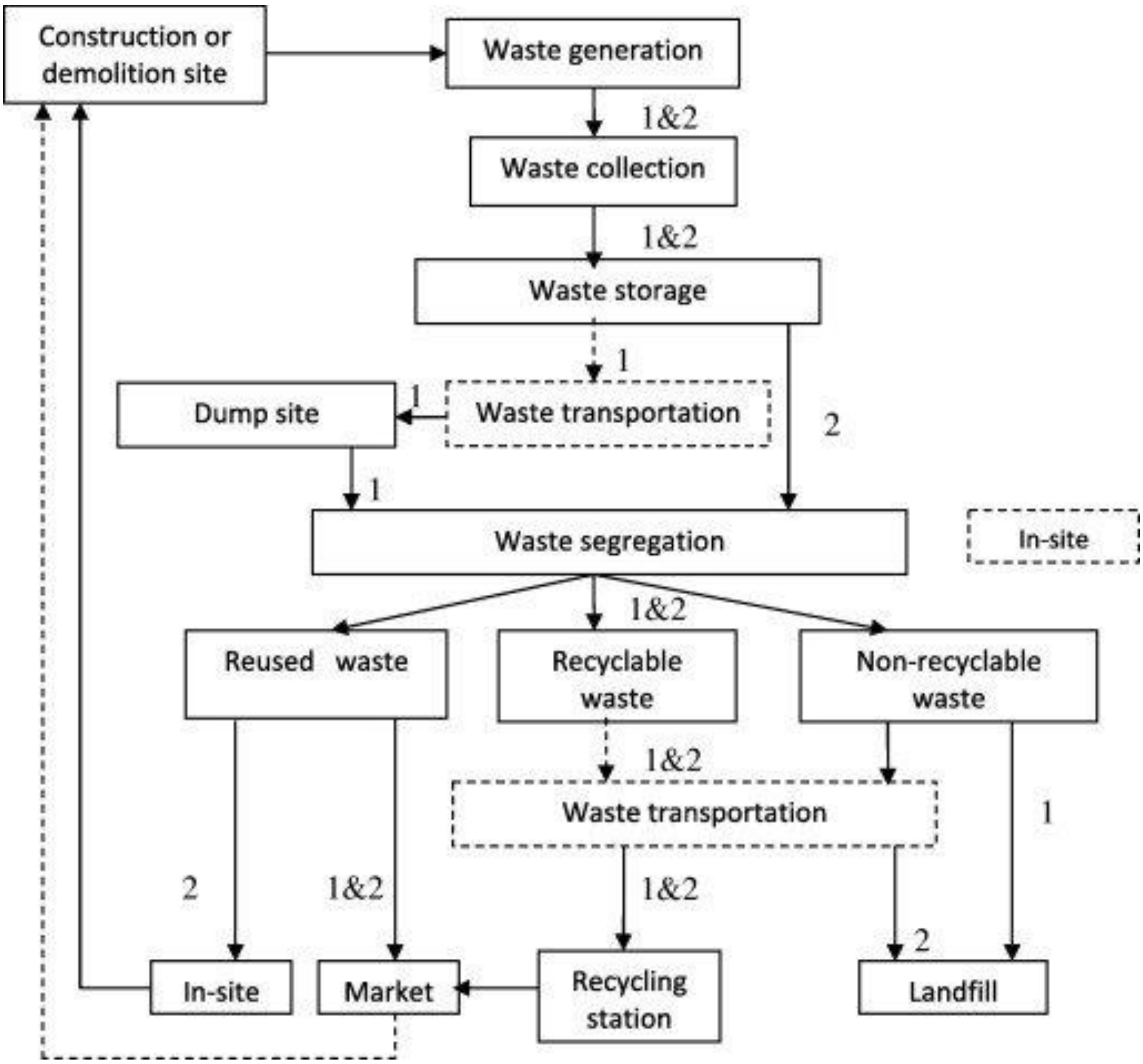

Fig 14: C&D waste recycling process

16.1. <u>CONCRETE RECYCLING:</u>

Concrete may be broken down into coarse and fine particles. Before crushing and grading, all contaminants like as insulation and steel reinforcing must be removed. As a result, to maximize the recycling potential, proper sorting at the building site or at the treatment plant is required. Construction sites frequently have mobile sorters and crushers installed to enable for on-site processing. In other circumstances, dedicated processing locations are formed. Air knives are sometimes used in machines to remove lighter materials like wood, joint sealants, and plastics. Steel is extracted using magnets and mechanical methods, and then recycled.

(a) (b)

Fig 15: Coarse and fine aggregates recycled from concrete waste

These aggregates can be utilized as is in road construction or reintroduced into the concrete making process once they have been sorted and treated.

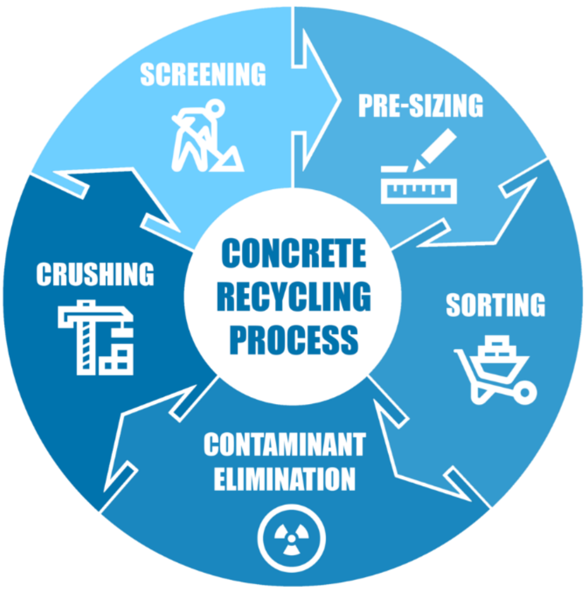

Fig 16: Concrete recycling process

16.1.1. RECYCLING TECHNOLOGIES OF DEMOLISHED CONCRETE IN JAPAN:

16.1.1.1. HEATING AND RUBBING METHOD:

The heating and rubbing procedure involve heating concrete masses to 300°C and weakening the cement paste content to remove mortar and cement paste from the aggregate. Figure depicts a system for producing recycled aggregates using this technology. The recycled coarse and fine aggregate produced by the system is seen in Figure 18. While the manufacture of recycled aggregate produced a considerable volume of fine powder, it also suggested that fine powder may be used as a solidification material in place of the deep mixing stabilizing method (soil cement walls).

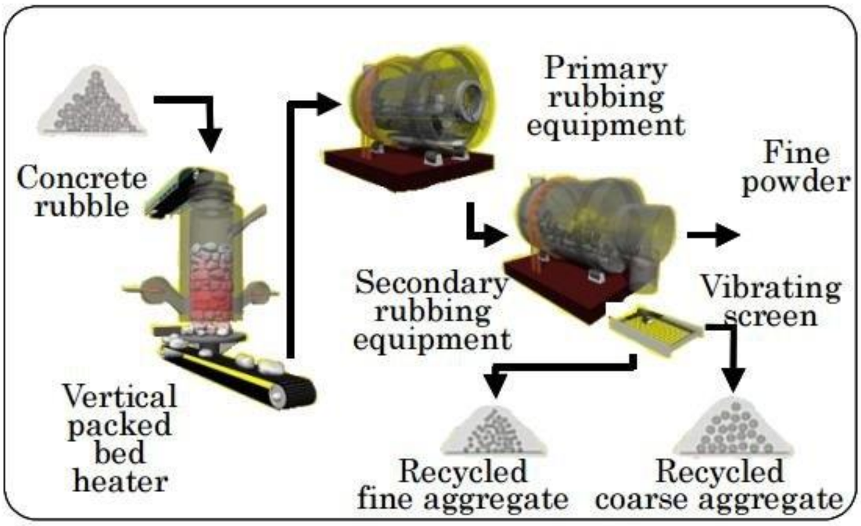

Fig 17: Heating and rubbing method

Fig 18: Recycled aggregates by heating and rubbing method

16.1.1.2. ECCENTRIC-SHAFT ROTOR METHOD:

Crushed concrete lumps are fed downhill between an outer cylinder and an inner cylinder that eccentrically rotates at a high speed to divide it into coarse aggregate and mortar using the eccentric shaft rotor method. Figure 19 depicts a system for producing recycled aggregates using this method.

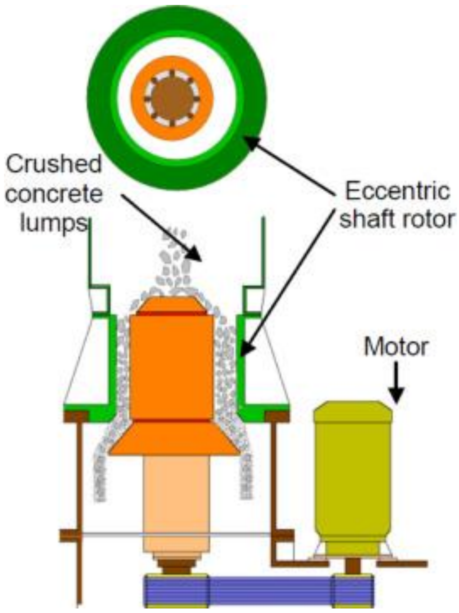

Fig 19: Eccentric shafts rotor method

16.1.1.3. MECHANICAL GRINDING METHOD:

Mechanical grinding is a process for producing coarse and fine aggregate that involves partitioning a drum into tiny parts, filling the drum with grinding iron balls, and rotating the partitions. Figure 20 depicts the system for producing recycled aggregates using this method. These processes have created coarse aggregate that has been utilized in actual construction projects.

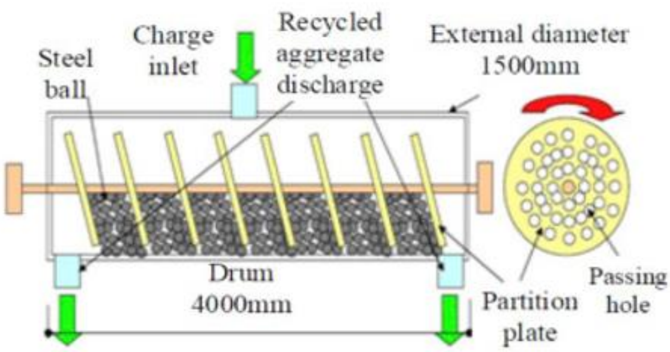

Fig 20: Mechanical grinding method

16.2. AGGREGATES RECYCLING:

- Clean material acquired as a consequence of demolition activity was segregated as much as possible from concrete and brick waste.

- Transport to the location of the grinding equipment. If there are surface options at the demolition site and the ability to do noisy operations, mobile crushers with sieves can be used to separate distinct aggregate fractions.

- Debris crushing in jaw/hammer crushers, either stationary or mobile.

- On rotating sieves, various aggregate fractions are separated.

- The tiniest fractions of aggregates, known as volatile fractions, are collected in filters that remove dust from the crushing process.

- Transport to the processing facility where the "raw material" is transformed into the finished product.

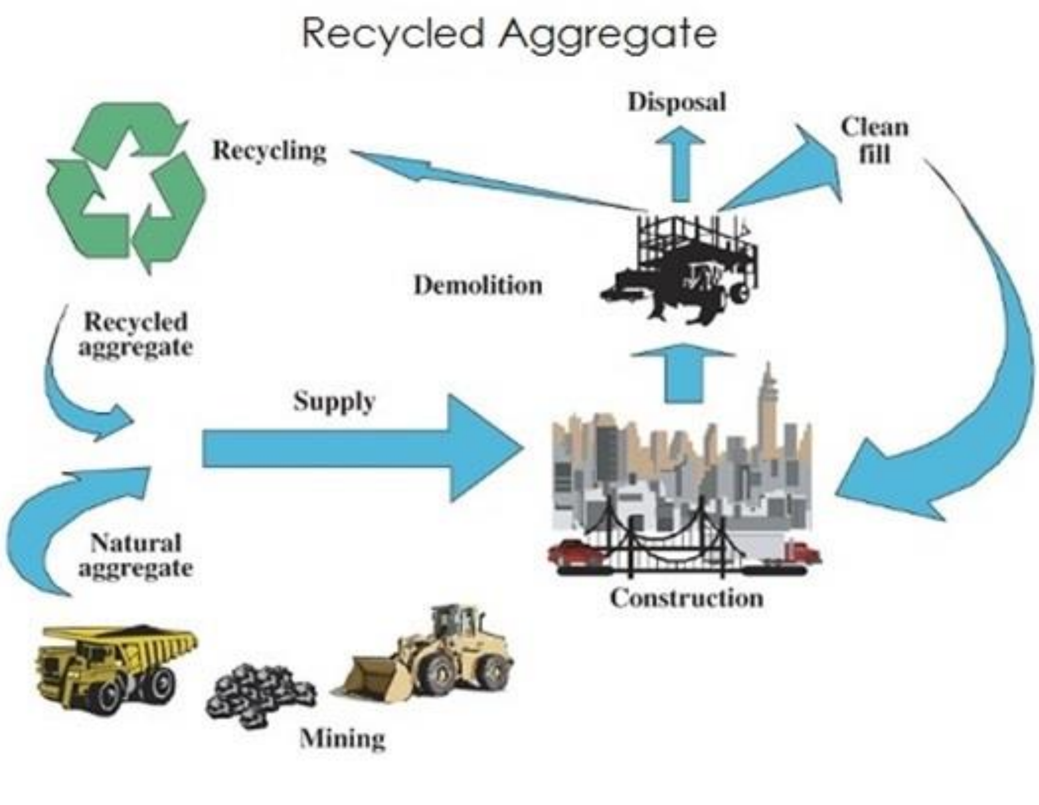

Fig 21: Recycling process of aggregates

16.3. BRICKS, TILES AND CERAMIC RECYCLING:

In some lower-grade applications, such as engineering fill and road sub-base, a large amount of ceramic C&D waste is well adapted to being crushed and recycled as a substitute for newly quarried (primary) aggregates.

Fig 22: Clay tiles from demolition waste

The following are the many recycling solutions supported by the European Tiles and Bricks Association:

- Minor roads should be filled and stabilized, especially in moist locations like woodlands and fields. This is a popular procedure in nations with few stone supply, such as Denmark. In most cases, the material is crushed.
- Crushed clay bricks, roof tiles, and other masonry can be utilized as unbound base material on bigger road construction projects. Due to quality criteria for frost assaults and impact resistance in Germany, the maximum brick content for such application is 30 percent. Natural resources like as sand and gravel, which are generally utilized in vast quantities for this purpose, are replaced by the substance.
- Aggregates for in-place use. Pipe ditches can also be leveled and filled with crushed clay bricks and other masonry. Natural resources such as sand will be replaced with the fine crushed material.
- Bricks and tiles that are no longer usable might be donated to other projects or organizations.

- Alternatively, unwanted bricks and tiles can be delivered off-site or on-site to be recycled into aggregate.

16.4. WOOD RECYCLING:

Wood waste is a valuable raw resource that may be utilized in both material recycling and energy generation, depending on its quality. Recycling of wood waste is becoming increasingly significant as disposal costs rise, and environmental awareness rises.

Wood waste is crushed and stripped of foreign materials, such as metal components, during the recycling process. Depending on the quality of the chips generated, they are recycled or burnt to generate energy. Wooden waste that may be recycled is frequently utilized as a raw material for particle boards and other wood-based goods. Wood chips are a good fuel in biomass power plants and combined heat and power plants when it comes to thermal usage.

Wood waste generated in technological/production processes, such as dust formed while cutting wood or wood-based components, chips, and sawdust, can also be utilized.

Fig 23: Recycled wood waste

- Floorboards, rafters, doors, frames, offcuts, temporary works, fences, posts, poles, and railway sleepers are all examples of wood that may be retrieved from demolition, renovation, and subsequent new construction. It can be re-used right away or transported to recycling centers to be cleaned, de-nailed, resized, or made into chipboard.

- Wood that has been treated with chemicals or preservatives can be dangerous trash, and it should never be combined with untreated wood.

16.5. GYPSUM RECYCLING:

In order to be recycled, the recovered plasterboard must go through various stages. The plasterboards' paper layers are removed as much as possible, then the gypsum is crushed into powder, which is then shipped back to the plasterboard makers to be used to build new plasterboards. Approximately 94 percent of the total plasterboard waste recovered is gypsum powder. The remaining 6% refers to the paper and cardboard (together with its associated contaminants) that make up plasterboards and can be re-used in a variety of ways, including composting (due to the small amount of gypsum left on the paper) or heat generating.

Fig 24: Gypsum waste

There is always a residual paper portion in the powder, which makes it difficult to enhance the rates at which recycled powder is introduced into the present processes. The related hazards include damage to the manufacturing gear as well as an impact on the end product's acoustic or thermal quality.

Emerging techniques:

- Recycling as a raw material in the manufacture of cement.
- Recycling as a soil treatment for agricultural benefit.

16.6. ALUMINUM RECYCLING:

The aluminum recycling process is a standard method of producing aluminum alloys. Recycling aluminum saves around 5% of the energy used to manufacture aluminum from bauxite. Aluminum scrap may include a variety of contaminants, depending on its source. During the processing of aluminum in metallurgical furnaces, these impurities are eliminated by technical methods.

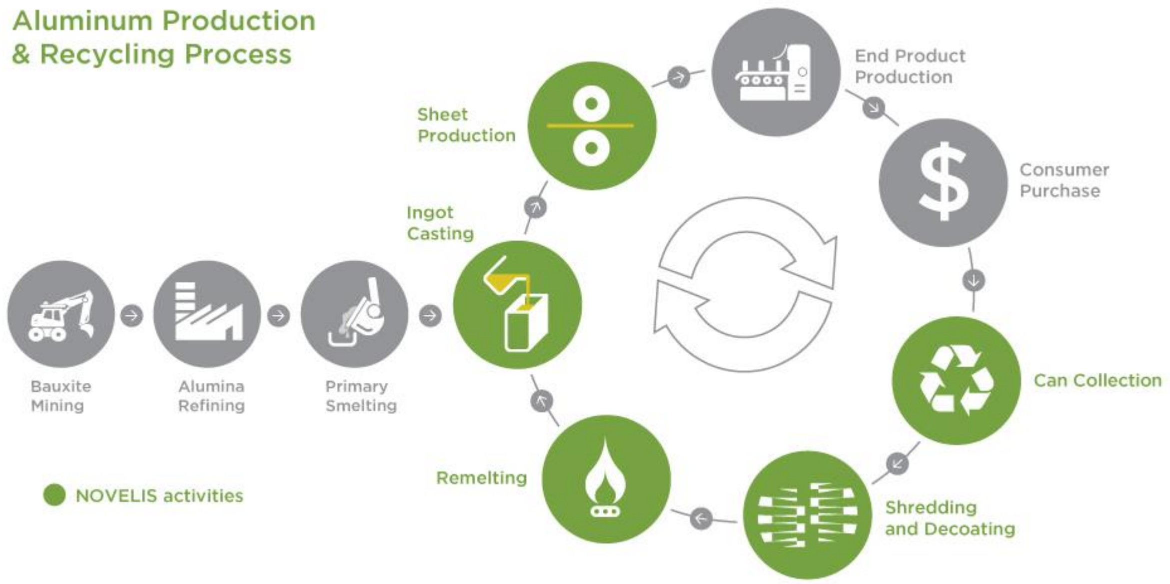

Fig 25: Diagram of the aluminum circulation

Aluminum scrap resources enable the manufacturing of aluminum alloys with a composition of recycled aluminum of up to 40% by weight. From a technical standpoint, there are no limits to the amount of recycled aluminum that may be used in aluminum alloys; given enough waste, alloys can include 100% recycled aluminum without affecting their qualities. Limiting the amount of recycled aluminum in a product is consequently a business decision rather than a technological one.

16.7. METALS RECYCLING:

Metals are the most valuable materials in C&D waste in terms of monetary value. There are many distinct types of metals that may be recognized. The LoW has divided ferrous metal and steel into the following categories: copper, bronze and brass, aluminum, lead, zinc, tin, mixed metals, polluted metals, and cables. Metals like as copper, zinc, and lead are utilized in the construction industry for facades and roofing. Tubes are also made of copper. Steel is utilized in the construction of buildings to make them more stable, as well as in reinforced concrete. Despite the fact that the LoW differentiates six separate classes of nonferrous metals, the metals in this study were divided into ferrous metals, nonferrous metals, and cables.

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Fig 26: Metals from demolition waste

16.8. POLYMER'S RECYCLING PROCESS:

Plastic waste is expected to be created in Europe at a rate of 26 million tons per year. Around 30% of them are recycled. The industry agreed to boost re-use and recycling, avoid waste from entering the environment, and improve resource efficiency on a voluntary basis. Plastic packaging is predicted to be re-used and recycled at a rate of 60% by 2030. Germany is first in Europe in terms of plastics demand, followed by Italy, France, Spain, the United Kingdom, and Poland. Packaging (32.5%), building (almost 26%), automotive (about 10%), and production of electrical and electronic equipment manufacturing are the main areas of application (6.4%). Every piece of packaging must be reusable or recyclable.

Because of the large number of plastics manufactured and brought to the market, the European Community is obligated to take all necessary steps to promote the development of recycling technologies in order to reduce the negative environmental consequences of plastic manufacturing, recycling, and use.

Types of plastic recycling:

- Mechanical
- Chemical
- Thermal
- Composting (Biodegradation)

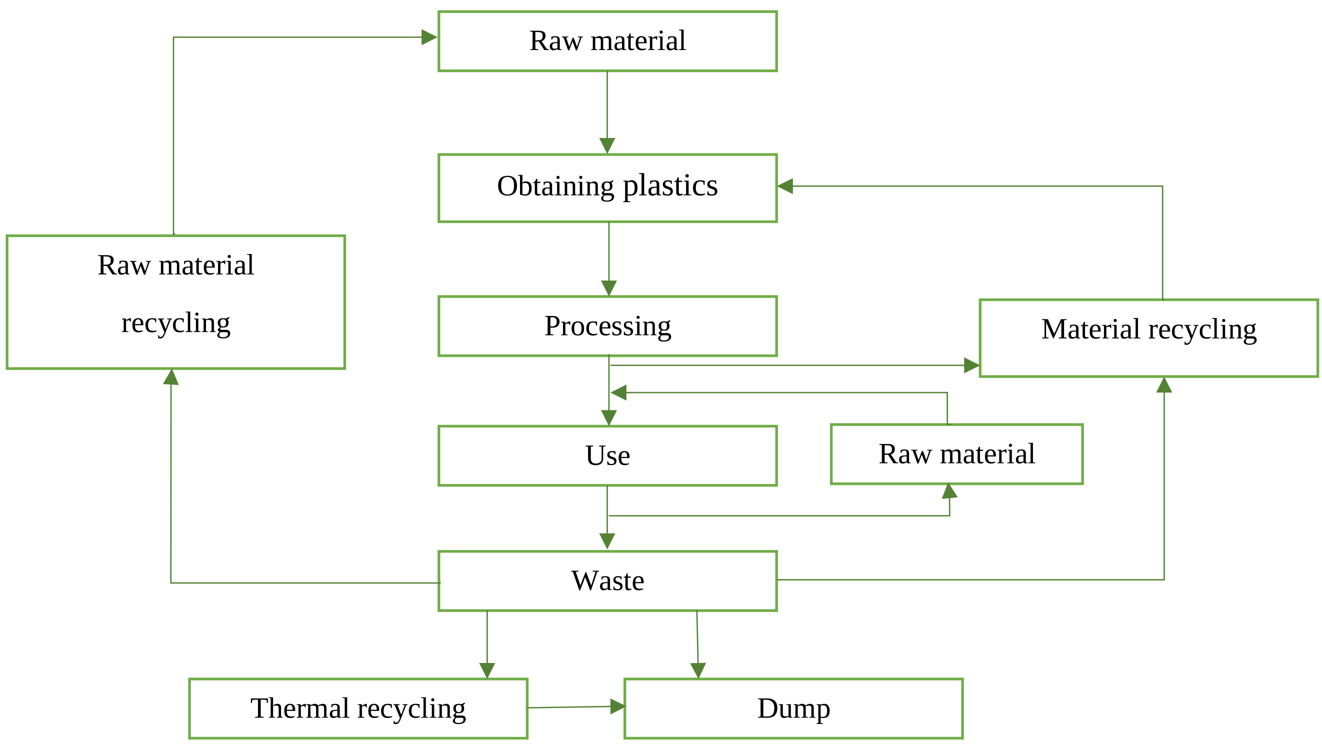

Fig 27: Optimal cycle of plastic circulation

16.9. ASPHALT RECYCLING:

Asphalt recycling can take several forms, including hot or cold recycling, as well as full-depth recycling (FDR), which allows worn-out pavements to be rebuilt by reusing the current one. The following is a typical recycling method for asphalt:

- Asphalt chunks or millings are combined with water and additives in an asphalt recycler (or reclaimer).
- The mixture is tumbled and heated for about 20 minutes before it is ready for use in hot mix asphalt. Cold recycling, on the other hand, does not need the use of heat and so saves energy.
- Asphalt cement (the glue that keeps the pavement together) may often be reused as a binding agent since it retains its adhesive properties.
- Fine mineral particles created during the manufacture of asphalt pavement material can be reused, helping to save natural resources.

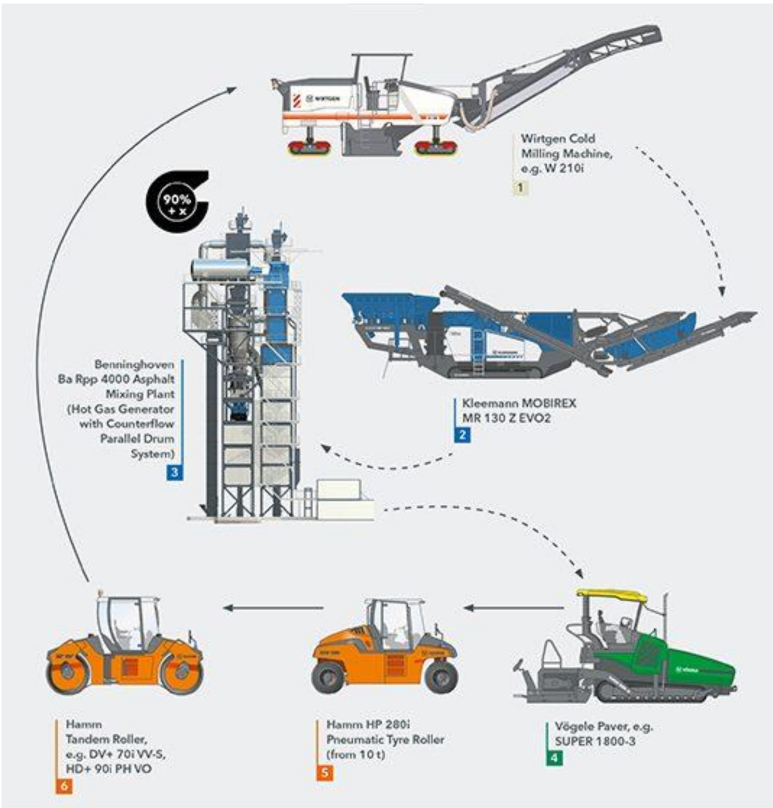

Fig 28: Asphalt recycling process

16.10. TEXTILE RECYCLING:

Textile waste may be recycled in three different ways. They are:

- Mechanical
- Chemical
- Thermal
- Mixed technologies

Mechanical recycling, which involves combing, stratifying, or crushing garbage, is the most frequent process for this type of material. Textile waste encompasses a wide range of items, including floor coverings, furniture tapestries, seats and other vehicle components, clothing, shoes, bags, curtains, tiny clothing, scouring, and so on. These objects can be made of a variety of materials, including polymers and natural materials.

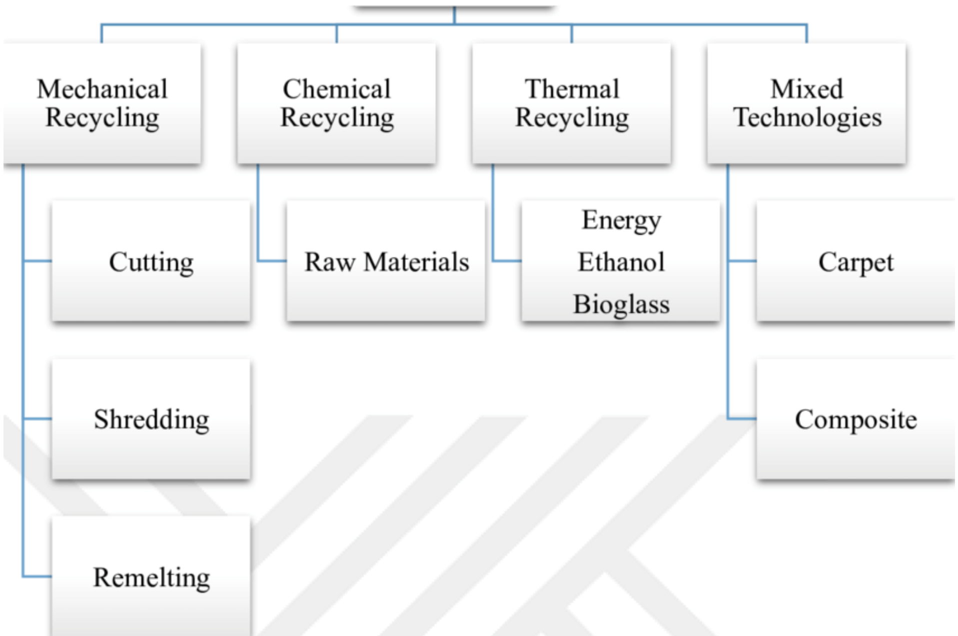

Fig 29: Recycling process of textile wastes

16.11. GLASS RECYCLING:

Glass is perfect for reprocessing since it can be recycled an endless number of times. After all actions associated to the re-use of this raw material, it does not lose its properties or quality after re-melting. Different recycling techniques are required for different types of glass (packaging, float glass). This is due to variations in pollution levels and chemical composition.

Fig 30: Recycling plant of glass from demolition waste

16.12. NUISANCE MATERIALS:

Sheet plastic, carpeting, and drywall all require special handling processes to ensure that the remainder of the waste stream is handled efficiently. When mixed with other building and demolition trash, these materials are often selected with hydraulic digging equipment or grapples a costly and time-consuming process before being put onto a chain belt and passed across a manual sort line.

Waste composition	Recycle/Reuse	Composting	Incineration	Landfilling
Asphalt	72.7%	0.0%	0.0%	39.4%
Concrete	36.4%	0.0%	0.0%	81.8%
Steel	92.5%	0.0%	0.0%	17.5%
Brick and block	57.9%	0.0%	0.0%	60.5%
Insulation	36.7%	0.0%	0.0%	56.7%
Glass	43.3%	0.0%	0.0%	56.7%
Ceramic	32.1%	0.0%	0.0%	71.4%
Aluminum	68.8%	0.0%	0.0%	37.5%
Plastic	36.4%	0.0%	9.1%	54.5%
Paint	65.7%	0.0%	2.9%	34.3%
Wood	73.0%	16.2%	21.6%	40.5%
Gypsum	45.5%	9.1%	12.1%	57.6%
Cardboard	38.9%	11.1%	16.7%	63.9%

Table 2: Current treatment methods for material waste

17. MOBILE PLANT:

One crusher and various sorting machines make up a mobile plant. Hand sorting and self-cleaning electromagnets are mostly used to remove impurities and steel. Two crushers are sometimes used in mobile units. The material is crushed and screened in the mobile plant, and ferrous impurities are removed using magnetic separation. The plant is taken directly to the demolition site.

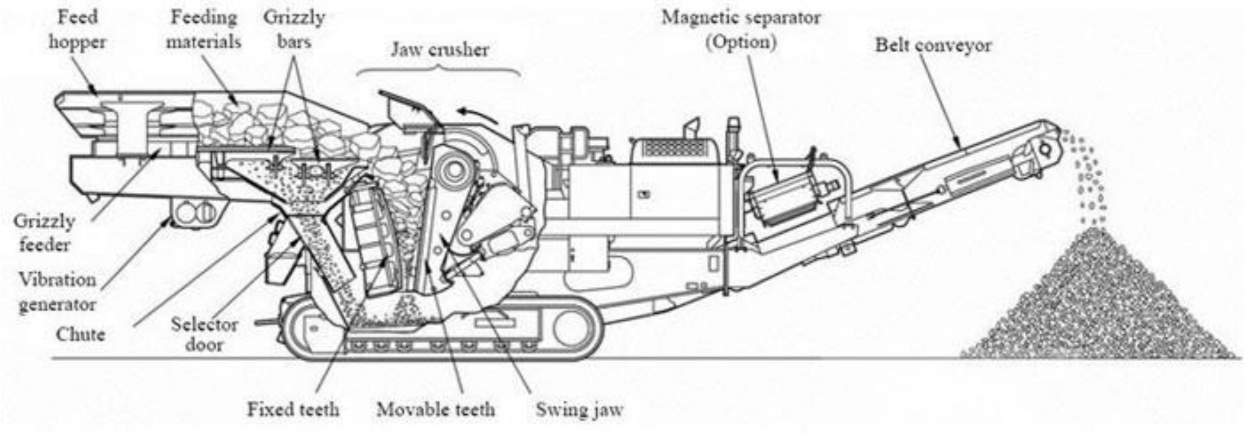

Fig 31: Mobile crusher and its components

17.1. Advantages of mobile plant:

- Suitable for large-scale demolition projects involving a large amount of CDW, such as re-building expressways and huge industrial complexes.
- Economic feasible from an amount of 5000 to 6000 t per site.
- Local transportation is decreased, especially if the rubble is produced, recycled, and reused on the same site.
- Because there is less dumping, disposal expenses are minimized.
- Because the local aggregate supply has risen, less aggregate must be imported into the site.
- The recycling plant may be readily relocated to a new location.

17.2. Disadvantages of Mobile Plant:

- Because cleaning facilities are restricted in this sort of installation, the recovered product is often of inferior quality.

- The recycling plant might generate a lot of dust and noise, which is unacceptably close to a residential neighbourhood.

- This sort of plant may only be employed if the amount of debris on the site is sufficient to warrant the cost of putting up the recycling plant.

18. STATIONARY PLANT:

To create high-quality aggregate, a stationary recycling plant typically contains a big primary crusher that works in tandem with a secondary crusher, as well as numerous cleaning and sorting equipment. To generate a somewhat clean recycled aggregate from a mixed and polluted input material, self-cleaning electromagnets, sieves, and manual sorting are used. In the United Kingdom, this sort of plant usually consists of two jaw crushers and may produce a variety of graded products.

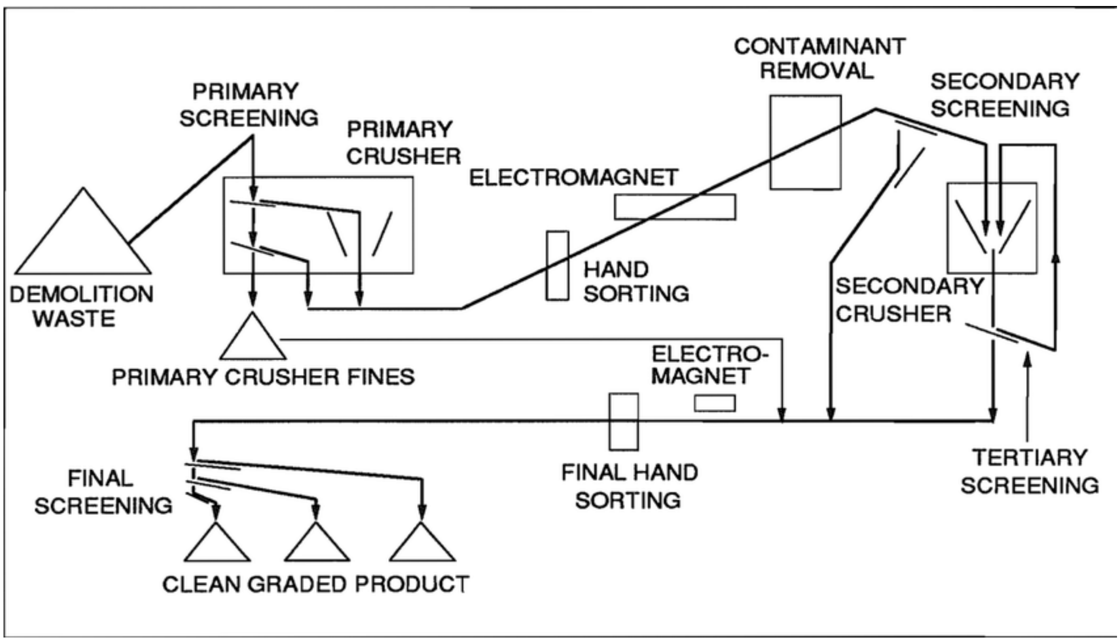

Fig 32: Typical layout of a stationary recycling plant

18.1. Advantages of stationary plant:

- In high-density locations, it's ideal for recycling facilities.
- Because there is less dumping, disposal expenses are minimized.
- The recycling plant has the ability to produce high-quality products.
- Because the local aggregate supply has risen, less aggregate must be imported into the area.
- Because multiple recycled products of varying grades may be generated, the plant's efficiency is higher than that of a mobile recycling plant.

18.2. Disadvantages of Stationary Plant:

- The initial cost of establishing such a plant might be rather expensive.
- In the proximity of the recycling plant, there is an increase in transportation.
- Noise levels may rise as a result of the recycling plant.
- The efficiency of manufacturing is determined by the availability of rubble in the area.

19.BIM FOR C&D WASTE MANAGEMENT:

Construction and demolition (C&D) activities create massive amounts of waste. Improper design, bad procurement and planning, inefficient material handling, raw material leftovers, and unanticipated changes in building design are the primary causes of construction waste. By minimizing design flaws, revisions, and rework, building information modelling (BIM) may effectively manage C&D waste. BIM-based ways to minimize, reuse, recycle, and manage construction waste are presented, including conflict detection, quantity take-off, construction activity planning, site usage planning, and prefabrication.

This section introduces a BIM-based tool that has the potential to make C&DWM easier. The figure 33 summarizes the primary BIM-based applications relevant to each BIM dimension, as well as the benefits those applications provide in addressing C&DW issues.

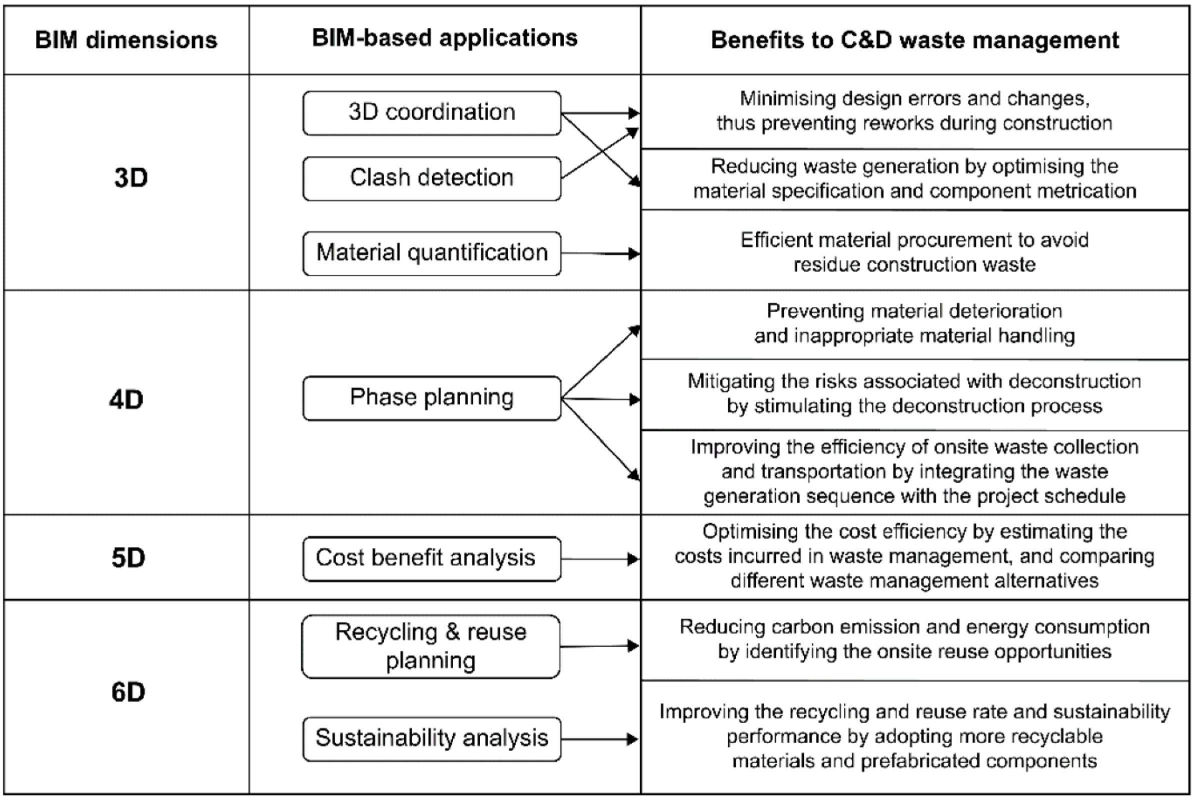

Fig 33: Benefits provided by implementing BIM in C&DWM practices

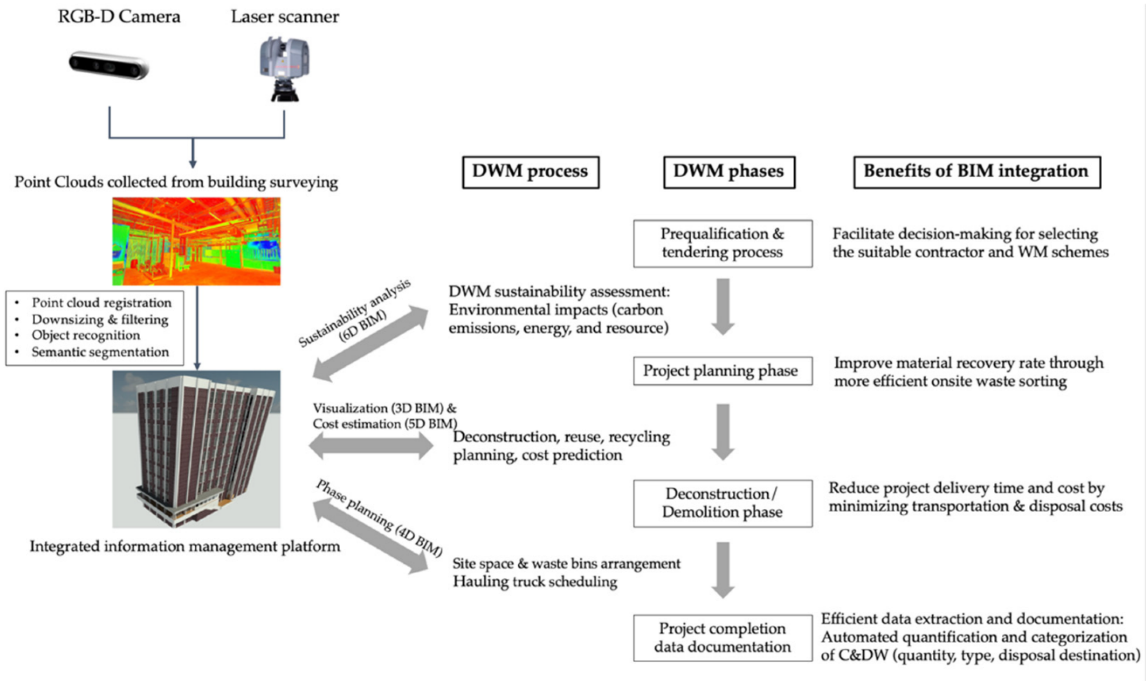

Fig 34: Visual process map of BIM integration in demolition waste management process

20.ENVIRONMENT AND SUSTAINABILITY ISSUES:

The construction sector is a major consumer of natural resources in Europe. Despite this, enormous volumes of these materials now end up in landfills with no way of recovering or reusing them. More efficient material usage, both at the start and at the conclusion of their lives, would go a long way toward decreasing construction's environmental effect. This advantage would be realized primarily through reducing the depletion of scarce natural resources and the reliance on landfill. Furthermore, effective material usage and re-use would help the industry and Europe as a whole to become more economically efficient.

At the EU level, the need for better natural resource management in this sector has been recognized. This is reflected in the ambitious goal of increasing the recovery and recycling of C&D wastes across Europe (70% by 2020, as previously stated). There are several prospects for resource efficiency improvements in C&D waste management. Instead of being disposed of, this waste stream has a high proportion of inert components that are very easy to treat and may be utilized for a variety of secondary purposes. One of these prospective uses is the use of the material as a structural material at a landfill. In landfills, some inert material is necessary, and inert C&D wastes might serve this role.

C&D wastes also contain a number of valuable components with large 'embodied' environmental consequences (measured by the amount of money invested in their production). The re-use or recycling of these components can reduce the requirement for additional original production investment. It would be much better if their usage could be prevented in the first place, and the construction industry has a number of waste avoidance measures at its disposal that can assist in addressing this issue and resulting in major environmental and economic benefits.

The EU message A Thematic Strategy on Waste Prevention and Recycling emphasizes the importance of waste management and incorporates life cycle thinking into waste policy.

20.1. CLIMATE BENEFITS:

The climate challenge is largely viewed as an energy problem in the construction industry, with solutions being sought in light of the shift to renewable energy and the adoption of energy efficiency measures. This viewpoint must be supported by an underlying driver of high energy demand: a linear economy's high material consumption. According to Circle Economy, the extraction of minerals, their processing, and the production of commodities account for 62% of world greenhouse gas emissions, excluding those from land use, land-use change, and forestry. The built environment uses over half of all materials entering the global economy and accounts for around 20% of all greenhouse gas emissions. In a circular built environment, there are five important circular methods to adopt: maximizing product usage and extending their lifespan; improving recycling; adopting circular design; lowering material consumption; and employing lower-carbon alternatives.

The net gain in CO2 reductions has been computed based on lifecycle analysis methods in the assessment of the influence of a circular economy in the built environment, comparing its carbon footprint in a typical linear economy to alternative circular economy management options. The outcomes are case-specific and dependent on the variables in the waste management scenario chosen. For reporting on the environmental performance of building materials, comparisons between various goods with the same purpose are widely used.

The focus of impact evaluations in the construction industry is on building goods and materials with high embodied energy, or the energy required to manufacture construction products and materials from raw materials. This comprises energy used in the extraction of resources, the fabrication of building materials, the construction phase itself, and destruction at the end of the life cycle, but not energy consumed directly during the usage phase. In order to compare the embodied energy of different materials, the impact must be assessed using building works with the same purpose and performance, rather than merely comparing embodied energy per weight. In general, the carbon footprint of materials is related to the embodied energy of the materials.

The CO2 emissions included in construction materials account for 40–50% of an office building's overall carbon footprint, owing to the need for cement and steel manufacture. In a baseline scenario, materials used in construction will emit 250 million tonnes (Mt) of CO2 by 2050 if they are manufactured using today's manufacturing procedures. Demand-side actions may save at least 80 Mt CO2 per year by 2050, according to the report. Furthermore, despite the fact that steel accounts for just roughly 2% of total building materials by weight, it accounts for 25% of the carbon footprint. When considering energy related with extraction, using secondary resources instead of virgin materials generally takes less energy. Instead of mining ore and processing it into steel, reusing steel may greatly cut greenhouse gas emissions. Examples of CO2 savings in steel multi-reuse situations are shown in Figure 35.

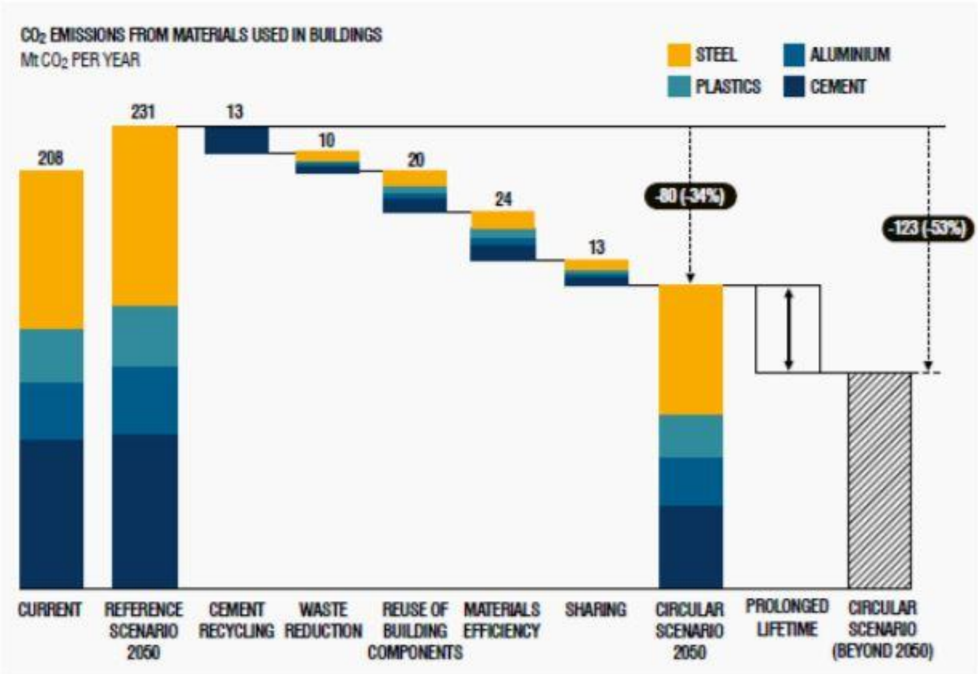

Fig 35: A circular scenario reduces CO2 emissions from building materials, million tonnes of CO2 by 53 per cent.

21.<u>CONSTRUCTION CONTRACT REQUIREMENTS:</u>

The Owner and their architect/engineer must decide how their waste management needs will be expressed in the contract agreements and implemented into the project. A number of conditions are important to the project's overall waste reduction success.

1. In contract papers, there are essentially three ways to convey waste reduction criteria.

    - Specify the waste reduction objectives and rely on the Contractor's effort to meet them. If the Owner and Contractor have an excellent working relationship, urging the Contractor to "do the right thing" may be enough to get the job done.

    - Define clear minimum waste and debris diversion standards. This is sometimes expressed as a numerical criterion in Demolition specifications, such as "divert from landfill disposal a least of 75% of the non-hazardous construction waste generated at the jobsite."

    - Create incentives for the Contractor to be rewarded. This can be done as an award-type incentive depending on the diversion rate, or by offering Options for each of various diversion rate levels in the Bid Schedule.

2. Make it mandatory for the contractor to present a C&D Waste Management Plan. In most cases, the Plan will include the following:

    - Name of individual(s) in charge of waste prevention and management.

    - Actions that will be performed to minimize the amount of solid waste produced.

    - Regular meetings to discuss waste management are described.

    - The precise procedures to be employed in recycling/reuse are described.

    - Waste characterization: material kinds and amounts calculated.

    - The name of the landfill and the projected expenses, assuming that no salvage or recycling is possible.

    - Local and regional reuse programs should be identified.

    - This Plan is expected to divert a certain percentage of waste.

    - Facilities for recycling will be utilised.

- Materials that cannot be recycled or reused are identified.

- Describes how any items that will be recycled or recovered will be protected from contamination.

- The methods for collecting and transporting recycled and salvaged items are described.

- Net cost or savings that can be anticipated.

3. Throughout the project, require the contractor to document their real waste diversion performance. As a result, the Waste Management Plan should contain mechanisms for tracking actual diversion and cost corresponding to each diversion and cost estimate.

4. The agreed Plan should be implemented into the Contractor's Quality Control and Owner's Quality Assurance procedures because it is part of the contract document. Some public owners even state that progress payments will not be allowed unless updated real diversion performance reports are produced.

5. Allow the Contractor to keep ownership to the debris and waste materials, as well as the economic advantages. These include cost savings from reduced garbage disposal costs, revenue from salvaged and recycled materials, and cost savings from repurposing items removed from the jobsite.

22. <u>CONCLUSION:</u>

This research has explored approaches for repurposing building resources, such as waste debris, by recycling them into other construction-related components. Demolition activities to recover or recycle building materials and systems are the primary potential highlighted in this study to divert Construction and Demolition debris from the solid waste stream.

All of the project's major players are involved in a good construction waste management plan: the owner, architect, engineer, contractor, and subcontractor. It is simpler to fulfil specified goals when all partners are involved early in the design process. The contractor should be required under the construction waste management plan to limit waste and discover ways to repurpose existing components, which might be used in the new design or elsewhere. The architect should be aware with the regional waste management infrastructure and work with the contractor to set a waste management target.

To encourage concrete recycling, acceptable rules and design/green-rating systems should be implemented. Concrete recycling will become a critical component of long-term building sustainability.

C & D waste management must be prioritized in order to save earth resources such as river sand, stone, soil, and energy while also protecting the environment from harmful contaminants. C & D waste has a potential use after processing, and the application of such waste is common in industrialized nations. However, there is no systematic effort has been made to minimize, reuse, and recycle C & D waste, while certain NGOs and private firms have taken the initiative. Managing C&D waste in the future will be a huge task. To analyse the waste and its potential for re-use, reduction, or recycling, data on C & D waste production and characteristics should be collected. All stakeholders and the general public should have simple access to data on C&D production, governmental and regulatory frameworks, and actions. Inter-disciplinary research in all areas connected to C & D waste management is required in all nations. With increased building activity as a result of the economy's expansion, it's critical that this sector be tackled in a mission mode to assure long-term growth.

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