CREATION OF THE TRAINING MODULE ON THE RECOVERY OF BUILDING DEMOLITION WASTES FOR THE PERSONNEL TO BE EMPLOYED IN THE CONSTRUCTION INDUSTRY

PREFACE

Rapid population growth in the world, improvements in people's living comforts, and important developments in technology and industry have played a major role in the development of the construction industry. Developments in the construction industry have created a lot of waste. Construction and demolition waste constitutes approximately 40% of the solid waste generated in most countries in the world. It is thought that 50% to 60% of this waste consists of concrete waste. Likewise, irregular waste storage in our country has brought about many environmental threats. In order to prevent this situation and create a sustainable living space, studies on the usability of waste as recycling material have also accelerated. Reducing waste at its source, recycling and harmless disposal has been made mandatory by legal regulations in Turkey.

Within the scope of membership efforts to the European Union, Regulation No. 25406 on the Control of Excavation Soil, Construction and Demolition Wastes has been prepared in Turkey for the recovery of construction and demolition wastes. However, the studies that need to be done regarding the recycling and reuse of materials in the presented regulation are very insufficient. The most common and valid recovery method used in Turkey is the "field sorting" method. The number of regular solid waste separation and recycling facilities in our country is very small.

Due to the 7.7 and 7.6 magnitude earthquakes, whose epicenter was in the Pazarcık and Elbistan districts of Kahramanmaraş on February 6, 2023, 6,624 buildings were demolished and many buildings were demolished in a controlled manner, receiving heavy and moderate damage. Due to the earthquake, a lot of construction waste occurred throughout Türkiye. This situation has brought to mind the question of how to recycle such huge amounts of demolition waste. Finally, considering the current deficiencies in waste management in Turkey and the fact that Turkey is a leading country in the world within the scope of 2050 Net Zero Emission targets, it is now mandatory to create a training module on the recovery of building demolition waste for personnel employed in the construction industry. It was thought that it had become.

With the Erasmus+ project titled 'Creation of the Building Demolition Waste Recovery Training Module for Personnel to be Employed in the Construction Industry' with the code 2021-2-TR01-KA210-VET-000049402 and prepared with the contribution of 2 foreign partners (Hungary and Lithuania), the building demolition waste will be recycled. In order to improve the regulations regarding recycling both in developed countries and in Turkey, existing practices have been discussed in depth and in order to contribute to the training of employees in this sector; A Lecture Notes Book has been prepared. In this way, a module has been created where everyone working in the construction industry can easily access and receive training.

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1. ENTRANCE

1. ENTRANCE

Factors such as the rapid increase in the population around the world, the rise in living standards and the great expansion of urban life by industrialization have greatly contributed to the global development and growth of the construction industry. In addition to the increased consumption needed by the rapidly growing population, especially in big cities, the amount of waste resulting from consumption has also increased. Irregular waste storage in Turkey in the past years has brought environmental threats. In order to prevent this situation and create a sustainable living space, the usability of waste as recycling material has begun to be investigated. Reducing waste at source, recycling and harmless disposal has been made mandatory by legal regulations around the world, including Turkey. In general, approximately 40% of the solid waste generated in any country in the world consists of construction and demolition waste (Maçin and Demir, 2018). 50% to 60% of this amount consists of concrete waste, which is the most consumed substance in the world after water. The values given are average rates worldwide. However, as it is known, housing construction in countries is significantly affected by geographical conditions, livelihoods (livestock, industry, agriculture, etc.) and the culture of the region. For example, in Taiwan, 20% of waste consists of wood and 10% consists of concrete (Manowong and Brockmann, 2010). While approximately 30% of construction and demolition waste in Kuwait consists of concrete, in the Netherlands and Denmark this rate consists of 80% to 85% concrete waste (Ölmez and Yıldız, 2008). A significant part of these wastes is used as additives to binding materials such as cement, but at the same time, these wastes can be used instead of aggregates in the production of concrete, asphalt and geopolymer concrete, and in the construction of base and sub-base layers in road construction. An image of Muğla Metropolitan Municipality Excavation Soil and Construction Waste Recycling Facility is presented in Figure 1.1. Muğla Metropolitan Municipality stated that this delivery prevented 8,666 truck wastes polluting the environment and contributed 1,570,000 TL to the municipal budget (Muğla Metropolitan Municipality, 2022).

Figure 1. 1. Muğla Metropolitan Municipality Excavation Soil and Construction Waste Recycling Facility

3R is an abbreviation consisting of the first letters of English words and refers to the policy of reducing at source, reusing and recycling. This policy has begun to be implemented in many European countries and around the world for construction and demolition waste, and positive results have been achieved in countries that implemented this policy correctly (Huang et al., 2018). The green building concept, which supports the 3R policy, has begun to be implemented in many countries. As green buildings (Figure 1.2) become more common, it is thought that these buildings will reduce energy use by 24-50%, water consumption by 40%, CO2 emissions by 33-39% and solid waste by 70% (Cedbik, 2023).

Figure 1. 2. Example of a green building (Bosco Verticale) in Italy (Milan)

1.1. Aim

The main purpose of this training program is to provide general information on the separation, recycling and reusability of construction and demolition waste.

This training program has been prepared for students studying engineering and architecture, employers and employees operating in the construction industry, vocational high school students, individuals attending public education courses, public institutions and organizations, private sector representatives and other organizations operating in this field.

1.2. Scope

The content of the training program includes general information on the following topics:

What is the importance of recycling?

What are the types of construction and demolition waste?

- How to ensure the separation, recycling and reusability of construction and demolition waste?
- What are the current regulations regarding construction and demolition waste in Türkiye and around the world?

Within the framework of these headings, answers to the following questions were sought:

1. What is the current situation regarding recycling in our country?
2. What regulations regarding recycling exist in our country and around the world?
3. What are the definitions, annual amounts and characteristics of construction and demolition waste?
4. How to separate, recycle and use construction and demolition waste?
5. How should construction and demolition waste be managed?
6. What are the most common construction and demolition waste in your environment?
7. How much do you know about recycling construction and demolition waste?
8. How do you contribute to the recycling of construction and demolition waste?
9. How adequate is the regulation of construction and demolition waste in our country?

Before the training program was prepared, 22 survey questions were prepared by the groups from Turkey, Hungary and Lithuania. The knowledge level of people working in different groups about construction and demolition waste was measured through these surveys. In this way, the content of the training program to be prepared was created. This helped prepare the training program in a customized way according to the needs and knowledge level of the participants.

1.3. Survey Participants

1. Engineers and architects operating in the private construction sector
2. Construction workers working in different construction positions (concrete pouring, hoeing, wall building, mold making, etc.)
3. Students receiving undergraduate education in engineering and architecture faculties
4. Authorized engineers and architects working in relevant units in public institutions
5. Municipality and local authorities
6. Foreign nationals who wish to express their opinions on the issue

1.4 Preparation of the Training Module

a) Partners from Türkiye, Hungary and Lithuania organized surveys.

b) The responses of participants from different working groups were evaluated at the meeting held in Hungary.

c) According to the results obtained, the topics of the training program were determined and the topics were distributed among the groups.

2. RECYCLING AND ITS IMPORTANCE

2.1. The current situation

With the rapid growth of the construction industry, construction waste increases every year during the implementation of renovation projects, and recycling and usage opportunities also increase. Changes are already being planned and implemented in Lithuania to implement the goals of the circular economy. What is a circular economy?

Unlike the "take-make-dispose" model of the circular economy, it eliminates waste through advanced product design, product reuse and repair, recycling, sustainable consumption and innovative business models such as renting, lending or sharing services that offer an alternative to purchasing a product. It aims to reduce resource use as much as possible (Figure 2.1).

Why should we switch to a circular economy?

As the world population increases, the demand for raw materials also increases. However, the supply of basic raw materials is limited and some EU countries are dependent on supplies from other countries. Additionally, the extraction and use of these resources has a significant impact on the environment. This increases energy consumption and CO2 emissions, and smarter use can reduce these numbers.

Benefits of the circular economy Waste prevention, ecodesign, waste reuse and similar measures can help EU companies save money. Currently, the production of the materials we use daily accounts for 45% of CO2 emissions.

Transitioning to a circular economy can be beneficial for the following reasons:

- It reduces the impact on the environment.
- It increases the security of supply of raw materials.
- It increases competitiveness.
- It stimulates innovation and helps create new jobs (could create around 580,000 jobs in the EU).
- It also allows consumers to purchase more durable and advanced products that will save them money in the long run **(Figure 2.2).**

Figure 2. 1. Circular economy

Construction and demolition waste is one of the largest waste streams in the European Union. One tonne of waste is produced per person per year, totaling 500 million tonnes per year across the EU. Unfortunately, valuable materials from these wastes are not always properly separated and recovered.

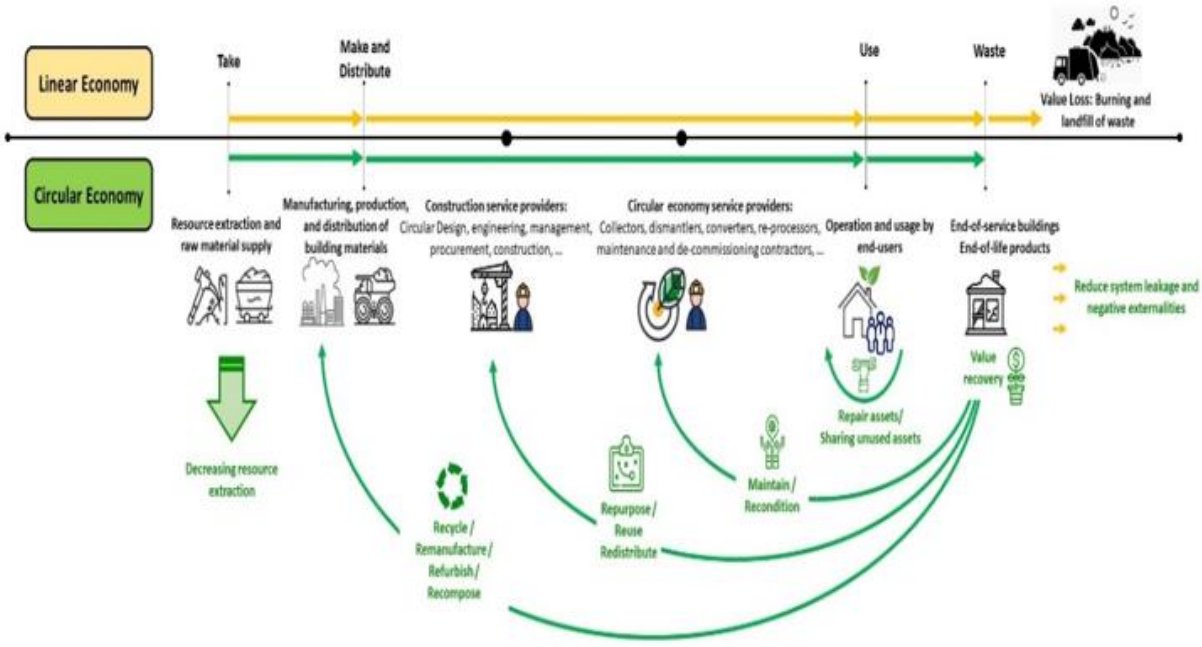


Figure 2. 2. Linear Economy and Circular Economy Approaches in the construction supply chain

According to official statistics, the amount of construction and demolition waste produced in Lithuania is constantly increasing. The amount of these wastes exceeded 1 million tons. According to market participants, the actual amount of construction and demolition waste could be 50% higher due to high administrative burden, inefficient control and failure to properly account for all waste generated in the sector. Therefore, the amount of waste in the construction industry may be the same or greater than the amount of municipal waste. At the same time, this waste stream constitutes the largest portion of the manufacturing waste stream.The majority of the waste produced in the construction industry (around 40%) is inert building material waste generated during the demolition of buildings - materials such as concrete, bricks and tiles. By using modern selective demolition technologies and crushing equipment, these wastes are converted into various building aggregate materials at the construction site and are in no way inferior to aggregates produced from fossil natural resources in terms of quality characteristics (Figure 2.3).

Figure 2. 3. Processing of construction waste containing materials such as brick, clay and concrete

Unfortunately, mixed construction waste accounts for a relatively high share (around 30%) of the flow of waste generated in the construction sector, despite stricter legislation on waste segregation in 2014 (changes to construction waste management rules have set stricter requirements for waste segregation on construction sites). . Inert materials, secondary raw materials (glass, plastic, wood) and household materials are still unsorted and disposed of together. More efforts are required to recover materials from such waste, as the waste must first be separated, and the aggregates produced from mixed construction waste are of lower quality due to contamination with other materials, and it is not possible to recover other materials suitable for secondary use from the mixed construction waste stream (glass, wood, plastic). is almost impossible (Figure 2.4).

Another source of concern is the inadequate segregation of waste where it is generated. In the Lithuanian construction industry, very small quantities of secondary raw materials such as glass, plastic and wood are collected separately. Moreover, there is still no solution in Lithuania on how to properly dispose of obsolete insulation materials.

The quantitative task of construction waste management envisaged by the European Union Waste Directive, the circular economy document and, accordingly, the Lithuanian state waste management plan is currently already being realized (currently more than 70% of construction and demolition waste is recycled). This is due to the fact that there is capacity to manage inert waste generated during demolition (concrete, broken stone), while waste generated in other construction waste streams (recyclables, insulation materials) mostly still goes to landfill. This situation is due to the fact that the construction industry still does not collect quantities of secondary raw materials separately, most of them go into the mixed construction waste stream.

In this way, the opportunities provided by the circular economy are lost – recovering quality raw materials from waste or reusing certain products. Leaving the situation as it is now will make it difficult to properly implement all measures for the construction sector regarding waste management (aside from the aforementioned quantitative task on construction waste management, the circular economy envisages forcing member states to take measures to promote construction and demolition waste separation systems package).

The Ministry of Environment is initiating the preparation of a new State Waste Management Plan - it should evaluate and integrate the measures foreseen in the circular economy set of documents. A critical assessment of the current situation in the guidelines published by the European Commission (EU Protocol on Construction and Demolition Waste) and other relevant documents, as well as best practice examples and recommendations for policy-makers and decision-makers to plan and implement a construction and demolition waste management system that will meet the objectives of a circular economy It will help you to implement it.

Figure 2. 4. Contaminated soil: caused by poor handling of waste.

2.2. Waste definition, waste types (by substance, by source/activity location, by hazard status, etc.)

Construction waste: Waste generated during construction, reconstruction, repair or demolition.

Construction waste management rules oblige builders to separate and store 5 types of construction waste separately:

Municipal waste - Food waste, textiles, other household and wastes of a similar nature or composition to household waste;

Inert waste - Concrete, brick, ceramics and other waste in which physical, chemical or biological changes are not noticeable;

Waste, secondary raw materials suitable for processing and reuse - Packaging, paper, glass, plastic and materials obtained directly from waste suitable for processing and/or suitable for processing or reuse;

Hazardous waste - Wastes that are harmful, flammable, explosive, corrosive, toxic or have other properties such as solvents, paints, adhesives, resins, their packaging and other properties that may have a negative impact on the environment and human health (Figure 2. 5).

Figure 2. 5. Hazardous waste.

Waste that is not suitable for recycling (insulation materials, rock wool, etc.) Separated waste should be transferred to companies that have the right to process such waste according to contracts for their use and disposal.

At the construction site, more types of waste can be separated (sorted) depending on the types of construction, their volume and the possibilities of waste management.

Non-hazardous construction waste can be stored temporarily at the construction site for no longer than one year from the date of production, but until the completion of construction work. Hazardous construction wastes should be stored temporarily in accordance with the requirements specified in the Waste Management Rules, in a way that does not pose a risk to the environment and human health, for a maximum of 3 months or 6 months from the date of production, but until the date of completion of construction works.

Construction and demolition waste, concrete, brick, mineral, stone and glass wool, plaster, insulation, construction materials, ruberoid, plastic, glass, construction paper, hardened paint, varnishes, painted and varnished surfaces, tiles and ceramic products, slate, expanded It includes polystyrene, gas silicate, concrete, keremsite concrete, silicate and concrete blocks, linoleum, floor coverings, wood from construction, domestic plumbing equipment (tubs, sinks, sinks, etc.) (**Figure 2.6).**

Figure 2. 6. Construction Demolition Waste

Construction and demolition waste generated during construction, reconstruction, repair or demolition of medium and large enterprises, where such works require a construction permit or written approval of the building design, in accordance with the rules established by the Official Lithuanian guidelines, who have the right to provide construction waste management services It is processed by waste processors according to individual contracts, in line with the guidelines of the Ministry of Environment. In such cases, it is necessary to sign a contract with the construction waste collection company, which, for a certain fee, delivers this waste to the waste management and landfills of specialized companies. Additionally, companies can deliver waste to landfills themselves, in which case they pay a certain fee.

It is forbidden to throw construction waste generated during minor repairs into mixed municipal or packaging waste containers or leave them nearby. These wastes should be delivered to large waste collection areas. The amount of construction and demolition waste that can be delivered at a time should not exceed 300 kg.Atık, köken aldığı faaliyet alanına göre 3 gruba ayrılmıştır:

1. Wastes resulting from full or partial demolition of buildings and infrastructure elements (roads, bridges).
2. Wastes generated during the construction and repair of certain parts of buildings and infrastructure elements.
3. Soil, rock and plant fragments formed in connection with land leveling works and area management works.

According to their composition and properties, construction and demolition waste is divided into groups as follows:

- Concrete, brick, tile, ceramic
- Wood
- Pine
- asphalt mixtures
- Metals and alloys
- Soil, stones, pumped mud
- Insulation materials and construction waste containing asbestos
- Plaster building materials
- Other materials (often hazardous)

Construction processes can be divided into 3 main groups according to waste production:

1. The main supporting skeleton of the building,
2. Early completion of work,
3. Don't finish work late.

During the construction of the static foundation skeleton, steel, concrete or wood is generally used. At this stage, the material quantity requirement can be easily estimated, thus avoiding excess material waste. Additionally, such building materials are minimally packaged with containers or other protective materials that protect against environmental influences. Early finishing works, installation of partition walls, installation of pipelines, plastering, installation of floor tiles, etc. Includes jobs. At this stage, construction and demolition waste is formed in different groups.

During late finishing works, plaster, paint, flooring, etc. things get done. These jobs do not use material scraps and leave many packaging containers (polyboxes, polyethylene films, empty fill foam containers, etc.).

The three phases of construction are sequenced in such a way that the work performed on the construction site overlaps each other due to the synchronization of technologies. This is determined by the versatility of construction site work; Here, teams from different areas of expertise can carry out construction work simultaneously.

As can be seen from Figure 2.7, the largest portion of waste consists of concrete and steel.

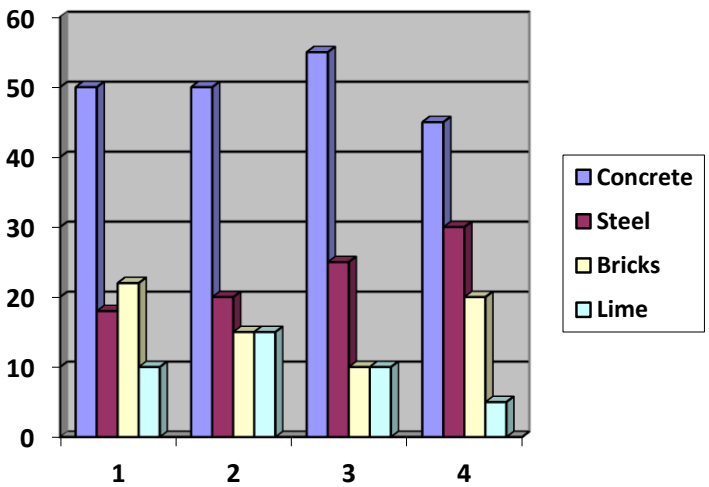


Figure 2. 7. Waste amounts.

2.3. Recycling and its importance. The most important recycling methods.

To realize the ambitious goals of the circular economy, it is necessary to increase the recycling volumes of construction waste and promote the use of recycled construction waste as raw materials. At the same time, we need to increase the sustainability and climate neutrality capacity of the construction sector by challenging businesses to design and manufacture construction products and packaging according to the most advanced technologies that ensure their durability and reusability.

What is circular economy?

In contrast to the “take-make-dispose” model, the circular economy aims to reduce waste as much as possible through advanced product design, product reuse and innovative business models that offer alternatives to repair, recycling, sustainable consumption and, for example, renting, lending or purchasing a product sharing service. and aims to reduce resource usage.

Why should we switch to a circular economy?

As the world population increases, the demand for raw materials also increases. However, the supply of essential raw material resources is limited and some EU countries are dependent on supplies from other countries. Additionally, the extraction and use of these resources has a significant impact on the environment. This increases energy consumption and CO2 emissions, and smarter use can reduce these figures.

Circular economy benefits:

Waste prevention, ecodesign, waste reuse and similar measures can help EU companies save money. Currently, the production of the materials we use every day accounts for 45% of CO2 emissions.

The transition to a circular economy can be beneficial because:

- It will reduce the impact on the environment.
- It will increase the security of supply of raw materials.
- It will increase competitiveness.
- It will encourage innovation and contribute to the creation of new jobs.
- It will offer consumers the opportunity to purchase more durable and advanced products that can improve the quality of life in the long run, thus saving money.

Table 2.1 shows the recovery amounts of construction and demolition waste in Lithuania. The following methods are used to manage construction and demolition waste generated in Lithuania:

1. Recycling;

2. Using;

3. Processing;

4. Expulsion;

5. Incineration;

6. Field Storage

Table 2. 1. Processing of construction and demolition waste in Lithuania.

	2010	2011	2012	2013	2014	2015	2016
Storage, tons	106542	114666	108954	91613	66538	90641	69558
burning, tone	436	616	410	446	450	507	907
Export, tons	247065	250836	108283	157717	131566	162011	145629
recycling, tons	221045	325086	282462	437725	490642	658576	645998
Using, tone	21165	38001	31364	26397	41551	66102	109743
Processing, tone	2103	8250	141123	44757	249832	138642	141348

Recycle

Recycling is the process of processing recycled waste that is reused. The majority of construction and demolition waste consists of concrete, brick, ceramics and tiles. These materials are the most easily processed, meaning they can be ground and fractionated. Granular waste such as concrete, blocks, tiles and mortar can be ground and reused as concrete aggregate. It can also be used as a crushed stone layer if it is ground to a certain fraction and the processed residues do not contain hazardous substances.

Use

Concrete, brick, tile and ceramic wastes, concrete, brick, tile and ceramic mixture wastes are reused.

Processing

Cables containing wood, plastic, copper, bronze, brass, aluminum, lead, zinc, iron and steel, tin, mixed metals, oil, tar and other hazardous substances are processed.

Fire

Incineration accounts for a very small proportion of the total construction and demolition waste stream. Combustible wood, glass, plastics and wood containing or contaminated with hazardous substances, asphalt mixtures containing tar, other insulation materials containing or composed of hazardous substances, construction and demolition waste containing hazardous substances (including mixed waste) are incinerated in rotary kilns or liquid bed.

Export

Copper, bronze, brass, aluminum, lead, zinc, iron and steel, metal mixtures, soil and stones containing hazardous substances are usually exported. The amount of exported materials is decreasing.

Disposal to landfill

Landfill disposal is continuously decreasing. When analyzing the waste composition, we see that landfills mainly dispose of concrete, tile and ceramic waste, concrete, brick, tile and ceramic mix waste. Wood, glass, plastics, tarry mixtures, asbestos-containing insulation materials and asbestos-containing building materials are also disposed of in landfills.

2.4. International and country-specific (Lithuania) legal and fiscal framework

İnşaat ve yıkım atıkları, AB'deki en büyük ve en karmaşık atık akıntılarından biridir. AB'de üretilen tüm atıkların yaklaşık %25-%30'unu oluşturur ve beton, tuğla, sıva, ahşap, cam, metal, plastik, çözücüler, asbest gibi geniş bir malzeme yelpazesi içerir, bunların birçoğu geri dönüştürülebilir.

Construction and demolition waste is the largest waste stream in Europe, both in terms of weight and volume. The amount generated in different EU countries is difficult to compare due to the wide variety and irregular statistics. Legislation regulating the management of construction and demolition waste in Lithuania has been under development since 2006. The legal requirements of the European Union have been transposed into national law. These are the basic requirements required by the European Union.

The two main directions are:

- Reducing the use of resources;

- Reducing environmental pollution.

It has been determined that the main priorities for systematizing the use of construction and demolition waste are consumption reduction, reuse and separation. Consumption reduction, as one of the construction and demolition waste management strategies, offers two main management principles:

a) Promoting production from recycled raw materials;

b) Reducing fees for processing, transportation and disposal of non-recyclable sorting waste.

These are the most effective ways to reduce the amount of waste produced and eliminate many waste disposal and environmental problems. The legal environment for the management of construction and other waste in Lithuania is established by the Ministry of Environment of the Republic of Lithuania. The importance of waste management is also reflected in the legislation enacted by the European Union. The Ministry of Environment's goal is to create an ecologically and economically sustainable national waste management system that will meet national and EU requirements:

- Directive 2008/98/CE. The revision of the Waste Directive (1) offers the opportunity to provide a modern approach to waste management, changing from thinking of waste as an undesirable burden to thinking of waste as a resource.

- Waste Directive 2008/98/CE. The directive provides a five-level waste hierarchy where prevention is the best option. This is followed by reuse, recycling and other forms of waste use, with landfill as a last resort.

- The Waste Law establishes general requirements for waste prevention, accounting, collection, separation, storage, transportation, use and disposal in order to prevent negative effects on the environment and human health. The law determines the functions of state management institutions and other legal and natural persons in waste management (Waste Law No. VIII-787).

- Waste management rules establish requirements for waste separation, temporary storage, collection, transportation, processing; also additional requirements for product distributors to accept product waste from consumers, additional requirements for the processing of biological and hazardous waste (including petroleum waste), requirements for trading in waste and mediation in the regulation of the use or disposal of waste, requirements for technical regulation of the use or disposal of waste, waste accounting and determines the procedure for storing transaction documents (Waste Management Rules No. 217).

- The Construction Law (Construction Law No. I–1240) establishes the basic requirements for buildings to be constructed in the Republic of Lithuania, the procedure for research, design, construction, reconstruction, repair, commissioning, use and demolition of these buildings

- Construction technical regulations are mandatory for all construction participants, public administration bodies, natural persons, legal entities, other foreign organizations and their departments.

Source separation of construction and demolition waste is not encouraged.

The parsing process takes place manually. It is cheaper to store waste than to separate it.

- Lack of trust in recycled construction and demolition waste materials. Construction participants do not trust recycled construction and demolition waste because they do not have knowledge about the physical-mechanical properties of construction and demolition waste materials.
- Raw material prices are lower than recycled materials. The cost of primary raw materials is lower than the cost of processed raw materials.
- The fee charged for storing construction and demolition waste is very low.

2.5. Actors and Process

With the implementation of waste prevention targets, the growth of construction and demolition waste will be reduced, and the negative impact of construction and demolition waste on the environment and health will be reduced. Cooperation of construction participants will contribute to the implementation of waste prevention goals:Before starting the design of new structures, designers must foresee how parts or materials of the structures can be used when demolished (Figure 2.8). Architects must anticipate how the building's spaces will be used and whether they can be easily reconfigured when the building's function changes. This will extend the life of the structure. Manufacturers must label materials and the composition and durability of materials must be known at the time of demolition.

Contractors should try to build structures that can be easily dismantled.

Personnel working in the construction industry. The human factor determines the destruction processes of construction and demolition waste.

Participants of the recycling market. Cooperation, high recycling technologies and suitable markets for the sale of recycled waste.

State regulation.

Promoting production from recycled raw materials;

Reducing non-recyclable sorting waste processing, transportation and disposal fees.

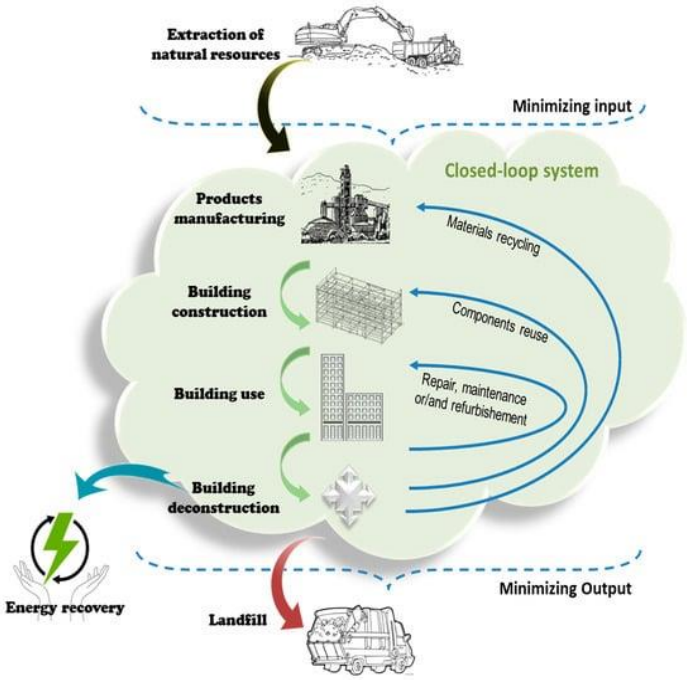


Figure 2. 8. Cycle of buildings

- The main strategy that can increase the market demand of construction and demolition waste must meet the following conditions:
- To regulate the supply of raw materials for primary use;
- Reducing energy resources for transportation and material production;
- Using waste in such a way that completely unprocessable items do not end up in landfill;
- To protect areas suitable for waste accumulation, not urbanization;
- Continuously tightening environmental protection requirements;
- Increasing landfill fees for unsorted waste.

3. WHAT ARE CONSTRUCTION DEMOLITION WASTES?

3.1. Lesson on Waste Definition, Scale and Quantity

- **Entrance**

Wastes and waste management are one of the determining issues of environmental protection today. Construction and demolition waste constitutes a special type of waste that is generated in significant quantities every year in Hungary and the member states of the European Union.

What Exactly is "Construction and Demolition Waste"?

- We can separate waste according to its origin and place of production:
- Municipal waste or community waste
- waste production

Wastes generated in the construction industry are classified as production wastes. 100 million tons of production waste is generated annually in Hungary, and almost 30% of this belongs to the construction materials industry.

According to the law:

According to the Law on the Creation and Protection of the Building Environment No. LXXVIII of 1997: waste resulting from construction activity.

- *According to the law, construction activity: works carried out due to the construction, transformation, expansion, renovation, repair, modernization, maintenance, repair, demolition or relocation of any buildings, building parts or building complexes.*
- *According to UN-KvVM Law No. 2004/45, detailed rules for the processing of building and demolition waste: waste generated during the construction of buildings and listed in the first annex of the regulation is considered construction and demolition waste. Construction and demolition waste can be divided into 8 large groups according to their materials:*
- **Excavated Soils,**
- **Concrete Waste,**
- **Asphalt Waste,**
- **Wood Waste,**
- **Metal Waste,**
- **Plastic Waste,**
- **Mixed Construction Demolition Waste,**
- **Mineral Based Construction Waste.**

Construction and demolition waste is called inert waste. The definition of inert waste can be found in Regulation 20/2006. This regulation establishes the rules for the storage of other waste and the conditions of the dump.

Inert waste: Does not undergo any significant physical, chemical or biological transformation;

- Insoluble, inflammable,
- Does not react with other physical or chemical means,
- Does not biodegrade,
- It has no negative impact on other materials, so it will not cause environmental pollution or health harm,
- Its ecotoxic effect is insignificant and it does not endanger surface or groundwater.

Construction waste is generally solid, inorganic, non-hazardous waste, but hazardous materials can also be used and hazardous materials can be produced in the process.

Quantitative questions regarding the amount of construction and demolition waste in the European Union

The magnitude of the problems caused by construction and demolition waste can be measured by the annual production amount of waste. According to EUROSTAT data, a total of 2,494,700 tons of waste was produced in the 28 members of the European Union in 2014. 34.5% of these wastes are construction and demolition wastes, and 29.8% are inert wastes from mining and quarries.

In Figure 3.1 we can see the percentage distribution of waste produced by economic activities and households in the 28 members of the European Union.

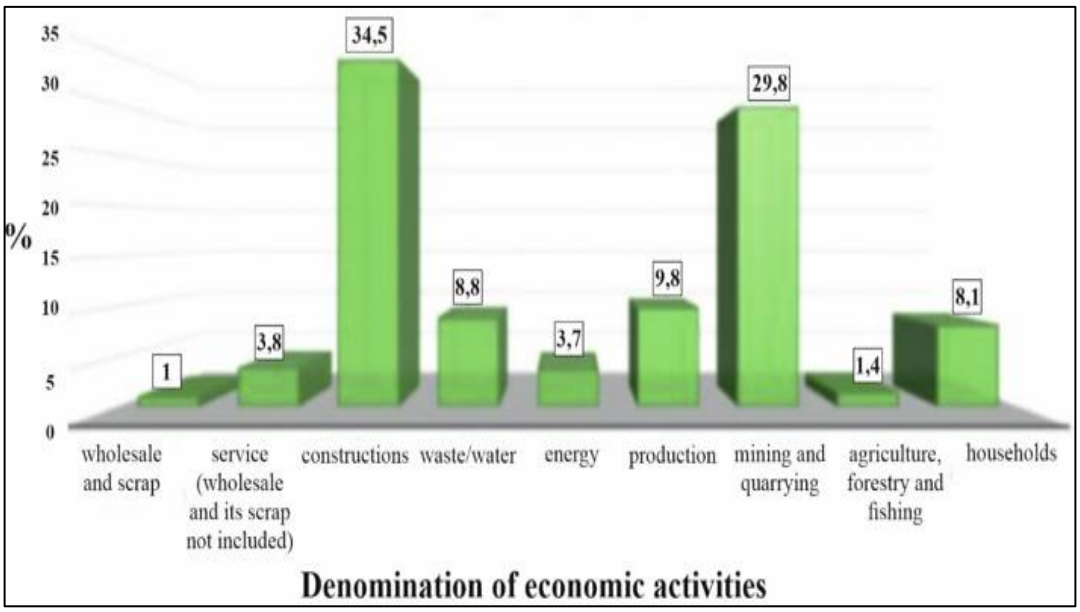


Figure 3. 1. Percentage distribution of waste generation by economic activities and households (2014) [http://ec.europa.eu/eurostat].

As we see in the image, the construction industry and mining are the two most important sectors responsible for the production of construction and demolition waste and inert waste.

The European Union has developed an action plan in the field of circular economy (Figure 3.2):

The European Union has described construction and demolition waste as a "waste stream" due to its large volume and quantity. The EU's goal is to ensure that 70% of this waste is recycled.

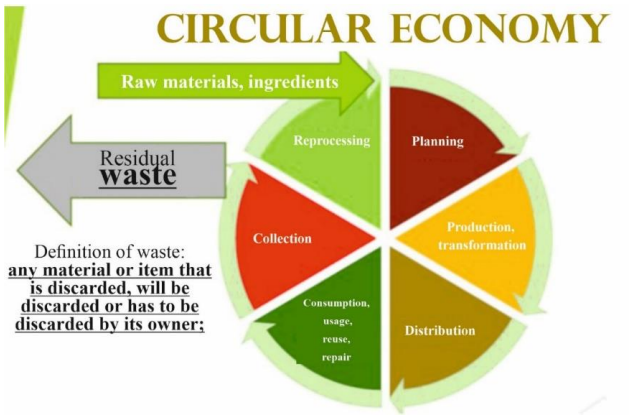


Figure 3. 2. Circular economy action plan.

Figure 3. 3. Hierarchy of waste**.**

Recommended video : https://www.youtube.com/watch?v=1UgwRQSP37Y

- **Quantitative questions regarding the amount of construction and demolition waste in the European Union**

The amount of waste produced in Hungary in 2014 was 16,650,639 tons. According to KSH data (visible in Figure 3.4), waste from the construction industry constituted the largest amount of waste compared to the total amount of waste produced in Hungary in 2012 and 2014, as in the European Union.

In Figure 3.4 we can see the waste produced in 2012 and 2014 and the distribution of this waste (expressed in tonnes) produced by 8 major economic activities and households in Hungary.

As we see in Figure 3.4, construction waste is produced to different extents in each sector and its significant amount shows an increasing trend. Construction and demolition waste causes serious problems for professionals working in the field of waste management in Hungary. The Hungarian Waste Management Plan for the period 2014-2020 reports that the separate intake and use of construction and demolition waste has been resolved only on a small scale.

Separate collection and professional processing of construction and demolition waste can lead to the cost-effective acquisition of significant quantities of high-quality materials with the development of an appropriate procedure and legal framework. There are many examples in Europe where even 80% of construction and demolition waste can be recycled with the development of an appropriate procedure and legal framework.

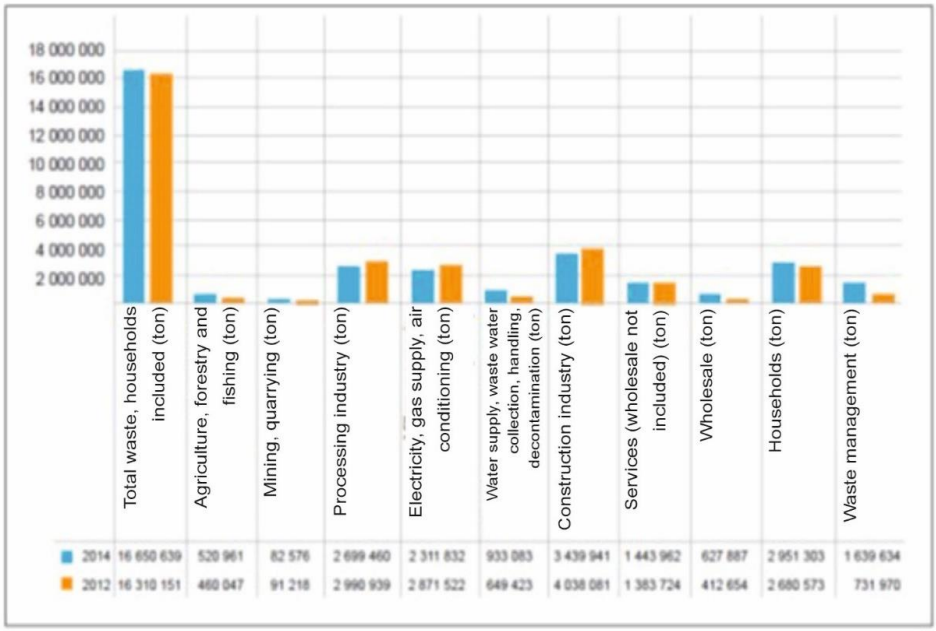


Figure 3. 4. Amount of waste produced in Hungary in 2012 and 2014 [www.ksh.hu/]

Examples of promoting recycling in Europe: landfill fees, tax exemption on income and turnover for businesses engaged in recycling, tax benefits for users, support for local investments.

3.2. Lesson on Types of Construction and Demolition Waste and Waste Identification System

Entrance

Waste generated during construction and demolition activities can consist of many different materials, for example;

- Mixed Construction Demolition Waste (Figure 3.5),
- Brick, Tile and Ceramic Waste (Figure 3.6),
- Wood Waste (Figure 3.7),
- Bitumen Mixtures, Asphalt Waste (Figure 3.8),
- Insulation Material Waste (Figure 3.9),
- Metal Waste (Figure 3. 10),
- Cable Waste (Figure 3. 11),
- Gypsum-based Waste (Figure 3.12),
- Soil Waste (Figure 3. 13).

Figure 3. 5. Mixed construction demolition waste.

Figure 3. 6. Brick, tile and ceramic waste.

Figure 3. 7. Wood waste**.**

Figure 3. 8. Bituminous mixture and asphalt wastes.

Figure 3. 9. Insulation materials waste.

Figure 3. 10. Metal waste**.**

Figure 3. 11. Cable waste**.**

Figure 3. 12. Wastes of gypsum-based materials.

Figure 3. 13. soil waste.

Identification and classification of waste

- To identify different types of waste with the same and understandable content for everyone, a waste identification code is provided for each waste (Table 3.1). These codes clarify and standardize the name of the given type of waste.
- Classification and naming of construction and demolition waste is permitted by the Waste Catalog Regulation No. 72/2013. The waste catalog identifies waste types with a six-digit code:
- The first two numbers indicate the fraction of the waste.
- The second two digits indicate the subsection within the section.

European waste catalog (EWC) and its structure

According to the waste catalogue, construction and demolition waste is located in section 17. This section is defined by the activity that produces a particular waste. (Of course, we may not need to consider a material listed in the catalog as waste.)

Tablo 3. 1. Atık tanımlama kodları.

Describing:		Waste Product Name
Section(Main Group Number)	Subsection (Subgroup Number)	
17		Construction and Demolition Wastes (Including Excavated Soil from Contaminated Areas)
	17 01	Concrete, Brick, Tile And Ceramics
	17 01 01	Concrete
	17 01 02	Brick
	17 01 03	Tiles And Ceramics
	17 01 06	Mixtures or Separate Sections of Concrete, Brick, Tile and Ceramics Containing Hazardous Substances
	17 01 07	Concrete, brick, tile and ceramic mixtures not specified in 17 01 06

As seen in Table 3.1, the names of waste types can be found by their identification codes as well as their sections and subsections. (In this case, this table does not include all construction and demolition waste, it is just an illustration.)

In the annexes of the Joint UN-KVVM Rules for the Treatment of Construction and Demolition Waste No. 45/2004, there is a waste catalog that divides waste into 8 groups (according to their materials) (Table 3.2):

Table 3. 2. Classification of construction and demolition waste.

	Groups based on the quality of the waste material	EWC code of the waste	
1.	Excavated soil	17 05 04 17 05 06	Soil and stones Casting material
2.	Concrete waste	17 01 01	
3.	Bituminous mixtures	17 03 02	
4.	Wood waste	17 02 01	
5.	Metal waste	17 04 01	Copper, brass, bronze
		17 04 02	Aluminum
		17 04 03	Lead
		17 04 04	Copper
		17 04 05	Iron and steel
		17 04 06	Tin
		17 04 07	Mixed metals
		17 04 11	Cables
6.	Plastic waste	17 02 03	
7.	Other IYAs	17 09 04	Mixed construction and demolition waste without hazardous substances
8.	Mineral wastes	17 01 02	Bricks
		17 01 03	Tiles and ceramics
		17 01 07	Concrete, brick, tile and ceramic mixtures
		17 02 02	Glass
		17 06 04	Insulation materials
		17 08 02	Gypsum-based building materials without hazardous substances

Source: *According to the first annex of the Unified UN-KVVM Law 45/2004 on Rules for the Treatment of Construction and Demolition Waste.*

3.3. Lecture or conference on the generation, management and handling of construction and demolition waste

Introduction

Who owns waste? Who creates waste?

According to the Waste Act, the waste owner can be either a waste producer or a legal entity in possession of the waste.

A waste generator is any organization whose activity generates waste or carries out any pre-treatment, mixing or other process that causes the nature or composition of the waste to change.

How is waste generated?

Waste formation is as shown in ***Figure 3. 14 and Figure 3. 15.***

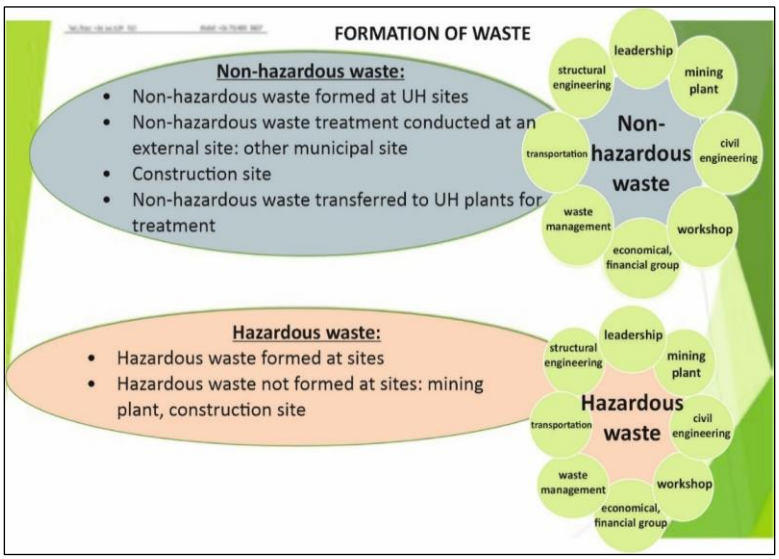


Figure 3. 14. Waste generation**.**

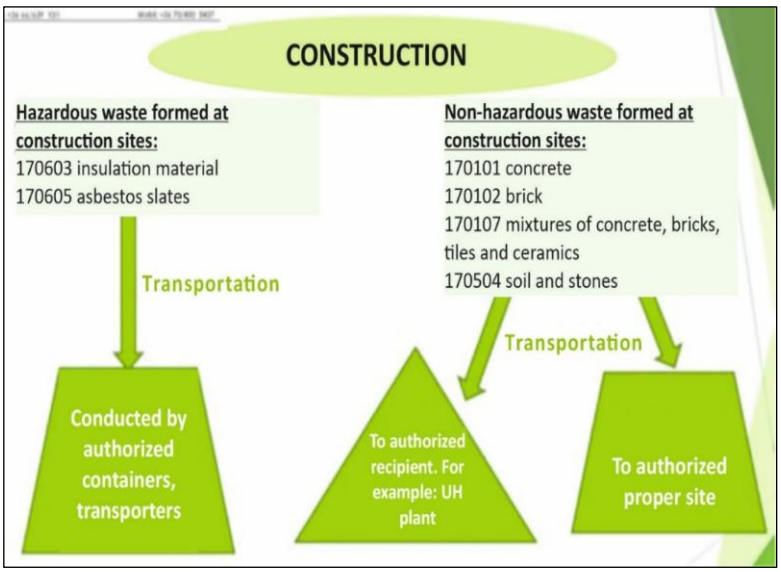


Figure 3. 15. Generation of construction waste.

Waste management

EVENT SCENARIO - OPERATIONAL STATUS

You and your colleagues are undertaking the demolition of a medium-sized building. Your business has the necessary licenses and plans for the demolition. Initially, you thought you would extract a large amount of reusable construction material from the building to be demolished. Your calculation was correct, but there is also a lot of construction debris that cannot be reused and this is causing you some problems. It is your duty to deal with waste and debris. Let's think about the tasks and regulations for handling waste generated during a construction activity!

What is waste management?

Waste treatment is defined by law as a sequence of recycling or disposal operations, including preparation prior to use or disposal.

What exactly is utilization?

It can be any process - including selection - that has the purpose of giving waste a useful purpose - to replace other materials used to fulfill a specific function. It can also be a process that aims to prepare the waste so that it can have that function in a particular facility or in the wider economy.

Who is responsible for waste generation? Who is responsible for waste management?

The treatment of construction and demolition waste generated during execution is a requirement of the processes listed in the regulation and is the responsibility of the person who planned and implemented the construction of the building. (The person who plans and implements the construction of a building may be a legal or non-legal person or organization that orders the design and implementation of a building.)

The regulation establishing that the person who constructed the building is responsible for the waste generated corresponds to the "polluter pays" principle. This principle states that the owner or producer of waste must in any case pay the waste treatment fee or dispose of the waste. The polluter is the person responsible for eliminating environmental pollution, restoring environmental conditions and compensating for the damage caused.

What types of obligations do construction developers have with regard to waste treatment?

- Before starting construction and demolition activities, a CONSTRUCTION/DEMOLITION WASTE PLAN FORM must be created to plan the amount of waste to be generated. This form must be submitted to the building authority together with the construction or demolition request.

- If the amount of construction/demolition waste exceeds the quantitative threshold specified in Annex 1 for classification based on the qualitative material of the waste, the building developer should collect it separately from other types of waste until it is handed over to the processor to facilitate its use (Table 3.3).

- Above the threshold specified in the regulations, the person planning the building construction has additional planning, authorization, reporting and management obligations.
- Processing of waste is necessary to make the material of the waste usable. During pre-treatment, the waste must be chopped, sorted and subjected to quality improvement and cleaning processes.
- Care must be taken to dispose of waste that is not or cannot be used. Disposal of construction and demolition waste can only take place at inert waste disposal sites.
- After completing the activity, the person who planned the building construction must fill in an Administrative Form about the actual amount of waste generated during the construction and demolition activity.
- The person planning the building construction must submit the Administrative Form and the receipt issued by the waste handler to the competent building and environmental authorities together with a request for authorization.

Table 3. 3. Quantity threshold values of construction demolition waste

	Groups of waste materials	EWC code	Quantity threshold(tons)
1.	Excavated soil	17 05 04 17 05 06	20,0
2.	Concrete	17 01 01	20,0
3.	Bituminous mixtures	17 03 02	5,0
4.	Wood waste	17 02 01	5,0
5.	Metal waste	17 04 01	
		17 04 02	
		17 04 03	
		17 04 04	2,0
		17 04 05	
		17 04 06	
		17 04 07	
		17 04 11	
6.	Plastic waste	17 02 03	2,0
7.	Mixed construction demolition waste	17 09 04	10,0
8.	Mineral-based construction waste	17 01 02	
		17 01 03	
		17 01 07	40,0
		17 02 02	
		17 06 04	
		17 08 02	

***Source**: Annex 1 of Joint UN-WVM Law 2004/45 on Rules for the Treatment of Construction and Demolition Waste.*

ÉPÍTÉSI HULLADÉK NYILVÁNTARTÓ LAP

az építési tevékenység végzése során keletkező hulladékhoz

Az építtető adatai:	**A vállalkozók[1] adatai:**	**Dátum:**
Neve:	Neve, címe:	
.....	KÜJ, KTJ száma:	
	Neve, címe:	
Címe:	KÜJ, KTJ száma:	
	Neve, címe:	
.....	KÜJ, KTJ száma:	

Az építési hely adatai:
Címe: .....
Helyrajzi száma: .....
A végzett tevékenység: épület építése, átalakítása, bővítése, felújítása, helyreállítása, korszerűsítése, továbbépítése. (A kívánt rész aláhúzandó!)

Sor-szám	Építési hulladék			Kezelési mód	
	A hulladék anyagi minősége szerinti csoportosítás[2]	EWC kódszám	Tömeg (t)	Megne-vezése[3]	Helyszíne[4]
1.	Kitermelt talaj				
2.	Betontörmelék				
3.	Aszfalttörmelék				
4.	Fahulladék				
5.	Fémhulladékok				
6.	Műanyag hulladékok				
7.	Vegyes építési és bontási hulladék				
8.	Ásványi eredetű építőanyag-hulladék				
Összesen:					

1 Az építési hulladékot az építési helytől különböző helyszínre szállító vállalkozó(k).
2 Az építési és bontási hulladék kezelésének részletes szabályairól szóló 45/2004. (VII. 26.) BM-KvVM együttes rendelet 1. sz. mellékletében meghatározott csoportosítás szerint.
3 Amennyiben a hulladék hulladékkezelőnél kerül hasznosításra, a táblázatban 1-es kódszámot, amennyiben a hulladék ártalmatlanításra kerül 2-es kódszámot, amennyiben a hulladék további felhasználás céljából a helyszínen marad 3-as kódszámot kell feltüntetni.
4 A hulladékkezeléshez igénybe vett létesítmény nevét, címét, KÜJ, KTJ számát kell feltüntetni.

Figure 3. 16. Construction debris waste schedule used in Hungary.

SEPARATED COLLECTION AND STORAGE OF WASTE

Non-hazardous waste, for example: construction-demolition waste	Communal waste	Hazardous waste, construction-demolition waste
• In a depot at a construction site (under the lot number submitted in the building permission) • In a container • Signaled with a board (with the denomination of waste and its EWC code)	• A contract with the public service provider is needed for the period of implementation. • The public service provider is the only one that can transport this waste. • Waste has to be collected in waste containers.	• It must be stored at a closed, rain-safe place with damage control. • Signaled with a board (with the denomination of waste and its EWC code)

Non-hazardous wastes formed at construction sites

Regular waste transportation:

- Non-hazardous wastes can be transported business likely by only licensed waste transporters.
- The company (for example ITS SUB-CONTRACTOR IF THEY LEGALLY OWN THE WASTE) can transport waste if it's not businesslike, it's occasional and they use their own vehicle to transport waste to a different site or place of take over.

Non-hazardous wastes formed at construction sites

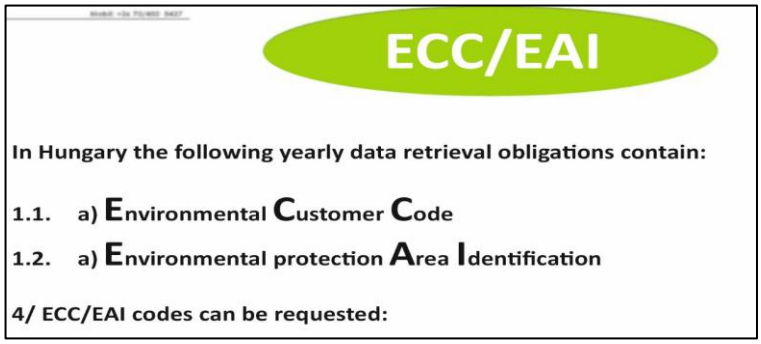
IT CAN BE TURNED IN ONLY AT LICENSED TAKE OVER PLACES.
For example:
public service provider, recycling plant, licensed proper site

DATA RETRIEVAL OBLIGATION!

309/2014. (XII. 11.) Government decree on administration and data retrieval obligation in case of wastes.

11. § (1) Data retrieval **must be done by site and by waste types and in regard of all wastes formed.**

(2) The waste producer – except the (3) paragraph – must fulfill their obligation based on the content required at the 3rd annex's 1st and 2nd points if **the waste formed at the site exceeds**
a) 200 kg in case of hazardous waste
b) 2000 kg in case of non-hazardous waste – excluding c) point
c) 5000 kg in case of non-hazardous construction-demolition waste



Recommended video : https://www.youtube.com/watch?v=GU-raVRiLIo

Control Activities - Waste generated during construction activities and its proper handling.

Study 1

What is the purpose of waste management? What are the elements of waste management?

Study 2

What is the "polluter pays" principle? Who is responsible for handling construction and demolition waste?

Study 3

What are the obligations of the construction planner in relation to planning, reporting and management?

Study 4

List the activities related to waste treatment

SOLUTIONS

Study 1

Waste management helps to limit the amount of waste generated, protects against the harmful effects of waste and promotes waste recycling. The elements of waste management are:

Reducing/preventing waste generation and/or reducing/preventing hazardous characteristics

Separate collection and utilization of waste

Temporary storage and disposal of non-recyclable waste without harmful effects

Study 2

The "polluter pays" principle states that the owner or waste generator must in all cases pay for waste treatment or dispose of the waste. The responsibility for eliminating environmental pollution, restoring environmental conditions and compensating for the damage caused lies with the polluter. The treatment of waste generated during construction and demolition activities is a requirement of the activities specified in the regulations and the responsibility for this lies with the person planning the construction of the building. (The person planning the construction of the building may be a legal or non-legal person or organization that gives orders for the planning and implementation of a building.)

;Study 3

Before starting construction and demolition activities, it is necessary to plan the amount of waste that will be generated and take into account the waste generated after these activities have ended.

Before starting construction and demolition, the person planning the construction of the building must plan the amount of waste to be generated in a construction/demolition waste plan form. This form should be submitted to the building authority together with the construction or demolition request.

After the activity is completed, the person planning the building construction must fill in an Administrative Form about the actual amount of waste generated during the construction and demolition activity.

The person planning the construction of the building must submit the Administrative Form and the receipt issued by the waste handler together with the request for authorization to the competent building and environmental authorities.

Study 4

Waste treatment includes the following activities:

- Waste collection (separate or mixed),
- Transportation of waste,
- Physical or chemical pre-treatment that enables waste to be reused,
- Do not use it,
- Disposal
- Bulk

3.3. Lesson on handling tasks of construction and demolition waste

PLANNING IS NEEDED BEFORE THE START OF THE WORK!

Task	
Clarification of waste ownership, transport and managing obligations.	Must be regulated in a contract.
The amount and type of waste must be evaluated.	Depending on the quantity and type, the method of waste storage must be determined.
Definition of the (separate) storage location.	Creating a storage area, choosing the location of containers and vessels.
Definition of personal resources and tasks.	Waste disposal, note the quantity and type; data collection; personal definition of creating a register.
Waste management activities, transport, collection and management can only be carried out with a license.	The license of the CARRIER/MANAGER must be checked.

Builder + contractor are jointly responsible for waste management!

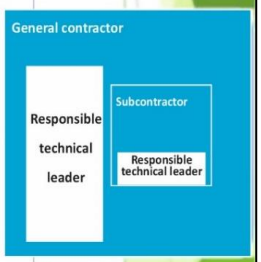
Contractor: General and subcontractor

A mandatory content of the construction contract is who is the owner of the waste and who is responsible for the removal/management.

Duties of the construction manager/foreman in support of the responsible technical leader:

a. Organization of the separate waste collection in the construction area.
b. Legal delivery of waste to a licensed waste management company.
c. Keeping an up-to-date record of the amount of separately collected waste in the e-logbook.
d. Signaling to the builder that the threshold value has been exceeded.
e. Collecting the receipts of the waste managenent.
f. In the case of waste is ABOVE THE THRESHOLD VALUE, preparation of the:
   - Demolition waste registration sheet or
   - Construction waste registration sheet

g. Handing over the Construction or Demolition waste registration sheet and handling receipts to the builder.
h. Responsible for the activities of the subcontractor:
   - collection of waste receipts from the subcontractor's responsible technical leader.
   - in the case of any subcontractor activity without an responsible technical leader, the general contractor's responsible technical leader is responsible for the collection of waste receipts.



THRESHOLD VALUE

BELOW	TASKS	ABOVE

Duties of the contractor:

- European Waste Code (EWC) and determination of the waste management method performed (e.g. collection).
- Choosing of waste manager and waste transporter based on their valid license >> waste removal >> delivery
- Collection of proof of receipt from the waste supplier, collector, manager (shipping form/consignment note AND acceptance declaration)
- Waste manager: 1/own site; 2/ external licensee

Duties of the contractor:

- Tasks BELOW THRESHOLD VALUE +
- Handing over the demolition waste registration sheet and receipts to the builder
- Handing over the construction waste registration sheet and receipts to the builder

Management of waste registers, annual data provision for all EWC, in accordance with the applicable legislation.

SEPARATED COLLECTION AND STORAGE OF WASTE

Non-hazardous waste, for example: construction-demolition waste	Communal waste	Hazardous waste, construction-demolition waste
• In a depot at a construction site (under the lot number submitted in the building permission) • In a container • Signaled with a board (with the denomination of waste and its EWC code)	• A contract with the public service provider is needed for the period of implementation. • The public service provider is the only one that can transport this waste. • Waste has to be collected in waste containers.	• It must be stored at a closed, rain-safe place with damage control. • Signaled with a board (with the denomination of waste and its EWC code)

MANAGEMENT OF CONSTRUCTION-DEMOLITION WASTE IN CASE OF CONSTRUCTION WORKS	
Task:	**Notes:**
I. Definition of EWC and estimated quantity	Basic data: Based on the waste management section of the Technical design documentation and on-site information, in tons.
II. Determining the ownership of the waste in a construction or subcontracting contract	Whoever owns the waste is responsible for the removal and costs. XY Ltd., as an external licensed supplier, can transport the subcontractor's waste to the receiver for a fee.
III. Search for a waste collection point. Checking the license of the receiving location	- Metal waste: checking of metal trade legal obligations. - Checking of hazardous waste management licenses. - Checking of non-hazardous waste management licenses.
IV. Find a waste carrier. Verification of the carrier's license	Checking of hazardous waste and non-hazardous waste transportation and collection licenses.
V. Determination of waste costs	Storage, collection (e.g. container), transport and managing costs.
VI. Keeping a construction log. Separate collection and storage of waste during construction work	During work, separate collection and storage of waste in collection containers, depots, etc. required. The contractor's task is to continuously record the amount and type of construction and demolition waste generated on the workspace in the construction log. Exceeding the THRESHOLD VALUE must be reported to the responsible technical leader and the builder.
VII. Delivery of waste to the collection point	Waste can be transported by someone else to the receiver only on the basis of a transport license. You can transport your own waste directly to the receiver with your own vehicle.
VIII. Holding and preservation of receipts proving taking over and transport	Holding and preservation of the waybill/conveyance note, weighing note, consignee's declaration (5/10 year retention obligation).
IX. Preparation and delivery of the construction and demolition waste registration sheet to the responsible technical leader and the builder	IX. Preparation and delivery of the construction and demolition waste registration sheet to the responsible technical leader and the builder

3.4.Lesson on the processing of construction and demolition waste

Introduction

Construction and demolition waste, i.e. soil, stone, concrete and other construction material residues, is generated in increasing quantities. When these wastes are collected separately, they can be used for the production of new products or as raw materials after appropriate treatment **(Figure 3. 17).**

Figure 3. 17. Sorting of demolition waste.

Technical solutions for managing construction and demolition waste

The processing of construction and demolition waste is mainly characterized by physical procedures. Physical pre-processing processes change the physical structure and shape of the waste, e.g. by mechanical effects during shredding, cutting and sorting of the waste size. The types of waste that, after appropriate preparation and processing, can be made suitable for the construction sector or the construction material industry are included in Table 3.4 in relation to the use of Inert Recycling Aggregate products.

Table 3. 4. Waste types potentially suitable for reprocessing as inert recycled aggregate products, verification of the technical performance of the recycled product and consideration of relevant legal requirements.

Construction demolition waste	**Soil and stones free of harmful materials**	**17 05 04**
	Floor excavation waste not containing hazardous substances	17 05 06
	Concrete	17 01 01
	Bricks	17 01 02
	Tiles and ceramics	17 01 03
	Mixture of concrete, bricks, tiles and ceramics without harmful materials	17 01 07
	Glass	17 02 02
	Construction demolition waste not containing hazardous substances	17 09 04
	Gypsum-based construction materials not contaminated with hazardous substances	17 08 02
Waste from heat generation	Unprocessed slag	10 02 02
Municipal waste	Soil and stones	20 02 02

It is possible to create products from the types of waste listed in **Table 3.4** through an appropriate utilization process (recycling). In this process, the applicable legal regulations on waste treatment and the mandatory registration of waste, as well as the regulations of environmental protection authorities, must be taken into account!

Table 3.5 summarizes the possible types of products that can be produced by recycling.

Table 3. 5. Grouping of recycled inert aggregate products according to product types, possible functions and products/structures.

EWC	Type of recycled product	Possible function	Possible structure/product
	Excavated:	Filling material	Ground, leveling, filling, backfilling
17 05 04	Soil and stones		
17 05 06	Evacuation material		
20 02 02	Soil and stones		
	Stone materials recycled from construction-demolition waste.	Filling material, stone mix, Aggregate: - concrete, - mortar, - composite	Concretes for non-load-bearing or load-bearing structures, corrected concrete or mortar layers, assembly concrete layers, special mixtures, compounds, prefabricated concrete products
17 01 01	Concrete		
17 01 02	Brick		
17 01 03	tiles and ceramics		
17 01 07	Concrete, brick, tile and ceramic mixtures.		
17 09 04	Mixed construction and demolition waste.		
17 02 02	Glass		
17 08 02	Gypsum-based building material		
	Waste from thermal products	aggregate	filling
10 02 02	Unprocessed curuff		

The main processes of converting construction and demolition waste into products:

Technical steps grouped according to the type of waste management procedure:

IN THE CASE OF EXTRACTED EARTH MATERIALS, if they are used in the construction/demolition site where the extraction site is located:

- Soil excavation
- Storage according to soil types,
- Examination of excavated and stored soil materials
- Based on the evaluation of the results, the responsible technical manager can decide on direct use on the construction site.

If it is used at a construction site other than the place of extraction:

- Soil excavation
- In-situ sampling of excavated soil types and examination for planned performance characteristics,
- Evaluation of the test results and creation of a performance declaration by the waste owner based on the results. You can then store/distribute/use the excavated soil materials as a "producer" product.

IN THE CASE OF INERT WASTES PRODUCED FROM CONSTRUCTION-DEMOLITION WASTES:

- Collection/sorting of construction and demolition waste according to product groups,
- Depending on the circumstances, preparation for on-site reprocessing or transportation to a waste treatment facility and preparation for reprocessing,
- Shredding, separation of metal materials in the recycling machine line,
- Classification by size fractions when necessary,
- Storage by components or fractions or transportation to a waste treatment facility,
- Sampling and testing by component/process (according to relevant product standards),
- On-site use: the decision of the responsible technical manager on its use at the construction site, based on an evaluation of the test results,
- Sale: if the material or product produced from construction-demolition waste meets the requirements of the (compliant) product standard based on tests, the waste owner - henceforth as a producer - creates a declaration of performance based on the technical specifications verified by tests. The producer - at his own risk - may store, distribute and use the aggregate of stone material from recycling as a product,
- In the case of continuous production and sales, where aggregate produced from recycling cannot be considered a unique product, factory production control is necessary.

Preparation of demolition materials for use I.

Preparation can take place at a construction/demolition site (with mobile devices) or at a waste recycling site. In the latter case, the DELIVERY TO SITE must be carried out by someone with a license.

Preparatory technological processes:

- One big sort: Municipal waste ("nylon bags"), metals, wood and plastics, glass, etc. removal or separation
- Sorting by material types: Separation of bricks, ceramics, concrete and binding agents if necessary or possible.

Preparation of demolition materials for reuse II.

- Shredding/Milling: Mechanical shredding to a specific size (e.g. 0-80 mm)
- Classification according to grain size: Sorting into fractions (e.g. fractions 0/20, 20/50, 50/80 mm, "discharge" mixed with soil, etc.)
- Storage: By fractions and material types,
- Delivery: If it does not come out of the "waste state", THEN LICENSE IS REQUIRED!

Demolition waste processing technology in a few pictures

Figure 3. 18. High-performance excavator for handling bulky debris from construction sites.

Figure 3. 19. Stream or pit for construction debris.

Figure 3. 20. Crushing, shredding and classifying machine line.

Figure 3. 21. Storage of materials classified according to grain size.

Figure 3. 22. Specially designed and built shredding equipment.

Figure 3. 23. MB crusher.

Figure 3. 24. HARTL - PC 10-55 J stone crusher**.**

Figure 3. 25. Pegson 1100 X 650 Premier Trak.

Figure 3. 26. E7 mobile classification tool.

Figure 3. 27. VTN SB10 screening bucket.

A few pictures of processed products from demolition waste:

Figure 3. 28. 0/80 (90) mm mix without binder.

Figure 3. 29. Residue after grinding: 0/10 mm.

Recommended video : https://www.youtube.com/watch?v=lUGvXviOPaU

3.5.Lecture on recycling of wood materials.

As a product of demolition processes, the fate of wood left behind as waste is often clear: it must be burned. This usually does no harm to the environment. Wood burning has become popular again, as it requires wood that has already been removed, so untreated beams, boards and planks left over from demolition are perfectly suited for this purpose and can prevent the felling of still living trees. But this represents only a small fraction, most of these wood products have been treated with chemicals or environmentally destructive paints. In addition to the immeasurable damage to the air, the return of fly ash, ash and other combustion products to the soil inevitably affects nature and thus fauna.

Figure 3. 30. Separation of wood waste.

Now we will talk about the possibilities for reuse and their importance. If the wood material is still suitable for industrial use after the official material inspection, it can be used as laminate board, plywood, particleboard or fiberboard, OSB board or bar furniture board.

Figure 3. 31. Laminate, chipboard and fiberboard

Figure 3. 32. Kitchen countertop, OSB board and lath

If the condition of the wood material no longer allows it to fulfill its transport function or to be used in industrial conditions, it can be used as a decorative element indoors or outdoors. Take, for example, an old rural farmhouse built at the turn of the century. Although this building has been renovated several times, it has not seen any serious reconstruction. Therefore, different forms of wood recycling can be observed. It would be a mistake to use the furniture and windows for other purposes, so it is necessary to rebuild and restore them. But next to them we can find some very interesting formations, from beams from a hundred years ago, to boards from the 70s that have been painted several times, and even painted boards made a few years ago.

Figure 3. 33. Rural farmhouse**.**

During renovation, most wood materials can be used as wall cladding, but after proper treatment, they can also be perfectly installed as floor coverings and stair coverings. The most suitable for this is beam cladding, which can also be seen in Figure 3.34, cladding material created from wooden sheds that serve as wooden roof coverings or outbuildings that have already been demolished.

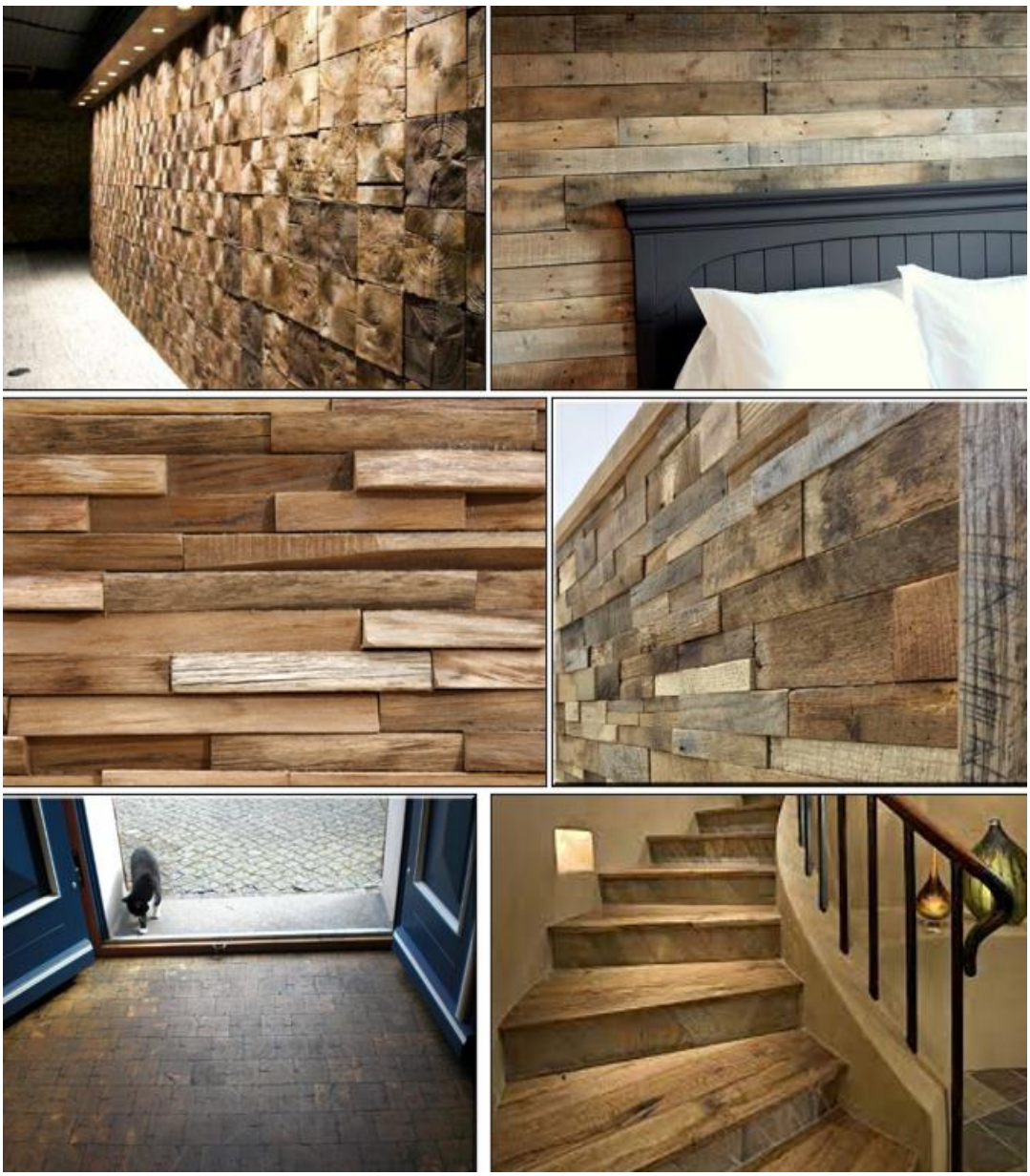


Figure 3. 34. Wood cladding materials.

The same raw material can also be used as raw material for the construction of different borders, paths, raised beds and possibly furniture in the garden (**Figure 3. 35).**

Figure 3. 35. Borders, paths, raised garden bed, etc.

Antique furniture made from old materials is currently in fashion and can also be produced using recycled wood materials. Such furniture can be easily adapted to the environment in terms of size, shape, color and style, and their atmosphere is unique and, of course, the makers can be proud of their creations.

Figure 3. 36. Old furniture.

3.6. Lecture on brick recycling

Construction waste is created everywhere, we can even walk down the street and find waste in a container next to the sidewalk, or worse, on the grass. Broken brick can be used in different ways. It can be used to pave our garden, our entrance way or under the terrace on the ground floor, but it can also be used to pave the floor of the basement. Recycling old, worn or broken bricks seems to be more than just a passing fad. Many people are fascinated by this building material and it can be impressively reused in countless ways.

Figure 3. 37. Bathroom, room, etc.

We just need to know where and how to use them.

Old bricks are often used for cladding walls and floors. This goes well with almost any style and fits rustic or country-style interiors. But it is also a common design element of loft apartments designed in an industrial style. Unsurprisingly, it also looks perfect in a modern or minimalist space.

Figure 3. 38. An element used in the design of penthouse apartments.

How to treat the surface of old brick?

Old and stained building materials can be reused in many different ways. However, this requires some care beforehand. The condition of broken bricks can be very different. Their surface can be made beautiful by placing stone sandpaper on a parquet sander, after which work can begin. Make sure that the size of the joints is proportional to the size of the paving material.

Figure 3. 39. Processed brick wall.

It is useful to impregnate the finished brick wall by the blowing method, for which it is recommended to use a water-based varnish. When applied with a brush, the varnish can easily overflow, so the result may not be aesthetic. A very glossy varnish should be avoided, as it is incompatible with the style of the broken brick and gives the surface a plastic effect.

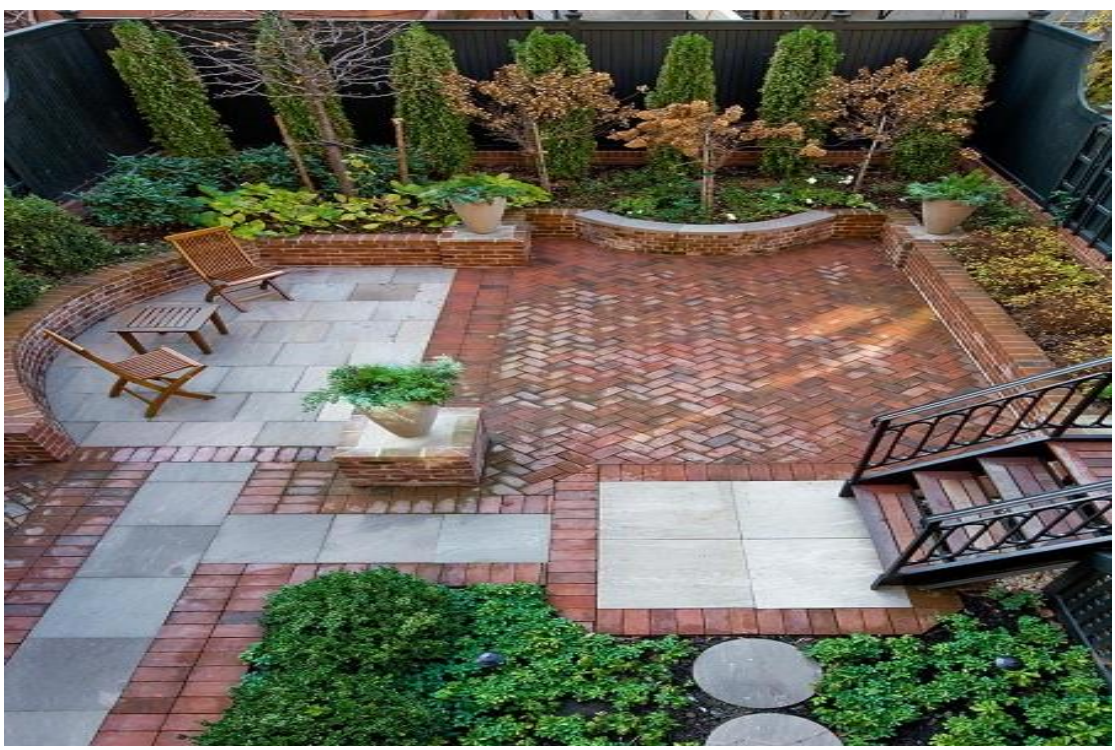


Figure 3. 40. Processed brick floor.

If we want to create a sidewalk, access road or outdoor staircase from sliced bricks, it is usually advisable to place the pieces on a bed of gravel. The sliced version is usually placed on top of a type of base; it can be concrete outdoors, but indoors it can even be papier-mâché.

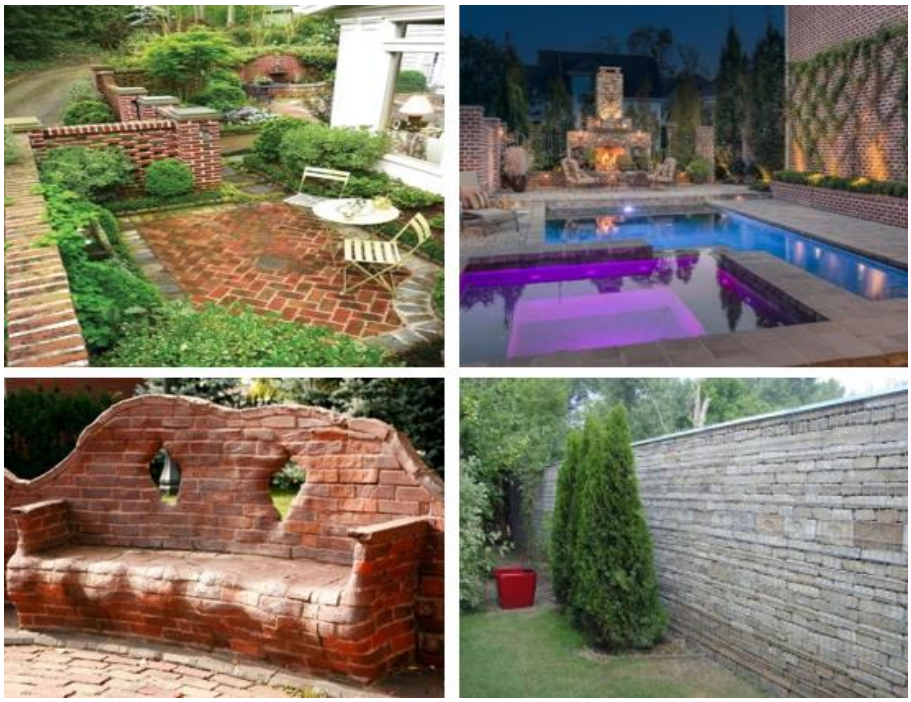


Figure 3. 41. In-situ recycling of demolished construction materials with gabions.

4. HOW DO WE SORT, RECYCLE AND REUSE CONSTRUCTION AND DEMOLITION WASTE?

4.How do we sort, recycle and reuse construction and demolition waste?

1. Construction and demolition waste management in general (1 course)
2. Country-specific conditions, actors, process for placing construction and demolition waste on the market (2 lectures)
3. Separate discussion of types of construction and demolition waste (7 lectures):

- Current management methods
- Main problems in processing
- Possibilities to sort, recycle and reuse
- Logistics, transportation
- Specific laws for a given type of waste
- Visiting a practice site
- Participation of partner companies (guest speakers)**4.1. Construction and demolition waste management in general (1 lesson)**

The regulation on construction and demolition wastes in Turkey is the Regulation on the Control of Excavation Soil, Construction and Demolition Wastes dated 18.03.2004 and numbered 25406. In this regulation, wastes generated by construction activities are divided into two parts as construction and demolition wastes. Wastes generated during the construction of infrastructure and superstructures such as buildings, residences, social and cultural buildings, bridges, roads and dams constitute construction wastes. Wastes generated as a result of repairs, renovation, demolition, renovation or natural disasters constitute demolition wastes. These wastes are generally generated during the construction of structures with load-bearing systems such as reinforced concrete, masonry, wood, steel and prefabricated structures. The wastes of these structures generally consist of materials such as concrete, reinforced concrete steel, plaster, bricks, cinder block, wood, glass, metal (steel, aluminum, copper), drywall, ceramics, tiles, plaster, tiles, plastics, electrical and plumbing materials, metal and plastic pipes, bitumen. Figure 4.1 shows an image of the Construction Demolition Waste Recycling Plant in Hungary.

Figure 4. 1. Construction and demolition waste recycling plant (Hungary).

In Turkey, the "Regulation on the Control of Excavation Soil, Construction and Demolition Wastes" dated 18.03.2004 and numbered 25406 was published in the official gazette and entered into force in order to prevent the direct or indirect disposal of construction and demolition wastes into the environment in a way to harm the environment, to ensure the reuse, recycling and disposal of construction and demolition wastes. In addition to this regulation, Turkey's waste management targets include

Soil Conservation Law,

- Pasture Law,
- Mining legislation,
- Environmental Law No. 2872,
- Law No. 5216 on Metropolitan Municipality,
- Zoning Law No. 3194,
- Law No. 5326 on Misdemeanors,
- Regulation dated 23.01.2010 on the Restoration of Lands Degraded by Mining Activities to Nature,
- 26.03.2010 dated Regulation on Landfilling of Wastes,
- 30.09.2010 Implementation Regulation of Article 16 of the Forestry Law,
- Regulation No. 29314 on Waste Management,

laws and regulations also contribute. The process steps such as collection, reduction, transportation, recovery and disposal of wastes are carried out by taking into account the relevant legislation of the given laws and regulations. Figure 4.2 shows construction and demolition wastes brought to the recycling facility.

Figure 4. 2. Construction and demolition waste brought to the recycling plant.

Studies on the management of construction and demolition waste in Turkey have been prepared within the framework of harmonization with the European Union. However, the issue of inspection and implementation has not yet become widespread in our country. Construction and demolition wastes are generally used as filling material without any sorting process. However, since these wastes contain some harmful substances such as lead, asbestos, etc., they pose a great danger to both human health and the environment if used randomly (Aytekin, 2021). Therefore, people who do the recycling process unconsciously can cause a bigger disaster while trying to recover these wastes. The Regulation No. 25406 dated 18.03.2004 on the Control of Excavation Soil, Construction and Demolition Wastes classifies wastes. Wastes will be separated and evaluated according to this classification. Some of the articles in the relevant regulation regarding the separation, transportation and storage of construction and demolition wastes are presented below: Article 13 of this regulation prohibits the dumping and filling of excavation soil and construction and demolition wastes into seas, lakes, rivers or anywhere else, except for the recovery and storage facilities designated and permitted by the municipalities or the highest local administrative authority. Article 15 of the same regulation states that "Persons and organizations and construction companies that make small-scale repairs and renovations that will cause the generation of waste up to 2 (two) tons shall notify the relevant municipality within the borders of the contiguous area and the relevant district municipality in metropolitan areas, If outside the boundaries of the adjacent area, they are obliged to apply to the highest local authority or to the companies that have received permission/authorization from these authorities to collect and transport the wastes and to ensure that the construction/demolition wastes are collected, transported and taken to the place indicated by the municipality or local authority with appropriate containers. " is determined as follows. Article 16 states that "In large-scale repair and renovation operations and construction and demolition operations that will cause the generation of more than 2 (two) tons of waste, the owner of the activity must apply to the relevant municipality within the boundaries of the contiguous area, to the relevant district municipality in metropolitan areas, and to the highest local authority outside the boundaries of the contiguous area and obtain permission. The related procedures are carried out according to the principles specified in Article 23.« Private or public persons, institutions and organizations that will cause the production of excavation soil and construction/demolition wastes are obliged to apply to the relevant municipality / the highest local authority before the production of these wastes, to obtain the necessary permits, and to ensure that the wastes are transported to the recovery/storage area indicated by these authorities according to the procedures and principles specified in this regulation. It has been made obligatory to carry out the related procedures according to the principles specified in Article 23 (Obtaining Waste Transportation and Acceptance Certificate).

According to the "Regulation on the Control of Excavation Soil, Construction and Demolition Wastes" numbered 25406, there is only one article regarding the Recycling of Construction/Demolition Wastes. According to Article 27, it is essential to recover construction/demolition waste in order to protect natural resources, sustainable production, reduce the amount of waste to be landfilled and create economic value. It is stated that wastes should be separated where they are generated in order to obtain high quality recovery products and reduce costs. According to this article, construction/demolition wastes that cannot be recovered can be used as daily cover material in the landfill area after necessary separation and size reduction according to the principles specified in the Regulation on Solid Waste Control.

Article 28 of Regulation No. 25406 on Recycling of Asphalt (Road Pavement) Wastes reads as follows: "Asphalt wastes generated during the renovation/repair and demolition of roads, airport runways and similar structures are collected, transported and recycled separately from other construction/demolition wastes. It is forbidden to throw asphalt wastes in random places. Recycling of asphalt wastes is essential and asphalt wastes converted into secondary products in recycling facilities are used as filling material on roads with low traffic density or primarily in asphalt production facilities."

There is no other more comprehensive regulation on the recycling of construction and demolition waste in Turkey. The above-mentioned articles of the regulation are quite limited. Considering that urban transformation projects will increase in the coming years and millions of houses will be demolished and rebuilt, there is a need for a comprehensive regulation on the management of construction and demolition waste.

4.1. Country-specific conditions, actors, process for placing construction and demolition waste on the market (2 lessons)

Since the early 1980s, structural wastes in countries such as Germany, the Netherlands, Austria, Sweden and Hungary have been recycled and reused by being processed in various facilities (Kılıç, 2012). It has been reported that the amount of structural wastes in Europe is around 180 million tons/year and the recycling rates of these wastes vary between 5–98% in member countries (Dorsthorst and Kowalczyk, 2022). In 2011, in the report presented by the European Commission on the management of construction and demolition waste, it was stated that the most successful countries in this regard were the Netherlands with 98% and Denmark with 94%. In other countries, this rate continues as Estonia (92%), Germany (86%), Ireland (80%), Belgium (68%), England (65%), France (62%), Austria (60%), Lithuania (60%), Latvia (46%).

In the European Union (EU), the use of secondary recycled construction resources has become widespread, primarily in road construction works (Nunes et al., 2007). Member states have some systems in place that include environmental considerations and techniques for the reuse of these wastes. Germany has a Waste Management Authority for the utilization of construction and demolition waste (Weil et al., 2006). In Spain, the technical review on the use of secondary products is linked to the content of the National General Technical Specifications for Road Construction (Pamuk, R., 2018). Recovery rates are slightly lower in countries such as Portugal, Italy, Greece and Luxembourg. The reason for this is stated as the sufficient availability of aggregate resources in these countries and the lack of a secondary material market (Nunes, 2007). There are many recycling facilities in the USA operated by private companies. There are many recycling facilities in the USA operated by private companies. According to 2005 data, there are 3100 asphalt and concrete recycling facilities, over 700 wood processing facilities, more than 24 drywall and asphalt gravel recycling facilities in the USA (Ölmez and Yıldız, 2008). Within the scope of European Union accession efforts, the Regulation on the Control of Excavation Soil, Construction and Demolition Wastes No. 25406 was prepared in Turkey for the recovery of construction and demolition wastes. However, the work to be done for the recycling and reuse of materials in the regulation is very insufficient. The most common and valid recovery method used in Turkey is "sorting on site". However, the amount of regular solid waste sorting and recovery facilities in our country is very small. The conversion rate in Turkey is 25%. Of this rate, 20% belongs to the private sector and 5% to the public sector.

Construction and demolition wastes are generated as a result of the activities of all kinds of infrastructure, maintenance-repair, production and construction projects in Turkey. The transportation, storage, disposal and reuse of these wastes in a way that does not cause environmental pollution are carried out by the Metropolitan Municipalities in Turkey in line with the principle of sustainable development and in accordance with the laws and regulations (Pamuk, 2018). İZBETON, an organization of Izmir Metropolitan Municipality, recycles construction and demolition waste at the facility shown in Figure 4.3. The recycled aggregates they obtain are used as filling material in road construction. Eskişehir Metropolitan Municipality, on the other hand, uses recycled waste aggregates as infrastructure and filling material with the facility established on the 13 hectare land shown in Figure 4.4. In Denizli, 306,000 tons of construction and demolition waste is recycled annually in a facility operated by a private company (Figure 4. 5.).

Figure 4. 3. IZBETON recycling facility (Istanbul Metropolitan Municipality, 2021).

Figure 4. 4. Eskişehir Metropolitan Municipality recycling facility.

Figure 4. 5. Denizli Metropolitan Municipality recycling facility.

The way of administration in the process of recycling construction and demolition waste is specified in the "Regulation on the Control of Excavation, Construction and Demolition Waste". In this regulation, the duties and authorities of the ministry, local authorities, municipalities, landfill operators, waste generators and recycling facility operators are specified. Some of the duties and authorities specified in the Regulation are given below.

a) Duties and powers of the Ministry

It is stated in Article 6 of the regulation numbered 25406. According to this

- Encouraging the use of recycled products,
- To control and supervise all activities to be carried out from the generation to the disposal of the wastes specified in the Regulation,
- Determining the programs and policies related to the treatment of these wastes and fulfilling the principles, ensuring the necessary coordination and taking administrative measures

b) Duties and powers of local authorities

Article 7 sets out the duties and powers of the highest local local authority.

- Determining the location of recycling facilities and landfills outside the boundaries of the municipality, establishing, having established, operating or having operated these facilities,
- To grant permits to recycling facilities and waste storage areas outside the boundaries of the municipality or to revoke these permits when necessary,
- To determine the fees for collection, transportation and disposal of wastes outside the boundaries of the municipality,
- They have the duty to use or make available the collected construction and demolition waste primarily for infrastructure works.

c) Duties and powers of municipalities

Article 8 of the relevant regulation specifies the duties and powers of municipalities. Some duties and powers are presented below.

- To prepare a plan for the collection, temporary accumulation, transportation, recovery and disposal of construction and demolition waste and natural disaster waste,
- Determining the areas of recycling facilities and storage facilities, establishing, having them established, operating and having them operated,
- To determine the collection, transportation and disposal fees of waste,
- To implement the decisions of the Crisis Center established under the coordination of the governorship on the management of natural disaster wastes,

- They are obliged to announce the contact information and addresses of the companies that will provide services related to the collection and transportation of wastes and the transportation fees in a way to inform the public.

d) Obligations of producers of excavated soil and construction/demolition waste

- The obligations of waste generators are set out in Article 9 of the relevant regulation. Some important obligations of waste generators are given below.
- To ensure waste management in a way that minimizes the negative effects of waste on the environment and human health,
- Obtaining the necessary permits and approvals for the generation, transportation and storage of waste,
- Collecting, recycling and accumulating wastes separately according to their components and not containing hazardous and foreign substances in wastes,
- Not dumping wastes outside the recycling or storage facilities authorized by the local authority or municipality,
- They are obliged to cover the damages that may occur in accidents that may occur during the generation, transportation and storage of wastes and to clean up the pollution that may occur as a result of the accident.

f) Duties and powers of landfill operators

It is stated in Article 10 of the Regulation. Some of their duties and authorities are given below.

- Designing the storage area according to the appropriate conditions, obtaining the necessary permits and making it,
- To operate the facility established according to the project according to the specified principles and to provide the necessary improvements upon completion of the work,
- To ensure the necessary safety measures in the storage of waste,
- To record the amount, type, place of production, date of arrival and vehicle license plate data of the waste arriving at the storage facility in the computer system and to make this information available for inspection by the municipality, the local administrative authority and the ministry,
- They have important obligations such as not taking the wastes that should not be taken to the storage facility and the wastes that are prohibited to be stored and the excavation soil, construction and demolition wastes mixed with the aforementioned wastes to the storage facilities and notifying the management.

g) Duties and powers of those operating recovery facilities

Article 11 sets out some obligations regarding the duties and powers of those operating recovery facilities.

- Planning the facility according to the specified rules, obtaining the necessary permits and operating the facility according to the specified rules,
- To ensure the authenticity of the data in the transportation and acceptance document by examining the waste at the time of acceptance to the facility,
- Receiving the wastes of the collection and transportation companies authorized by the municipality or the local authority and those with Waste Transportation and Acceptance Certificate to the facility,
- Taking adequate safety and environmental measures during waste recovery,
- They are obliged to provide the principles of the Crisis Center and establish its coordination.
- The actors involved in the recovery of construction and demolition waste and their duties and responsibilities are given in the relevant regulation. In Turkey, there is no more comprehensive regulation on the duties and responsibilities of these actors and the recovery process.

4.2. Discussion of Construction and Demolition Waste Types Separately

In this section, the current functioning in our country during the recycling of construction and demolition wastes, the problems of the functioning, the reuse possibilities of the recycled wastes, logistics possibilities, special legislation regarding the recycling of construction and demolition wastes in our country will be mentioned.

4.2.1. Current operation regarding recycling of construction and demolition waste

The first objective in the generation of waste and the operation of this process is to avoid the generation of waste. If the generation of waste cannot be avoided, the following management hierarchy should be followed:

- Reduction at source,
- Reuse if it can be used,
- If it cannot be used, to ensure its recycling by sending it to recycling facilities,
- Storage of recycled products,
- Disposal of non-recyclable products.

Demolition process;

Obtaining the Demolition License from the municipality to which the demolition site is related,

If there are wastes that are likely to pollute, determining the amount of these wastes, taking the necessary actions in accordance with the Environmental Law and disposing of them properly,

The amount of recyclable and non-recyclable waste needs to be determined.

a) In the process of building foundation excavations;

- Obtaining Excavation License and Construction License from the relevant municipality to which the excavation area is connected,

- Cleaning the surface contamination of the vegetative soil, if any, in the excavation area, determining this amount and taking measures in accordance with the Environmental Law,

- Removal and quantification of approximately 0.10–0.80 m of vegetative soil and preparation for the actual foundation excavation,

- The actual foundation excavation must be carried out in the area where the construction works will be carried out, and the excavated soil must be separated and the amount of excavated soil must be determined.

b) Infrastructure works;

Obtaining Excavation License from the relevant municipalities for the excavations made by electricity, water and other institutions on the roads

- Cleaning the surface contamination of the vegetative soil, if any, in the excavation area, determining this amount and taking measures in accordance with the Environmental Law,
- Approximately 0.10–0.80 m of vegetative soil needs to be removed, quantified and prepared for the actual foundation excavation.
- Collection and transportation of construction and demolition waste

These wastes must be collected in the recovery and storage areas specified by the municipalities or the local highest local authority in accordance with the regulation. It is forbidden to dump and fill in lakes, rivers, seas, etc., except for the specified areas. Individuals, companies, institutions and organizations that cause waste generation after demolition activities must apply to the relevant municipalities and obtain the necessary permits. In Articles 15 and 16 of the Regulation on the Control of Excavated Soil, Construction and Demolition Wastes, other principles regarding the transportation of waste up to two tons and more than two tons, respectively, are specified. The transportation of these wastes should be carried out by trucks painted yellow with a Transportation Permit Certificate and a Transportation and Acceptance Certificate as specified in Article 23 and Article 24 of the Regulation on the Control of Excavation Soil, Construction and Demolition Wastes (Official Gazette, 2004).

- Recovery of construction and demolition waste

It is essential that construction and demolition wastes are firstly reduced, collected separately, reused and recovered in the area where they are generated (Official Gazette, 2004).

Construction and demolition wastes coming to the recovery facility generally include concrete, brick, glass, reinforced concrete, briquette, metal, tile, plasterboard, wood, drywall, etc. Mixed construction and demolition waste can be separated manually or by automatic machines. The steel in reinforced concrete is separated by crushing the concrete and the large pieces of concrete are reduced to smaller sizes by crushers.

Storage of construction and demolition waste

Vegetable soils will be used as cover soil in park, garden or other green area applications. After the materials recovered from construction and demolition wastes are used as road and foundation filling material, the remaining wastes will be used as filling material in landfills. Article 16 of the Forestry Law dated September 30, 2010 and numbered 27715 states that "Upon the end of mining activities, permission may be granted to metropolitan municipalities in metropolitan areas and to provincial and district municipalities in other areas in return for a fee in order to rehabilitate the areas considered as forests whose natural structure has been lost, which are transferred to the relevant forest administration or abandoned, in order to rehabilitate them with filling by requesting a certificate of no objection from the General Directorate of Mining Affairs." After the construction and demolition wastes are filled in the areas that have been mined and whose natural structure has been destroyed, vegetative soil will be spread on it in order to make afforestation.

4.2.1. Main problems of the recycling of construction and demolition waste

The functioning of recycling of construction and demolition wastes in Turkey has been explained in the previous section. However, there are some problems in the current functioning in our country. First of all, as in developed countries, recycling of construction and demolition wastes and providing economic benefit should be made a basic policy in our country. In our country, various studies on the management of construction and demolition wastes are carried out within the scope of the harmonization program with the European Union. However, the implementation and supervision of these studies could not be made widespread in our country. In addition, there is no target for recycling in this regulation. Separation of construction and demolition wastes is generally not done properly and these wastes are directly used as filling material. However, since these wastes may contain harmful substances such as lead, asbestos, etc., they may pose a great threat to the environment and human health if they are used without knowing the properties of the wastes. In the Waste Statistics Survey, it is reported that the amount of waste collected daily in municipalities is 1.17 kg/person. However, construction and demolition wastes are not included in these data. Although there are 20 different groups of waste in the Waste Management Regulation of the Ministry of Environment and Urbanization, there are 5 groups of waste (municipal waste, medical waste, packaging waste, hazardous waste, special waste) in the statistics. No waste data could be obtained where construction and demolition waste is included or presented on its own. The amount of construction and demolition waste generated in Turkey cannot be accurately determined due to insufficient inspection and monitoring activities (Aytekin, 2021). (Aytekin, 2021).

However, the annual amount of waste from the construction sector is estimated to be around 125 million tons. With the Law No. 6306 on the Transformation of Areas under Disaster Risk entered into force in 2012, urban transformation efforts have accelerated in our country. The Waste Management Directorate of the General Directorate of Environmental Management of the Ministry of Environment and Urbanization predicts that the amount of construction and demolition waste will increase by 10 million tons annually and the amount of material to be recovered will be approximately 6 million tons/year (Ministry of Science, Industry and Technology 2017).

In our country, the duty of preparing the management plan for the collection, temporary accumulation, transportation, recovery and disposal of construction and demolition wastes, determining, establishing or having established storage areas, and operating or having operated these areas is assigned to municipalities within the scope of the "Regulation on the Control of Excavated Soil, Construction and Demolition Wastes". Construction and demolition wastes are stored in the landfills designated by the municipalities for a fee. In Article 33 of the relevant regulation, it is stated in which works the recovered products can be utilized.

In the 2023 National Waste Management and Action Plan targets; it is stated that a system should be established for the collection of construction and demolition waste and a vehicle tracking system should be developed for the control of vehicles carrying these wastes. It is also stated that the highest level of recovery of demolition waste in recovery facilities should be the main objective (Ministry of Environment and Urbanization, 2016).

However, as stated in this action plan, recycling of excavation, construction and demolition waste is carried out in very few provinces. In these facilities, recycling and storage processes are carried out unconsciously, and even if waste materials are recycled, they often cannot be used because they do not meet the requirements of the relevant standards (Aytekin, 2018). In this regard, the ministry and municipalities should frequently check recycling facilities in cooperation and ensure that deficiencies in the system are eliminated. Authorized units should set some targets for recycling and make different strategic action plans to achieve these targets. However, the necessary sensitivity should also be ensured for the implementation of the action plans (Kılıç, 2012). Also the ministry

- VAT exemption on the initial installation of facilities,
- VAT exemption on expenditure items such as electricity, fuel and water,
- Providing premium support for those working in the facility or supplying personnel through İŞKUR,
- SCT reductions,
- Increase the number of private recycling facilities by providing incentives such as assisting in finding customers for placing the recovered materials on the market or cooperating with municipalities, public institutions and organizations to ensure that the recovered products are supplied from these facilities.

It is thought that there is not a full awareness of recycling in our country. In this regard, state authorities should carry out various studies on the awareness of recycling at every stage of educational institutions, especially from a young age (For example; giving compulsory courses under the name of sustainability).

4.2.2. Separation, recycling and reuse of construction and demolition waste

The management hierarchy in the recovery of construction and demolition waste is resource conservation, waste minimization, reuse, recycling, recovery and disposal. In most developed countries, waste minimization, reuse and recycling activities have developed significantly. In Turkey, on the other hand, studies on the management of construction and demolition waste are still in the development stage. The amount of waste materials can be significantly reduced before disposal by reducing, reusing and recycling waste before it is generated. The first two stages that play an important role in reducing waste generation are resource conservation and waste minimization. In this context, the ways to be followed to minimize the amount of construction and demolition waste;

- To ensure that the quantity of the product to be supplied is correct,
- Proper storage of the supplied products until the time they are to be used,
- To be able to evaluate the materials in the region,
- Reuse demolition waste in the next phase,
- Establishing a form of management to reduce surplus materials,
- Creating an area for sorting and storing waste at construction or demolition sites.

A significant portion of the waste generated during construction and after demolition can be reused. By reusing these wastes, the amount of waste that may be generated can be reduced and the rapid consumption of natural resources can be prevented. This can significantly reduce environmental pollution. In addition, the recycled wastes can be reused in existing areas or in different areas, providing significant economic contributions (Ölmez and Yıldız, 2008). Areas of use of products that are recycled and reused,

It is shown in **Table 4. 1.**

Table 4. 1. Materials that can be reused by recycling and their areas of use (Öztürk, 2017).

Building Materials/Components	Recycling Process	Recycled Product
Beton	Crushing, crumbling	• Recycled aggregate (crushed stone), • Filling material, • Aggregate (grobeton) in concrete mixtures with low strength, • Infrastructure material for road construction, • Plastering, keystone and landscaping.
Tile/Brick	Cleaning of mortars, crushing, crumbling	• Bricks to be reused, • Filling product, • Tile/brick production.
Natural Stone	Crushing, shrinking	• Reclaimed aggregate, • Filling material.
Marble	Pulverization, crushing	• Aggregate in asphalt and concrete production, • Filling material, • By substituting cement in cement-concrete mortar, • In ground improvement applications.
Metals	Melting, direct use	• Reused metal, • New metal production
Cardboard/Paper	Cleaning	• Recycled paper.
PVC based materials	Melting, washing, washing, chopping, cutting, crushing, crushing, pulverizing	• Recycled plastic, • Panel, • Recycled aggregate, • Asphalt, synthetic soil, • Floor drainage.
Glass	Direct use, producing second quality glass, melting, grinding, crushing	• Glass for reuse, • Recycled glass, • Glass fiber insulation material (glass fiber, glass wool), • Reflective paint production on roadsides.
Ceramic	Grinding, crushing	• Concrete, mortar and brick production, • In the production of kitchen countertops.
Wood	Direct use, cleaning, cutting, cutting, burning, shredding into sawdust, fiber and chips	• Furniture and kitchen elements, • Wood for reuse, • Energy source, • Wood-based materials, • Paper, • Insulation and filling material.
Insulation materials	Washing, burning, crushing and grinding	• Insulation material to be remanufactured, • Asphalt production
Gypsum based materials	Crushing, grinding	• Obtaining new gypsum • Can be used for gypsum materials and other purposes
Asphalt	Crushing, grinding	• Recycled aggregate in asphalt production, • Filling material, • Infrastructure material for road construction.
Window/door/kitchen equipment	Cleaning, sizing and direct handling	• Reuse

As shown in Table 4.1, construction and demolition waste consists of many components such as bricks, tiles, asphalt, metal, wood, ceramics, marble, insulation materials, plastics, doors, windows, kitchen materials, mostly concrete (Ersin and Coşgun, 2007). The amount of construction and demolition waste generated in Turkey cannot be clearly determined due to the inadequacy of inspection and monitoring activities. However, in the National Waste Management and Action Plan 2023 report, it is stated that approximately 300 million tons of excavated soil, construction and demolition waste is expected to be generated in 2023 (Ministry of Environment and Urbanization, 2016). Approximately 0.6 m3 of 1 m3 of construction and demolition waste can be recycled (Kılıç, 2012). Considering the 2020 data of the European Ready Mixed Concrete Association (ERMCO), while the total concrete production amount of the European Union member countries is 252.7 million m3 , Turkey alone produces 95 million m3 of concrete. According to these data, Turkey ranks first among EU countries, followed by Germany with 55.3 million m3 and France with 37 million m3 (Turkish Ready Mixed Concrete Association, 2022). Waste concrete and masonry materials have the highest proportion in construction and demolition waste and a significant portion of these can be recycled. Recycled concrete and masonry materials can be used as main materials in many areas such as lightweight concrete, geopolymer concrete, filling material, pumice and brick production as shown in Table 4.1 after the necessary recycling processes provided that they meet the relevant standards. The following summarizes the studies on some recycled construction and demolition wastes and the results obtained from these studies.

Recycling of Concrete Waste

Concrete wastes generally consist of demolished buildings, natural disaster debris, prefabricated production wastes, samples taken for quality control, maintenance and repair activities. Concrete wastes can be crushed with the help of crushers and used as coarse and fine aggregates. If these wastes are ground to cement fineness, they can be used in cement-based mortar, concrete or geopolymer concrete applications by replacing binding materials such as cement, blast furnace slag, fly ash. Sefidehkhan and Şimşek (2018) used coarse and fine aggregates obtained by recycling concrete samples to produce concrete again. In the study, recycled concrete aggregates were substituted to natural aggregate at a ratio of 0, 20, 40, 60, 80 and 100 %. As the proportion of recycled concrete aggregate increased in concrete mixtures, compressive strengths decreased. However, it has been reported that recycled aggregate reduces environmental pollution and provides an economic value to the waste material (Sefidehkhan and Şimşek, 2018).

Wagih et al. (2013) investigated the properties of concrete produced by substituting recycled concrete aggregate for natural coarse aggregate. It was found that 25% substitution of recycled aggregate did not have a significant negative effect on concrete performance compared to control mixtures. When the substitution rate increased to 50%, there were significant reductions in concrete performance. Mixes with 100% recycled aggregate substitution showed the lowest compressive strength. However, these mixtures are suitable for most structural concretes in Egypt and have a compressive strength of 33 MPa (Wagih et al., 2013).

Xiao et al. (2018) substituted recycled powders obtained from construction and demolition waste for cement. It was observed that up to 30% substitution rate had no positive or negative effect on mechanical properties compared to control mixtures. When the substitution rate exceeded 45%, significant decreases were observed in all mechanical properties. Therefore, the amount of recycled powder to be substituted was desired to be in the range of 15%–30% (Xiao et al., 2018). Alakara et al. (2022) produced geopolymer mortar with recycled concrete powders. In their study, they substituted concrete powder for blast furnace slag at a rate of 10, 20, 30 and 40%. They found that mechanical properties decreased as the substitution rate of concrete powder increased. The compressive strength was 53.35 MPa when the concrete powder substitution rate was 40%, which is a very high value for many construction applications. In addition, the absence of cement in geopolymer mortars significantly reduces environmental pollution and provides economic gain (Alakara et al., 2022). As can be seen, as a result of recycling concrete wastes, it has applications in many different fields.

Recycling of Brick and Tile Waste

Brick and tile waste is usually obtained from collapsed buildings and natural disasters such as earthquakes. These wastes can be crushed with the help of crushers and used as coarse and fine aggregates. If these wastes are ground and brought to cement examination, they can be used as a substitute for cement, blast furnace slag and fly ash in cement-based mortar, concrete or geopolymer concrete applications (Şimşek and Çiftçi, 2006; Tuyan, 2019). Also, waste bricks and tiles can be used in geopolymer concretes (Bayer, 2020). Alakara et al. (2022) studied the effect of high temperature on cement mortars with refractory brick powder. As a result of the study, it was determined that the mechanical properties of mortars replaced with 5%, 10% and 15% refractory brick powder were better than the reference mortars. Sevim et al. (2023) investigated the mechanical and physical properties of mortars replaced with refractory brick powder. In the study, refractory brick powder was substituted for cement at 5%, 10%, 15%, 20% and 25%. When the specimens were tested after 28 days of curing, it was observed that the reference specimen and the specimens with 5% and 10% refractory brick dust additives exceeded the specified minimum compressive strength (42.5 MPa).

Recycling of Asphalt Waste

One of the recycling applications used in our country is the recycling of milled asphalt pavements. Asphalt waste is generally used on stabilized roads in our country. Especially in recent years, the price of petroleum products has increased significantly, which has increased the recycling of bituminous pavement materials. Recycling operations can be done by taking the milled pavement to the power plant, reprocessing it and converting it back into pavement material, or by using specialized equipment, such as the same hot or cold mix asphalt, or by in-situ milling, revitalization and re-laying of the pavement. In their study, Oruç et al. (2018) produced asphalt under laboratory and field conditions by using different proportions (10%, 25% and 40%) of the materials obtained by excavating asphalt pavements in the Istanbul region that have completed their economic life. When the results obtained were analyzed, it was determined that the stability values decreased as the recycled asphalt pavement content increased, but this decrease was not very significant and this decrease was reasonable considering the gain. It was found that the additive content was 10%, which increased the routine resistance the most and provided an increase of 10.65% compared to the mixture without additives. Figure 4.6 shows a plant where asphalt pavements are recycled.

Figure 4. 6. Recycled milled asphalt pavements plant (Wirtgen Group, 2022).

Recycling Wood Waste

Wood is another building material derived from nature that is widely used around the world. The raw material for wood comes from forests and recycling waste wood materials is crucial for a sustainable environment. Many structural wastes contain large amounts of wood materials. Wood waste can be recycled and used in many areas. Once solid wood materials are cleaned, they can be used as second-hand products. In this way, the energy cost of production will be reduced and the need for raw materials will decrease. As a result, a more sustainable environment will be achieved (Salgın et al., 2021). Lightweight concrete can be produced from waste wood pieces. Chopped wood can be converted into a material called "geofibre", which is sprinkled as a powder on sloping soil surfaces. To strengthen the soil texture, wood waste in the form of wood chips can be mixed on top of the soil layer. Furthermore, the chips can be coated with plastic and used in the production of laminate flooring (Tam and Tam, 2006). Waste wood can be recycled and used in many construction products such as the production of wood-based panels for use in floors, roofs and ceilings, cladding in agricultural buildings, packaging substitutes, walls, stacking and sound insulation. Waste wood can be recycled for kitchen utensils, insulation panels made of wood chips, furniture production, etc. (Tam and Tam, 2006). Waste wood can also be recycled as fuel for coal and energy production. Waste wood can also be used as a by-product in cement kilns or coal-fired power plants (Hendriks and Pietersen, 2000).

Recycling of Marble and Ceramic Waste

In the construction industry, marble and ceramics are often used as decoration products both indoors and outdoors due to their aesthetic and durability properties. Marble and ceramic products are widely used in many areas such as kitchen countertops, floor coverings, sculptures, tables, coffee tables, stair steps, souvenir making, tomb making, decoration, furniture industry and sink production (Özmen, 2003). Since the chemical composition of marble is calcium carbonate, it can be widely used in many fields such as chemistry, fertilizer and animal feed. Marble and ceramic wastes can also be used as filling materials in highway construction, to produce concrete and asphalt, and to produce artificial marble and mosaics (Sarıtaş, 2006). Figure 4.7 shows an image of a plant where marble waste is recycled.

Figure 4. 7. Marble waste recycling factory (Haber48, 2020).

In marble mining, two different types of marble waste are generated during the extraction and processing of blocks. These wastes are in the form of dust or chunks. Approximately 50% waste is generated during the extraction of block marble from marble quarries. In marble processing factories, between 15% and 50% waste dust is generated during the cutting phase. During these processes, large amounts of solid waste, marble dust and marble sludge are generated. On windy days or in hot weather, a large amount of dust pollution is generated around marble quarries and processing plants, which causes serious damage to vegetation, especially around the plants. The management of these wastes must be managed in harmony with the environment. Otherwise it will cause major environmental pollution. Since marble waste is not classified as hazardous waste, its recycling and utilization will contribute to reducing environmental pollution. While the utilization rate of these wastes is about 80% in Western Europe and the United States, it is only 20% in Turkey (Ozturk, 2018).

Marble and construction waste can be utilized in different areas in the construction sector. Alakara and Ağaoğlu (2022) used waste marble chips as coarse aggregate in asphalt mixtures. According to the results obtained, although the marble aggregate reduced the stability of asphalt samples, it was found to be above the minimum value (750 kg) given in the specification. Aliabdo et al. (2014) used marble dust as a substitute for both sand and cement. In both cases, it was reported that a less porous concrete could be produced compared to control mixtures. Kara and Karacasu (2017) used waste tile fragments at different ratios (10, 20, 30 and 40) as aggregate substitute in asphalt production. Stability values decreased as the tile aggregate content increased. However, the stability values are above the minimum value required in the specification (750 kg).

Recycling of Glass Waste

One of the wastes generated in the construction industry is glass waste. All glass waste can be recycled and reused in glass factories. However, the main problem here is the different quality and color of glass waste. Recycling mixed glass of different colors and from different sources can lead to the formation of uncontrollable colors and properties in glass (Jani and Hogland, 2014; Vafaei and Allahverdi, 2017). However, since the color parameter is not important in areas such as the construction industry, this factor can be eliminated by using glass waste. Approximately 130 million tons of glass is produced worldwide every year. Approximately 100 million tons of the glass produced is thrown away as waste. Only 21% of glass waste is recycled and the rest is thrown away (Siddika et al., 2021). Since glass powder contains a significant amount of amorphous silica, it is a suitable option for use as a binder in concrete. There are studies on the use of glass powder in the field of construction, and it has different uses such as the production of cementitious binder (Letelier et al., 2023), aggregate (Kuri et al.), alkali-activating binder (Janowska-Renkas et al., 2023) and filler (Vaitkevičius et al., 2014). In his study, Öz (2017) investigated the effect of glass powder substituted for cement at different ratios (5%, 10%, 15% and 20%) on self-compacting mortars. It was determined that the substitution of glass powder for cement improved the fresh, mechanical and durable properties of self-compacting mortars (Öz, 2017). Tho-In et al. (2018) substituted different proportions (10%, 20%, 30% and 40%) of glass powder for fly ash to produce geopolymer pastes. When the results obtained were analyzed, it was observed that the compressive strength of the geopolymer paste produced with 20% glass powder additive was higher than that of the reference sample.

4.2.3. Logistics and Transportation Facilities

In this section, the importance of logistics and transportation facilities in the recycling of construction and demolition waste is mentioned. In addition, important issues such as transportation of construction and demolition wastes and areas where recycling facilities should be established are discussed.

Article 15 and 16 of the Regulation on the Control of Excavation Soil, Construction and Demolition Wastes No. 25406 provides details on the collection and transportation of construction and demolition wastes. The Regulation states that temporary accumulation containers or containers should be yellow in color and the types of waste to be thrown and not to be thrown should be written on them. It is forbidden to dispose of harmful, hazardous and household wastes in these containers. After the containers are full, municipalities/ local authorities or companies that have received permission/authorization from these authorities to collect and transport waste transport these containers to recycling or storage facilities.

Expenses related to the collection, transportation and disposal of these wastes will be borne by the waste generators as stated in Article 17 of the relevant regulation. Figure 4.8 shows Izmir Metropolitan Municipality teams removing a full container from the street. Companies carrying out maintenance, repair and demolition activities such as large-scale buildings, roads, etc. are responsible for reducing, reusing, recovering and transporting construction and demolition waste to disposal facilities. In the relevant regulation, it is stated that excavation soil and construction and demolition wastes that will be reused as a result of excavation, repair, renovation and construction works to be carried out on roads, streets, avenues and pavements should be accumulated in portable containers. It was also stated that these wastes should not cause visual and dust pollution on the streets.

Figure 4. 8. Container allocated for construction and demolition waste (Buca Municipality, 2019).

Article 23 of the Regulation No. 25406 states that excavation soil, construction and demolition wastes should be transported to landfills that have obtained the necessary permits by transportation vehicles that have obtained transportation permits. It is also stated in this article that those who generate excavation soil and more than 2 tons of construction and demolition waste are obliged to apply to the relevant district municipality in metropolitan municipalities, to the municipality within the boundaries of the adjacent area, and to the highest local authority outside the adjacent area and obtain a "Waste Transportation and Acceptance Certificate". Article 24 of the relevant regulation states that persons or organizations wishing to transport excavation soil, construction and demolition wastes must obtain a "Excavation Soil, Construction/Demolition Wastes Transportation Permit Certificate" from the relevant municipality within the boundaries of the adjacent area and outside these areas by applying to the highest local authority. Vehicles carrying construction and demolition wastes are required to be yellow in color and have the words "EXCAVATION SOIL AND CONSTRUCTION/ DEMOLITION WASTE TRANSPORT VEHICLE" written on them in large letters. Figure 4.9 shows a vehicle transporting these wastes. In addition, persons or organizations transporting these wastes should have sufficient yellow containers and containers of different sizes. The names and contact details of companies that have obtained permits to transport waste, the location of recycling or landfill sites, and outlines of road routes to these sites should be publicized by the relevant municipalities in a way that informs the public.

Figure 4. 9. Excavated soil and construction and demolition waste transport vehicle**.**

Article 25 of Regulation No. 25406 states that the persons or companies that will carry out the transportation of these wastes must first take the necessary precautions such as not polluting the environment, not disrupting traffic flow and ensuring the safety of life and property. Vehicles should be covered with a suitable cover to prevent environmental pollution during transportation. Transport vehicles should not be loaded beyond their capacity and if any, pollutants such as mud etc. should be cleaned from the wheels and traffic should be allowed. In addition, the municipality and the highest civil authority of the local government have the right to make the necessary arrangements for the vehicles carrying this waste to be on the road during certain hours so that they do not adversely affect urban traffic.

- Some important information about the locations where recycling facilities and construction and demolition waste storage areas will be established and the details of accepting these wastes can be listed as follows (Pamuk, 2018):
- It is not appropriate to establish and operate these facilities in areas with high landslide, erosion and avalanche risk, in areas with high flood risk, in river beds and valleys where the flow of rainwater is difficult, in areas where irrigation and service water is collected.
- Reclamation areas should be located five hundred meters away from river areas. In addition, fixed recovery sites should not be less than one kilometer from the nearest settlement.
- Construction and demolition waste storage units can be established with infill permits by organizing former mines as green spaces and structuring the areas.
- Explosive, oxidizing, corrosive, highly flammable and combustible materials as well as animal and household wastes are not accepted to these facilities.
- Necessary documents of the wastes coming to the facilities are checked. Wastes brought by companies that do not have a waste acceptance form, transportation and permission certificate should not be taken into the area and the situation should be reported to the relevant institutions.
- The amount of waste to be brought to the facilities, production area, arrival and unloading date and license plate information of the transportation vehicle are recorded and the vehicle is taken into the facility.

5. SUSTAINABILITY

5.1. Concept and Principles of Sustainability. The link between energy deficiency and reuse and recycling. (1 lesson)

Sustainability refers to the ability to survive in perpetuity. Sustainability is about the way humans use natural and renewable resources over a long period of time. The concept of sustainability is inseparable from the United Nations' concept of sustainable development, which also includes ecological issues.

Figure 5. 1. United Nations' concepts of sustainable development

<u>The main principles of sustainability:</u>

Protect the environment, be socially responsible;

Ensure the comfort and well-being of residents;

Reduce heat loss and use efficient energy sources;

Reduce waste and reduce the negative impact on the environment;

Maintain a healthy and thriving local ecosystem, enabling long-term value creation.

The United Nations' concepts of sustainable development focus on sustainability.

Construction is one of the main sectors of the economy and a major consumer of energy resources. Current technological and social trends aim to implement the principles of sustainable development. Their main goal is to reduce the destruction of the environment and the overuse of natural resources. Therefore, all participants of the construction process - from the developer to the architect - should be open to market innovations and make decisions in accordance with the principles of sustainable construction.

Principles of sustainable construction:

- Ensuring the comfort and well-being of residents,
- Reducing heat losses and using efficient energy sources,
- Reducing the amount of waste and negative impact on the environment.

The above-mentioned statements should be applied not only to newly designed buildings, but also to the reconstruction or modernization of existing houses. These principles should be followed, for example by insulating walls and reducing heat loss through building walls.

Figure 5. 2. Principles of sustainable construction.

Therefore, the approach to sustainable construction should start from the design phase and continue with the construction of buildings up to their reconstruction or even demolition. Taking into account the innovative approach of caring for the natural environment and ensuring people's well-being, we should consider the possibility for buildings and facilities to reduce energy losses by using proper insulation, but also to use renewable energy wisely. For example, using solar energy, photovoltaic systems, waste water treatment plants, trees and vegetation (e.g. collecting rainwater and using it for green spaces).

Table 5. 1. Advantages and disadvantages of using natural energy sources, waste and biomass to create new energy

Type of Energy	Source	Advantage	Disadvantage
Solar Energy	Sunlight	Infinite resource Environmental friendly	Expensive Large space
Wind Energy (Wind Power)	Wind	Rapid growth Low operational costs	Environmental issue Noise problem
Geothermal Energy	Underground heat of Earth	Potential infinite	Limited area (Volcanic activity)
Biomass Energy	Decaying plant or animal waste	Carbon neutral Cost effective	Expensive Requires space
Hydropower (or Hydroelectric Power)	Gravitational force of falling or flowing water	Reliable Flexible	Expensive Environmental issues Limited reservoir
Tidal Energy	Movement tide	Predictable Long lifespans	Environmental issue Expensive
Wave Energy	Movement of seawater	Ideal for island	Environmental issue Expensive

Efficient energy consumption. The basis of sustainable construction is to reduce the energy consumption of newly constructed buildings. In European Union countries, legal regulations or standards aimed at reducing energy consumption in buildings are developing. Directive 2010/30/EU, adopted on May 19, 2010, introduces important changes in the construction sector. According to these provisions, from 2021 the highest A++ energy efficiency requirements will have to be applied to newly constructed buildings in Lithuania. Therefore, when designing such buildings we need to pay attention not only to the appropriate thermal parameters of external walls or roof insulation, but also to ensuring the energy efficiency of air ducts, ventilation ducts, heat pipes and other building elements.

Renewable energy sources. Renewable energy sources should also be used in construction to create a sustainable energy balance - for building heating and hot water. Solar energy, photovoltaic systems, biomass or geothermal energy can be used for these purposes. Geothermal energy can be obtained by utilizing energy from deep underground with the help of underground source heat pumps. Additional elements that can operate based on renewable energy principles are mechanical building ventilation systems, commonly known as recuperation. By reusing the extracted heat, we reduce the energy costs associated with heating the ventilated air in winter.

Sustainable construction is consistently focused on protecting the environment, improving human health and adopting low energy costs. This is one of the sectors that the European Union has included among its priorities and which has extremely important potential for the European economy. A good example of this initiative is to reduce the energy impact from 2021 according to the directive. Public buildings must comply with this directive from 2019. The adopted directive aims to increase the energy security of EU member states, reduce the emission of harmful CO2 gases and reduce the dependence of the European Union economy on imports of gas, oil, fossil fuels and other products.

Figure 5. 3. Sustainable construction from the eyes of architects**.**

5.2. Future perspectives, best practices, sustainable architecture, waste prevention (2 lessons)

A thoughtful building design has a significant impact on future construction costs and subsequent building operating costs. It is important that an architect or designer tries to minimize the negative impact of construction on the natural environment. Since buildings are complex structures made up of different types of materials and components, each material choice can be based on best practice and even ecological standards.

When designing a building according to the principles of sustainable development, we must use materials based on raw materials obtained from natural resources - some of these can be: rock wool, wood wool, straw, stone, wood, recycled metals, ecologically neutral industrial waste, for example concrete or brick waste.

Figure 5. 4. Sustainable and “green” construction.

Those involved in "sustainable" or "green" construction today should know the basic aspects and components of sustainability.

The life cycle of a building (structure) - starting with the extraction of natural resources, transportation, production of building materials or products, continuing with design, construction (installation), use, repair and renovation, destruction and transformation of waste into the same composition or material forms found in nature and returned to nature It includes all periods or stages that are rolled back or presented to the beginning of another life cycle.

Şekil 5. 5. Kanada kırmızı sedir çatı kaplamaları ve emprenye edilmiş ahşap yonga levhaları.

The target is to reduce CO2 emissions, waste generation, etc. throughout the life of the building. To reduce environmental impact as much as possible, including At each stage of the building's life, it must be ensured that they are created as little as possible – they must be recycled and used to achieve the same composition or form of materials found in nature.

Figure 5. 6. Thermal insulation materials of natural origin: wood wool and hemp fiber wool.

Example: The beginning of a road's life cycle is small stones mined in different, perhaps far-flung places, and the end of a road's ideal life cycle is the same stones being placed in the same place. Although this type of end of life cycle is not usually possible, placing stones in a similar natural environment is the type of end of life cycle we are aiming for.

Questions: Do you know which construction product has the longest life cycle? What is the shortest life cycle? Which of the following products is environmentally friendly and why?

Circular economy is an economic system that aims to reduce waste and stop the constant use of resources. Circular systems are characterized by reuse, sharing, repair, renewal and recycling to create a closed loop system that reduces resource consumption and waste, pollution and carbon emissions. The circular economy aims to ensure that products, equipment and infrastructure are used for the longest possible period of time, thereby increasing the efficiency of these resources. This does not mean that consumers' quality of life will decrease - it allows us to continue using similar products and services.

Figure 5. 7. Circular recycling.

Example: All "waste" must become "raw material" for another process: by-products, renewable resources or reproducible natural resources, such as compost.

Questions: What type of waste from the construction site could become raw material for the next (or next) job?

Energy efficiency of buildings - Directive 2010/31/EU of the European Parliament and of the Council, with amendment dated 30 May 2018, promotes the improvement of the energy efficiency of buildings in the European Union (EU). This directive aims to reduce greenhouse gas emissions by at least 40% (compared to 1990) by 2030, increase the share of renewable energy used, take into account outdoor, climate and local conditions, indoor climate requirements and economic efficiency, and increase energy consumption in line with EU targets. It implements ambitious EU commitments to save money and improve European energy security, competitiveness and sustainability.

This directive obliges EU countries to determine minimum legal requirements regarding the energy efficiency of buildings and expresses them as short and understandable energy efficiency classes. Today's buildings must have A++ class or almost zero renewable energy consumption.

BREEAM is a method of assessing, rating and certifying the sustainability of buildings developed in the United Kingdom and widely used around the world. This method is applied to determine and calculate the added value (benefit) created throughout the entire life cycle of the building, from its construction to its use and renewal. BREEAM evaluates the supply, design, construction and operation of the structure against a range of targets based on performance indicators. The approach focuses on sustainable value across several categories, including energy, land use and ecology, water, health and well-being, pollution, transport, materials, waste and management. Each category focuses on the most important factors, including reduced carbon emissions, mitigation solutions, climate change adaptation, ecological value and biodiversity conservation.<<

Figure 5. 8. Green building.

A green building is a building that reduces or eliminates negative impacts or creates positive impacts on our climate and natural environment through its design, construction or operation. "Green" buildings protect valuable natural resources and improve our quality of life. There are several features that make a building called "green". These include: efficient use of energy, water and other resources; use of renewable energy such as solar energy; implementing pollution and waste reduction measures and creating reuse and recycling opportunities; good indoor air quality; use of non-toxic, ethical and sustainable materials in the construction process; implementation of environmental protection measures during building design, construction and operation; achieving the best quality of life for residents during building design, construction and operation; Finding a design that can adapt to the changing environment.

LEED (Leadership in Environmental and Energy Efficiency) - is a widely used rating system for ecological ("green") buildings. This system applies to all building types and includes guidelines for the construction of buildings that provide health, high energy performance (efficiency) and cost savings. LEED certification is a globally recognized symbol of sustainability achievement and leadership. LEED applies to all building types and all phases of construction, including new construction, interior design, operations and maintenance, load-bearing structures and facades.

It is an international environmental management standard that evaluates the impact of services on the environment, determines risk management measures, plans environmental targets, implements programs to achieve these targets, and performs corrective measures and performance analysis. The compliance of the management system with the requirements of the ISO 14001 standard is verified by a certificate issued by an accredited institution.

Example: Even when producing non-organic products, a company can meet the requirements of the ISO 14001 standard and receive a certificate confirming this if it determines the environmental impact of its production process and products, plans environmental impact reduction targets, and approves and implements programs to achieve these targets.

Question: This standard establishes certain requirements for products and services. Can this standard be applied to construction activities?

EU Ecolabel (EU Ecolabel) - Recognized throughout Europe and around the world, the EU Ecolabel is a mark given as a sign of ecological excellence whose products and services meet high standards of environmental protection, from the extraction of raw materials to production, use and disposal. The EU Ecolabel promotes the circular economy by encouraging manufacturers to produce less waste and CO2 during production. The EU Ecolabel criteria also encourage companies to develop products that are durable, easily repairable and recyclable. The EU ecolabel is not mandatory and the operating efficiency and environmentally friendly business decisions of companies seeking it must be checked and approved by accredited bodies.

Ecological design is a form of design of a product that is designed with a specific focus on reducing the environmental impact of a product throughout its life. In evaluation, the life cycle of a product is usually divided into the stages of acquisition of raw materials, production, use, and disposal of the product. Ecological design demonstrates increased responsibility and awareness of our ecological footprint on the planet. Increasing awareness of “greenness,” high population density, industrialization, and increasing environmental pollution have eventually forced a reassessment of consumer values. It became clear that new - environmentally friendly - building solutions should be sought that would reduce material and energy costs.

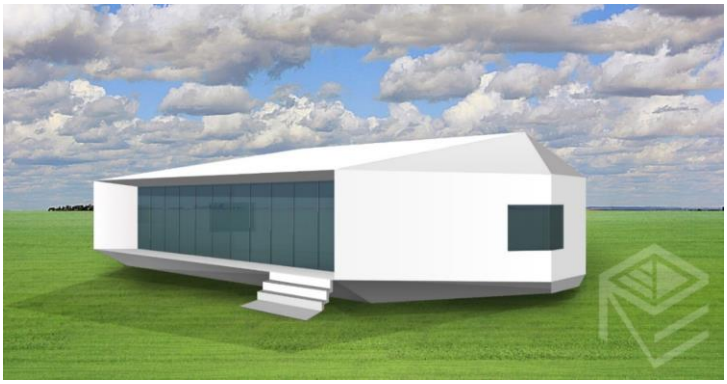


Figure 5. 9. A++ class house design ”Solar house”

Passive House is a voluntary building energy efficiency standard that started in Germany and reduces a building's ecological footprint. Compliance with the requirements of this standard aims to reduce the energy consumed by the building - for heating or cooling the spaces - to the minimum possible. This is the first recognized dedicated building energy efficiency initiative focused specifically on the conservation and use of passive energy produced by occupants or household equipment in a building.

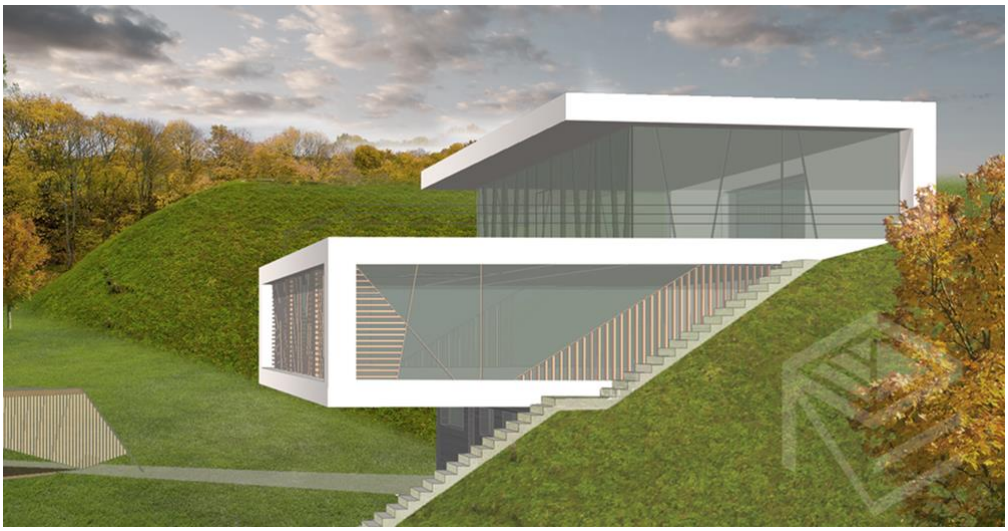


Figure 5. 10. A++ class ecological house design “House in the hill”

Preventing waste generation.

Energy consumption during the use of buildings. The amount of energy consumed by a construction object depends on both the building itself and its users. The energy consumption of future buildings depends primarily on the designer and is expressed in energy efficiency class. Requirements for energy efficiency class may be different in different countries. The highest grade is usually grade "A" or "A++". When designing a building, it is imperative to take into account the energy efficiency requirements established by that country - the energy efficiency class cannot be below the requirements for a particular type of building specified by the country's laws.

For engineering structures, e.g. roads, pipelines, sports fields, etc. The energy consumption efficiency to be achieved is determined by the owner according to his needs, as is often the case where buildings do not have different heating or cooling systems or are radically different from what is typical.

In other words, the purpose of the designed structure (expected processes in the building or engineering structure), the needs of future users and the typical behavior of users are the main assumptions for determining the planned level of energy efficiency. That is, the high energy efficiency of a perfect building cannot be achieved if the owner uses it for purposes other than those intended at the time of design.

Every user of a building must follow the rules, often unwritten, but must not sacrifice habits of hygiene, health or appearance, or comfort of life. The ultimate goal of designers, manufacturers of building products or elements, and civil engineers and builders is to construct a building that can use little or no energy from non-renewable sources without compromising the desired high level of comfort and hygiene.

Energy use during building construction. Cranes, trucks, lighting, winter heating, welding, drying with auxiliary heating, drilling and many other machines and processes must be planned on the basis of the "best known" technology. Also, there must be a desire to do everything at once - without fixing, redoing or changing.

“Time to lead” makes sense in the sustainability chain – if the building is completed in whole or in part earlier than planned, or if some parts are completed too late, some energy-consuming systems become useless as vacant spaces require heating and maintenance.

In many countries, demolition or dismantling is also a type of construction work. Therefore, the energy costs required to demolish a building should already be planned during the design and construction of the building. By choosing products (materials) with appropriate properties and appropriate structural and construction process solutions, it may be possible to reduce the energy costs required for the demolition of the building and the classification of waste (into reusable, recyclable and disposable).

Example: Demolishing an unnecessary high-class concrete structure requires more energy. Therefore, building and construction business cannot be sustainable!

Questions: Can additional energy needs be used due to poor planning of the construction process? Can improper concrete installation lead to additional energy use?

Use of other resources. We need to evaluate all stages of construction, use, repair and demolition of a building, but the construction, repair and renovation stages are the most important for those working in the construction industry. It is inevitable to use all the resources foreseen in the project during the construction, repair and renovation stages. The key question is how we can reduce additional infrastructure: additional space is required, such as a temporary office, material storage, waste collection place, assembly or fastener production or assembly location, construction cranes and space for security and workers. Engineers are crucial in the design (construction planning) phase, but workers play a critical role in the construction phase.

Another precaution number 1 is water. We drink water, we use water for technological processes, we use water for domestic needs, hygiene needs and auxiliary needs (washing of equipment and space, etc.). It is also important to evaluate wastewater. When used water enters the sewer, the irrigation field will use electricity to pump and clean it; also this process will use a certain amount of oxygen.

All simple measures suitable for saving water and reducing the amount of wastewater are:

- Sedimentation tanks are installed at the construction site to settle mud and simple dirt, making water available for specific purposes again.
- First, we should clean the tools and equipment immediately after work, and then wash them.
- We should introduce the water consumption calculation and bonus system, if the water consumption decreases or the consumption is too low, the reward system will be activated, etc.

Another important measure is the wood required for the installation of auxiliary infrastructure (ladders, paths, fences, temporary supports and other needs of the construction site). Reducing wood consumption does not mean using thinner boards for walkways and staircases, as this reduces worker safety, but does mean cutting wood to leave as little or no unusable small parts as possible. It is very important that the wood can be used as many times as possible.

The list of other resources used in the construction field includes soil, aggregate, solvents, formwork plywood, cleaners, greasers, temporary fasteners, etc. can continue with. An important task for builders - to keep all auxiliary tools and materials in clean, dry and tidy places and reuse them as many times as possible!

Example: To be called an environmentally friendly "green" worker, you need to not drink as little water as possible, but try to use as little fresh water as possible: you should not keep the water tap open for a long time after pouring water; you should not "throw away" a half-drunk water bottle every night, but open a new bottle every morning; You should not pass by a drinking water tap that is left half open, etc.

Question: Is collecting rainwater to irrigate hardening concrete a good way to save water?

Use of environmentally friendly construction products and auxiliary materials.

There are countries that have databases about organic products or their suppliers. The environmental impact of two identical construction products can be completely different due to the amount of energy used in their production and transportation to the construction site!

Today, the legislation of the EU and many countries limits or prohibits the use of certain materials in the production of construction products. The European Union regulation "REACH" is directly applied in every EU country with the aim of reducing human health and environmental risks caused by chemicals. It also establishes evaluation methods, product registration procedures and rules and requirements for providing information about the substances they contain. The builder should be aware that the construction product safety label (which is mandatory) determines which chemicals were used in the production process of the product, and this is a consequence of REACH. The safety data plate indicates that the product complies with legal requirements and that its use requires the implementation of measures to protect workers and the environment.

Today, it may become mandatory in European countries to determine and report the amount of energy used in the production and transportation stages of each construction product. The result of this calculation should form part of the performance statement of the construction product.

Materials mixed with water – do not require the solvents needed to prepare the mixture or wash vehicles, and are also an important ingredient in the preparation of many dry mixtures (such as paint or adhesives).

Figure 5. 11. Use of environmentally friendly materials**.**

Figure 5. 12. Heating of buildings using environmentally friendly wool.

If the selection of construction products is the builder's duty, then he should choose from products that include:

- The most natural,
- Does not contain solvents,
- Using packages as small as possible,
- It has an ecological label and its performance is given by the manufacturer,
- Able to deliver to the construction site as soon as possible,
- Provided by suppliers on the "green manufacturers" list or suppliers with environmental management system ISO 14001 certification,
- Can be transformed after use, but durable enough,

Example: A snow house - also known as a 'snow house' - is usually built when there is the right amount of snow. It may seem strange, but it is true - natural suitable snow on the snowfield can be recognized as the most environmentally friendly construction product without any labeling, performance declaration and certification.

Question: Can you list all the aspects that can explain why natural snow (suitable for snow house construction) is an ecological construction product?

5.3. Results. How can the methods discussed above be applied in practice? What can we personally do as construction professionals and business owners? How can we encourage recycling? (2 lessons)

Construction produces two main types of waste – construction waste and hazardous waste. Of course, a significant amount of ordinary household waste is also generated due to employees' home conditions and office activities. Management requirements vary depending on the type of waste.

The waste management hierarchy (principles) classifies optional waste management strategies; the main ones are known as waste reduction, reuse and recycling (English "3 Rs" or "3R rule": reduce, reuse, recycle). The waste management hierarchy applies to all areas of activity and is also extremely important in construction.

The best waste management is waste reduction. This can also be economically beneficial for the construction company. Otherwise, excessive waste generation will always affect the company's profits and, as a result, negatively affect salaries, including for construction workers.

The second good waste management practice is to reuse or convert waste into raw materials. Non-hazardous inert construction waste generated at the construction site can be shredded by mobile equipment and reused in construction as foreseen in the construction project.

Figure 5. 13. Collection of construction debris waste**.**

The third good waste management option is to sort waste and reuse it in other construction processes or supply it for recycling.

Classification, accounting and storage must be carried out at the construction site in accordance with the requirements of national and municipal laws, company policies and, even more strictly, company rules.

Hazardous waste must be handled, packaged, marked, stored and accounted for in accordance with the rules and procedures established by law. Many of these requirements should be part of training programs. Students should be able to recognize the most hazardous wastes found in every construction site.

Example: If we do not manage and classify waste at the construction site, these wastes will somehow be dumped into nature and brought together in a large pile, and soil will be poured on it, creating a hill that we will admire for hundreds of years. But every time we admire this "beauty", we do not think about how many different professionals strive to prevent rainwater from this landfill from flowing into local streams, drinking water sources or just a beautiful residential area in the neighborhood.

Questions: Is it enough to separate non-hazardous waste into recyclable and non-recyclable waste? What does this depend on?

social activity

The role of higher education institutions and vocational training institutions

Every school and institution should encourage its students to understand the most pressing issues of our time. The expectations placed on schools – to provide students with the skills to establish themselves in an increasingly complex multi-layered environment – can be met when the education system establishes clear teaching objectives and assessment methods that will help them reflect on their involvement in the implementation of specific initiatives or “green” changes. Learning environments should challenge young people to understand the world beyond their immediate surroundings, to interact with others while respecting their rights and human dignity, and to take action to create a sustainable environment and a thriving community. Therefore, a particularly important task of vocational training centers and higher education institutions is to ensure that future specialists acquire not only theoretical knowledge (in lectures or seminars), but also practical skills that form or begin to form daily habits of behavior.

An educational institution can benefit by promoting environmental protection and exposing students to and even involving them in processes such as advanced waste separation and building energy monitoring. For example, it may be equipped with hardware and equipment such as photovoltaic elements, smart heat pumps, ventilation and recovery systems, LED lighting systems, sensors that record the indoor climate and outdoor weather conditions, or other tools and systems. The operating parameters of this equipment may be such that all students can access it in public areas or on the internal network.

In educational institutions, it will be quite appropriate to organize participation in sealing and thermal imaging tests of buildings, preferably in problem areas of their own premises or buildings.

All employees of a vocational training center or higher education institution must also comply with the rules for sustainable use of buildings determined by the educational institution and thus become examples that shape the habits and behavior of students.

Finally, developing global competencies can help shape new generations that care about global issues and will solve social, political, economic and environmental challenges. The sustainable development agenda to 2030 recognizes the critical role of education in achieving sustainability goals. Therefore, all countries must ensure that "by 2030, students in educational institutions acquire the knowledge and skills (along with knowledge of human rights, gender equality, a culture of peace and non-violence, global citizenship and cultural diversity) necessary to promote sustainable development through sustainable lifestyles." (target 4.7 of the Incheon Declaration and Education 2030 Action Plan, page 20).

Question: The "green" habits of a future professional can be formed even in professional or higher education, and these habits can be implemented not only in the workplace, but also in his personal life.

Example: How can an educational institution influence the formation and consolidation of "green" skills in a student, what tools, methods or examples can be used?

The role of proactive students

Every student can take action to increase collective well-being and promote sustainable development. This dimension focuses on the role of young people as active and responsible members of society and refers to the ability of individuals to respond to a particular local, global or intercultural problem or situation. Recognizing that young people have many areas of influence; Understands that they can influence personal and local, digital and global dimensions. Empowered young people have opportunities to act thoughtfully and responsibly and make their voices heard. Just as you can advocate for a schoolmate, you can launch a campaign to spread the word about their personal approach to sustainability. On a global scale, we are already seeing many young people aiming, through action and mobilization of their peers, to not only improve living conditions in their communities, but also to create a fairer, more peaceful, responsible and environmentally sustainable world.

Example: A group of students decides to launch an environmental and resource conservation awareness campaign focusing on how their school contributes to reducing local and global waste and pollution. With the support of their teachers, they organize a series of talks on how to reduce waste and energy consumption. They also develop and aim to distribute informative brochures that increase their ability to make better decisions about product purchasing and waste disposal. In addition, they are working with the student community and school administration to place containers for waste segregation on school grounds and to approve and enforce an energy saving strategy.

Question: What tools, methods, or examples can be used to maximize student peer engagement in sustainability initiatives?

Figure 5. 14. Sorting of construction debris.

Employer's role

It is true that most people understand that the environment must be protected. A collaborative worker understands that their individual actions contribute to society's impact on the environment, but humans are surprisingly resistant to change: we tend to resist changing our behaviors and habits, even if we don't want to change them. Knowing and wanting may not always be enough. Successful green change requires everyone's awareness and buy-in from all employees.

Therefore, it is important to have a clear set of core organizational values that are effectively communicated and discussed with employees so that they feel responsible for upholding these values. "Being greener" must be a commitment of the organization or company, and it delivers on that commitment through specific policies and actions, because it is not enough to say it in the mission statement, brand history, or marketing and promotional materials. It is very important that clear actions are regularly taken that encourage the evaluation of personal preferences and that each employee feels responsibility for the values proclaimed by the company and takes pride in these values and the workplace.

Involving employees in the "green change" process can increase employees' awareness, eliminate their initial doubts and make the necessity of "green change" more acceptable. It can also increase employees' motivation to develop relevant skills and thus help them adopt new "green" procedures and technologies more smoothly. Additionally, employee involvement can reduce the negative impact of “green” changes on job quality. Employees must know why a particular action is important and how to do it. Therefore, they need to hear relevant messages frequently and through various channels in order to understand the information being sent.

"Green changes" have often been proven to reduce the company's costs, but this does not directly benefit employees, for example job retention, higher income or qualifications, better health, safety, etc. The benefits created by “green changes” are often not properly communicated in companies, so they are not understood or felt. Limited understanding of the benefits created by “green change” and insufficient awareness of the meaning of implementation actions can encourage employee resistance to “green change”, inadequate efforts, and even negative attitudes towards the implementation of “green change” processes. Therefore, the benefits created by “green changes” need to be clearly communicated.

Many organizations include “Sustainability” or “Green Practices” sections on their websites to communicate their commitment to sustainability to both customers and employees. These web pages often describe the organizations' goals and "green" actions taken by the company. Another source of information could be "Sustainability reports" prepared every quarter or year. These reports may be distributed to employees or the public via email or intranet, or simply published on the company's website.

Example: If the company's efforts to protect the environment are not based solely on disclosure, the change strategy chosen by the employers will only be effective if it does not involve as many employees as possible adopting the "green" goals set by the employers and carrying out the "green" actions chosen by the company.

Question: What measures should employers take to involve as many employees as possible in the "green" operation the company has chosen?

Role of employees

Employees also observe their managers and colleagues as they decide how to behave. People tend to follow certain behaviors if others they respect are more willing to comply with or support certain behaviors. Group activities can be a way to help employees make sure their colleagues are included. "Green teams" are very useful tools that help create and develop an environmentally friendly work culture within the organization. However, in order for the activities of such a team to be successful and effective, not only moral but also financial support from the management of the organization is needed. Therefore, before meeting with management, it is necessary to draw up a clear action plan showing the benefits that the presence and activities of the "green team" provide for the organization. This action plan should define why the organization's environmentally friendly "green business" practice is important to the business and its employees. Of course, not every “green team” will have formal management support and funding for all proposed activities. However, with the motivation and in-principle approval of management, some simple actions can be carried out without financing, for example training colleagues on certain environmentally friendly actions (e.g. saving energy and resources). The entire team, colleagues and management must establish and properly communicate clear goals and priorities of their activities so that the “green team” understands what they are aiming for. A good goal should be specific, measurable, achievable within a set time frame, and consist of clear actions. At the same time, setting priorities will help determine the clear direction of "green team" activities. Therefore, the team must have an action plan that includes the main areas of activity and basic information about them, goals and priority actions.

Main areas of activity may be waste prevention, recycling, composting, water, energy, social sustainability, transportation and supply. This tactic may seem simple, but daily habits and routines are important components of creating and maintaining habits at work.

Figure 5. 15. On-site separation of construction and demolition waste**.**

There are many simple steps you can take to make sure your 'green team' and colleagues understand the importance of such activities and are willing to participate and collaborate. Involving employees in the implementation of 'green' initiatives is key to the success of the 'green team' - after all, the support and help of colleagues is essential for the spread and implementation of 'green' sustainability ideas in the company. That's why it's important to communicate with colleagues at every opportunity – during employee meetings, annual company event discussion events, work groups, etc. with deals or simply by producing and distributing regular newsletters. Even lunchtime meetings are a great opportunity to raise awareness of colleagues about 'green team' activities, engage them and educate them on sustainability issues. At any opportunity, it is important to discuss green initiatives that can be implemented in the company, green practices that have already been implemented or success stories of other companies. It is also important to share information about future actions, but these should be linked to results/goals already achieved.

Example: In a company that has chosen a 'Sustainability' path, a group should be formed and try to involve as many colleagues as possible with the aim of promoting sustainability in daily behavior and actions.

Question: What types of collaboration activities can be carried out by the initiative group aiming to consolidate the path of "Sustainability" in the company before funding is allocated?

6. RESOURCES

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