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M. Sc. in Civil Engineering

Fatih BAKIR

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A STUDY OF URBAN RECYCLING WASTE AND ECONOMIC INVESTIGATION

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Fatih BAKIR

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A STUDY OF URBAN RECYCLING WASTE AND ECONOMIC INVESTIGATION

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in

Civil Engineering Department

Hasan Kalyoncu University

Supervisor

Assist. Prof. Dr. Nurullah AKBULUT

by

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	GRADUATE EDUCATION INSTITUTE **M.Sc. ACCEPTANCE AND APPROVAL FROM**

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I declare that all the information and documents in this thesis have been obtained and resented in accordance with academic rules and ethical behavior. I further declare that I have fully cited and referenced all non-original materials and results from this work, as required by this rule and conduct.

Fatih BAKIR

ABSTRACT

A STUDY OF URBAN RECYCLING WASTE AND ECONOMIC INVESTIGATION

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In today's urbanized world, cities have become the primary centers of resource consumption and urban waste regeneration. However, with the acceleration of the urban regeneration process, the issue of managing construction and demolition (C&D) waste has become a major challenge in urban renewal. C&D waste is generated in large quantities worldwide, including in Türkiye. Although it has low environmental impact when compared to other wastes, it is characterized by its high volume and weight. The objective of this thesis is to manage urban regeneration wastes effectively to prevent resource wastage, protect the environment, and save money. The aim of the study involves creating a waste hierarchy, separating the wastes at their source through selective disposal, ensuring that the wastes are recovered and reused in a zero-waste cycle, and developing a management model with calculation cost tables for a small area. This study also includes a statistical assessment of urban regeneration in Türkiye, a strategy for the ministry and municipalities on how to manage C&D waste, and an economic analysis of recycled materials. In recent years, there has been an increase in awareness about sustainability and resource management, and Türkiye has started exploring the reuse of C&D waste materials for the circular economy and zero waste approach (reducing, reusing, and recycling). The study indicated that Türkiye has the potential to save significant amounts of money every year through recycling: up to 31% from concrete, 33% from reinforcing bar, 24% from glass, and 16% from timber. The current study provides guidance for C&D waste businesses, the recycling procedure, and the role of recycling waste in the circular economy.

Keywords: Urban regeneration, construction, demolition, waste, recycling, economy.

ÖZET

KENTSEL GERİ DÖNÜŞÜM ATIKLARI ÜZERİNE BİR ÇALIŞMA VE EKONOMİK İNCELEME

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Günümüzün kentleşen dünyasında şehirler, kaynak tüketiminin ve atık dönüşümünün başlıca merkezleri haline gelmiştir. Bununla birlikte, kentsel dönüşüm sürecinin hızlanması, inşaat ve yıkım atıklarının yönetimi konusu kentsel dönüşümde önemli bir zorunluluk haline gelmiştir. Türkiye dahil olmak üzere dünya genelinde büyük miktarlarda inşaat ve yıkım atığı oluşmaktadır. Diğer atıklarla kıyaslandığında düşük çevresel etkiye sahip olmasına rağmen, yüksek hacmi, ağırlığı ve geri dönüştürüle bilirliği ile kategorize edilmektedir. Bu tezin amacı, kaynak israfını önlemek, çevreyi daha iyi korumak ve ekonomik kazanım için kentsel dönüşüm atıklarını etkin bir şekilde yönetmektir. Tez kapsamında atık hiyerarşisi oluşturmak, seçici yıkım ve bertaraf yoluyla atıkları kaynağında ayrıştırmak, atıkların geri kazanılmasını, sıfır atık döngüsünü sağlamak ve küçük bir alan için maliyet hesabı yapmaktır. Bu çalışma, Türkiye'deki kentsel dönüşümün istatistiksel bir değerlendirmesini, bakanlık ve belediyeler için inşaat ve yıkıntı atıklarının nasıl yönetileceğine dair bir stratejiyi ve geri dönüştürülmüş malzemelerin maliyet analizini içermektedir. Son yıllarda Türkiye'de atık malzemenin geri dönüşümünün sürdürülebilirliği ve kaynak yönetimi konusundaki farkındalık artmış, sıfır atık yaklaşımı (azaltma, yeniden kullanma ve geri dönüşüm) için inşaat ve yıkıntı atık malzemelerinin yeniden ekonomiye kazanımı araştırılmaya başlamıştır. Bu çalışma kapsamında, Türkiye'nin betondan %31'e, inşaat demirinden %33'e, camdan %24'e ve ahşaptan %16'ya kadar geri dönüşüm yoluyla her yıl önemli miktarda para tasarrufu yapma potansiyeline sahip olduğu ortaya konulmuştur. Mevcut çalışma, inşaat ve yıkıntı atık işletmeleri, geri dönüşüm prosedürü ve geri dönüşüm atıklarının ekonomideki rolü için rehberlik sağlamaktadır.

Anahtar Kelimeler: Kentsel dönüşüm, inşaat, yıkıntı, atık, geri dönüşüm, ekonomi.

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LIST OF ABBREVIATIONS

EU	European Union
USA	United States of America
IBB-IMM	Istanbul Metropolitan Municipality
ISFALT	Istanbul Asphalt Factories Industry and Trade Inc.
OHS	Occupational Health and Safety
ISKI	Istanbul Water and Sewerage Administration
ISTAC	Istanbul Environmental Protection and Waste Materials Evaluation Industry and Trade Inc.
ISTON	Istanbul Concrete Elements and Ready Mixed Concrete Factories Industry and Trade Inc.
PCB	Polychlorinated Biphenyl
RAC	Recycled Aggregate Concrete
RCA	Recycled Concrete Aggregate
ECDW	Excavation and Construction Demolition Wastes
CDW	Construction Demolition Wastes
TOBB	Union of Chambers and Commodity Exchanges of Türkiye
TOKI	Mass Housing Administration
THHB	Türkiye Ready Mixed Concrete Association
TUBITAK	Scientific and Technological Research Institution of Türkiye
MAM	Marmara Research Center
ITU	Istanbul Technical University

YTU	Yıldız Technical University
TURKSTAT	Türkiye Statistical Institute
CSIDB	Ministry of Environment, Urbanization and Climate Change
QR	Quick Response
RAC	Recycled Aggregate Concrete
RCA	Recycled Concrete Aggregate
C&D	Construction and Demolition

CHAPTER-1

INTRODUCTION

1.1 General

The city is the largest and most important work created to organize human life and it is a structure that surrounds and shapes human life. Ancient civilizations introduce themselves to the world with their original cities. Cities creates an integrity that not only shows this structurally and physically, but also expresses it in terms of social life and culture. Societies shape this structure based on their culture, belief, values, and traditions. The city is the place that shapes the relations between people, where social life and relations gain the greatest intensity and where social distances are minimized. Cities are building groups, all buildings and the roads connecting them, in which a wide variety of activities take place; transportation, infrastructure, hardware systems and the institutions and organizations that regulate and operate them, and above all, the people living there are the society itself (Cresswell, 2017).

The main element of the city center is people. It is the people who make the city a city. Man forms the core and basic building block of the city and society. Civilizations are also established in cities with all kinds of cultural accumulation that the society has. When we talk about the spirit, aesthetics, beauty, taste, smell and vitality of cities, we express the cultural accumulation, social life and the manifestation of the existing civilization. Ibn Khaldun said, “Geography is the destiny of man.” says. In fact, geography is the destiny of cities. Each city has its own ecology, history, physical structure and cultural accumulation. Every city expresses itself with this accumulation. Cities express themselves by revealing the values of belief and life in accordance with the ecology and morphology of the geography where they are founded (Oktaviani & Supriatna, 2018).

At the point we have reached in terms of urbanism, unfortunately, there is a crisis in the country, and the problems and problems never end. While dealing with immigration and squatting problems in the recent past, Urban Regeneration problems, one of the most important problems of the country, are being dealt with in this process. Urban Regeneration is a multidimensional process. This process has many social, cultural, economic, psychological, sociological and architectural layers. One of these layers is the waste dimension of Urban Regeneration. In today's systems, where production and consumption know no boundaries, a lot of waste is produced in the Urban Regeneration process, as in every area. While we need to protect natural resources and our environment by seeing these wastes as a resource and reusing them without wasting them, unfortunately we are not good at managing these wastes in the country. However, we are the members of such an ancient idea and a magnificent civilization that we feed off of a belief that waste is considered haram, and that removing a piece of stone, an obstacle or a pollution on the road is a level of faith (Uzun & Çete, 2005).

The destruction, establishment and renewal of cities has always existed throughout history. Especially when we look at the processes after the industrial revolution, Urban Regeneration practices in the world are much older than in Türkiye. Since it emerged in developed western countries, especially in urban centres in countries where industrialization is experienced, this period is mostly referred to with this period. (Doğaner, 2017) Due to the development of the city, the wealthy people in the city centre move from the city centres they live in to the larger, more spacious, nature-infused, and cheaply priced attractive summer resorts outside the city, resulting in abandoned areas in the city centres. Depending on the emptying experienced in these regions, the deterioration of the urban fabric or structures that begin with aging, then becomes problematic areas with the introduction of the obsolete processes. This situation, which is generally encountered in the historical centres of cities, occurs as a result of the decrease in economic activities and vitality, and then causes it to become obsolete (Görmüş, 2018; Yılmaz & Cengiz, 2018).

In developed countries, what is understood from the concept of Urban Regeneration is mostly the elimination of these problems and the renovation works in the areas that are almost funny. In a global world, cities come to the fore in many areas with their assets and the functions they undertake, and they almost surpass countries. Some cities are even more recognized than the names of the countries they belong to and compete. Everyone has the right to live in a healthy and balanced environment in cities. At the same time, the right to housing is the most important aspect of the freedom of settlement, which is a personal right. Just like the history of the countries, their cities have a history. If Urban Regeneration is handled with this vision and approach, the place of cities in history can be sustained more effectively and meaningfully (Kaymak & Gürün, 2018).

When it comes to Urban Regeneration in Türkiye, it is understood that reconstruction in slum areas, which were the result of illegal and unauthorized construction in the past, structures damaged by disasters caused by floods and precipitation, and the construction of new apartment buildings instead of unqualified and unsound structures due to earthquake risk. However, the meaning of the concept of Urban Regeneration is much broader and includes the processes of renovating the collapsed areas and historical areas in the city centres and revitalizing them by giving them new functions.

Urban Regeneration takes place in our country due to many reasons. However, since the cities in our country are mostly located in the earthquake zone and the buildings were not built as earthquake-resistant in the past, the first thing that comes to mind when Urban Regeneration is mentioned is the risk of earthquakes. In our country, there has been intense migration from rural areas to cities after 1950, mostly due to economic and technological reasons, and after 1980, mostly due to political and terrorist reasons. Due to these intense migrations, squatting in cities has emerged. Later, slums turned into apartments. In these apartments, as in the slums, unlicensed and unauthorized illegal floors were built. Therefore, buildings in general have been formed in this way in cities without being dependent on earthquake and building regulations, without technical engineering services.

Urban Regeneration is carried out for specific and real reasons. It is foreseen that the physical, social and economic differences between the neighborhood's will be eliminated. Elimination of problems such as urban poverty and social exclusion is also seen as a requirement of Urban Regeneration. In addition to reconsidering urban life quality standards, reducing building densities and minimizing possible earthquake damages are also seen as important reasons for Urban Regeneration (Yörür, 2022).

The cities we live in have reached the present day by carrying their ages in general terms. The historical accumulation and historical structures of the cities are identified with the city, a city-specific architecture has been formed and it is very important to protect them well. Knowing the textures that have reached the present constitute the identity of the cities and carry older traces than the structures, which should always be done in Urban Regeneration studies, we must preserve all this historical past and protect all the elements that make up the texture such as structures, topography and altitude (Sezik, 2018).

Urban Regeneration in cities in Türkiye is not only dependent on earthquake risk, but also unplanned urbanization, slums, population growth and rapid urbanization are factors that put pressure on this process. With the increasing demand for housing in metropolises, the renewal of the old stock gains great importance. In the Urban Regeneration and Türkiye Report prepared in 2014, it is estimated that approximately 6.7 million housing units will be demolished and rebuilt across the country in the next 20 years, which corresponds to approximately 334,000 units per year. Approximately TL 44 billion each year for demolition and rebuilding costs alone. It is stated that financing is required (Doğan & Bostan, 2019).

Urban Regeneration is the general name of the applications carried out for the renewal of the existing city or neighbourhood structure. However, in Urban Regeneration, there are different approaches and forms of application according to the current situation and conditions. Different approaches have emerged in the presentation of these application forms. The main reason for this is that different disciplines are related to the subject and each project region has its own conditions and characteristics in different countries (Ertaş & Bayındır, 2020).

These different forms of application that the concept of urban return includes spatial cleaning, revitalization, gentrification, quality improvement, renewal, redevelopment, and rehabilitation. All these concepts, whose functions, subjects, purposes, and methods differ from each other to a certain extent, are utilized in bringing the outdated or obsolete regions of cities to both society and economy. Implementation methods of Urban Regeneration are summarized below.

In spatial cleaning, the depressed area is completely cleaned (destroyed) and new structures are built in its place. A region in ruins is also part of the city. The tissue completely disappears, and a new tissue is formed in its place. Land is generally expropriated. The unsanitary qualities of the devastated and poorly populated areas are removed.

It is the revival of the collapse area with the changes made again. It is aimed to revitalize urban areas that lost their vitality in the past, especially historical city centres, with various social practices. With this concept, it is expressed that the urban areas, which have entered the process of collapse and abandoned physically, are brought back to life by destroying the factors that cause the collapse (Aktaş, 2015).

It is the renewal of the area with the change of the social fabric in order to save the collapsed area. Gentrification method: The renewal of the built environment in the city centres takes place in the form of the former residents of the region leaving these areas and the people from the middle and upper classes taking over these areas. With this policy, with the settlement of middle- and upper-class people in urban centres with historical identity, the places are physically healed, and the region gains a new identity.

Gentrification includes the replacement of middle- and upper-income class residents with low-income residents and the resulting physical, social and cultural changes. With the effect of globalization policies, urban space comes to the fore among the places where capital accumulation is used the most. This situation causes cities to take new shapes in line with the expectations and rules of all kinds of planning and implementation of the city. In the historical buildings of the coastal part of Istanbul; After the 1980s, the renewal process that took place in districts with both historical and original characteristics such as Ortaköy, Cihangir, Kuzguncuk, Arnavutköy, Beyoğlu, Fener, Balat and Galata, which has collapsed over time, has been such a renewal (Tekkeli, 2009).

In Türkiye, Urban Regeneration is carried out in line with certain goals. Various types of Urban Regeneration projects are carried out by municipalities, ministries, private sector, and citizens. Considering the scope and application form of these projects; this thesis aims to investigate a statistical assessment of urban regeneration in Türkiye, a strategy for the ministry and municipalities on how to manage construction and demolition wastes, and a cost analysis of recycled materials for circular economy.

1.2. Objective of the Study

Urban regeneration is carried out in line with certain goals. Based on this, there is always the goal of better and healthier housing, more live able and sustainable cities. First, the physical collapse in the cities should be stopped and the sustainability of the quality building stock should be ensured. In addition to this, urban regeneration has sustainable goals with its economic, social, and environmental dimensions. The renewal must bring mobility and vitality to circular economic life with recycling the wastes of urban regeneration. Main objectives of the thesis are as follow.

- To make a statistical assessment of urban regeneration in Türkiye.

- To make a strategy for the ministry and municipalities on how to manage construction and demolition wastes.
- To make an economic analysis of recycled materials for a circular economy.

1.3. Outline of the Thesis

Chapter 1- Introduction: In this chapter, the importance of using the methods used, what urban regeneration is, how urban regeneration is done, what urban regeneration wastes are, are discussed by conveying the results.

Chapter 2- Literature review: In this section, previous studies on urban regeneration, previous studies on construction waste and recycling, and general characteristics of the study area are mentioned. In addition, information is given about the economic analysis of the recycling of urban regeneration wastes in the thesis.

Chapter 3- Materials and Methods: In this section, the methods used in this study are mentioned. Literature review, observations and examinations made in the field are included. After the literature review was completed, it was found by working in the urban regeneration areas without the necessary observation and examination, and all the studies were recorded. As a result of the information obtained in the field study, both urban regeneration, construction waste and economic analyzes were made.

Chapter 4- Results and Discussion: In this section, the tables and figures created within the scope of the research and relevant evaluations and discussions are included.

Chapter 5- Conclusions and Recommendations: The results and recommendations of the thesis are given.

Chapter 6- Conclusions: The results and calculations obtained in the thesis are given in this section.

CHAPTER 2

URBAN REGENERATION AND URBAN REGENERATION WASTE

Waste is a very broad concept. In general, any substance or material that is undesirable, thrown or released into the environment or has to be disposed of by the producer or the real or legal person who actually holds it is called waste (Waste Management Regulation, 2015). Anything produced turns into waste after completing each useful life. Waste is undesirable. However, what one of us does not want may be needed by another. Therefore, all materials should be used until the last stage of the healthy life cycle. In addition, wastes need to be managed well in terms of health, environmental, economic, and future sustainability.

In today's world, where production and, more importantly, consumption has increased so much, the amount of waste generated increases so much. Because with exceptions, anything produced is potentially waste, and products that have reached the end of their life cycle become waste. If we do not manage these wastes well, we cannot protect the environment and cause a waste of our resources. Waste production is growing day by day and is turning into a big sector. Waste is divided into different groups according to waste types. Urban Regeneration wastes are also a different group of waste, such as household waste, packaging waste, and electronic waste. Urban Regeneration includes construction and demolition processes in terms of waste. With the expression of Urban Regeneration wastes, we actually mean construction and demolition wastes, that is, construction and demolition wastes (Bilgili, 2021).

A substance seen as waste for one enterprise can be used as raw material for another firm. Thus, the source of raw materials will be revealed, waste storage costs will be eliminated, and economic gain will be achieved. It will be an important step in reducing consumption needs by ensuring the continuity of raw materials (Begüm, 2016). With this approach, minimizing waste generation should be the main goal in Urban Regeneration, and the resulting waste should be well managed according to the zero waste principles determined by the Ministry of Environment, Urbanization and Climate Change.

66% of Türkiye's territory is in the 1st and 2nd degree earthquake zones, and 71% of the country's population lives in these regions. At the levels of another earthquake zone, the geography covered by the 3rd and 4th degree earthquake zones constitutes more than 90% of the country's territory. In the recent history of Türkiye, which is a country with a high risk of earthquakes, there are many disasters that cause serious loss of life and property. Projecting in accordance with earthquake regulations in new constructions and choosing construction materials that comply with implementation and regulations is an important issue in terms of building safety (TOBB, 2011).

How to recycle and evaluate construction and demolition wastes is an important subject of study and differs according to the needs and development status of countries. Unfortunately, the management of construction debris waste in Türkiye is not the desired level. The sources and components of excavation and construction waste are indicated in the figure below.(Table 2.1)

Table 2.1 Sources and components of excavated soil and C&D wastes

Resource and Components of Soil Excavation and Construction Wastes			
Soil Excavation	**Road Building Waste**	**Washed Wastes**	**Washed Mixed Wastes**
Resources			
Excavation activities	Construction, repair, and demolition Work of highway, railway, and airport	Demolition of building such as residences, schools, and factories	Non-selective demolition of buildings, such as renovation and retrofitting
Components			
• Soil • Gravel • Sand • Stone	• Concrete • Crushed Asphalt • Road paving materials • Rail ballast and sleepers	• Concrete containing iron • Roof construction • Wall materials such as brick, and briquettes	• Concrete • Wall • Gravel • Timber • Ceramic • Metals • Glass

2.1. Lifecycle of Material and Building

Due to the use of natural resources in the construction industry, it is widely accepted that there are negative effects on the environment such as irreversible regeneration of the natural environment, accumulation of pollutants in the atmosphere and consumption of the world's non-renewable energy resources and minerals. In addition to these negative effects, construction activities also cause soil loss, loss of agricultural lands and air pollution. Another and perhaps the most important negative impact of the construction industry on the environment is the generation of large amounts of waste from buildings and structures throughout their entire life cycle (Bayrak & Telatar, 2021).

Today, many studies are carried out on construction debris wastes, and these studies can be divided into three main groups, although they are examined under many titles. The first of these is the studies that try to determine the main causes of waste, the second is the studies that deal with forecasts, and the third is the studies on the management of construction waste and the prevention and reduction of waste generation. There are many factors when looking at the root causes of waste production. These are generally; Factors related to design and contract documents, factors related to tender, factors related to separation at source, factors related to storage, factors related to employees, factors related to field management and inspection and external factors (Damcı et al., 2017).

Structures have a life cycle, and this cycle is divided into four phases as seen in the Figure 2.1 below. Considering the material flows of construction debris waste management, more or less waste occurs at all stages. In a building, some parts have a short lifespan and need to be replaced or refurbished several times over the life of the building. Other parts are more durable or do not require repair or modification. For building sections, approximately foundations more than 100 years, bearing parts of structures more than 50 years, facades and other partitions more than 30 years, Interior walls, kitchen, etc. sections show durability for more than 10 years (Lauritzen, 2019).

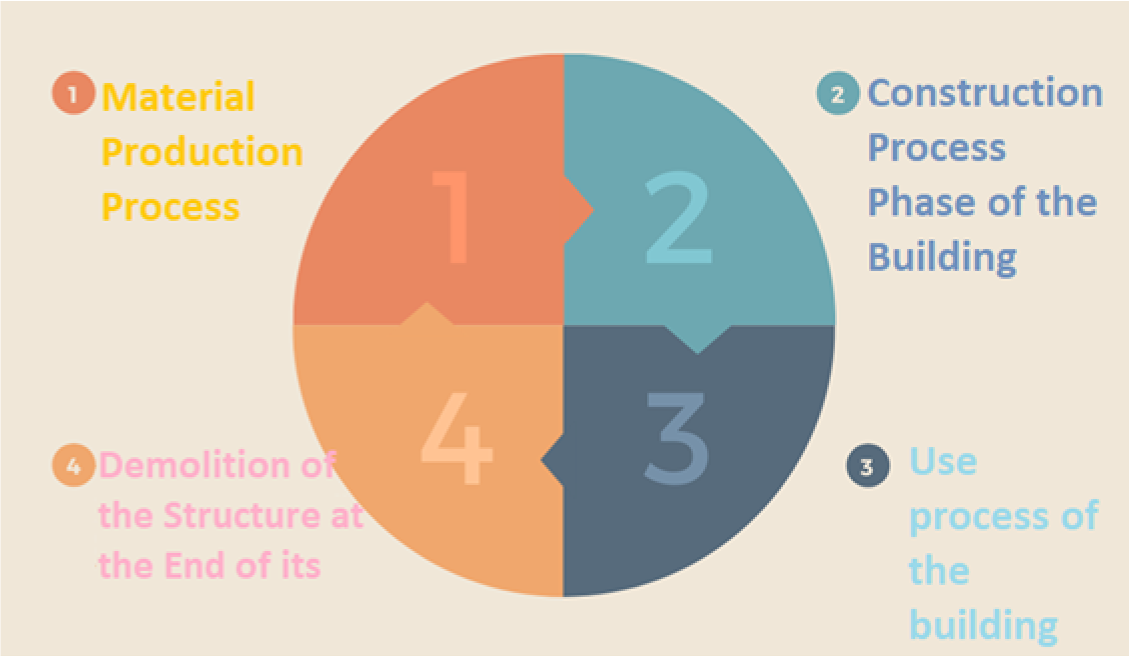

Figure 2.1 Lifecycle of building materials and resources used in construction area (Brol, et al. 2015)

The amount of construction debris waste on a large scale is mainly due to the renovation and demolition works of the buildings. Depending on the end of its useful life, demolition and waste management processes in buildings involve certain activities. First of all, all services, electricity, water, natural gas, data connections etc. is cut. Abandoned furniture and other materials main side the building is removed. Asbestos, polychlorinated biphenyls, heavy metals and other hazardous materials are removed. Doors, windows, roof, light interiors and partitions are dismantled. After the building is completely stripped, then the demolition of the structure is carried out. Finally, the foundations are removed, the area is cleaned and rehabilitated. (Maçin & Demir, 2018).

There are many things to consider when demolishing buildings. These can be summarized as problems arising from the adjacent order, structural problems that have not been fully evacuated, staying alive inside, and remaining connected to the networks. Another important point is that it is necessary to pay attention to environmental safety during demolition works. The experience of the operator and compliance with the rules during demolition can prevent many problems. The recycling of the waste from the demolition is unfortunately a sensitive issue in our country only for metal. However, in the construction debris waste; concrete, brick, stone, timber, steel, paper, plastic etc. materials exist and their recycling is vital.

In general, construction debris waste management involves specific activities. Hazardous wastes must be cleaned and disposed of first. Subsequently, concrete, brick, stone, timber, steel, paper, plastic, etc. materials are classified. After sorting, materials are prepared for reuse, recycling and recovery. Energy is obtained by incineration of combustible wastes that cannot be recycled. Depending on all these processes, buildings and waste materials generated at the end of their useful life should be integrated into the reuse, recovery, and recycling waste management system (Aksel, 2021).

Construction debris wastes can be used in infrastructure and superstructure. The important thing is to store it and make it suitable for recycling.

The use of buildings for different purposes is also an important issue. In recent years, it has often been seen that old industrial buildings have been converted to other types of industries, offices or residential use. However, after a life of 30-40 years, the building appears to have been replaced by a newer and higher building. However, when looking at the buildings with life-cycle-based management approaches, it is necessary to focus on the management of construction debris waste in the regeneration process of buildings and the evaluation of construction debris waste as a resource.

2.2. Waste Hierarchy and Urban Regeneration Wastes

In general, waste management has three main stages as prevention, recovery, and correct storage. In the Waste Framework Directive of the European Union, the waste management hierarchy in waste management is clearly defined. The main thing is to prevent waste generation, to prevent waste and to try not to produce waste. At this very first stage, before buying the product in order not to waste it, it is necessary to calculate well whether it is really needed and to determine how much material we need. In the second stage, in order not to create waste, it is necessary to adopt the reuse method and to act in accordance with it by determining it from the beginning. This situation especially requires not using disposable packaged products. In the third stage, it requires a good calculation of how to recycle while designing the product packaging from the very beginning. Since waste will be generated in the fourth stage, minimum waste should be sent to the landfill by both providing energy recovery and reducing the volume from materials that cannot be recycled. Storage is very important. Storage and transfer of waste; Since it is a labor and costly process, these items should be thoroughly reviewed and planned (CSIDB, 2014).

In the last final stage, it is necessary to store the last non-recyclable and energy-recoverable wastes since it is undesirable to store the wastes. In the Figure 2.2 below, these situations, which have been expressed above, and which should be in a good quality waste management, are shown below.

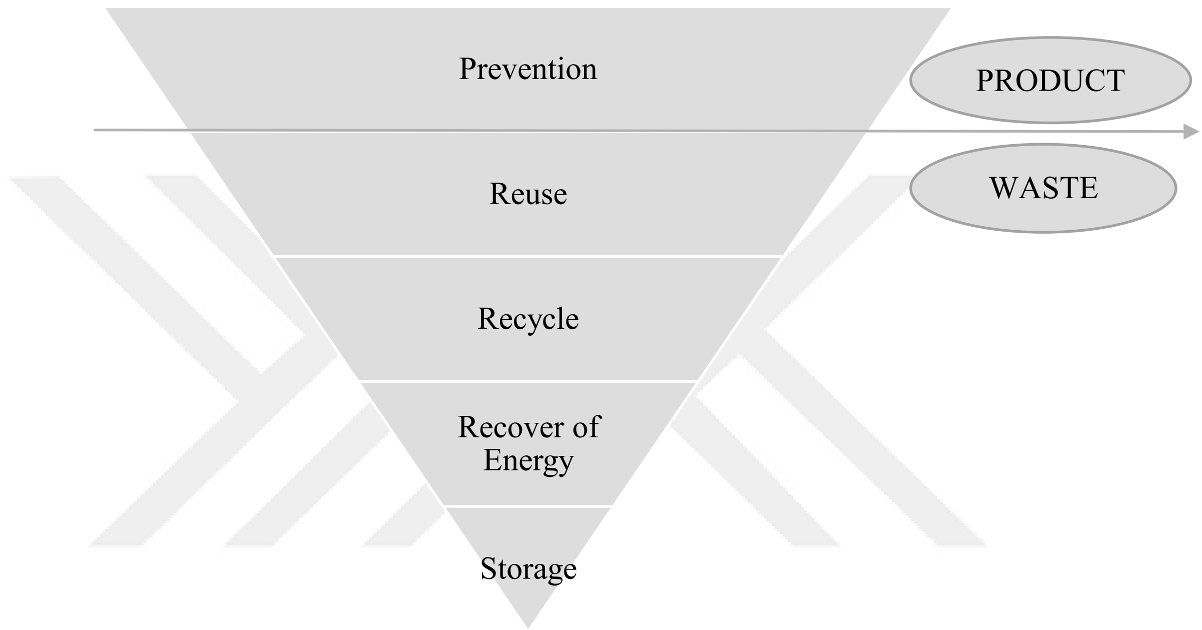

Figure 2.2 Waste hierarchy of a good quality waste management (Directive 2008/98/EC, 2008)

When the situation in the above figure is reversed, a bad waste management process and hierarchy occurs. If waste generation is not considered and prevented at the very first product stage, places to store wastes become unavailable in this age of consumption frenzy. In addition, if reuse, recycling and energy recovery are not made, you will not have much choice but to store the wastes. After a certain period of time, this situation will not be sustainable and there will be no place to store the wastes. Figure 2.3 below shows the situation showing this process, describing a bad quality waste management approach and waste hierarchy. (Waste Management Regulation)

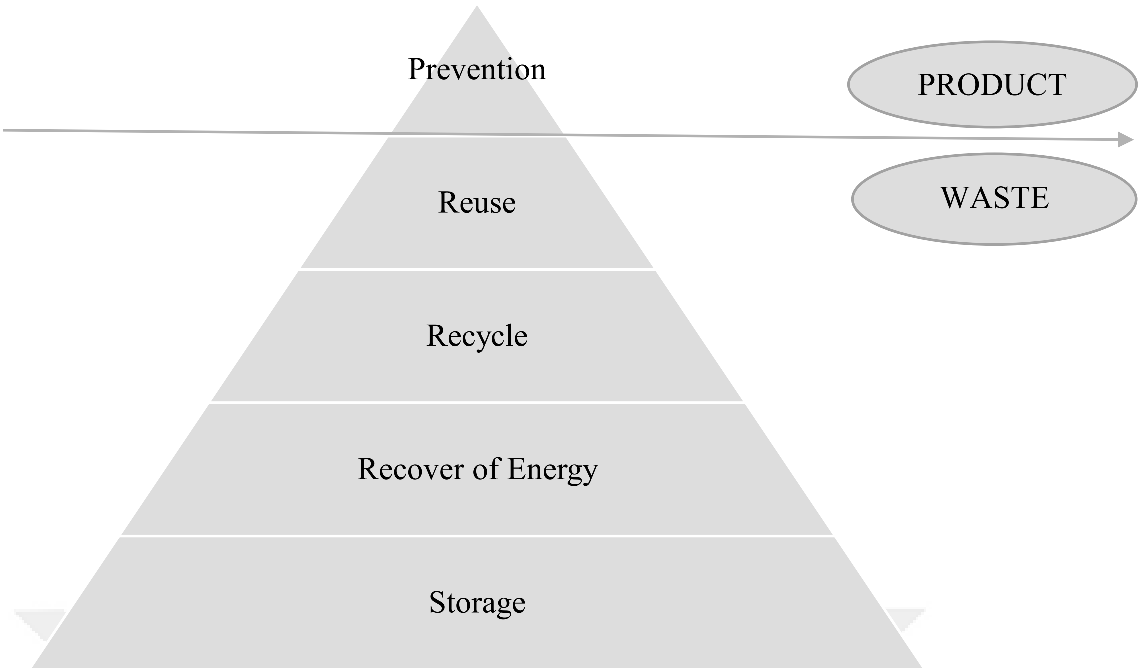

Figure 2.3 Waste hierarchy of a bad quality waste management (Directive 2008/98/EC, 2008)

In implementing the waste hierarchy, measures should be taken to encourage and, if necessary, enforce options that yield the best environmental outcome. In waste management, sustainability, protection of resources, economic and social effects, human health, general environmental protection principles should be taken into consideration. Construction and demolition waste is the heaviest, most extensive, and bulky type of waste produced and is almost entirely recyclable. Although it shows a fluctuating increase over the years, construction debris waste is the most common type of waste in many countries (Wilson et al., 2001).

Actions to be taken to minimize construction waste are broadly categorized in thirteen separate clusters as follows.

1-Evaluation of construction waste as a resource.

2-A strategy to minimize waste while purchasing.

3-Reuse and recycling in construction

4-Separation and selective destruction at the source of construction demolition waste.

5- On-site waste inspection and evaluation.

6-Making designs that will not create waste

7-Improving on-site waste management practices.

8-Making waste data collection models, including waste streams and waste management mapping, to assist in the evaluation of waste at the site.

9-Knowing the benefits of waste reduction.

10-Preparing waste reduction guides for designers.

11-Using the impact of legislation on waste management practices.

12-Exhibiting behaviors towards minimizing construction waste.

13- Carrying out comparative waste management studies (Osmani, 2012). As can be seen, detailed and hard work is required at every stage for the minimization of construction debris waste.

One of the aims of the EU Waste Framework Directive (2008/98/EC) is to provide a framework for moving towards a highly resource efficient European recycling society. In particular, Article 11.2 requires member states to take the necessary measures to ensure that, by 2020, at least 70% (by weight) of non-hazardous construction and demolition waste, excluding naturally occurring material defined in category 17 05 04, is recovered (EU CDW). Management Protocol, 2016: 4). This situation increases the importance of reuse, recycling and recovery of construction debris waste. Mixed construction demolition waste poses certain risks to the environment, as it may contain hazardous wastes without selective demolition.

2.3. Classification of Waste Occurring in the Scope of Urban Regeneration

Urban Regeneration wastes are not homogeneous. The heterogeneity of the waste depends on the type of building, purpose of use, structure, location; It varies according to geography, age, size and materials used in its construction. Even between countries, regions and buildings, the characterization of construction debris is different. These differences vary with geography, preferences, proximity of raw material sources and building techniques, and the state of natural disasters.

In Urban Regeneration, buildings become completely ruined waste except when some building products can be reused as second hand. For this reason, in Urban Regeneration applications, it is important to separate the wastes at the source during the demolition process of the buildings and to make them planned and systematically in terms of reducing the waste. The success of Urban Regeneration practices in terms of construction debris waste management depends on selective demolition and systematic management of deconstruction and demolition processes (Salgın & Coşkun 2018).

For the recycling of Urban Regeneration wastes, separation should be done at the source. For separation at source, selective demolition must be done in order to manage Urban Regeneration wastes well. Although it is a very difficult process in the field, this can be achieved with a well-trained team and tools. Selective demolition includes the processes of carrying out demolition processes according to the demolition principles and techniques determined beforehand for the buildings to be demolished. Urban Regeneration projects are not building-based, but rather area-based, that is, the destruction of many buildings. It can be found in adobe structures in the area, it can be found in reinforced concrete structures, and it can be found in composite structures made of both reinforced concrete and steel. The buildings to be demolished should be seen like a mine, each material should be seen and evaluated as a new resource, and the buildings to be demolished should be separated at source, starting from the top. (Regulation On Destruction Buildings, 2017)

2.4. Preparation for Urban Regeneration

In demolition, renovation or construction of buildings, it is necessary to facilitate the recovery of materials and components and maximize recycling. In demolition, reuse and recycling must be achieved without compromising the safety measures and practices outlined. Any demolition, renovation or construction project needs to be well planned and managed. Preliminary work on demolition provides significant cost and planning benefits while reducing environmental and health impacts. Before any renovation or demolition project, hazardous waste as well as materials to be reused or recycled must be specifically identified. It may contain some harmful materials as well as recycling wastes. Such wastes should be carefully sorted and transported to the relevant recycling center. In addition, public administrations should determine the limits of pre-destruction inspections well. The waste market should be investigated and the marketing situation for reused and recycled materials should be fully established. Good debris management should be done by a qualified specialist inspector (Abed & Mahdi, 2018).

The waste inspection aims to give a clear idea of the infrastructure of the building or buildings to be demolished, including estimates and calculations of waste material to be generated and recommendations for waste management. It is the first step towards recycling and proper waste management. The inspection process also aims to submit documents that the owner must attach to a demolition or renovation permit application in order to be awarded a contract. In addition, the result of the inspection should ensure the reliability of the waste estimates for comparison with the results in the waste management report (EU CDW Management, 2018).

There are stakeholder groups that work together in demolition works. Among these stakeholder groups; including practitioners in the construction sector, renovation companies and demolition contractors, waste treatment, transportation, logistics recycling companies, local and national authorities of public institutions, quality certification bodies. These groups need to work together and transparently among themselves.

Preliminary preparation and work with stakeholders in Urban Regeneration are important for the healthy progress of demolition processes. In addition, all these processes should be managed well by the municipalities and the municipalities should lead the works. Local governments should take the necessary responsibility for the necessary areas for the storage of demolition wastes, their transfer to these areas and the management of the areas. In general, municipalities can be successful in a very important issue such as recycling if they establish a good legal infrastructure, create a good business process and establish a good administrative structure by establishing a system and creating a model in order to manage Urban Regeneration wastes well (Johnson, 2013).

2.5. Recycling of Urban Regeneration Wastes

In order to protect natural resources, prevent waste, make waste a resource, reduce the amount of waste to be stored and use it as secondary raw material, it is essential to primarily recover construction and demolition wastes. In order to obtain good quality recycling material and to reduce costs, wastes must be separated very well at their source or in the relevant area. Construction and demolition wastes are highly recyclable. Recycled construction and demolition wastes are reused and reused in the same sector or in different areas.

While planning the recycling of demolition wastes, strategic action should be taken according to the 4R (recycling, reuse, recovery, reduction) principle. Recycling should be given great importance in the management of construction and demolition wastes, and the 4R principle should be applied meticulously in terms of good management of resources and sustainable environmental management. For a good understanding of recycling, it is important to understand and know these concepts well in order to know exactly what is meant by 4R (Lauritzen, 2019).

Recycling is a collective term used to reduce the amount of waste that is incinerated or dumped and to reduce the amount of reuse, recovery and waste to conserve resources.

Reuse: The use of materials in their more or less original form for the original purpose, resulting from the renovation and demolition of buildings and structures from new building or after processing.

Recovery: We can express it as obtaining resources from waste. For example, materials obtained from wastes and used as secondary raw materials, such as the use of scrap metals as raw materials, are in this group.

Reduction: The act or phenomenon of reducing or reducing something in quantity, degree, or size. For example, the size or amount of waste is made smaller by obtaining energy in incinerators. The use of non-recyclable timber waste or hazardous wastes to generate energy by incineration is in this group.

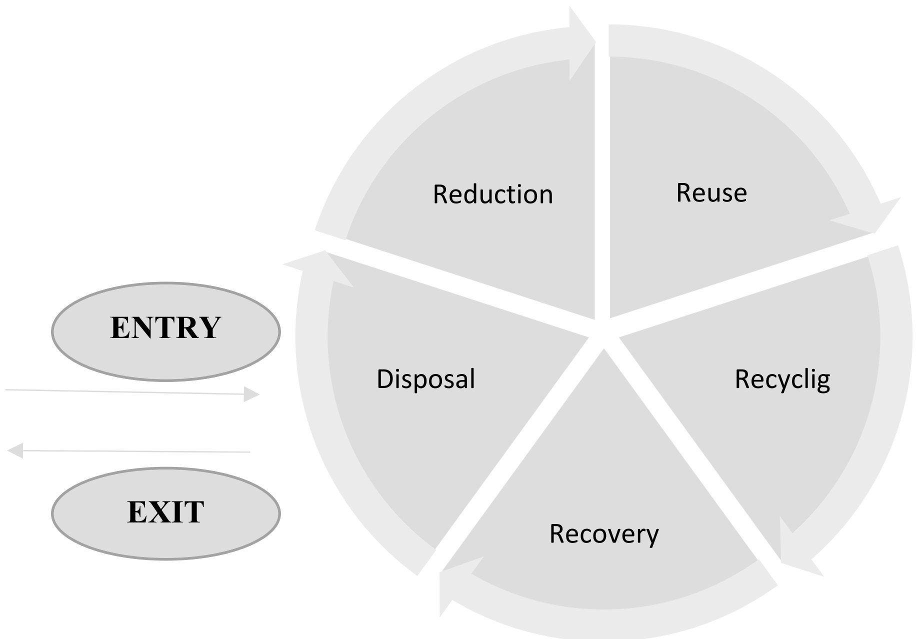

Figure 2.4 Cycle of construction and demolition waste recycling (4R Cycle) (Mercande et al., 2012)

The figure above shows (Figure 2.4) the 4R cycle in the recycling of construction and demolition waste. In case of strategically acting in accordance with this cycle in waste management, waste generation is prevented from the very beginning of the process, since it will act in accordance with zero waste management processes from beginning to end. As in all waste groups, in the management of construction debris waste, the waste management hierarchy should be acted upon, and reuse should always be considered as a priority in order to complete its final life so that there is no extra cost and waste. Afterwards, wastes that are appropriately separated and stored for recycling should be processed and evaluated as raw materials. Afterwards, waste should be reduced, especially hazardous wastes should be disposed of, and if possible, electricity should be used for energy recovery in incineration plants. In fact, since the slag formed in the incinerators is sterile, it can be easily used for filling purposes. Although slag is used as a filling material, it can also be used as an additive in materials such as concrete and asphalt. While doing all these, it is necessary to act in accordance with the principles of not polluting the environment and occupational health and safety.

In the construction and demolition processes, there are ways to reduce the generation of construction debris waste. In this process, especially wrong and large quantities of materials should not be ordered, the economy should be taken into account when the costs have increased so much, and materials that will cause waste should not be purchased. In order not to damage the received materials, they should be stored correctly until the time of use, stacked and protected well according to the rules. It is necessary to try to transfer the surplus materials to other projects and make preparations so that they are not wasted. It is necessary to ensure the recycling of construction demolition waste by creating an area where the wastes can be separated and stored at the construction or demolition site and making a plan to reuse and recycle the wastes (Ölmez &Yıldız, 2008). If the waste is managed correctly and properly, the amount of recyclable material is recycled more. The company working in the area where the construction will be done should prepare the work program for the construction debris waste before starting to work. It should specify in the work program where and how it will evaluate the construction and demolition wastes. It must be monitored and controlled.

2.6. Usage Areas of Urban Regeneration Wastes

As a result of Urban Regeneration, some of the wastes generated after construction and demolition are reusable or recyclable. Many materials such as doors, windows, cabinets, tiles, bricks, electrical materials, fluorescent lamps, bathroom accessories can be reused in other construction (Johnson, 2013).

Reusing these materials is important in terms of both reducing the amount of waste to be produced, providing economic benefits, preventing the consumption of natural resources and preventing waste. High costs may be charged to waste owners to discourage the storage of Urban Regeneration wastes in landfills. Construction wastes brought to domestic waste landfills should be processed and used as daily cover material or recovered in the facility to be established. The reuse of construction and demolition wastes should also be supported from an environmental point of view. The use of these wastes as secondary raw materials should be made economical, and the random dumping of these wastes should be prevented. Usage areas of construction and demolition wastes are show in table 2.2. The most important factor affecting the evaluation of Urban Regeneration wastes is the abundance of natural aggregate resources and the lack of a market because certain standards have not been established. The abundance of construction aggregate raw materials is seen as an obstacle to the consideration and implementation of recycling in this regard, causing discourses such as 'what is needed'.

Table 2.2 Usage areas of C&D wastes

Components of Construction and Demolition Wastes and their Usage						
Concrete	Brick and Tile	Metals	Timber	Tile Ceramic	Door, Window and Glass	Plastic Waste
• As an aggregate • Road construction • Building foundations • Infrastructure works	• Can be used in brick and tile production	• Recycling in metal factories	• In new buildings • In the outdoor for landscape • As fuel	• Mixed as a secondary aggregate • Can be used in Pavement and infrastructure	• Can be used in new constructions • Recycle	• New plastic production

The figure above shows the components of construction debris waste and where they are used. As can be seen, there are many areas where construction debris wastes can be used for evaluation after processing. Since there is no facility for the scientific and systematic recycling of construction debris waste in our country, the evaluation of these wastes can be done as much as the demolition and scrapyard companies do. There is no data on how much was done in this.

The construction debris waste products generated in the Urban Regeneration processes are recovered, provided that the relevant standards are met, and after the necessary processes, together with the original materials or separately, in the production of new concrete, filling in roads, parking lots, pavements, walkways, drainage works, sewer pipes and cable laying. It is primarily used in infrastructure and superstructure constructions, sports and playground constructions, and other filling and recreation works (Yarımçam, 2020). These wastes can be used as secondary raw materials to a certain extent, especially in the factories where they are produced, when necessary, studies are carried out.

Construction slag is used as a binder or additive and contributes to the production of new materials. For example, the production of more robust and efficient concrete by collecting construction waste fly ash and using it in the concrete alloy is a study carried out in our country's Fırat University.

2.7. Urban Regeneration Waste Management in Türkiye

The unplanned urbanization processes and earthquake threat experienced in the past in Türkiye and unfortunately continuing in some of our cities, necessitate Urban Regeneration practices. With the declaration of regeneration of risky areas, the wastes generated as a result of demolition of risky buildings, improvement and renovation works are dumped into excavation collection areas. It is generally not paid attention to in landfills and the mixed storage of non-waste excavation and Urban Regeneration wastes is a major problem.

In Türkiye, the method of soil excavation, construction and demolition wastes is mostly tried to be made in metropolitan cities. However, together with the Urban Regeneration activities, the construction and demolition wastes, as well as the excavation soil formed and to be formed as a result of the construction activities throughout the country, will increase in great quantities. It is stated that over 100 million tons of excavation soil, construction and demolition wastes were disposed of in Türkiye in 2014. It is expected that approximately 300 million tons of excavation soil and construction and demolition waste will be generated in 2023 (National Waste Management and Action Plan 2016).

Building demolition in Türkiye is carried out by the Provincial Directorate of Environment, Urbanization and Climate Change, the Special Provincial Administration, municipalities, demolition companies and scrap dealers. Building materials that can be reused and sold are dismantled before the bearing elements of the building are demolished. These consist of roof, water and heating systems installations, door, window and parquet systems. The parts of the building that cannot be reused are poured into the excavation casting areas with the rubble after the demolition companies have separated the iron, or there is unmanaged and uncontrolled use for filling purposes. There is no management system developed for the country's conditions and defined within the framework of the requirements regarding the management of large amounts of structural wastes that will arise as a result of Urban Regeneration studies. Although there are legal obligations regarding construction and demolition waste management in general, studies such as selective demolition and selective recycling are not carried out. Looking at the legislation on construction and demolition waste in Türkiye, there are the following laws and regulations.

Environmental Law No. 2872; Since the penalties related to environmental pollution are handled according to this law, when the determined principles and legal regulations regarding construction and demolition wastes are not complied with, penalties are imposed according to the articles specified in this law. (Environmental law, 1983)

Metropolitan Municipality Law No. 5216; since the duties, authorities and responsibilities of metropolitan municipalities are specified, it is stated in this law that metropolitan municipalities have duties and responsibilities regarding construction and demolition wastes.
Zoning Law No. 3194; since it is arranged to ensure that the settlements and the settlements in these places are formed in accordance with the plan, science, health and environmental conditions, it contains the rules and principles related to all kinds of settlements in general terms. (Metropolitan Municipality Law, 2004)

Misdemeanors Law No. 5326; In order to protect the social order, health, environment and economic order, general principles regarding misdemeanors, administrative sanctions that can be applied, principles regarding the implementation of administrative sanctions have been determined. It is relevant in terms of managing construction and demolition waste according to the current legislation, as it defines various misdemeanors, especially since there are sanctions that the environment should not be polluted with wastes. (Misdemeanors Law, 2005)

Excavation Soil, Construction/Wreckage Waste Control Regulation was published in the Official Gazette No. 25406 on 18.03.2004. This regulation constitutes the legal infrastructure of construction and demolition waste management, and all studies on construction and demolition waste are carried out in accordance with this regulation.

The Regulation on Recycling of Lands Degraded by Mining Activities was published in the Official Gazette No. 27471 on 3.01.2010. Since this regulation includes the issues related to the recovery of the natural structure deteriorated by mining activities, castings and wastes left in the nature, it is especially important in terms of the places where excavation soil, construction and demolition wastes will be stored.

The Implementation Regulation of Article 16 of the Forest Law was revised in the Official Gazette No. 27715 on 30.09.2010. Here, too, the application procedures and principles of the consent and permits to be given regarding the waste storage areas of the forest, the fees to be collected from these areas, and the rules and principles regarding the rehabilitation of the permit and/or consent area are included.

Zero Waste Regulation was published in the Official Gazette No. 30829 on 12.07.2019. Since it aims to protect the environment and human health and resources in waste management processes, it is relevant in terms of establishing a system, storing and managing construction and demolition waste according to zero waste management principles.

Urban Regeneration wastes are directly or indirectly related to the above-mentioned laws and regulations, and within this scope, relevant persons, institutions and organizations carry out their work for the protection of the environment, the regular storage and management of wastes.

2.8. Challenges in the Management of Urban Regeneration Wastes

As a result of the increase in Urban Regeneration activities against the earthquake risk and unplanned urbanization, the concentration of the population in the cities and becoming a consumer society, the disposal of solid wastes, the amount of which has increased rapidly, has started to pose a major problem, especially in metropolitan cities. Urban Regeneration works, high-rise buildings, bridges, subways, infrastructure works, etc., especially in our cities where there is very rapid construction. The emergence of large amounts of construction waste, rubble and excavation soil due to activities requires new legal regulations for the management of these wastes. Especially in Istanbul, the management of urban regeneration wastes is a large structure with different dimensions such as selective destruction, recycling and disposal and in which many actors are involved. Construction and demolition waste management is tried to be carried out according to the principles and rules determined in the relevant legislation.

Construction debris waste management should be done as a whole and integrated on a regional or provincial basis. In addition, it would be more correct to use these powers by the provincial municipalities to strengthen the provincial municipalities. In fact, when we evaluate it in terms of local government, it would be more accurate to define the provincial borders as municipal service areas by removing the contiguous area limitation in all our other provinces, just like in metropolitan municipalities. Depending on this arrangement, the production and business potential of our provinces will increase, and our cities will develop faster.

Since there are no standards for the recycled materials for construction and demolition wastes, their usage areas are limited, and since there is no stock market and market for the marketing of these wastes, the absence of sales opportunities is one of the important obstacles to recycling. Illegal casting is another important problem. Due to reasons such as the lack of casting areas and intermediate storage areas, casting vehicles cause many environmental problems by randomly casting to areas just outside the city instead of going to the dump sites. In Türkiye, especially in Istanbul, there are many difficulties related to legal, administrative, and technical infrastructure inadequacies in the management of construction debris.

2.8.1. Studies of Urban Regeneration Waste Recycling

Construction and demolition wastes can be recovered, recycled, and used as secondary raw materials. The recycling of inert materials here is carried out with mobile and fixed facilities. Recycled materials are used as secondary raw materials, roads, buildings, etc. can be used in construction work. Recycling and utilization of construction wastes is becoming a research and study area where interest has started to increase in Türkiye due to its economic advantages and benefits for environmental protection.

Successful management of construction and demolition wastes also needs initiatives other than legislation. These initiatives are initiatives of municipalities, conducting scientific research on the management of excavation soil, construction and demolition waste, preparing reports on the subject, facilitating the supply of cheaper secondary materials to the construction sector, setting targets, especially recovery, in management, and developing strategies to achieve these targets (Maçin & Demir, 2018).

Since the owner of the waste is the owner of the waste in general, the responsibility for the recycling and storage of waste is primarily given to the waste producers. Waste producers are responsible for obtaining the necessary permits during the transportation and storage of waste. Waste producers are responsible for collecting, separating, recycling, accumulating wastes according to their components and separating harmful, dangerous and foreign materials in the waste and not keeping them. They cannot dump their waste in places other than the recycling facilities or storage facilities permitted by the municipality or local authority (Regulation on Control of Excavated Soil and Construction Wreck Waste, 2004). Since construction and demolition waste producers see construction debris waste as waste, not a resource, they first want to get rid of these wastes immediately. For this, they traditionally send these wastes to landfills in a mixed manner, without turning to recycling and without selective destruction.
There is no facility for the recycling of construction debris waste in almost all cities of our country, especially in Istanbul. Istanbul Environmental Management Industry and Trade Inc., which was previously an IBB company in 2008. A facility established by (ISTAC) for the processing and recycling of construction waste was closed in 2012 on the grounds that materials to be processed were not brought and the recovered materials could not be evaluated.

Different materials are also used in indoor applications. Again, different materials such as different types of briquettes and bricks are used on the walls. While more masonry buildings were built before 1980 in Türkiye, more reinforced concrete buildings started to be built after 1980s. Recycling studies and investments should be made according to developing new technologies and taking into account the materials used in buildings (Korkmaz et al., 2014).

Comprehensive research and R&D studies on where these wastes can be recycled and where they will be used in studies carried out in Türkiye are carried out by both municipalities and the Ministry of Environment, Urbanization and Climate Change. Tubitak Mam Materials Institute has conducted extensive research on this subject. In addition, studies on the evaluation of construction waste and the production of aggregates are carried out in universities such as ITU and YTU in Istanbul. If a market is created for construction debris materials in our country, these wastes have the opportunity to be used in certain places.

The Feasibility Report of the Project for Recycling of Construction and Demolition Wastes and Determination of Use Criteria was prepared by Tubitak Mam Materials Institute. Within the scope of the study, the criteria for the use of construction and demolition waste in the production of cement, concrete, brick and asphalt were determined, and the optimum utilization rate for each product was determined. Within the scope of the project, four different products were produced using construction and demolition waste and a general evaluation study was made for each product (Tubitak Mam, 2015). The optimum construction and demolition waste utilization rates determined within the scope of this project are shown in the table below. (Table 2.3) Since transportation is one of the most important costs in aggregate production, facilities are established in places where raw materials are close.

Table 2.3 Amount of C&D wastes that are used per year (TUBITAK MAM, 2015)

Materials used in C&D Waste	Brick Waste (ton)	Tile Waste (ton)	Concrete Waste (ton)	Mixed C&D (ton)
Brick (13.5 Hole Brick)	30	30		
Ready-mixed Concrete			20	
Concrete Pipe			20	
Reinforced Concrete Pipe			21	
Bordure			25	
Furniture			35	
Manhole Cover			15	
Asphalt (Subbase)			65	
Asphalt (Mix base)			60	
Asphalt (Bitumen base)			15	
Road Fill Layer				100
Asphalt (Subbase)				50
Asphalt (Mix base)				40
Asphalt (Bitumen base)				10
Cement (Clinker)				4

2.8.2. Mission of Municipalities

Municipalities issue demolition licenses for buildings to be demolished within their borders. In our country, some district municipalities request a report on whether there is hazardous waste before demolition, especially whether asbestos is used in buildings. If asbestos is used in the building to be demolished, it is required to clean the asbestos before the building is demolished. However, it is not required to carry out any work on the recycling of construction and demolition wastes before the license is granted.

Since the municipalities issue the demolition licenses and construction permits, the establishment of the system for the recycling of construction and demolition wastes should be started from the district municipalities. First the demolition permit is given, and after the area is cleared, the construction phase is started, and the construction permit is given later. Construction and demolition wastes are mostly formed during the demolition process and excavation is formed at the beginning of the construction process. Therefore, demolition processes and construction processes are separate works and are independent of each other. In order to manage the wastes and excavations generated during both demolition and construction processes in a healthy way, these processes should be managed separately, and the work and transactions should be determined separately.

In our country, the duly management of excavation, construction and demolition wastes is only possible with a properly functioning inspection system. First, an audit study that starts at the source of construction debris waste will ensure that the system operates more efficiently. The fact that municipalities require qualified demolition, waste acceptance certificate and transportation licenses in their inspection services will make the inspection system even stronger. In addition, municipalities can benefit from technology and prevent illegal license plates with vehicle tracking systems and QR code plate application, and the transportation of wastes can be controlled by providing uninterrupted inspection with camera systems.

As with domestic waste, the biggest problem is that construction and demolition wastes are not separated at their source. It is seen that the municipalities do not focus well on separation at the source, especially in waste management. Selective demolition is essential for the separation of construction and demolition wastes at the source. It will not be possible to separate the construction and demolition wastes at the source unless the municipalities create the necessary technical and legal infrastructure for the separation of the demolition wastes to be generated at the source during the demolition permit issuance process. In addition, there is no reliable record and data about where and how construction and demolition waste is evaluated. Municipalities issue a waste transport document in this regard. However, in these documents, they do not take any initiative regarding where and how the wastes will be evaluated. In addition, since there is no market and stock market for the evaluation of construction and demolition waste, citizens send construction and demolition waste to landfills by paying a serious price because they want to get rid of these wastes as soon as they see it as waste, not a source. Many rubble wastes are also randomly dumped outside the cities. In addition to material loss, it causes many environmental problems.

Their municipalities should have strategic plans for construction and demolition waste. Considering the amount of construction and demolition waste to be generated in this plan, agreements should be made with licensed recycling companies on how these wastes will be recycled, and if necessary, they should establish or have a facility to process construction and demolition waste. In addition, their municipalities should have construction and demolition waste management plans, they should abandon traditional methods and work with a planning that prevents waste, protects the environment, feeds the construction economy and protects natural resources.

2.8.3. Classification of Urban Regeneration Wastes

In the current situation, the primary purpose of demolitions in Türkiye is to save the area from old structures in order to construct new buildings; It looks like cleaning. Recovery is not seen as a goal and remains in the background. After the demolition license process, the classification of Urban Regeneration wastes cannot be done properly because demolition companies do not carry out demolition in accordance with selective demolition works. In order for the Urban Regeneration wastes to be well classified, it is absolutely necessary to separate them at the source. In order to decompose soundly at source, selective destruction must be mandatory. If the buildings are demolished due to selective demolition processes, separation at the source for Urban Regeneration wastes will be healthier and the resulting wastes will be classified appropriately, and the construction and demolition waste will be recycled in the best way.

The classification of construction and demolition wastes is done as much as the construction and demolition companies can do. Since repair, maintenance and repair wastes are produced in small amounts, they are mostly mixed with the containers where household wastes are collected. In most municipalities, waste collection centers, temporary collection and storage activities are not carried out. In order to protect the environment and not waste resources, municipalities need to establish a system that covers all these processes separately and manage them well.

2.8.4. Collecting and Transporting the Urban Regeneration Wastes

In our country, illegal dumping has not been fully prevented during the collection and transportation of construction debris wastes. Mixing of construction and demolition wastes with domestic wastes is common in neighborhoods.

There are many problems in terms of both environmental and road safety and security in the transportation of construction and demolition wastes. Since there is no market, recycling center or stock market for the evaluation of these wastes, and there are no standards for the use of construction and demolition wastes, citizens are obliged to take these wastes to disposal sites. Since the transportation and disposal costs of construction and demolition wastes are high, there are also problems in the collection of these wastes.

A permit and inspection system has been established for the inspection, collection, transportation and storage of Urban Regeneration wastes, enabling the inspection to be carried out effectively and efficiently, allowing the excavation trucks to reach the dumping sites from the determined route, unload their cargo and return from the determined route. For this purpose, inspections and controls are carried out in transportation processes by using technologies such as mobile application, vehicle tracking system and satellite tracking system. Vehicles carrying these wastes cannot be operated without a waste transport and permission certificate. Vehicles included in the system are controlled. However, the inspection of vehicles that are not included in the system cannot be carried out fully. The following figure shows (Figure 2.5) the permit and relationship processes between the Istanbul Metropolitan Municipality, district municipalities, companies carrying excavation and construction debris.

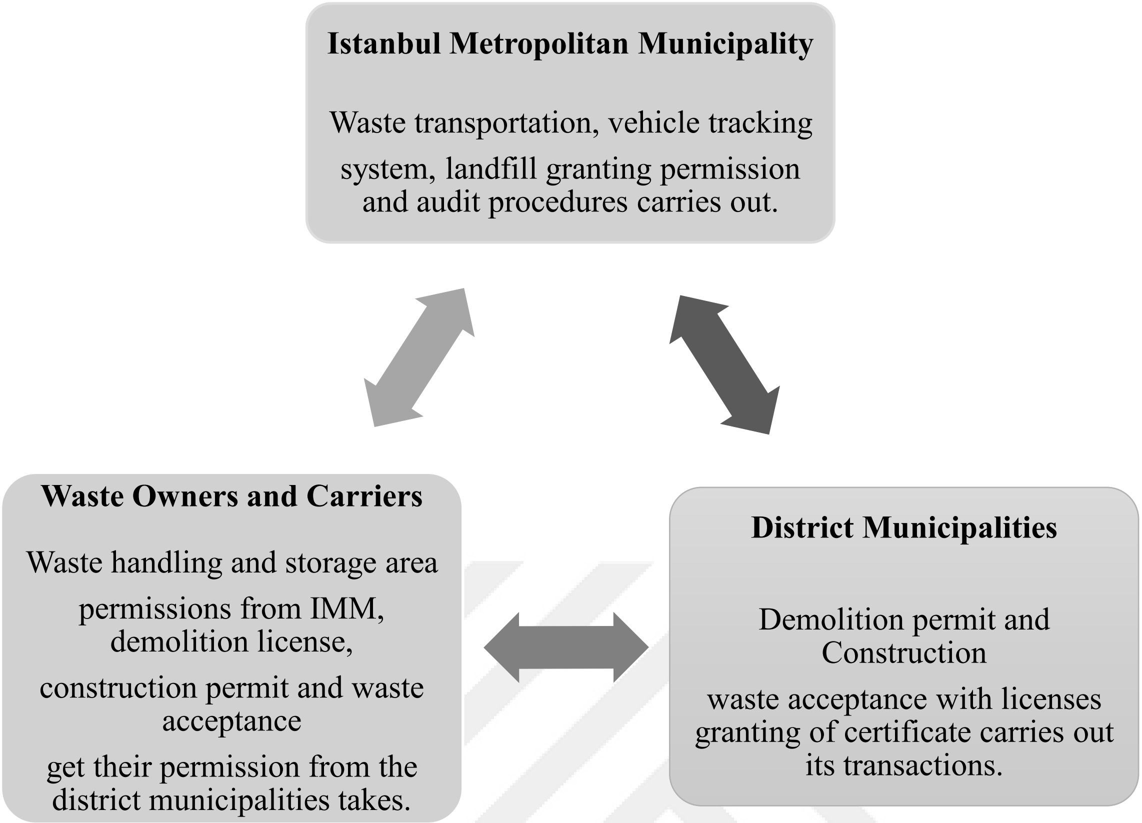

Figure 2.5 Management processes of urban regeneration wastes in Istanbul. (ISTAC, 2017)

2.8.5. Storage of Excavated Soil and Urban Regeneration Wastes

As seen in Table 2.9, depending on Urban Regeneration, construction and demolition activities, an annual average of 53.234.633 million tons of excavation and rubble has been stored in the last 12 years. It is not known exactly how much of the material in this construction and demolition waste is. Especially since there is no facility in Istanbul where construction debris waste is processed, these wastes are evaluated by companies that carry out demolition to a certain extent, and the remaining materials are stored together with the excavation in the storage areas.

In Istanbul, there are private companies that make storage with permission from the IMM Environmental Protection Directorate, although not in large quantities, apart from the one mentioned above. These companies get temporary storage permission from IMM, and they have filling in for major project works and filling and leveling of their own lands. There are also domestic solid waste storage areas of IMM, which are used as waste storage areas. An annual average of 6.370.769 tons of domestic waste is stored here as well. When storage areas in Istanbul are evaluated with all these dimensions, they create a huge volume every year. The table below shows (Table2.4) the amount of excavation soil, construction and demolition waste and construction debris waste generated in Istanbul over the years. The rates of excavation soil and construction demolition waste stored in Istanbul by years are show (Figure 2.6) below.

Table 2.4 Amount of ECDW per capita stored in Istanbul by years (Data Retrieved from ISTAC, 2022)

Years	**Number of Vehicles**	**Stored Excavation and Construction Waste (Ton)**	**C&D Waste = Excavation and Construction Demolition Waste*18% (Ton)**
2010	1.081.081	23.388.353	4.209.903
2011	1.309.496	28.774.392	5.179.390
2012	1.919.112	45.469.418	8.184.495
2013	2.826.468	67.108.659	12.079.558
2014	2.476.699	60.356.384	10.864.149
2015	2.758.216	70.405.221	2.672.939
2016	2.827.261	72.143.513	12.985.832
2017	3.231.815	83.420.184	15.015.633
2018	1.953.146	50.517.423	9.093.136
2019	1.183.388	30.762.781	5.537.300
2020	1.982.326	46.598.584	8.387.745

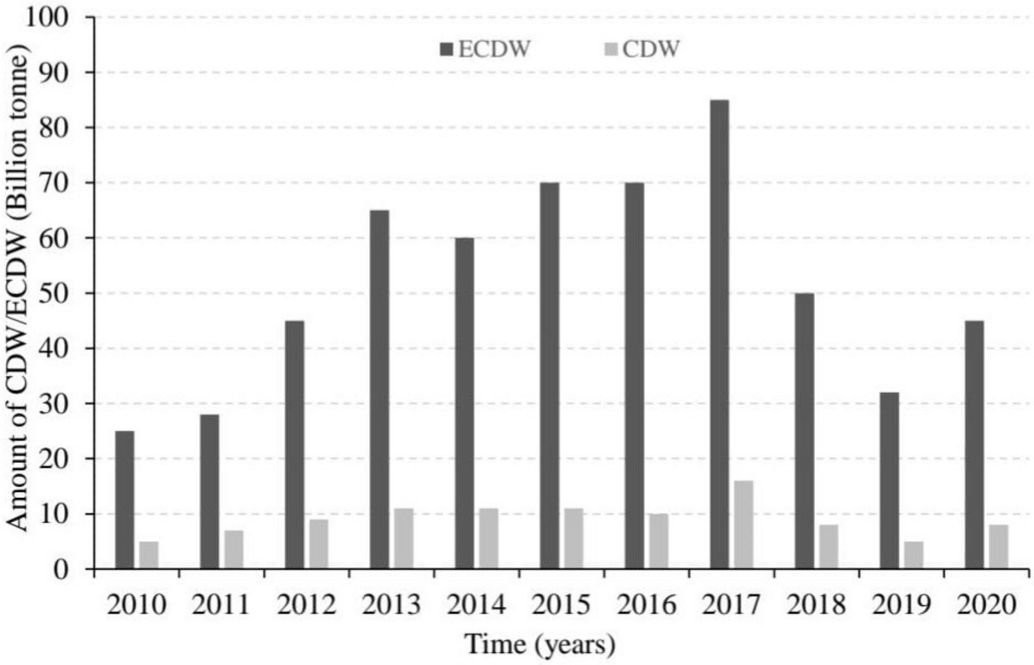

Figure 2.6 Amount of excavated soil and C&D waste stored in Istanbul by years (ISTAC, 2020)

As can be seen in the figure above, after the Law No. 6306 on Urban Regeneration was enacted in 2012, there has been a great increase in the amount of excavation and construction waste stored in Istanbul. However, there was a significant decrease in 2018 and 2019, and we can say that this is due to the economic recession in the country and the local election processes in 2019. The coefficient was found to be 18% for the last 7-year average of UTI/ ECDW.

$$\frac{11.295.468}{62.102.024} = 0.18$$

Table 2.5 Amount of ECDW per capita stored in Istanbul by years (ISTAC, 2021)

Years	Istanbul Population	ECDW (Ton)	Tons / Person
2010	13.255.685	23.388.354	1.76
2011	13.624.240	28.774.392	2.11
2012	13.854.740	45.469.419	3,28
2013	14.160.467	67.108.660	4,73
2014	14.377.018	60.356.385	4,20
2015	14.657.434	70.405.222	4,80
2016	14.804.116	72.143.514	4,87
2017	15.290.231	83.420.185	5,46
2018	15.670.724	50.517.423	3,22
2019	15.519.267	30.762.781	1,98
2020	15.462.452	32.589.158	2,11
Annual Average		**51.357.772**	**3.51**

The table above shows (Table 2.5) the amount of excavation soil, construction and demolition waste generated per capita in Istanbul over the years. As seen in the table, the population of Istanbul has become somewhat stagnant in recent years. However, the annual amount of excavation soil, construction and demolition waste generated per capita is affected by economic recession and crises. The figure below shows the amount of excavation soil, construction and demolition waste generated per capita in Istanbul over the years. When the calculation is made, the average of the excavated soil, construction and demolition waste for the past 10 years in Istanbul has been 3.51 Person/Ton.

The table below shows (Table 2.6) the amounts of excavation soil, construction and demolition waste, and construction and demolition waste generated per capita in some EU countries. Considering the amounts of excavation soil, construction and demolition waste, and construction and demolition waste generated in EU countries, they are very close to the average values in Istanbul. The amount of construction and demolition waste generated in countries over the years varies according to economic and political conditions.

Table 2.6 Amount of ECDW in some EU countries (Aktaş, 2015)

Countries	C&D waste per capita (ton/year)	ECDW per capita (ton/year)	$\frac{\text{ECDW}}{\text{CDW}}$
Denmark	0.83	3.99	4.81
Finland	1	3.99	3.99
France	0.99	5.5	5.56
Germany	0.88	2.33	2.65
Ireland	0.63	2.74	4.35
Luxembourg	1.42	5.9	4.16

Since the demolition and then the construction activities take place in the Urban Regeneration, construction debris waste emerges during the demolition phase and excavation soil is produced during the construction process. Excavation is definitely not a waste; it is a resource that should be evaluated. In fact, since we store the excavation soil together with the rubble, we also pollute the excavation soil, which is a clean and valuable resource. This situation is not sustainable and at this rate, it will not be possible to find storage space in the whole city of our country in the process (Maçin, 2018).

Random dumping of construction and demolition wastes into the soil causes pollution of the environment. It destroys the natural life in the soil and disrupts the structure of the soil. The use of the construction waste spilled area in agriculture or as a green area is significantly prevented. After the construction and demolition wastes are used in the filling areas, it is very difficult to transform these areas into green areas. Land use is severely restricted by the random dumping of construction and demolition wastes (Oztürk, 2017).

Casting sites are made by renting forest lands belonging to the General Directorate of Forestry, located in the border districts of Istanbul, where the settlement is low, such as Catalca, Beykoz, Sile and Arnavutköy. The leased areas are approved by the IMM Assembly. After these areas are filled by storage, they are rehabilitated and transferred back to the General Directorate of Forestry. In the past, vacant areas have been filled by mining activities such as stone quarries and sand quarries. Thus, millions of cubic meters of excavation soil and construction and demolition waste are stored every year in an area of millions of square meters. However, this situation will not be sustainable due to space problems to store these materials in the medium and long term. Therefore, excavation soil and construction and demolition waste should be managed and evaluated with a zero-waste model by taking necessary precautions today. Filling areas are rehabilitated, and afforestation is carried out after the filling is completed, and hundreds of thousands of trees are planted in order for these areas to regain forest quality. After the fields are leased by the IMM Environmental Protection Directorate, they are transferred to IMM's subsidiary, ISTAC Co, to be filled. ISTAC operates these areas, receives a fee for casting, and rehabilitates and reforests these areas before they are transferred to the General Directorate of Forestry.

Before the implementation of the Implementation Regulation of the 16th Article of the Forest Law No. 28976, the leasing of the filling areas of the forest was made by open tender method, but after this regulation was issued in 2011, it is only given to the metropolitan municipalities with the leasing method in order to fill in according to certain criteria. The management of excavation soil and construction and demolition waste storage areas in Istanbul is managed by IBB from a single source. In this regard, permits for all landfills are obtained from IMM and the filling fields belonging to the General Directorate of Forestry are given to IMM only in return for rent. However, leasing and rehabilitation of these sites creates great costs for IMM, high casting fees are charged to meet these costs, and this causes pressure on companies carrying waste. Apart from these areas, there are also storage areas in Şile on the Anatolian side, Silivri and Kemerburgaz on the European side to store household waste. Rental and transfer of these places are carried out by the IMM Waste Management Directorate, their operation and rehabilitation and afforestation after the closure of the field is again carried out by Istac Co. is done by.

The landfills in Istanbul are in the outlying districts of Istanbul and far from the places where Urban Regeneration wastes are generated. Especially for the recycling of construction and demolition waste, establishing a construction debris recovery facility in close locations would be a more accurate approach compared to the cost of transporting construction and demolition waste to long distances. The lack of facilities for construction and demolition waste recovery in Istanbul is a major shortcoming. In this regard, it is necessary for the IMM and the district municipalities to make the necessary plans together and establish or have the facilities installed, both in terms of the environment, in terms of protecting natural resources and preventing waste.

Rental fees vary according to the condition of the fields and change every year. Since the volume of the field is important when filling and the area of the field is important when afforestation, the rental fees and the fees for the rehabilitation and delivery of the field are formed accordingly. The calculation of these fees is made according to the rules and principles specified in the Implementation Regulation of Article 16 of the Forest Law No. 28976 (IBB, 2020).

Looking at the situation regarding these dump sites in Istanbul, it is better understood how well excavation soil and construction debris waste should be managed. However, unless construction debris waste is considered as a resource and processed and recycled, it will continue to be a major environmental problem and this will create an unsustainable situation in Istanbul in the medium and long term. In particular, mixing of construction debris waste into excavation soil and domestic waste is a major environmental problem. Therefore, it is necessary for a sustainable environment to manage the construction debris waste completely separately, without mixing it with the excavation soil and domestic waste, to evaluate it as a resource and to recycle it. In the figure below, filling field request processes from the IMM's Regional Directorate of Forestry are seen. As can be seen, the request process is quite long and approval from the IMM Assembly is required.

First of all, the recycling of construction debris waste is essential. Non-recyclable construction debris waste can be used as a daily cover material in the solid waste landfill after necessary separation and size reduction. In addition, excavation soil and construction debris waste should not be mixed. In order to establish a healthy recovery and disposal system, wastes must be separated at their source and selective destruction must be made. Excavation soil, other than vegetative soil, can be used primarily as a daily cover material in filling and solid waste storage areas and for similar purposes. In cases where it is not possible to reuse the excavation soil, it is stored in the filling areas (National Recycling and Strategy Document 2017).

Inspection of the collection, transportation and disposal of excavation soil and construction debris waste should be carried out in a healthy way. Coordinate work should be done with the relevant institutions in order to allow excavation soil and construction debris waste recovery facilities and storage areas within the boundaries of the municipality and to revoke this permit when necessary. Urban regeneration wastes should primarily be used in infrastructure works or should be used (Offical Newspaper, 2021).

Excavation soil should also be divided into vegetative soil and excavation soil and should be evaluated and managed separately. Because in the construction sector, vegetable soil, excavation soil and construction debris waste are formed during construction activities. The vegetative soil formed for many years is an important substance that needs to be recovered. It is very rich in humus, the habitat of microorganisms, the soil layer necessary for the growth of plants, the vegetative soil layer. The soil below about 35 cm, which is expressed as filling soil, is not vegetal soil because of the biological insufficiency of useful fungi and beneficial bacteria in the soil. Vegetative soil is life for trees and plants. Excavation soil is used only as filling material, while vegetative soil is used as a cover layer in rehabilitation areas, agriculture, and horticulture. Excavation soil should be managed correctly during the production phase, and the vegetable soil and the excavation used as filling material should be evaluated separately.

Burying waste in the ground is both wasteful and damaging to the environment. The wastes produced are a resource and this resource can be used in the most appropriate way in terms of sustainable environment by acting on the principle of zero waste. We are not free enough to pollute the environment. Because nature does not need us, we need nature and its resources. Then it should be well known that the resources are not infinite, and that nature will not accept whatever we give it. Lifestyles and consumption habits should be adjusted according to nature. If we want to leave a healthy environment to future generations, it should be well known that we are obliged to do this. For a sustainable and healthy environment and future; It should never be forgotten that the resources we have are not a legacy left to us, but a trust that should be handed over to future generations (Eren, 2021).

CHAPTER-3

WASTE MANAGEMENT OF URBAN REGENERATION

Demolition: it consists of a series of actions to remove a structure, a building, a part of a building. Destruction arises out of necessity for various reasons. Building owner(s) want to demolish depending on need, type and size of work. Sometimes the scale of demolition will be large, as in Urban Regeneration. Area-based demolition and structure-based demolition are carried out. If demolition is carried out by the municipality and covers a large area in the place where the Urban Regeneration will be carried out, the demolition here is considered. In such a case, the renewal of the urban area, the removal of various buildings (reinforced concrete, masonry, adobe, etc.), large and high buildings or complex structures as a structure, planning and design of the demolition are made. In case of demolition of risky buildings by the citizens individually or in case of a small house or structure, the building owners must have the demolition done by agreement with licensed contractor companies, which are experts in demolition, with the support of the municipality.

During the demolition request process, the municipalities may ask the building owners how to evaluate the demolition wastes together with the demolition plans and projects. Citizens can ultimately apply to the municipality for a demolition license together with these plans and projects. Generally, in extensive demolition projects; There is extensive planning, which entails pre-demolition inspection, evaluation of buildings and design for demolition, followed by the bidding process and contracting. The best possible method for the recycling of urban regeneration waste in Elazig and throughout Türkiye is selective demolition, as in developed countries. Because the separation and classification of construction demolition waste at its source can be achieved in the most effective way. As can be seen in the figure below, (Figure 3.1) the actions to be taken regarding the demolition works; It is discussed under three main headings as pre-destruction process, demolition process and post-demolition process.

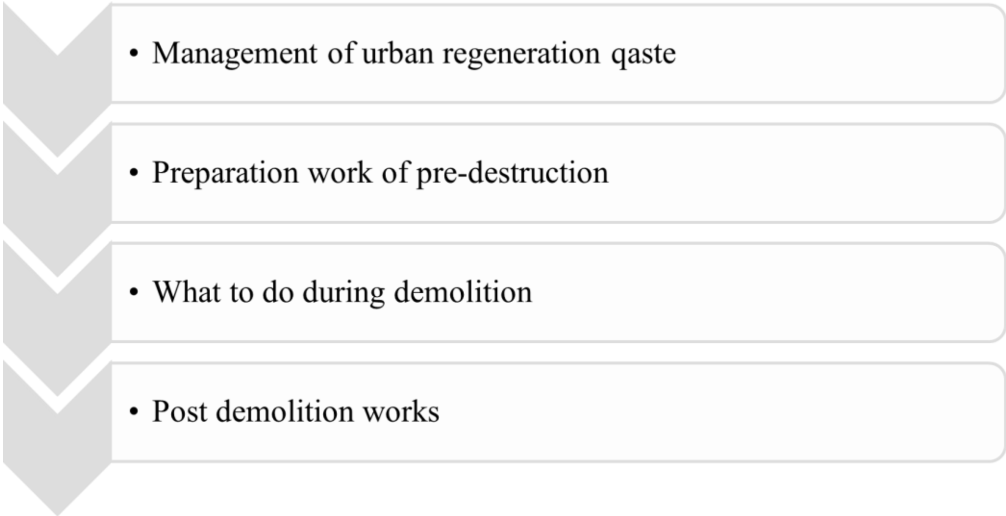

Figure 3.1 Process of demolition works

3.1 Works to be Done Before Demolition

In order for demolition to be carried out in district municipalities, building owners must obtain a demolition license from the municipality. Before issuing a demolition permit, the municipality must conduct an analysis of the demolition. All kinds of environmental measures, occupational health and safety measures, the amount of waste that will come out of the building and how these wastes will be evaluated can be included in this analysis study. The work to be done before demolition is shown in the figure below. (Figure 3.2)

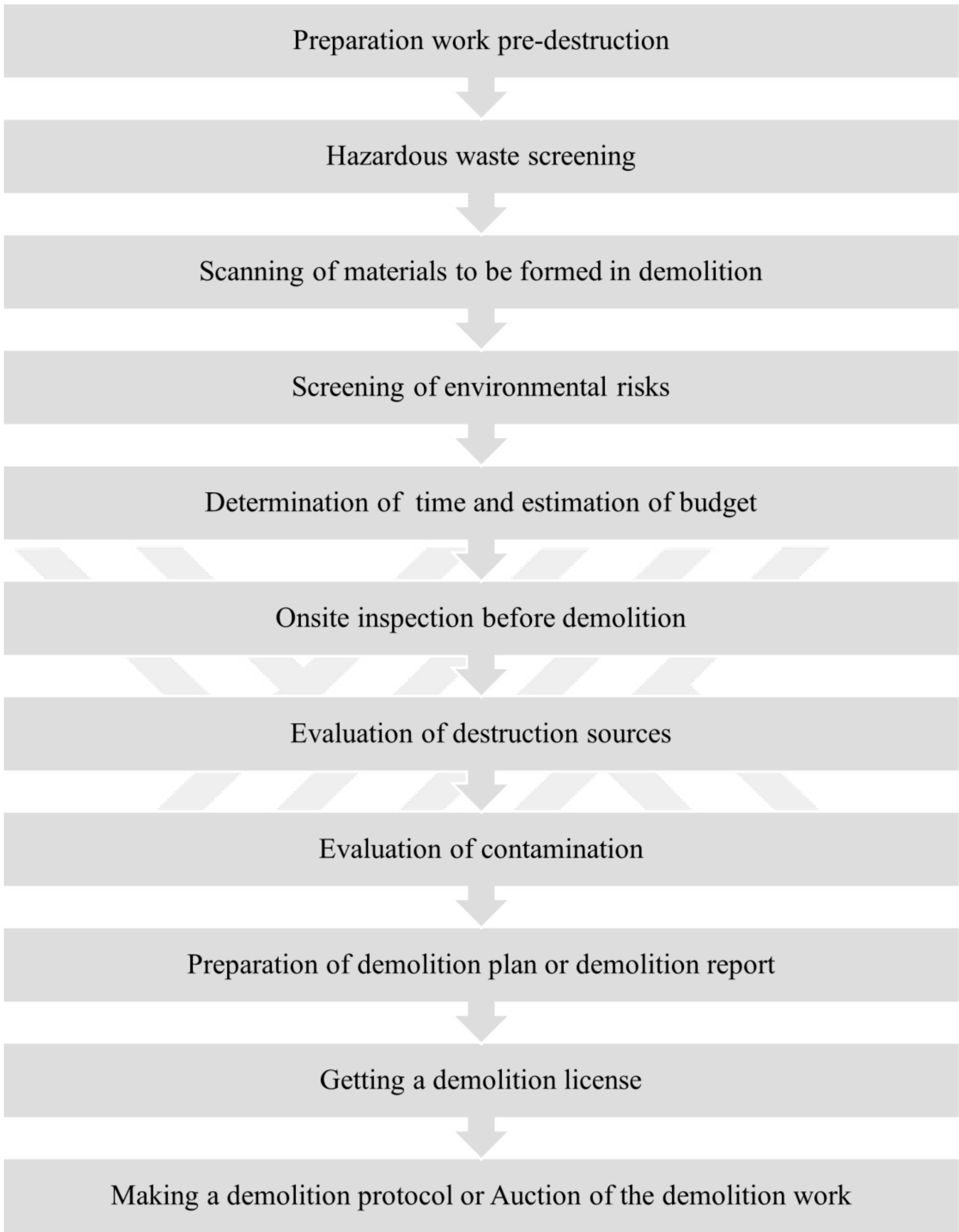

Figure 3.2 Steps of demolition process

In addition, after planning how to manage hazardous and inert wastes, if any, and how all these studies will be carried out through licensed companies by determining the time interval, these should be processed into the demolition license and a demolition report should be prepared and demolition licenses can be given depending on this report.

3.1.1. Hazardous Waste Detection and Removal

Asbestos, which is a very good insulation material, is an insulation material that is frequently used in buildings built before a certain date in many countries around the world. The most common asbestos usage areas in buildings, roof covering and insulation, pipe coating, glass paste, facade cladding are widely used all over the world, as well as in the construction industry in our country. As the use of asbestos is harmful to human health, its use is prohibited in many countries around the world and in our country. Its use was banned in the countries that are members of the European Union on January 1, 2005, depending on the relevant 1999/77/EC directive, and in our country, the use of asbestos was prohibited with the regulation published in the Official Gazette on 29.08.2010 (Sıradan, 2017).

A more comprehensive hazardous waste report may be requested in addition to the pollution screening of all buildings to be demolished in our country, whether there is material in the hazardous waste class, and whether there is any other hazardous waste besides the asbestos report given to the municipalities, especially regarding the asbestos risk. In municipalities, only an asbestos report regarding the determination of hazardous waste should be requested from the owner of the building to be demolished before demolition. The asbestos report is prepared by licensed companies that are experts in this field. The municipality may request a general hazardous waste detection report, which will include asbestos and other hazardous wastes, and which will remove all hazardous wastes. Cleaning of pollution is done according to this pollution detection report. Controls and inspections of municipalities are especially important in this regard. While the licensed company that prepares the hazardous waste detection report is working, an expert technical staff member of the municipality that will issue the demolition license can also be present in this study in terms of on-site inspection.

3.1.2. Scanning Materials in Structures to be Demolished

Material screening provides an overview and understanding of the quantities of waste materials and recycling opportunities at an early stage of demolition. The amount of steel structures reinforced concrete steel and other types of steel and metal positively affects the cost of demolition. Unfortunately, nowadays, the main purpose of demolition is construction steel (reinforcing steel), installation is in a large demolition project and often this waste is concrete, various recycling opportunities are primarily evaluated. While scanning the material, it is planned that the construction debris waste will be sorted and sorted at the source. In the process of screening the buildings to be demolished in our country, municipalities can be involved in screening studies on how to evaluate construction demolition waste. A plan is prepared on how to manage the construction debris waste that will occur. This plan includes issues such as where and how the waste will be classified, how much construction debris waste will be generated, where and for what purpose these materials will be used. In all these processes, the municipality can provide all kinds of support to the building owners for the good management and evaluation of construction demolition waste.

3.1.3. Evaluation of Environmental Risks

Evaluations are made according to the inconveniences of the immediate neighbors and the public, considering the risk of damage to the neighborhoods, third-party nearby properties, and the neighborhoods located around the demolition site. In addition, demolition processes may affect the environment, noise, dust, vibration, odor, traffic, etc. effects should also be considered. Occupational health and safety measures are necessary for employees, for the immediate environment, and for everyone residing or living in the immediate vicinity. The area around the demolished construction site and the demolished area or the demolished building should be surrounded with care. In summary, in urban works, the conditions of urban construction site should be fulfilled. In the process of assessing environmental risks in our country, the municipality should closely monitor and supervise the demolition processes, by predetermining the scope of the above-mentioned works and the time of the employee, and even by dividing them into hourly periods if necessary. Since construction sites will be established in the city in all kinds of demolition and construction activities, the municipality should take or have to take precautions regarding urban construction sites. Again, municipalities take or have all kinds of pollution measures related to the environment, such as noise pollution, visual pollution, air pollution, dust, as well as inspect and control all kinds of occupational health and safety measures regarding employees and those in the immediate vicinity of the construction site. Since the works and operations such as demolition and construction of buildings in Urban Regeneration works carry a first-degree risk in occupational health and safety, the municipality should be involved in all the works and should carry out the necessary controls and inspections in this regard.

3.1.4. Determination of Working Time and Estimated Budget

Before demolition, the required working time and budget of the project are determined, depending on the size of the demolition, screening and identification of hazardous waste, evaluation of construction debris waste and environmental risks. The cost estimation of the demolition contract is somewhat difficult and very uncertain. In general, contractors for demolition work are usually local or regional, and demolition costs depend on local conditions and the market. Demolition costs consist of the main cost elements consisting of a few specific titles. A few of these factors are the cost of transporting hazardous waste from the site, cleaning the buildings and removing hazardous materials from the site. Another factor is the costs of performing selective demolition, which covers almost a significant part of demolition work, including health, safety, and environmental management. Another cost element consists of setting up the construction site, stopping the construction, public interventions and all kinds of preparation and termination works. Again, recycling of construction and demolition waste and sale of scrap materials is also an important cost and gain factor. Depending on all of these, a firm that entered the tender in demolition tenders may request a certain amount of fee for demolition, a firm that entered the same tender may perform demolition in return for waste, and another firm may offer to pay an extra fee for demolition in the same tender. The biggest reason for this is the uncertainties about how the construction and demolition waste will be evaluated.

Municipalities or the Ministry of Environment, Urbanization and Climate Change can manage all demolitions, integrated, whether it is their own demolitions, or the demolitions made by citizens. Municipalities can cooperate with building owners and demolition companies for recycling and healthy recycling of both industrial and Urban Regeneration wastes. How and where the construction and Urban Regeneration wastes that will arise can be written in the tender specifications. If there is an opportunity to re-evaluate these materials to be recycled due to their properties, municipalities and other public institutions can use them in infrastructure works and in all kinds of recycling. Even municipalities can establish recycling facilities that will process these wastes, if necessary, and make agreements with companies or public institutions that use these materials as raw materials and make agreements with them to meet their needs for recycled raw materials at certain standards. If the marketing uncertainty of the regeneration of Urban Regeneration wastes is eliminated, where the construction and demolition wastes will be stored and where they will be recycled as recycling materials are determined, and if the necessary facilities are built, demolition costs will decrease significantly, while companies will bid more clearly in demolition tenders and wastes will be used as raw materials. Waste of resources is avoided.

3.1.5. Inspection of Pre-Demolition

The municipality may ask both the construction company and the owner of the building how to evaluate the demolition materials of the buildings before demolition and to prepare a plan for the recycling of the materials. Based on available drawings of the structure and visual inspection, all types of materials and their approximate quantities can be systematically deduced. Opportunities for reuse, recycling method, recovery method or other use can be evaluated for each type of material that will be released in demolition. Necessary recycling inspections can be made for the buildings to be demolished before demolition in municipalities in order to remove the hazardous wastes that will come out of the building and to evaluate the construction debris waste. It is important that municipalities have the necessary expert teams for these recycling inspections and that there are licensed companies that work on behalf of the public and are frequently inspected. Inspections are carried out on-site/in the field, and when necessary/to the extent possible, continuous evaluation and information can be made with relevant stakeholders. Before the demolition of the building, a coordination meeting with all stakeholders should be held under the coordination of the municipality, all risks should be determined, information should be given, and the issue of how the demolition wastes will be managed and recycled can be clarified.

All inspections, including recycling, waste management; should be inspected and controlled by public administrations. Especially since the Ministry of Environment, Urbanization and Climate Change and municipalities are the main actors of Urban Regeneration, although certification and trust are essential in every work done, audit and control studies should be carried out on site. Citizens' complaints on this issue should always be seen as an opportunity, as the most important other stakeholder in inspections and controls, as in the public sector, is citizens. Each complaint will provide another alternative, solution and systematic work for the future. Especially since there are right or wrong experiences gained in previous demolition works, these demolition experiences in the past can be benefited from in the future.

3.1.6. Evaluation of Construction and Demolition Wastes

Today, although construction and demolition waste management are part of the demolition contract, the owner of the building unfortunately does not pay much attention to this part of the contract. Normally, the contractor sells scrap iron or makes a subcontractor contract with the scrap seller, since only metal timber is seen as income in our country. Contracts should also be signed with the scrap subcontractor for the transportation of inert materials such as concrete and bricks, which will be released after demolition, to recycling facilities or landfills. While the disposal of hazardous wastes on site or in any recycling facility during demolition brings a great deal of economic burden, other demolition wastes can be economically decomposed both on-site or in the recycling facility and can provide serious income. The owner of the building takes all these into consideration and makes all the necessary agreements and contracts regarding the demolition accordingly.

Municipalities, in Urban Regeneration or any kind of construction demolition, can determine the amount of waste and waste types to be generated, research their market, calculate the cost of demolition and disposal, and determine all the revenues to be obtained from the recycling of wastes. Institutions; It would be beneficial for them to calculate the income and expense situation thoroughly and make the demolition tenders accordingly. In demolition, the municipality collects demolition wastes; It should be seen as a serious resource and should not waste these resources by making an economic and environmental evaluation according to the amount and condition of the material coming out of the demolition.

3.1.7. Planning the Demolition Process

In metropolitan cities, the demolition plan or demolition report of the building may be required to be approved by the district municipality by the company that will demolish the building. When planning the demolition, it is important to meet environmental cleanliness, all kinds of safety requirements for humans and the environment, environmental requirements, and special functional requirements (such as wrapping the structure from the outside, surrounding the vehicle operating distance with a safety strip, etc.). The building demolition plan, besides the pre-demolition inspection; It includes inseparable elements such as evaluation of working methods, replacement of infrastructure, construction debris management, environmental management, occupational health and safety management and information management.

Demolition works often involve infrastructure and plumbing changes. Infrastructure changes require municipalities to disconnect or replace water, electricity, natural gas and fiber connections according to plans with relevant providers and demolition managers. Since the change of infrastructure directly concerns the municipalities, it is essential for the municipalities to follow the changes closely and process all kinds of changes in the infrastructure information system.

The municipality can provide the necessary support to the building owner and the contractor to clarify how the construction and demolition waste will be evaluated, how and how all these will be done, including the necessary separation, recovery, and transportation of these resources, together with the cost analysis. It is both important and necessary for the municipality to lead and guide in these matters. Accurate information flow is essential to well manage a building demolition process. For this, necessary citizen announcements and informing all relevant public institutions and organizations are carried out in advance. All kinds of information can be shared with relevant institutions and organizations in a very open and transparent manner. The work and procedures to be done regarding the demolition, the techniques to be applied, the information of the demolition contractor and the precautions taken can be shared. Therefore, if all kinds of information and process management regarding the demolitions to be made in the Urban Regeneration processes of the municipalities are carried out by the municipality, negativities can be prevented (Güllü, 2020).

3.1.8. Granting a Demolition License

In demolition works, it is obligatory to obtain a demolition permit from the municipality that issued the building permit. District municipalities are authorized to issue building permits and demolition permits in metropolitan areas. After the necessary preliminary examination and preparations are completed before demolition, a building demolition permit is granted. While issuing a demolition license, the conditions specified in the demolition file, prior to the preliminary examination and adherence to all studies may be requested. All commitments made and stated must be auditable and controllable. The issuance of the demolition license may be carried out by a commission composed of competent persons rather than authorized persons in municipalities. Information such as building information, what type and amount of hazardous waste will be produced, how much construction and demolition waste will be produced, and how these materials will be evaluated can be written on the demolition license.

The plan prepared in the design of the demolition, the projects and reports of the building can be included in the demolition file created by the municipality. Depending on all these processes and processes, a demolition license is issued by the municipality. If the legal infrastructure of recycling has been established, demolition license should not be given unless the necessary and sufficient conditions specified in this preliminary preparation process are met. Before issuing a demolition license, municipalities should request some information and documents from the building owner. These documents include important data such as contracts for demolition and compliance with recycling. Again, the demolition plan and the construction debris waste management plan, in the building to be demolished; Relevant documents and documents are requested from the relevant institutions that their services such as electricity, water, natural gas and communication lines have been terminated. In addition to all these documents, after examining many other information and documents, if the work done meets the necessary legislation, determined principles and rules, the final demolition license can be issued.

3.1.9. Demolition Operations

Building owners who have obtained a demolition license can initiate the demolition agreement and tender process based on this demolition license given to them. Since demolition is a highly technical, risky subject and has many dimensions, demolition works are tendered to companies that are highly experienced, expert, and certified, and are carried out depending on certain official agreements. In the 2020 Elazig/Sivrice earthquake, unfortunately, careful destruction did not occur, and many material damages occurred. In general, tenders and contracts for demolition projects are similar in rules and principles to other tenders in the construction and construction industry. Tender documents as standard; including the requirements of the offer, if the invitation procedure; It includes documents such as an invitation letter to bid, demolition technical specifications, administrative specifications, contract draft, qualification requirements and financial proposal paperwork.

A multi-envelope transaction can also be used in auctions. The first envelope contains the second offer, the technical offer, which must be evaluated and sorted before opening the financial offer. The purpose of the multi-envelope process is to ensure that the technical proposal is evaluated without the impact of the financial proposal. In order to receive the most advantageous bids, bidders should have time to explore opportunities for the most efficient and cheapest solutions. If the municipalities use this method in the tenders for demolition, they can keep the requirements of the work healthy in the first place and get better results.

In the tender documents, the owner of the waste, the amount of waste, types of waste, the owner of the recycled materials, etc. is specified. To avoid misunderstanding of approximate cost and to eliminate inconsistencies in the job description, the owner and contractor can discuss the figures and work to be done during the bidding process before starting work. In demolition contracts, the conditions determined by the municipality, or the relevant institution and the permits required to be obtained from the relevant administration are also specified. Generally, demolition work begins immediately after the signing of the contract and work begins with the preparation of the construction site. The above-mentioned conditions must also be met, especially in demolitions made by municipalities for various reasons such as Urban Regeneration, expropriation, renovation, and cleaning. The municipality or the relevant institution may carry out the same inspections and controls in all demolitions, and take or have them taken the necessary health, environmental and safety measures, and measures.

3.2. Work to be Done During the Demolition Process

The municipality or the relevant institution may carry out the necessary permits and inspections during the demolition process, both on site and with documents from the office. All demolitions consist of a specific and sequential set of activities. Preparatory studies including feasibility, infrastructure change and establishment of the construction site are carried out. First of all, the parts of the building that are on the verge of collapse, containing hazardous waste, are cleaned. Selective demolition and sorting of construction and demolition wastes are carried out. In the final stage, the cleaning and finishing work of the construction site/area is carried out. The following figure shows (Figure 3.3) what needs to be done during the demolition process.

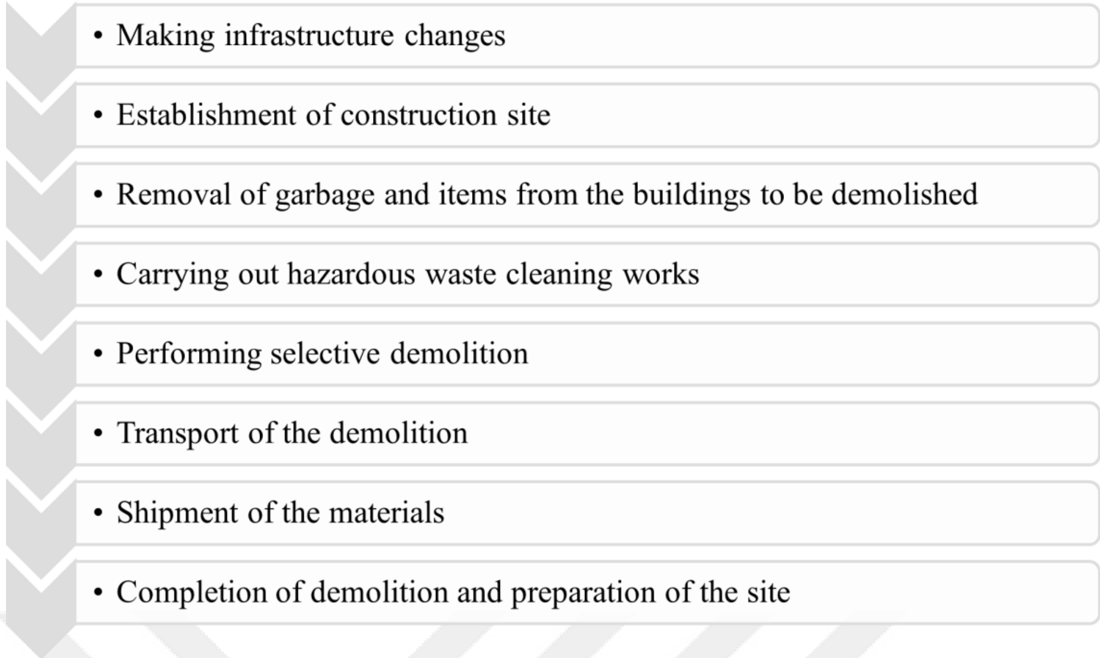

Figure 3.3 Things to do during the demolition process

The demolition process is a very delicate process. In the studies to be done here, the work is carried out according to the plans, programs and criteria that have been meticulously studied before. In the demolitions, the municipality can have an expert observer experienced in demolition on the field. Preparations are made for all kinds of unexpected situations, mishaps and accidents that may occur. Municipalities can manage and monitor on-site whether the demolition works are carried out correctly.

3.2.1. Installation of Construction Site

The construction site is established in the immediate vicinity of the area to be demolished and the places to be demolished are surrounded by taking the necessary precautions. After the construction site structures are installed, suitable workspace is created for the various construction and demolition waste components, containers, warehouses and around the building. The construction site management takes the necessary measures to protect human life, the environment and nearby settlements against environmental impacts caused by the demolition work. In particular, the structures to be demolished are screened against dust, splashing of the building piece and visuality.

For the energy consumption of demolition equipment and machines, measures are taken against noise and dust emission to prevent damage to the machine. If necessary, vibration, noise and dust control is carried out outside the construction site. Necessary tools and tools are available at the construction sites to meet the needs that will be required during the demolition. Construction sites are set up temporarily; Generally, easily transportable containers are preferred, and these structures can be used until they complete their life cycle by being transported to other construction sites where needed. Security, control, and inspection should be done at all kinds of entrances and exits at the construction sites.

3.2.2. Removing the Remaining Items

Sometimes, great care is not taken in demolition and the building is demolished together with the forgotten items. All materials are mixed with the demolition wastes and these wastes are sent to the dump sites without any separation process. Doing so is a bad demolition operation. Every forgotten item is mixed with demolition wastes and in all the following processes, it is both harmful to the environment and creates an economic burden in terms of waste management processes. Therefore, the specialist of the relevant institution should visit the building and pay attention to everything inside before the demolition begins, closely monitor the demolition processes and prevent the items left in the buildings from being mixed into the demolition waste.

Generally, once the demolition contractor has started work, he takes ownership of all remaining items and is his responsibility to remove and move all items, including trash. All the materials inside the buildings to be demolished are emptied and classified in accordance with the recycling purposes. No item, whether usable or unusable, is left in the building to be demolished. Again, all kinds of garbage and wastes are removed from the buildings to be demolished. The buildings are completely cleaned of all kinds of goods and garbage and these are also used for recycling purposes. Such works can be carried out under the supervision and control of the municipality, and the expert of the relevant institution should visit the building and pay attention to everything inside before the demolition starts.

3.2.3. Cleaning Process of Hazardous Wastes

Before starting the selective demolition, the building; Organic compounds, which are harmful to health and safety, should be purified from all kinds of pollutants including metal compounds, asbestos and other dangerous substances. Cleaning method, duration; varies depending on the structure, the surface of the structure and the type of pollution. Contaminated surfaces are cleaned using various technological methods. There are many different cleaning methods. To ensure the removal of hazardous wastes in the buildings to be demolished; Different methods such as "abrasive grinding, mechanical milling, sandblasting, particle blasting, cleaning with chemicals" are applied. Removal of hazardous wastes in buildings to be demolished is one of the most sensitive works for recycling. Since Urban Regeneration wastes will be evaluated in recycling, it is important that hazardous wastes are not included in the construction and demolition wastes to be recovered. In order to prevent the mixing of hazardous wastes into the construction and demolition wastes, before the demolition proceeds, it is worked with companies that are experts in this field to detect and remove the hazardous wastes in the buildings. In all these works, municipalities or the Ministry of Environment, Urbanization and Climate Change can control, audit and monitor.

3.2.4. Selective Demolition

In conventional demolition, where selective demolition is scarce and not given much attention, it is the normal way of working to demolish the building from the roof to the basement caste without paying special attention to sorting demolition waste. After the recovery of construction and demolition wastes gained importance, the importance of selective demolition increased. With selective demolition, the reuse and recovery of construction and demolition wastes are carried out more effectively and efficiently. In the selective demolition, the main demolition cannot be started before the materials determined to be reusable are removed and removed, and the items are separated. As seen in the figure below, (Figure 3.4) selective destruction typically consists of five stages.

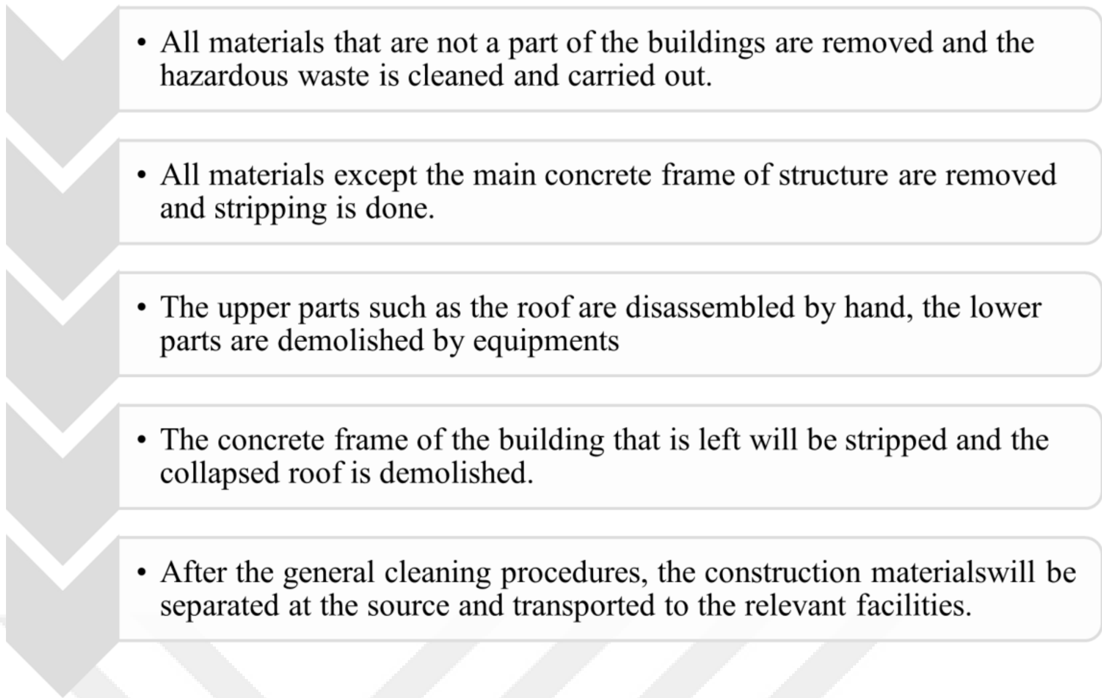

Figure 3.4 Selective demolition processes

The selective demolition process is the most sensitive process for the evaluation of construction and demolition waste. With selective demolition, it is ensured that construction and demolition waste is separated at the source. In developed countries, the logic of selective demolition is made with the logic of firstly removing the last piece that is placed while the building is being built. As with all wastes, the separation of construction and demolition wastes at the source is done according to the waste hierarchy, and in this way, construction and demolition waste is evaluated in the best and most efficient way. In demolitions in Türkiye, more traditional methods are used for demolition. However, demolition according to selective demolition processes is important in terms of human health, protection of the environment, efficient use of resources and prevention of waste. Selective demolition is applied in order to separate the Urban Regeneration wastes at the source and in a healthy way. Selective demolition is done with the aim of separating all the waste in the building directly at the source, as it is done in order to take advantage of all the opportunities for recycling the demolition waste.

In our country, demolition processes can be carried out not with the usual traditional methods, but according to the principles of selective demolition, in which the demolition wastes are evaluated as the most efficient and effective. We are capable of selective destruction, both as machinery and manpower. It is an important issue that all demolitions in our country are carried out by selective demolition method, under the supervision and control of municipalities and related institutions. Selective demolition is scientifically the most effective method for separating and recycling construction and demolition waste at source. Countries manage waste by setting specific targets in order not to despise their resources, to protect construction health, the environment, and to provide economic gains by recycling waste. In Türkiye, construction and demolition waste can be managed by setting specific targets for the recovery of construction and demolition waste. Recovery targets, on the other hand, are most effectively and efficiently achieved by selective destruction.

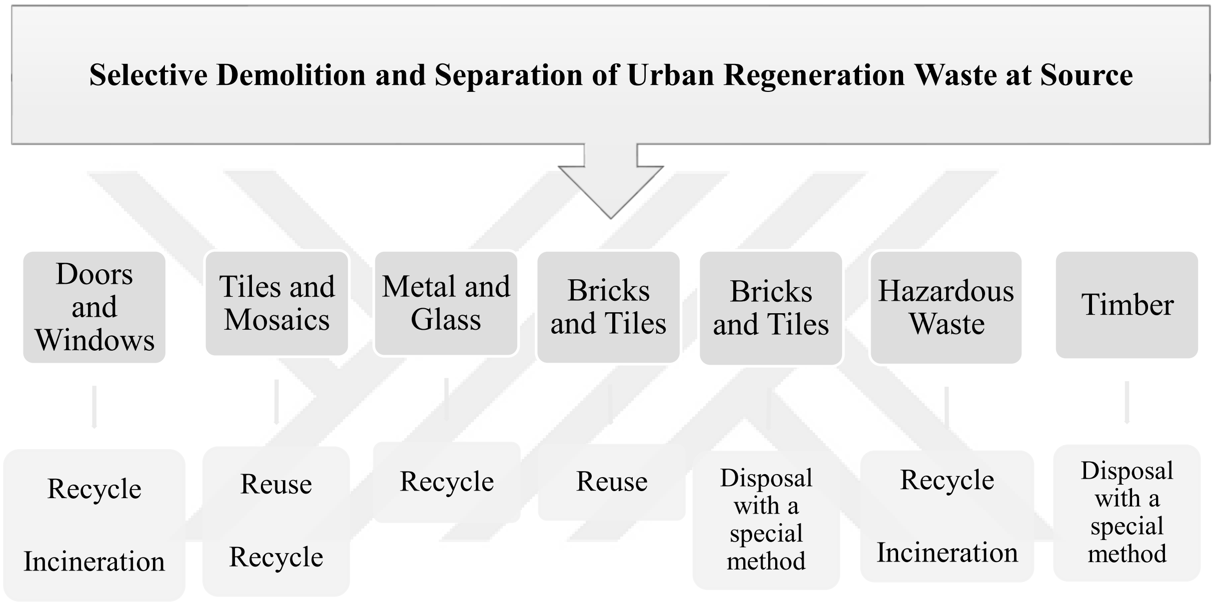

Figure 3.5 Selective demolition and evaluation of C&D wastes

The figure above shows (Figure 3.5) how construction and demolition wastes are sorted on site by selective demolition. In the building to be demolished, once the perimeter has been secured and stripping completed, the main structure including the walls, decks, bearing construction and basement will be demolished and clean recyclable concrete, masonry, stone and steel fractions remain. Demolition of the building is done with appropriate disassembly, equipment and demolition techniques. The choice of demolition technology depends on the height of the building, the thickness of the concrete, etc. It depends on the reasons.

Based on the analyzed results of projects done in Denmark, it is estimated that selective demolition and sorting requires around 30-35% more labor than conventional demolition and landfill. Selective demolition is approximately 18% cheaper than conventional demolition on grand vision projects. However, it was concluded that selective demolition may result in increased health and safety hazards due to the additional labor involved in the classification of in-situ materials. On the other hand, it has been concluded that most of the risks can be avoided with proper planning of the works and the use of special tools (Lauritzen, 2019. Generally speaking, selective demolition is always more advantageous than conventional demolition, as it recycles optimally, avoids waste and conserve natural resources, as well as have greater economic value and protect the environment and economically. Considering all these, in our country where Urban Regeneration continues rapidly, it is extremely important for the municipality to carry out or have it do selective demolition. In addition, it would be the most correct method to move to selective destruction as soon as possible, and national wealth will not be lost.

3.2.5. Demolition Techniques

Buildings: it is made according to the standards specified in TS 13633 Implementation Rules for Complete and Partial Demolition of Structures and published application guidelines. The demolition should be done by "demolition engineers" and the inspection of the demolition in accordance with the demolition plan is carried out by the static engineer inspectors. Demolition work is a highly technical subject.

Demolition Engineering: Civil engineers specialize in demolishing superstructures and buildings. In today's world, where post-graduate degrees, that is, master's and doctorate degrees, are too many, in fact, a demolition engineering department can be established in universities, depending on the faculties of construction. Demolition engineering is a field that deals with removing structures without harming people and the environment, after blending structural and architectural knowledge and experience, and combining them with the necessary equipment. Whether it's normal buildings or high-rise buildings, viaducts, factories, chemical production plants, they involve separate risks and require expertise and different equipment and equipment for demolition. One of the issues to be considered while in the planning phase of demolition projects is to minimize the damage to human health, the environment, and infrastructure lines during demolition and to evaluate the wastes generated. Demolition engineers have a lot of knowledge and experience in these matters. While there are companies specializing in controlled demolition and well-trained demolition engineers in developed countries, there are almost none in Türkiye.

Demolition methods vary according to the size of the buildings, the construction technique, the materials used and the recovery status of construction and demolition waste. Demolition is generally divided into three as manual demolition, controlled blast demolition and mechanical demolition. Mechanical demolition is divided into three: demolitions with light equipment, medium equipment and heavy equipment. Depending on the technological developments, other techniques can be applied in the constantly developing world.

Municipalities, the Ministry of Environment, Urbanization and Climate Change, contractors and other relevant institutions that will take part in the demolition work, before starting the demolition activity, during the demolition process and after the demolition, take safety and environmental protection measures for demolition workers and third parties, as stipulated in the relevant legislation. liable. Before the demolition, sufficient information is obtained about the ground on which the building sits, the design of the building and the construction principles, and the demolition is designed according to the results of these data.

Manual demolition operations are also often used as an additional method to prevent damage to remaining parts of the building or adjacent buildings and as a preparation prior to mechanical demolition or blast demolition. The demolition industry has developed a large number of different types, sizes and functions of machines for all types of mechanical demolition. The key drivers for technical developments in the demolition sector are workers' health and safety, reduced energy consumption, environmental protection and effective working performance, along with the reduction of vibration, noise, dust and other emissions. Controlled blasting technique is a demolition technique that requires much finer precision and requires precise calculations. It is done in the demolition of very high-rise buildings, in cases where the demolition with the machine will take a lot of time or in cases where it is more economically advantageous. Such demolitions require very precise investigations, calculations and special expertise, from how much explosive to use where and how, and how to detonate it.

In developed countries, there has been a lot of progress in demolition with the blasting technique. Türkiye has not made much progress in this regard. Especially in Türkiye, which is located in the seismic belt, many buildings are in the position of risky structures due to their construction techniques and location. While a certain part of these buildings are demolished, it is inevitable to apply the blast demolition technique. However, the number of applications in return for this requirement is quite low.

Before demolition is done by blasting technique, it is done after the buildings are completely cleaned according to the selective demolition criteria. Demolition by blasting technique is a method applied in cases where machine demolition is much more difficult and costly. Blasting technique is the fastest demolition technique, and it is important to take all kinds of health, safety and environmental precautions before demolition, especially since it contains serious risks in itself.

3.2.6. Transportation of Urban Regeneration Wastes

Waste materials from the demolition of the building are collected in separate sections on site and stacked in special containers for waste material. Today, machines have very precise working principles for selective and efficient sorting and these machines are highly developed. However, manual sorting is done to separate and control all of the materials, both from each other and in bulk. Wastes of bulky materials such as concrete and masonry are collected on site and sent directly to recycling facilities or storage facilities from there. Since separation at the source and recycling of waste concerns our future and everyone, especially municipalities can work on the separation of wastes at the source and on-site inspection of the work done. It is important that both the municipalities and the Ministry of Environment, Urbanization and Climate Change support the studies on this subject and support these studies with special incentives. In order to strengthen social awareness, the recycling of construction and demolition waste can be explained to the stakeholders in detail and recycling support can be found from all segments of the society. In order to raise awareness of citizens, advertisements and announcements can be made by the municipality and the ministry. Like the 'Zero Waste' project initiated by the Ministry of Environment, Urbanization and Climate Change, the whole society can be conscious.

Municipalities and the Ministry should approach urban regeneration wastes with the same sensitivity as in domestic wastes and care about recycling for urban regeneration wastes. Finally, all construction and demolition waste materials separated at their source are directed to the relevant places for recycling and disposal according to the need and market situation.

After the demolition is completed, the materials separated at the source should not be kept in the field, the materials that reach certain tonnages for transportation when the separation is finished or for transportation should be transferred to the places where they will be recycled. It is important to continue the waste management processes in municipalities as a chain from start to finish. Especially if the materials separated at their source and those who put these materials on the market for the first time are obliged to recycle, all sorted materials can be delivered to authorized institutions and organizations for recycling. The high waste recovery rates for all wastes in a municipality is one of the most important indicators that indicate that the municipality is working well in this area. For this, municipalities should focus on the recycling of urban regeneration wastes, it is important that they act together with people, institutions and organizations working on this issue and provide all necessary municipal support to those concerned.

3.2.7. Construction Site and Demolition Process

Depending on the completion of the demolition, the demolition is completed by leveling the site, removing all installed machinery, materials and site facilities. The demolished area is prepared and corrected according to the final agreed condition and the use of the area in the future plan. In some cases, the area can be transformed into a green area by landscaping. Recycled materials from demolition can be used for infrastructure material, site filling and leveling (Türkiye Regulation on the Demolition of Buildings, 2021).

In general, it is the responsibility of the municipalities to evaluate and plan the areas of demolished public buildings. Municipalities can plan and evaluate the areas within their adjacent area boundaries and each square meter well. The vacant areas after demolition offer great opportunities for municipalities. Whether re-building, social reinforcement area or green space is built here, since the plans are made by the municipalities, the better the arrangements and buildings that are seen as urban aesthetics and needs will contribute to the future of the city. It is very important for municipalities to carry out urban design studies with a wide perspective in order to make the best use of the emptied areas in Urban Regeneration. By examining the examples in the world and taking the standards as a reference, municipalities can carry out urban design studies with an approach that will add beauty to the city in every aspect, be original, sustainable, accessible, aesthetic, compatible with the region for which it is designed, that the public can reach everything and in the shortest possible time, and that will meet the needs of the users in the best way.

3.3. Actions After Demolition

Urban Regeneration waste materials obtained after demolition should be processed and evaluated according to national legislation and local requirements. Construction and demolition waste management in general, all bricks, rubble, doors, windows, metals, joinery timber, etc. recycling, special disposal of hazardous waste, logistics optimization and documentation processes. Unfortunately, there is no performance, long-term plan and recovery target for the recovery of construction and demolition waste in our country. Studies on the direct disposal of construction and demolition waste, whether stored or not, are in the foreground. Unfortunately, our local governments do not have any studies and targets in terms of recycling of construction and demolition waste. They act as if they are solely responsible for demolishing the structure and removing construction debris. In the Urban Regeneration projects that started after the 2020 Elazig earthquake, all demolitions were made by the Ministry of Environment, Urbanization and Climate Change, there was no selective demolition, they were not stored in any way or sent to the recycling center. It has only been transferred to the road construction sites under construction as infrastructure filling material. The following figure shows the actions to be taken after the demolition of the building. The management of Urban Regeneration wastes can be handled in line with the principles and approaches outlined here.

- Reuse
- Recovery
- Disposal
- Separation of hazardous wastes
- Optimization of logistics
- Documentation

Figure 3.6 Actions after the demolition process

Municipalities and the Ministry can make a management plan and strategic plan regarding the management of Urban Regeneration wastes. Management plans are prepared annually or for 5 years and can be updated every year. The strategic plan, on the other hand, offers a future perspective, a new perspective and foresight. Concrete targets should be set in the plans, and the data can be recorded instantly, and it can be evaluated every year where the determined targets are. While making all kinds of plan studies, local and regional conditions, especially people and the environment, are taken into account, taking into account opportunities and needs.

3.3.1. Reuse

Due to environmental needs and economy, an environment should be created where demolition material suppliers and demolition material demanders come together for the sale of second-hand materials or products arising from Urban Regeneration. For this, it is necessary to create a serious and important market for reusable materials in the construction industry, going beyond the traditional and ubiquitous systems carried out by scrap dealers, by establishing an online-based waste management system. By creating an internet-based construction and demolition waste market, a wide information environment on construction and demolition wastes is provided, while those who demand second-hand materials for construction and demolition waste and those who will offer them to the market are brought together in a wider environment, thus providing more reuse opportunities. can be provided (Abanuz, 2005).

A significant portion of construction and demolition materials can be reused. These reused materials prevent waste generation seriously. The more we increase the reuse rate of construction and demolition waste, the more new resource use and the more waste we can create in the first place, and we can achieve significant economic gains. In order to increase the reuse rate, there should be policies in this regard and the buildings should be built in line with these policies while they are still in the construction phase.

3.3.2. Recovery

Crushed concrete and briquette and masonry materials can be recycled and used as aggregate in concrete for new constructions and as newly built road filling material. For years, a lot of research and development has been done on recycled aggregates as aggregate in new concrete and many academic studies have been done on this. There are standards and user guides for the use of recycled concrete and masonry materials in many other countries, especially the European Union. Recovery of metals and metals is almost the most economically important part of the demolition process. While creating the demolition budget, all the components in the construction and demolition waste are taken into consideration and should be evaluated separately.

A research report was prepared by the Istanbul Metropolitan Municipality for the Istanbul Technical University on meeting the need for aggregates and evaluating the demolition wastes, taking into account the environmental effects in the urban development and regeneration planning of Istanbul. Although it is stated in the report that the natural aggregate resources in Istanbul are sufficient to meet the needs of Istanbul, it is recommended that the recoverable and reusable parts of the excavation and demolition wastes be primarily recycled (Vardar et al., 2012). The quality of the aggregates obtained from construction and demolition wastes is directly proportional to the good and selective separation of the wastes at the source. Therefore, it is necessary to ensure that the quality of the aggregates to be used in cement and concrete production is good. (IBB, 2019)

3.3.3. Disposal of Non-Recoverable Wastes

In the construction and demolition waste formed as a result of the destruction of the building; All materials that are not reused, recycled or recovered are incinerated or disposed of in landfills. In demolition, the amount of construction and demolition waste left over from recycling depends on the type of materials used by the countries and regions, the tradition of using demolition wastes, and the natural resource availability of the countries. Since there are many natural aggregate resources in our country, it is not economically attractive to obtain aggregates from demolition wastes as a secondary source. In fact, this is indirectly the most important factor in the obstacles to the work of obtaining aggregates from construction and demolition wastes. However, in the case of a good resource planning for the aggregates used in our country, in the case of a certain restriction on the use of natural aggregates, it is obvious that obtaining aggregates from construction and demolition wastes will be a more accurate strategy depending on the protection of the environment and not wasting resources.

Many construction sites are established in Urban Regeneration areas and there are intense material inputs and outputs to these construction sites. Many different vehicles and machines operate in demolition areas. Oil spills, chemicals, oil leaking from vehicles, batteries, etc. in demolition areas. environmentally critical and hazardous wastes and polluted wastes from cleaning processes. These wastes are inert waste and should be disposed of in landfills. Removal of hazardous waste is an important problem and requires a meticulous cleaning process. All employees should be trained and informed about the safety and health issues associated with the disposal of hazardous waste. It is important that employees always use the equipment required by personal protection, occupational health and safety in their work areas. In the last stage, the contaminated areas are cleaned and finally the cleaning work is carried out in the demolition area, and the demolition area is made ready for the new structures to be built (Official Newspaper Date: 25.01.2017).

3.3.4. Logistics Optimization

Construction and demolition waste remaining after demolition is transported to their destinations after selective demolition and sorting on site. While some materials for reuse, such as sheet metal, plumbing equipment, solar hot water installations, can be picked up by private customers on-site, other materials are taken to industrial sites or private recycling companies by shipping companies to be converted into second-hand raw materials. In all these processes, it is important to determine the transfer program well in order to deliver the materials to the destinations when needed.

In our country, transportation costs and casting fees constitute an important part of the total demolition costs. This is why demolition firms and transport companies are always looking for the cheapest construction and demolition waste handling and shipping solution. Illegal solutions, such as illegal dumping in random locations, can happen from time to time. Therefore, detailed planning of construction and demolition waste handling and logistics optimization is important to reduce the cost of transportation and transportation of construction and demolition waste. In all these processes, especially the presence of vehicle tracking systems, waste transportation, processing with waste acceptance documents and monitoring and inspection systems related to this ensures healthy logistics of wastes.

3.3.5. Documentation and Registration System

In construction and demolition waste management, documentation is important in terms of correct use of waste, quality of materials and tracking where materials come from and where they are evaluated. Traceability of the sources and processing processes of the wastes is important, according to the determined criteria of the construction and demolition waste, the nature of the materials for reuse and recycling. Information with complete documents and recorded information can always be requested by the relevant organizations. Particularly, monitoring of waste processes and preparation of all necessary documents are carried out by municipalities. The documentation and monitoring of waste at the national level is carried out by the Ministry of Environment, Urbanization and Climate Change.

Documentation is necessary in terms of transferring and sharing information to the monitoring and monitoring units and presenting the information and documents to be requested. Documentation may also be a requirement to demonstrate and demonstrate that legal obligations are met. In addition, it can be used for the purpose of sharing experience and information later on, and it is important for the continuity of the information and document flow. Particularly, it would be beneficial for municipalities to attach importance to documentation and to document and archive all the work done, to create a registration system, and to analyze the work to be done.

3.4. Recovery and Processing of Urban Regeneration Wastes

Construction and demolition waste is a problem that emerged after the industrial revolution. Since life was in its natural state before the industrial revolution, there was not much waste in the life cycle. There was no waste problem in agricultural production societies. Because nothing was seen as waste in agricultural products, the organic materials that emerged were used as food for animals, animal wastes were used as fertilizer, and demolition wastes were inorganic materials and were reused over and over again primarily in newly constructed buildings, since they are a part of nature. However, after the industrial revolution, my production increased and diversified. Since the wastes generated due to the industrial revolution are also a part of nature and are not organic waste, they could not be destroyed, and at this point, industrialized countries were helpless in the face of the increasing amount of waste, and they saw recycling as a solution to reuse the wastes as secondary raw materials. However, it is important to remember that the real solution should start from the first step in general, and not to produce waste (Bilgili, 2021).

decomposition at source; It has advantages such as selective destruction, efficient recovery, low recovery cost, and prevention of waste. The disadvantages are the need for more than one sorting container at the construction site, the need for workers to sort the materials, and the difficulties in transportation. Mixed collection, on the other hand, has advantages such as the need for fewer containers at the construction site, no need for workers for the separation of materials, ease of transportation of materials and ease of application, and has disadvantages such as more inefficient recovery and high recovery costs (Akça, 2014).

In fact, today's world cannot fully cope with waste, studies are carried out to prevent it from creating any more, and the concept of zero waste is spoken a lot in daily life. In our country, zero waste management has come to the fore in recent years and a regulation has been issued on this subject. Zero waste is defined as a waste management process and approach that includes the prevention of waste, the more efficient use of resources, the prevention or minimization of waste generation, and the separation and recycling of waste at its source in case of waste (Zero Waste Regulation, 2019).

In zero waste management, both waste reduction and recycling, effective use of buildings and building materials are critical issues for the circular economy. Today, selective demolition and emerging technologies present opportunities and challenges for the recycling of construction materials. The most critical and main issue in the recycling of construction and demolition waste is the recycling of materials such as concrete, masonry, brick, stone and tiles (CSIDB, 2021).

In general, recycled aggregates can be classified into three parts: Type 1: Aggregates obtained from concrete rubble, Type 2: aggregates obtained from wall rubble, Type 3: aggregates obtained from the mixture of recycled aggregates. Type 1 recycled aggregates are of concrete origin and may contain brick material up to 10% by weight. Type 2 recycled aggregates are of brick origin but may contain up to 100% brick material by weight. Type 3 recycled aggregates are of concrete and brick origin but may contain brick material up to 50% by weight (Akça, 2014).

Construction and demolition waste; Recycling them to usable resources as building materials for the construction industry is one of the growing and important issues. Waste management should now be one of the main tasks of municipalities. Particularly, municipalities, which are directly or indirectly responsible for all kinds of wastes in cities, see construction and demolition waste as a resource, not waste, and then focus more on the recovery of construction and demolition waste, in terms of good management of construction and demolition waste, protection of the environment, and waste of resources. would be the right approach.

3.4.1. Concrete Recycling

Concrete is obtained from fine aggregates such as sand and coarse aggregates such as gravel or crushed stone, together with water, cement and additives. Concrete waste is the largest volume of construction and demolition waste, and recycled concrete waste is used for a wide variety of purposes in some countries around the world. In general, more than 50% of construction and demolition waste all over the world is concrete. In our country, this rate is much higher. The global concrete industry uses approximately 10 billion tons of sand and rock each year, and it is estimated that more than 1 billion tons of construction and demolition waste is generated each year. However, some concrete wastes are contaminated with harmful substances that come mixed with paint, oil and additives. When the contaminated parts of the concrete waste are removed, there is a recycling potential of almost 100%. If concrete wastes can be fully recycled worldwide, it can save approximately 1 billion tons of natural resources. Depending on the creation of a market in this field, the recycling of construction and demolition waste will enable it to become an ambitious and powerful industry producing recycled aggregates for construction (Lauritzen, 2019).

In order to protect the environment and resources and not waste resources, the first thing that comes to mind when searching for alternative sources for the materials required in concrete production is the recycled aggregates from wastes. Although a lot of aggregate is used in cement and concrete production, recycled aggregates are used to a certain extent as well as natural aggregates. Research is being carried out to use blast furnace slag, which has binding properties, as an alternative for cement, and the use of recycled aggregate obtained from concrete waste for aggregate. As a result of the examination of the standards related to recycled aggregate around the world, some classifications are made for this type of aggregates according to the aggregate test results, the source of the waste and the content of the waste. As a result of these classifications, it is decided whether the recycled aggregates will be used as concrete aggregate.

However, despite the many positive research findings regarding short, medium and long-term concrete performance, treated concrete wastes are mainly used to a certain extent instead of natural aggregate in structural concrete. Some European Union member countries such as Germany, England, Netherlands, Denmark encourage the recycling of concrete in the building and construction industry. In this regard, applications and R&D studies in the world are increasing rapidly. In our country, there are studies carried out by TUBITAK MAM and many universities on this subject. The figure below shows (Figure 3.7) the places where concrete wastes can be evaluated and the figure about the zero-waste process in the circular structure (TUBITAK MAM, 2015).

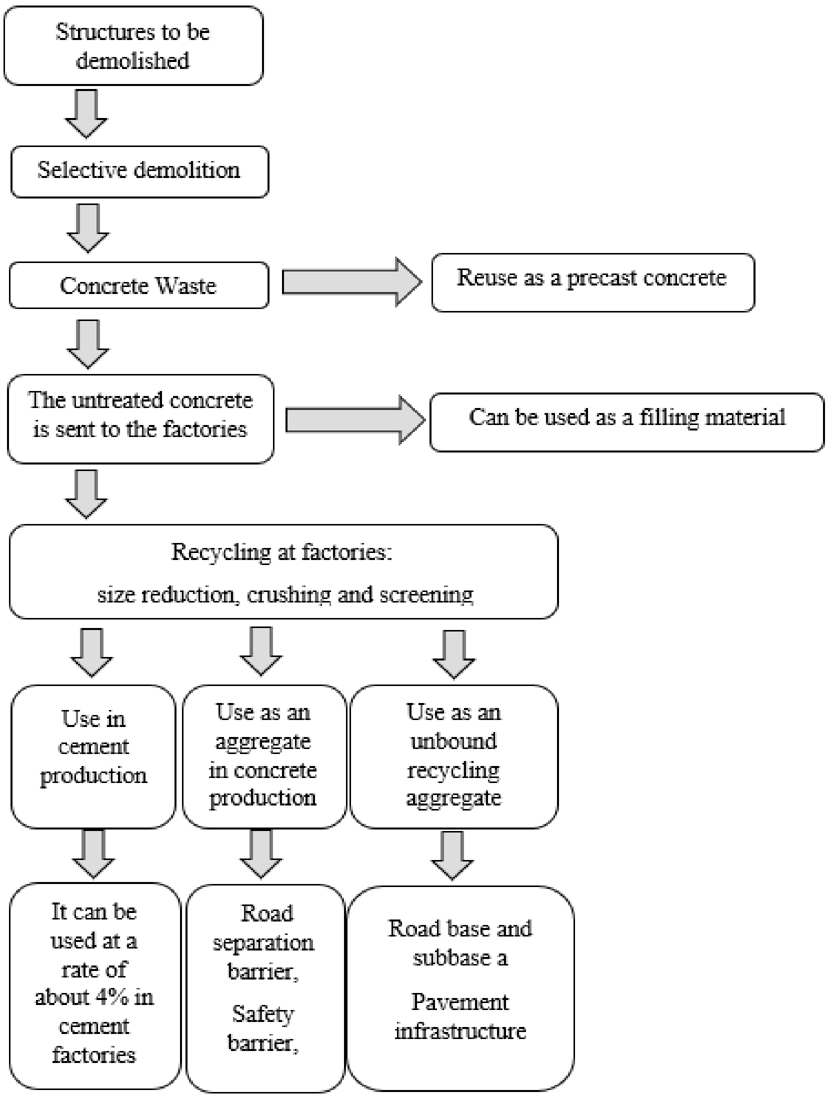

Figure 3.7 Usage of concrete waste and cyclic zero waste approach (ISTAC, 2019)

In fact, reusing structures without demolition is the best recycling. The advantage of this is to evaluate the skeletal concrete structure as it is, maintaining the concrete structure and the height of the building. Therefore, the most advantageous method is usually the reuse of buildings for other purposes. Opportunity to reuse buildings, economy, architecture, function, local policies etc. It depends on various factors and decisions regarding Before deciding on demolition for buildings, it should be well evaluated whether they can be reused for other purposes. In accordance with this vision, we can show the reuse of buildings, for example, the use of old state buildings as a youth center, the buildings that were used as a prison today as a five-star hotel, the use of former military barracks as a university campus and the buildings used for education in a similar way.

Concrete has been widely used in the construction of buildings with reinforced concrete structural elements since the middle of the 19th century. When a precast concrete building is demolished, contractors often choose to sell the entire structure for rebuilding as an asset or use all the precast units for their other construction. Precast concrete is a construction product that can be cleaned in reusable molds in a controlled environment, transported to the construction site, disassembled/assembled there and reused. Therefore, they can be separated neatly during the demolition of the building and these elements can be reused (Alexandre, 1935).

In our country, Tubitak Mam Materials Institute has worked at the Akçansa Büyükçekmece Factory to use construction and demolition waste as an alternative raw material in cement production factories. Cement is an inorganic substance that gains binding properties when interacting with water in building materials. It is a material produced by firing a mixture of natural limestone and clay at high temperatures, grinding and then adding one or more forms of calcium sulfate. When mixed with water, it forms a paste that hardens over time. The produced cement is used in concrete production at certain rates, at an average of 10% according to the concrete standards to be produced.

Since construction and demolition waste contains different materials, it is a very important requirement to separate the material that will impair the quality before coming to the factory, and to ship only the appropriate material. In other words, the construction and demolition waste aggregate to be used in cement factories must have a suitable quality. Breaking, separating and sorting construction and demolition wastes are important factors that will directly affect its quality. Therefore, the use of construction and demolition wastes in the cement sector will be possible by meeting the additional investment costs for use and compensating the additional costs encountered during operation. Incentive policies should be established for this (TUBITAK MAM, 2015).

Concrete produced using recycled aggregate is called recycled aggregate concrete, Recycled Aggregate Concrete (RAC). The conversion of hardened concrete into aggregates for new concrete production is considered a higher recycling quality than concrete. There are great similarities and great differences between European countries in the way they deal with concrete products from construction and demolition waste. Almost all European countries use recycled construction waste aggregates for the roadbed and foundation layers. Other applications for replacing gravel in concrete are less demanding. However, almost every application found is implemented in many countries. Major differences between countries arise in the technical and environmental requirements for the use of recycled aggregates. Limit values are usually based on national legislation. Although national legislation and standards are gradually replaced by European standards, the interpretation of these standards is different in each country (TUBITAK MAM, 2015).

It is not possible to eliminate the amount of natural aggregate needed in the world and throughout the country by recycling. However, recycling must be a must for its contribution to Urban Regeneration and for the elimination of waste storages and fields. If the construction and demolition waste aggregates are of appropriate quality, recycled concrete aggregates are used at an optimum rate of 20% in ready-mixed concrete production (TUBITAK MAM, 2015).

In many countries, most road and highway pavements today are made of asphalt. Recycling of construction and concrete wastes is not widely used here. Recycling unbound recycled concrete on the roadbed is given priority in use for recycling concrete residues in most European Union countries. The Netherlands is at the forefront of recycling in this regard. Today, it is the policy of the Dutch government to encourage the construction industry to use recycled concrete aggregate from construction waste to replace natural aggregates by up to 20%. Dutch government policies have been a major impetus for a private industry in the Netherlands that produces high-quality recycled aggregates from construction waste for concrete production (Lauritzen,2019).

Aggregates produced by processing construction waste concrete are called recycled concrete aggregate, Recycled Concrete Aggregate (RCA). The usage areas of aggregates obtained by recycling concrete as unbound road material (RCA) are quite common. The recycling of aggregate obtained by crushing concrete into secondary raw materials for use as unbound road material, infrastructure or fill is generally used all over the world. Depending on the particle size, recycled aggregates from construction waste can be used in road construction as a substitute for natural sand or stone as subgrade fill, pavements or under buildings. (Dündar, 2021)

When processed concrete and masonry materials become waste; It is used in many places for filling purposes. It is widely used in works such as filling pits, filling the infrastructure during road construction, making platforms in mine sites and solid waste storage areas for adjusting and raising elevations, leveling for canals, building constructions, leveling in large construction sites. Again, especially municipalities can use crushed concrete materials in infrastructure works and in construction sites, pavements, roads and parks they make for level adjustment. (Osmani & Villoria-Sáez, 2019).

Aggregates used for filling may differ in size, type, material and composition. The technical quality of the waste material is considered less critical than in other applications. Because this application does not act as a carrier, it is mostly seen as a low standard but working application. Since the aggregates obtained from this waste become a part of the sub-soil and may affect the quality of the surrounding soil and groundwater as a result of the infiltration of rainwater, it should not contain hazardous waste for both human health and the environment. The typical production facility of material to be obtained from construction and demolition waste consists of a crusher, belt and sieve system, depending on the required quality. Unlike primary aggregate production plants, secondary aggregates are normally produced with mobile crushers. For on-site use of recycled materials, it is preferred in terms of logistics and economy, in large demolition works, since the crushing plants are located in the demolition area or in an area close to the demolition area and the use area of aggregates. The following figure shows (Figure 3.8) the flowchart of a typically construction and demolition waste recycling facility.

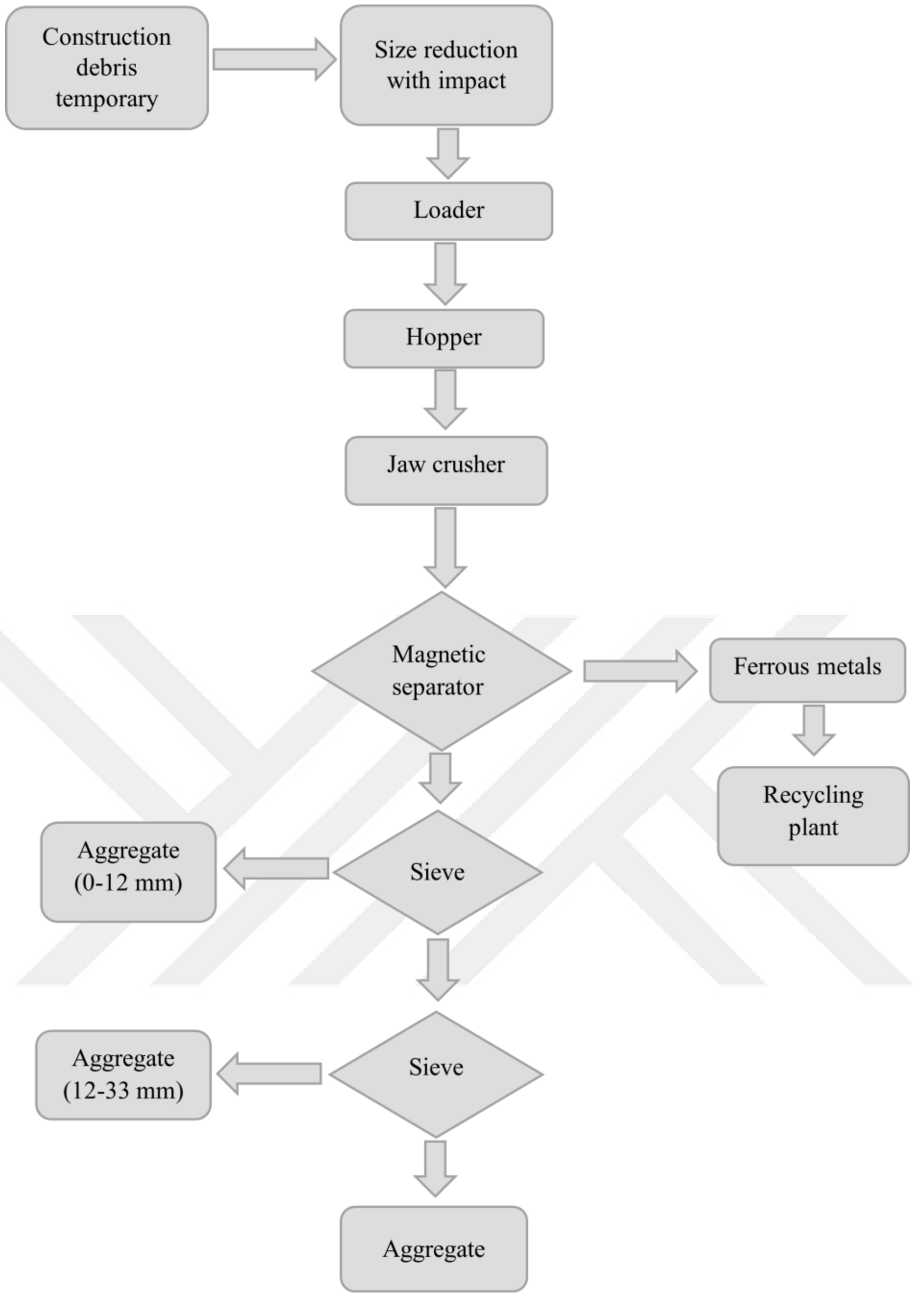

Figure 3.8 Typical flow chart of a C&D waste recycling plant (ISTAC, 2019)

Concrete recycling requires tailored solutions to create a sustainable and profitable market. For this, affordability, knowledge, training and quality of materials are critical. In market economy conditions, the choice between recycled materials and natural materials depends on price and quality. Concrete with aggregates from recycled materials may have the same quality as concrete with natural aggregates, but recycled concrete aggregates are viewed with suspicion. Therefore, recycled concrete materials are unfortunately not easily preferred due to this bias, even if the price of such aggregates is much more affordable than natural materials, even if the recycled aggregates meet the given criteria. Where natural resources are plentiful and close, the processing of natural aggregates, waste concrete, can be simpler and cheaper than recycled aggregates. Because natural raw material is easily obtained, it is more homogeneous and does not contain pollution. The cost of natural materials used in construction, such as sand, gravel and aggregate, depends on production costs and transportation costs. The use of recycled aggregates is more attractive in areas where natural resources are scarce and far from natural resources.

There are a number of technical requirements and standards for the general use of aggregates in Europe. In addition, only a few specifications and standards have been developed specifically for the use of recycled aggregates. Classes of application are limited, although some national or local standards exist. They also vary greatly from country to country and even at the regional level. These standards are often drawn up in the national language, making it difficult to act jointly in Europe. The biggest reason that makes it difficult to set a common standard is the material and quality differences in recycled aggregates (Lauritzen, 2019).

3.4.2. Recycling of Masonry Materials

Masonry materials, whether reinforced concrete or masonry, are widely used in masonry works in constructions. Most brick and tile products are potentially quite recyclable. Bricks, tiles, wall plates and tiles can be recycled in different ways. Looking at the brick, wall, tile and tile recycling hierarchy, the order is reuse, recycling, recovery. The reuse of bricks, masonry elements and tiles should be considered first. In new products, broken bricks and tiles that cannot be reused are crumbled, broken; bound or unbound can be recycled. Or it can be used as a filler, in landscaping and wall construction works.

According to the results of laboratory and industrial scale experimental studies using brick and tile waste, if 30-35% of brick and tile waste is substituted for brick and tile raw material, no problem occurs in the brick and tile production process. In this case, brick and tile waste allows to be mixed with clay directly without requiring any pre-treatment (Tubitak Mam, 2015).

The figure below shows (Figure 3.9) the recycling of brick and tile waste and the cyclical zero waste process.

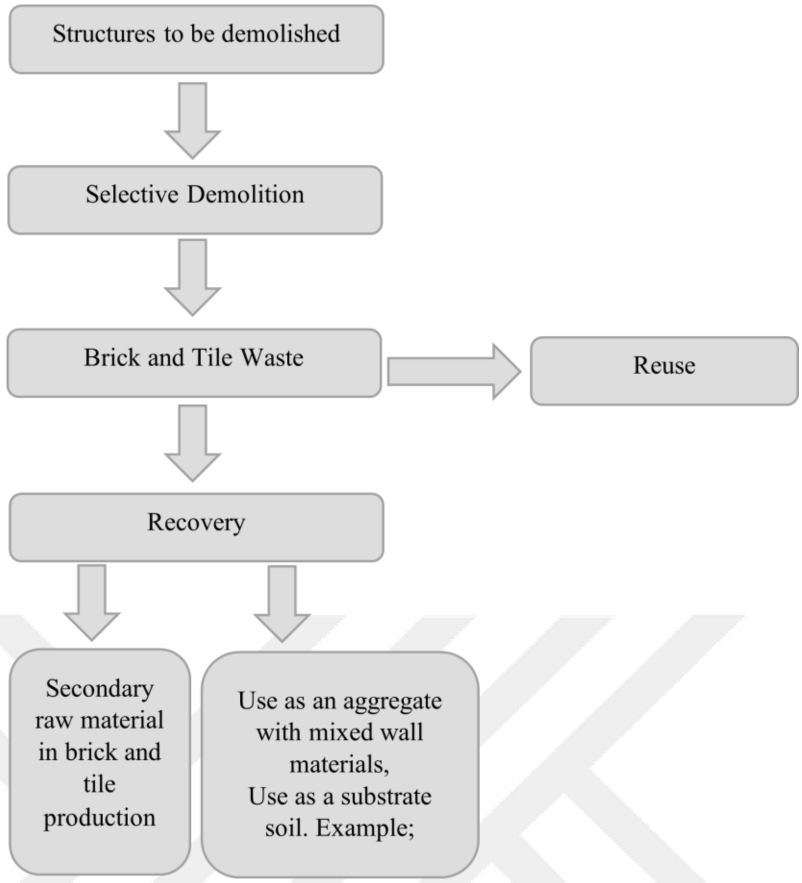

Figure 3.9 Recycling of brick and tile and zero waste approach (ISTAC, 2019)

It is possible to reuse all bricks, roof tiles and slabs after demolition of the structure. However, bricks and tiles can be recycled as raw materials to produce secondary raw materials. It can also be used as aggregate in the production of new concrete. It can also be used as unbound road infrastructure filling material after processing. As other applications, it can be used as infrastructure material in cat litter, tennis court underlay, walking paths and playgrounds. As filler, building foundations, landscaping, etc. In places, in addition to the direct use of crushed bricks as backfill, waste bricks can also be mixed into the soil due to its moisture-retention properties to reduce the water content of the soil and improve its compaction properties. The figure below shows (Figure 3.10) the recycling of mixed wall waste and the cyclical zero waste process.

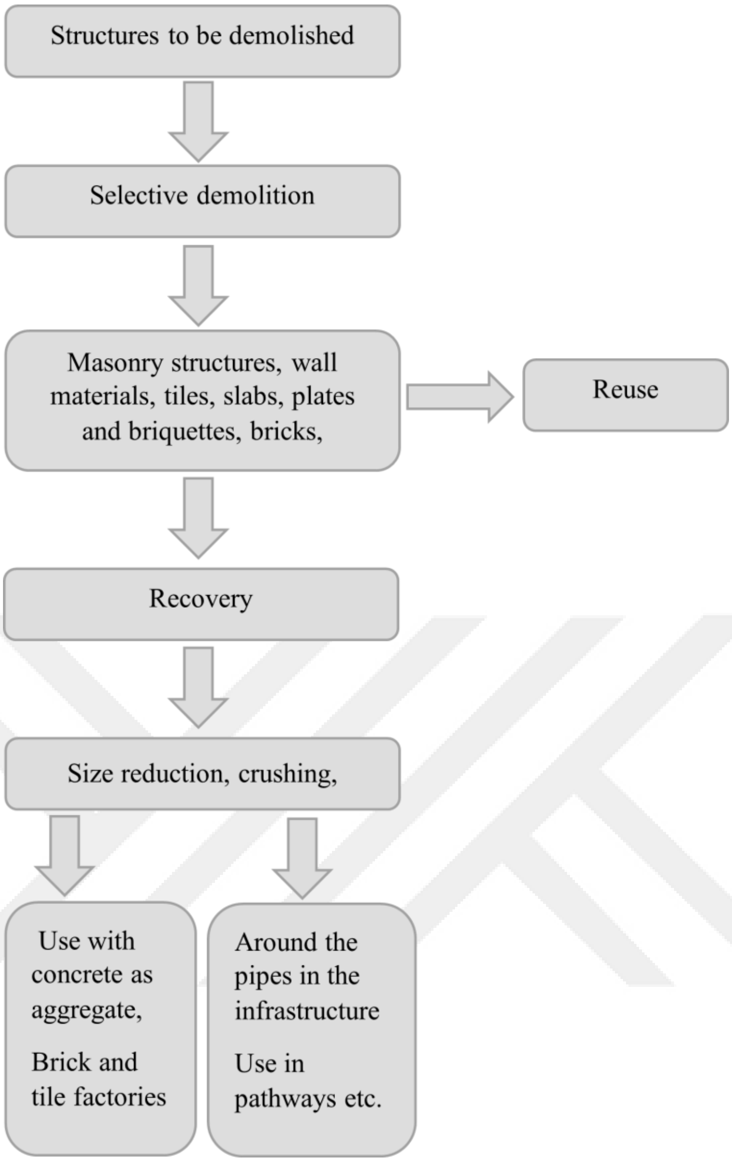

Figure 3.10 Mixed wall waste recycling and cyclic zero waste (ISTAC, 2019)

Mixed wall materials can be recycled with ceramics, briquettes, concrete and bricks, and they can be used again for the same purpose by making various additives. In addition, used ceramic pieces are broken and recycled together with the glass, used for countertop production, as decorative material, etc. used for the purposes. Along with these, used marble and other natural stones are classified and recycled and used in pavements, floors, decorative products and walls, etc. It can be used for other purposes (Kılıç, 2012).

Manual cleaning of all bricks, separation after demolition, as well as chipping and reuse has been a common practice throughout the ages. Today, manual cleaning of bricks is neither economically viable nor environmentally viable. Another important issue is that the bricks can be easily and properly separated from each other from the walls built with only lime mortar. It is not easy to separate the brick structure from the cement mortar for cleaning. If all bricks are reused, it will also show that all tiles and slabs can be reused. However, this needs to be evaluated from an engineering, technical and economic point of view. This kind of reuse requires some sensitivities. First, tiles, briquettes, tiles and slabs must be carefully separated from buildings by selective demolition.

Many brick, briquette and tile products are potentially recyclable. Crushed clay bricks, piece briquettes, tiles and other masonry materials can be used as aggregates in concrete. When used, it replaces crushed materials and other raw materials such as sand. Crushed clay bricks and other masonry materials can also be used in infrastructure work, to level and fill pits around transmission line pipes. These materials are considered the most effective and efficient when used in brick, briquette or tile factories for recycling purposes. These recycling materials can be mixed with organic materials into the compost and are particularly suitable for green roof applications. The porosity of these recycled materials provides moisture during dry periods and is beneficial for plants. In addition, broken bricks and tiles can be filled especially in wet areas such as fields and small pathways and can be used as stable materials.

The cost of sub-base materials prepared with both concrete block shards and mixed construction and demolition waste was found to be lower than the cost of foundation prepared with limestone aggregate. In addition, it has been calculated that mixed construction and demolition waste materials can be used as asphalt sub-base material at an optimum rate of 50-55% (TUBITAK MAM, 2015).

A mixture of brick, briquette and concrete is widely used. This mixed material has high strength. It can be used in very wet/wet conditions and offers good support for temporary roads. In general, pure crushed brick has better properties than briquettes and tiles. For this reason, it was decided to produce mixed material instead of separating the waste into pure components in recycling centers. When bricks recovered from demolition are industrially cleaned, reused bricks can be sold for the price of a medium quality new brick, provided appropriate logistics and brick supply are provided. Bricks that are cleaned by hand and are almost brand new are much more expensive. The market for reused tiles is much narrower. Because the tiles are very diverse, the individual demands for tiles are much less (Lauritzen, 2019).

3.4.3. Recycling of Timber Materials

Timber waste materials can be partially recycled. Many timber waste products can be reused in available sizes and shapes. The cleaned and nail-free timber boards can be reused in new construction. Uncontaminated timber can be used in the manufacture of veneer and panel boards, and for decorative purposes in gardening and outdoors, or redesigned to use parquet boards. However, large quantities of painted and impregnated timber from demolition are considered contaminated material and such timber materials are not designed and reused as products, as they are viewed as chemical or hazardous waste due to risks from water seepage.
Again, if timber coating is used in masonry structures, especially on the roof, a very significant amount of timber is used in mass. It is possible to reuse timber waste to a certain extent if selective demolition is carried out. In Urban Regeneration, timber, which is decomposed at the source in accordance with the selective demolition processes after demolition, can be reused to a certain extent. If non-reusable timber waste is managed according to zero-waste processes, it is recovered to a large extent and energy is gained by burning the waste timber, which has no possibility to be reused.

As long as there is no decay in timber materials and it is not mixed with hazardous wastes, the opportunity to be evaluated is very wide and it is always possible to recycle it to a large extent. In our country, timber materials, which are mostly recovered from construction and demolition waste, are used as fuel, such as timber and coal. However, the possibilities of using these timber materials in construction and demolition waste are quite wide, and municipalities can produce very different projects on these issues. They can be used in shelters for stray animals, fences, landscaping, and decorative works, especially in green areas. The figure below shows (Figure 3.11) how timber waste in masonry structures can be recycled and how the cyclical zero waste process will work (Choiriyah, 2017).

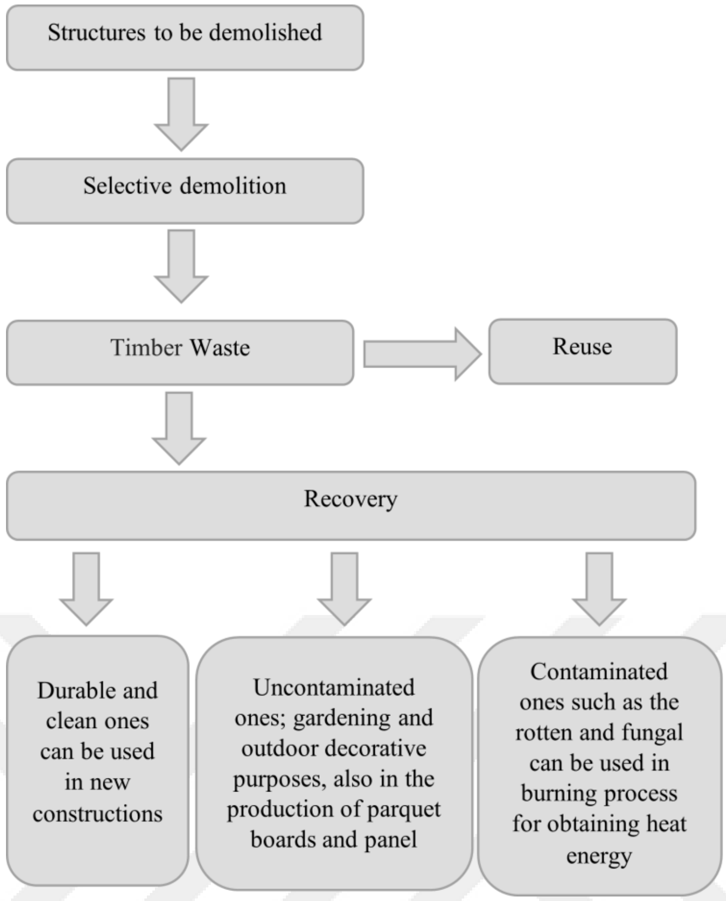

Figure 3.11 Timber waste recycling and cyclic zero waste (ISTAC, 2019)

3.4.4. Recycling of Metals

In the construction of the building, construction iron and steel are used together with concrete in the carrier system. In buildings destroyed in Urban Regeneration, these iron/steel and other metals are recovered. Recycling of metals has always been possible throughout history, as it has a serious economic return. Therefore, no public support is required to encourage this recycling. Highly processed non-ferrous metals, particularly non-reusable ferrous metals such as aluminum, copper and steel, are recycled.

In general, the recycling of metals, construction steel, roofing plates, etc. As reused metal tools, some other metals found in structures can be reused with a few minor operations. All metals, scrapped steel, aluminum and copper, which cannot be used with a few processes, are recycled 100%. The figure below shows (Figure 3.12) the recycling of iron and other metal wastes and the zero-waste process due to the cyclical structure.

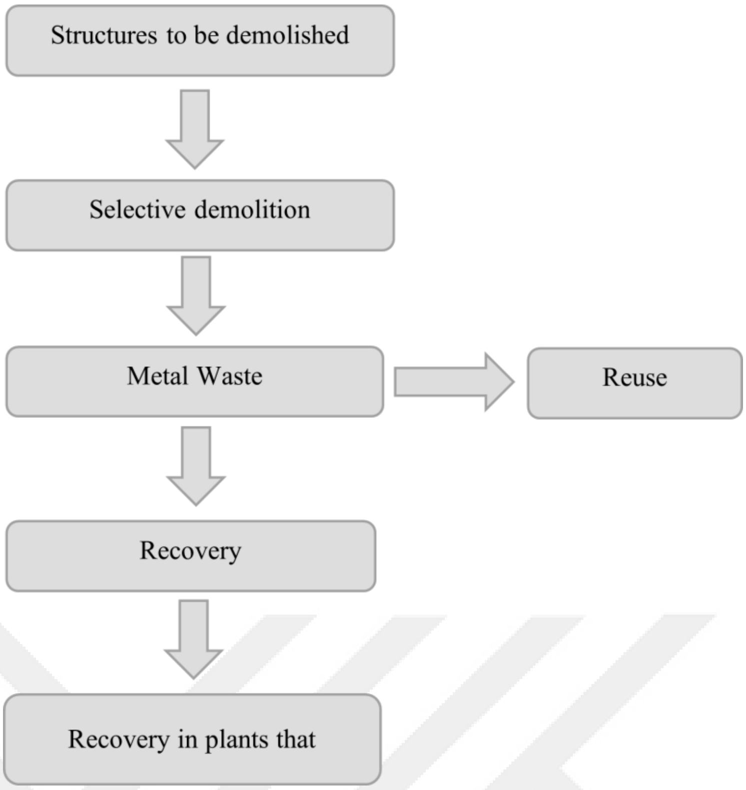

Figure 3.12 Metal waste recycling and cyclic zero waste (ISTAC, 2019)

The reuse of iron materials, machines in industrial plants depends on the actual situation and the demand in the market. The prices of scrap steel and metals depend on the political and economic situation and on the very volatile world market for that matter. From time to time, it is seen that the prices change significantly. Between 2018 and 2022, the price of metal in our country broke records one after the other and showed great increases. While 1 ton of metal was 2660 TL on average in January 2018, it is around 11000 TL in January 2022. Therefore, the price of demolition of industrial facilities with a high content of steel and metal depends on the price of scrap and the risk of prices falling and increasing during the progress of the demolition work. This is why demolition contractors focus on scrap metal recovery or prefer to store scrap metal and wait for better prices before selling scrap metal. There is generally no problem in the recycling of metals, they are collected by scrap dealers and sold to facilities that process these metals.

3.4.5. Recycling Other Materials

Many materials are used in buildings for different purposes. Concrete, steel, joinery, gypsum, glass and plastics are the leading ones. It is more possible to recycle these materials if they are separated and classified at the source at the construction site by selective destruction. The demolitions made or to be made in the process of Urban Regeneration are pre-planned demolitions. Different materials with economic value are used in demolished structures. Each of these different materials must be evaluated and recycled in an environmentally sensitive manner, without wasting resources and in order to provide economic recovery.

Glass represents approximately 0.66% of the annual construction and demolition waste production in the EU, according to 2011 data. Approximately 2.6 million tons of waste glass is generated per year, compared to 400 million tons of construction and demolition waste. These waste glass from buildings can be reused and recovered for the production of glass or insulating materials. However, glass in most construction and demolition waste is often mixed with other building materials and sent to landfills (Lauritzen, 2019).

Recovering glass for the production of low-quality glass or for the production of insulating materials (such as glass wool) requires careful cleaning of the glass as glass manufacturing plants are very sensitive to mineral purity. Glass wastes from constructions can be delivered to glass factories for recycling, in agreement with authorized organizations that collect glass waste. The use of glass in buildings is used in many ways, depending on the type of building, the frame materials used, the frame dimensions, the design and the fulfillment of different needs (Accorsi et al., 2015).

The following figure shows (Figure 3.13) the recycling of glass waste, the zero-waste process of the Ministry of Environment, Urbanization and Climate Change, which is connected to the cyclical structure. Although it is not done much, it is possible to recover when recovery-oriented studies are carried out as it is knitted. However, when the glass is in situ and when selective demolition and collection is carried out, nearly 100% is collected or received by authorized organizations and recovered from glass production factories. There is a legal infrastructure in this regard in our country, and municipalities and the Provincial Directorate of Environment, Urbanization and Climate Change can ensure the recycling of waste glass formed in all areas, especially in Urban Regeneration, if they make an agreement with the authorized institution on this subject.

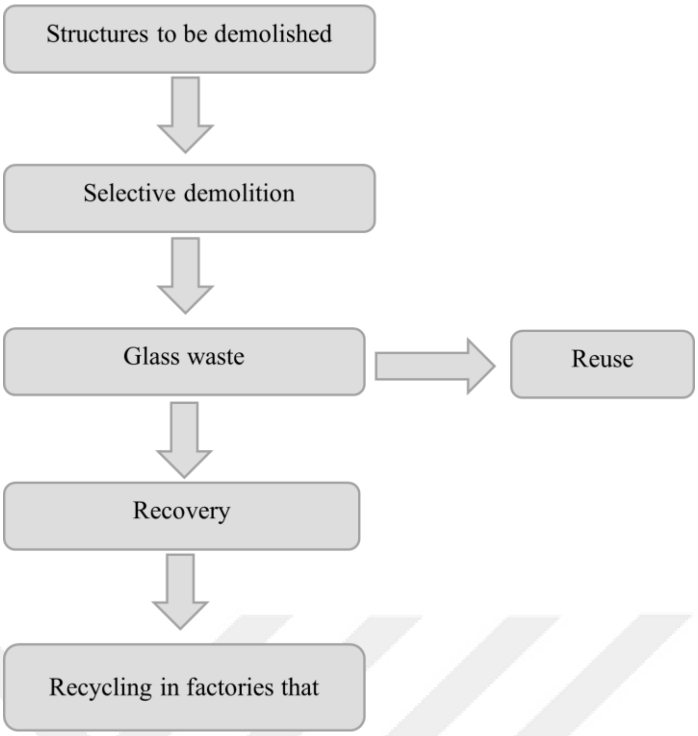

Figure 3.13 Glass waste recycling and cyclic zero waste (ISTAC, 2019)

Natural gypsum is a rock that is commonly found almost everywhere. It is abundant in Türkiye and is produced by underground mining activities. Gypsum is mainly used in the manufacture of non-load-bearing structural elements to open the ceiling and divide the interior and to use visuality in areas such as walls and exteriors. For this reason, the gypsum industry is mainly used in new and already renovated housing, according to demand, after the construction activity is completed. The recycling flow process of the collected drywall takes place after a few steps. First, the paper layers of the gypsum boards are separated and removed as much as possible, then ground into gypsum powder, which is eventually returned to gypsum board manufacturers, where new gypsum boards can be produced.

It is estimated that the gypsum powder obtained by this method represents approximately 94% of the total drywall waste collected. The remaining 6% remains in the paper and cardboard that make up the plasterboards and can be used in compost plants (Lauritzen, 2019).

Recycling is dependent on specific national legislation, civic awareness, environmental awareness and, in particular, the existence of a market and waste market to encourage economic activity associated with recycling. The figure below shows (Figure 3.14) the recycling of gypsum waste and the cyclical zero waste process.

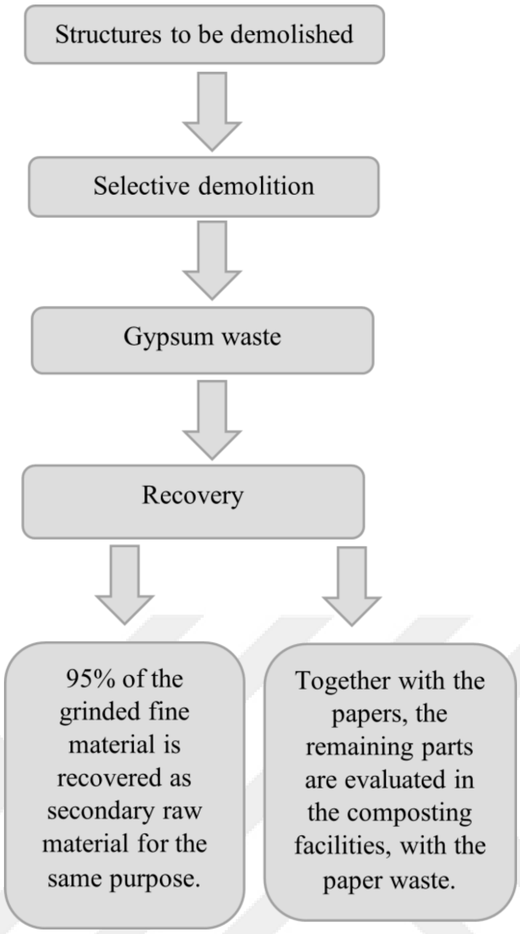

Figure 3.14 Recycling of gypsum waste and zero waste cycle approach (ISTAC, 2019)

The use of plastics is increasing day by day in the world. Depending on the increasing use of plastic and plastic product materials, the amount of plastic waste is also increasing. This makes it necessary to recycle plastic materials. However, reasons such as different types of plastics, changing recycling processes and dirty waste plastic materials make it difficult to recycle plastics (Browne et al., 2013).

Opportunities for reuse, market finding and marketing of plastic waste are limited. If a system is established where those who produce these products directly take them back, the reduction, collection and recycling of these wastes will be healthier and easier. In fact, other manufacturers of building products, such as metal, glass, timber and drywall, are also slowly accepting the idea of take-back and are buying their own products for reuse as raw materials (Kayılı & Çelebi, 2020).

If this understanding is made to be accepted by plastic material manufacturers and companies producing all other products, the marketing problem of wastes can be solved to a large extent.

Recycling is easier when recycling is made economical and easier. However, recycling should not be done only on the basis of economic calculations, environmental sensitivities and not wasting resources should always be at the forefront.

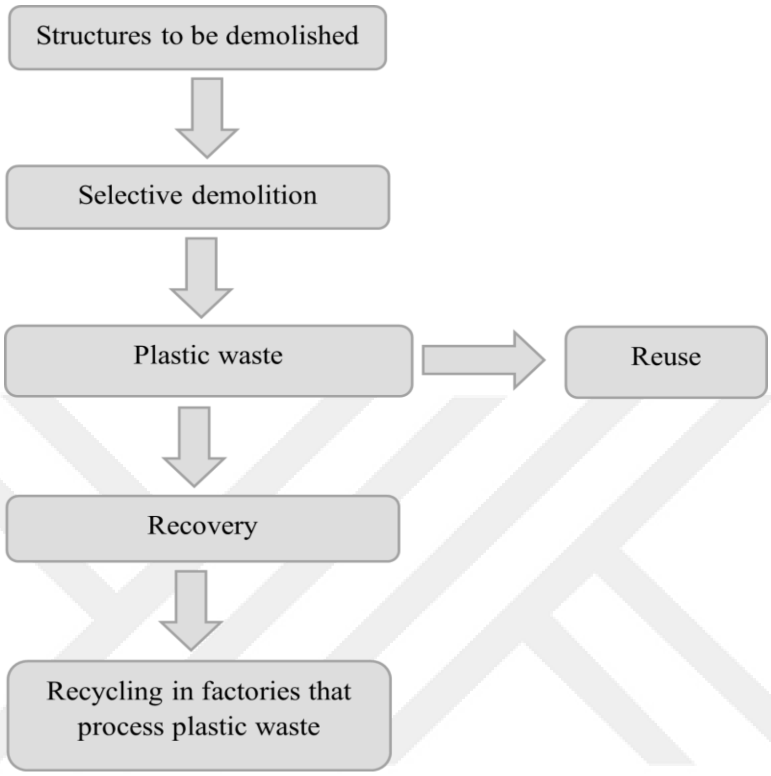

Figure 3.15 Plastic Waste recycling and a cyclic zero waste approach (ISTAC, 2019)

The figure above shows (Figure 3.15) the recycling of plastic waste and the zero-waste process based on the circular structure. In the process of Urban Regeneration, many kinds of materials and goods emerge in the buildings to be demolished. Many demolition companies do not recycle materials (except metal) and other miscellaneous items found at the demolition site. These include materials such as faucets, modern-day sinks, kitchens, fireplaces, ovens, shower stalls, hot water units, timber beams, skirting boards, floorboards, kitchen and cloakroom, cabinets, windows, doors and windows. In Türkiye, such materials are frequently used by scrap dealers and small-scale renovation companies. (Güllü, 2022)

As explained above, in this section, things to be done regarding the management of construction and demolition waste before, during and after the demolition, depending on the Urban Regeneration studies over the Elazig/Sivrice earthquake, are presented. By expressing these processes in figures, it has been revealed how the management model should be in the management business processes of Urban Regeneration wastes in municipalities. Afterwards, the separation, recovery and recycling of urban regeneration wastes are explained in separate tables depending on the zero waste life cycle processes. In terms of efficient use of resources, protection of human health and the environment, all these are also valid for all other municipalities whenever and wherever the demolition of buildings is concerned.

CHAPTER-4

ECONOMICAL EVALUATION OF URBAN REGENERATION

The problems related to the environment, which covers everything around the human habitat and is one of the necessary environments for the continuation of human life, are increasing day by day and are threatening both nature and the life and health of all humanity. In recent years, with the increase in population and the rapid decrease in natural resources, the importance given to human and environmental problems has been increasing rapidly due to global climate changes.

With the increase in environmental problems, environmental destructions are also increasing at the same speed, and humans are the first and most important responsible for these destructions. With globalization, there is a rapid change process in scientific and technological terms. Although it is the people who cause the most environmental destruction and are the most affected, it is the human being who has the technological and scientific infrastructure to be used for the restoration of the environment. Although the natural environment has a self-renewing feature, it is getting more and more difficult for the environment, which has subsequently been degraded by man, to restore itself. Although there is a lot of training and awareness-raising work on environmental problems, even if some laws and regulations are enacted and some international agreements are signed; The biggest problem is that these studies are not very effective and sufficient in terms of reducing the destructive effects of environmental problems, especially global warming.

Today, the emerging economies of Latin America and Asia have transitioned to more intense industrialization and are built with structures and systems that require large-scale energy, mineral and metal other non-renewable resources such as buildings, airports, railways, water and sewer systems, electricity networks, irrigation channels and other infrastructure elements. they are doing. Air, soil and water environments are affected to a certain extent during and after the construction of these structures. The unending material demand of industrialized countries, the speed of development of growing economies and the habit of using and throwing materials in modern life bring along problems (Worldwatch Institute, 2013). Climatic changes such as global warming in the world and rapid population growth etc. The depletion of natural resources with many effects such as the fact that wastes should be used more efficiently has revealed the fact that wastes should be used more efficiently, and the concept of recycling has started to spread rapidly with the efforts of governments to increase environmental awareness in recent years. With the full and effective use of products produced from limited natural resources, the interest in studies for re-use or consumption of products and resources, which have become unusable in their first form, by undergoing some chemical, physical or certain processes, or for consumption for a different purpose, is increasing rapidly. To meet the needs of the market with lower costs and to market better quality products; on the other hand, the desire of consumers to have higher quality products at a lower price has highlighted the reuse of products through recycling practices.

The modern disposable economy wastes not only the materials themselves but also the energy used in the production of these materials in the production, operation and discharge processes of materials. Industrial production, including the production of plastics, fertilizers, cement, steel and paper, accounts for more than 30% of global energy consumption. In the automotive, construction, electrical appliances, steel industry, petrochemical, cement and transportation sectors, energy consumption can be reduced by making use of the most efficient production systems as well as recycling. Making designs that will allow paper products, plastic, glass, building materials, automobiles, electrical appliances, household waste, office supplies, diesel engines, airplanes, computers, clothing, and other products to be easily disassembled for reuse or recycling. It plays an important role in returning the CO_2 level to its stable period (Brown, 2008). Although recycling seems to be a new concept in the literature, it is known that its history dates back to the 1900s. Concept, II. After the World War II, it started to be understood, albeit slowly, with the depletion of resources and the pollution of the environment (Brown et al., 2008).

Since the 1970s, many studies have been carried out around the world to prevent or reduce the generation of waste in general, as well as to reuse through recovery or recycling. Since the construction sector is an important driving sector for the economy, it is estimated that the damage caused to the economy by the inaccuracy of the construction and demolition wastes will be enormous. As with all solid wastes, if the wastes arising from construction and demolition wastes are not recycled, ecological destruction will accelerate in addition to economic losses. In recycling, professional companies are used for the collection, separation, recycling and reuse of materials. In order to prevent the waste of resources and the emerging energy crisis, developed countries have sought various methods for the recovery and reuse of wastes and developed new technologies. Unfortunately, compared to other developed countries, the amount of recycling in the construction industry is almost negligible, except for construction steel/iron products (İpekçi, 2017).

Although the construction sector contributes 9.8% to the economy of the European Union, construction and demolition wastes cause economic and environmental damage. Construction and demolition wastes occupy a larger space and area in volume than domestic wastes. II in Europe. After the World War II, activities related to construction and demolition waste started and accelerated with the globalization process of the world. Almost all European countries, especially England and Germany, are based on Waste Management Agency regulations regarding recycling, and these regulations include methods and regulations that include technological and environmental factors. It is estimated that 175-370 million tons or 0.5-1 tons/person/year of construction/wreckage waste is generated annually during construction/wreckage and rehabilitation works in European countries (Ölmez, & Yıldız, 2008). Metals and timber materials are in the first place among the construction and demolition wastes that are recycled and recovered in our country. It has been determined that most countries such as China, India, and Hong Kong utilize the increased construction and demolition wastes with the growth in the construction sectors, and they recover to a large extent. It has developed new strategies for sustainable recycling and a sustainable world by taking Europe and the USA's sense of responsibility about recycling seriously in other countries around the world (Altındağ, 2011).

It occurred in 1992 Erzincan, 1995 Dinar, 1998 Adana-Ceyhan, 17 August 1999 Marmara, 12 November 1999 Düzce, 2002 Afyon-Sultandagi, 2003 Bingöl, 2011 Kütahya-Simav and Van, 2020 Elazığ/Sivrice and finally in 2020. After the İzmir earthquakes that took place, a serious construction collapse occurred, and also buildings that were not destroyed in the earthquake but were seriously damaged.

The pictures below (Figure 4.1) show two buildings that were damaged and need to be demolished in the Elazig/Sivrice and Izmir earthquakes, which are among the most recent major earthquakes. The data and information obtained after the earthquakes revealed that the existing building stock of Türkiye is insufficient against the expected earthquakes (Alyamaç, 2020).

After these earthquakes, various scientific studies were carried out to increase the strength of the building, the building design criteria were changed, and various regulations and standards were revised. Efforts to make existing buildings comply with the design criteria in the constantly renewed standards and regulations continue, taking into account the national economy. In our country, the regions where there are serious economic activities, large population density and serious energy investments are also located in the earthquake zone. Earthquakes in these regions in the past caused many loss of life and property in the country and even showed itself as an important parameter in the occurrence of economic crises (Fırat & Soyu, 2014). For these reasons, buildings that are currently used but do not comply with the relevant standards, which are obviously weak despite the danger of earthquakes or natural disasters, need to be strengthened or demolished and rebuilt in order to increase their resistance against natural disasters. It is an apparent fact that this will result in serious construction and demolition waste. The debris formed in the Elazig and Izmir earthquakes is shown in the pictures below. (Figure 4.1)

(a)

(b)

Figure 4.1 Structures damaged after earthquakes a) a masonry building after the Elazig earthquake, b) a reinforced concrete structure after the Izmir earthquake

Recently, many projects have started to be implemented for the purpose of Urban Regeneration in our country. Urban regeneration, it can be defined as all of the strategies and actions applied to improve the economic, social, physical and environmental conditions of the problematic urban area that is aging or deteriorating or is predicted to be exposed in the near future, which is weak against any natural disaster that may occur. It covers the activities carried out for the purpose of renewal, improvement and rehabilitation in the areas of the settlement that have lost their intended use or in the slum areas, where the city is likely to be damaged by any natural disaster. In addition, in Figure 4.2, there are images taken from the Elazig/Sürsürü-2 Urban Regeneration project, and the old, ruined, unstable buildings and unplanned urbanization have been replaced by a more robust, healthy, safe and orderly city appearance with the regeneration. After the Urban Regeneration, a very serious amount of construction and demolition waste will emerge. In our country, "Regulation on Control of Excavated Soil, Construction and Demolition Wastes" was published in the Official Gazette dated March 18, 2004 and numbered 406, in order to prevent the accumulation or random disposal of construction and demolition wastes in a way that would harm the natural environment, and to ensure the recycling of these materials. For example, the materials obtained from the wastes of demolished buildings in Istanbul, where many Urban Regenerations are planned by the Ministry of Environment, Urbanization and Climate Change, were used as infrastructure filling in the third airport built on a 3,500-hectare area located at the intersection of Arnavutköy-Göktürk-Çatalca roads (CSIDB, 2021).

(a) (b)

Figure 4.2 Elazig/Sürsürü-2 urban regeneration plan a) the current situation before urban regeneration b) the image of the post-urban regeneration

4.1. Recycling for the Construction Industry

The fact of meeting unlimited needs with scarce resources, which is the general definition of economics, has become an important problem in terms of efficient use of insufficient world resources today. The problem of scarcity needs to be resolved before resources run out. The problem of scarcity means insufficient supply, and the most important factor of the supply problem is raw material and cost.

The greater the amount of energy required to extract a resource, the more expensive it is to extract a resource if environmental regulations prohibit simple extraction methods, or if low-quality resources must be extensively processed to make them economically viable. The advancement of technological developments can increase the supply by reducing the cost of resource extraction, and recycling can reduce the scarcity experienced in the markets by increasing the resource supply.

With the decrease in the resources existing in nature day by day, the reuse of existing wastes as a raw material source, their conversion, re-use of processed raw materials, recycling, and the reduction and management of these wastes have brought up the issue and importance. Wastepaper recycling, metal scrap collection, deposit applications for glass bottles have been made for a long time. In fact, products and materials used in the past were reused later. However, since technology was not as developed as it is today, the reuse of the products used at that time could be done with limited opportunities. With globalization, technological innovations have increased rapidly, recycling opportunities and methods have spread over a wide area.

Waste can be defined as any unwanted liquid, solid, gas or radioactive substance that is discharged to the environment in an amount that will adversely affect the nature. (Bayramoğlu, 1995) Wastes are harmful and harmless wastes in terms of their effects on the environment; liquid, solid, gaseous wastes according to their structure; According to their sources, they can be classified as domestic, industrial, commercial, institutional, agricultural and special wastes (ISTAC, 2007).

The concepts of recycling and recovery are defined in the Waste Management Regulation of the Ministry of Environment, Urbanization and Climate Change published in the Official Gazette dated April 2, 2015 and numbered 29314. According to this regulation: "Recycling: Any process where wastes are processed into products, materials or substances for their original use or other purposes, including the reprocessing of organic materials, excluding energy recovery and use as fuel or reprocessing of waste for filling purposes. a recovery process; Recycling: It is the preparation of wastes for a useful purpose in order to replace the materials used in the market or in a facility." In recycling, products completely lose their properties, and activities such as product renewal, product repair, product reuse, product re-production ensure that the properties and functions of used products are preserved.

Waste management, starting with the prevention of the formation of waste products at the source, reducing waste in unavoidable situations, ensuring its usability in the same source, collection, selective separation according to type, temporary collection, transportation of these collected wastes to relevant places, recycling and reuse, recovery, destruction includes inspection activities after the destruction process. Recyclable wastes are primarily separated from the source and the usable parts of the products or packages are collected during the product take-back process. The parts that make up the components of the products are grouped by the disassembly process and classified among the wastes (such as glass, plastic and paper). Inventory control is carried out for the returned products, and a new material is produced by changing the materials to be recycled chemically and physically. Thus, economic gain is achieved by using recycled products (Guide et al., 1999).

Table 4.1 Energy savings by recovery compared to primary (TOKI, 2021)

Metal/Material	Energy Saving (%)
Aluminum	95
Copper	85
Iron and Steel	74
Bullet	65
Zinc	60
Paper	64
Plastic	>80
Timber	75

Almost 35-40% of our country's economy is obtained from the construction sector, and the construction sector has an important place in ensuring economic development and sustainable employment, and it is a sector that is the locomotive of growth in a country's economy. Therefore, the more developed and efficient the construction sector in a country, the more its contribution to economic growth will be. Especially in a developing country, the whole construction sector, especially the construction material industry, will be affected significantly by the cyclical fluctuations. The construction sector and its practices will be directly affected by all economic policy changes in the country. In addition, the construction sector has various investment opportunities in terms of heavy industry. As can be seen in the figure above, these materials provide a high rate of energy recovery. (Figure 4.1) Construction materials also directly affect almost the entire industry. One of the sectors where raw materials are consumed the most is the construction sector. The construction sector, like other sectors, tries to minimize the cost of the inputs in the manufacturing processes economically, to reduce the use of raw materials, the consumption of workers, employers and energy as much as possible. Materials such as concrete, asphalt, timber, aluminum, iron and insulation come at the beginning of the most used materials in the construction sector. These materials are the main materials widely used in the construction industry and their recycling and recovery amounts are quite high. From this point of view, it is seen that recycling within the relationship of demand and consumption will provide a significant economic resource, especially when applied widely in the field of construction. Although all kinds of construction activities such as dams, hydroelectric power plants, nuclear energy facilities, ports, sea embankments, canals, bridges, skyscrapers, buildings, roads, tunnels, subways affect the country's economy positively, they seriously damage the natural environment. (Coşkun et al., 2017)

Recently, especially with the increase in environmental effects, the control of solid wastes has become an important problem that all countries focus on. Construction and demolition wastes, which constitute an important part of urban solid wastes, such as 20-35% by volume, will cause great harm to both civilization and the environment unless they are brought under control. (Ölmez & Yıldız, 2008) It is clearly seen that materials such as concrete, steel, brick, timber, plaster, glass, metals, plastics and excavation soil have a significant percentage in all solid wastes (Coşkun & Öztürk, 2012). Construction and demolition wastes are formed as a result of the construction, repair, modification, renewal, demolition of bridges, roads, houses and similar structures or natural disasters such as earthquakes.

Steel is one of the most efficient and financially rewarding materials in the construction industry in terms of recycling. According to the data of the Turkish Iron and Steel Producers Association, Türkiye imports around 17 billion dollars of steel raw materials annually, of which 11 billion dollars is iron and steel scrap and 4 billion dollars is iron ore. The Turkish iron and steel industry imports 70% of the scrap it uses as raw material and procures 30% from domestic sources. Likewise, 60% of the iron ore to be used as raw material is imported, 40% is domestic. At this rate, it shows that only the recycling in the iron and steel industry meets 72% of the sector's needs in Türkiye on average. About half of the steel produced is also exported ($17 billion). (World Steel Assocoiation)

4.2. Developments Related to Recycling in the World and in Türkiye

Countries place great emphasis on solid waste laws and regulations in sustainable development with regard to the protection of energy and raw materials. Among these regulations, there is also the issue of evaluating the rubble wastes generated after construction and construction. These recycled wastes will be reused in almost all kinds of constructions, thus protecting the environment and making a positive contribution to the country's economy (Erdin, 2022). Recently, there are different practices in construction and demolition waste management in both developed and developing countries. Many recycling policies have been tried to be implemented in the European Union and these practices have been supported by other countries. In the 2001 Gothenburg European Council, EU Countries targeted “A Sustainable Europe for a Better World and a European Strategy for Sustainable Development”. The long-term goal of the “EU Sustainable Development Strategy” has been determined as “to ensure that Europe and even the world become a society that recycles, prevents waste and reuses waste” (Ministry of Industry and Technology, 2014).

Table 4.2 Amount of construction and demolition waste produced in EU countries (Osmani, 2019)

Countries	Construction and Demolition Waste (Million Tons)	Construction and Demolition Waste (kg/person/year)	Recycled or Reused Used (%)	Incineration and Storage (%)
Germany	59	750	17	**83**
England	30	530	45	**55**
France	24	420	15	**85**
Italy	20	350	9	**91**
Spain	13	340	<5	**>95**
Holland	4	270	90	**10**
Belgium	7	700	87	**13**
Austria	5	650	41	**59**
Portugal	3	300	<5	**>95**
Denmark	3	575	81	**19**
Greece	2	200	<5	**>95**
Switzerland	2	240	21	**79**
Finland	1	200	45	**55**
Ireland	1	285	<5	**>95**
Luxembourg	0	-	n/a	**n/a**
AT	**180**	**28**		**72**

According to Table 4.2, while the Netherlands leads the way with 90%, Norway, Belgium and Germany stand out with their high recycling rates, and countries such as Spain, Ireland, Greece and Portugal have a recycling and reuse rate of less than 5%.

From the point of view of our country, after the recent financial crises, some economic, technological and social changes have accelerated with globalization. A new economic growth model has been implemented in our country, and new concepts have started to gain importance in these applications. One of these concepts is the recycling of construction waste. The increasing prevalence of garbage and waste in our country necessitated taking the leading countries in recycling as an example. In our country, which does not have a successful recycling history as in Europe and America, steps have been taken and the amount of waste recovered through recycling has increased in recent years. Regarding the increasing amount of waste, "waste management, waste management approach" has become an important issue. Currently, regulations regarding waste management are being made in our country and it has gained momentum in recent years.

Within the scope of the European Union's Waste Framework Directive, it is aimed to recycle 80% of construction waste by 2025. In Türkiye, 125 million excavated soils are evaluated every year within the scope of recovery activities. Currently, the amount of construction and demolition waste is estimated to be 6-7 million tons/year. With the implementation of the Law No. 6306 on the Regeneration of Areas Under Disaster Risk, the number of construction and demolition wastes will increase with the enactment of 10 million tons/year and the amount of material to be recovered, based on 40% of the annual target for the first 3 years. It is predicted that it will occur around 6 million tons/year. According to the data of the Ministry of Environment, Urbanization and Climate Change in our country, while the added value that the collection and recycling field added to the economy with 5 thousand employees in 2002 was 60 million TL, in 2013, an added value of 2.1 billion TL was provided to the economy with 60 thousand employees in this field. By 2023, the target is to reach 4 billion TL with 150 thousand employees.

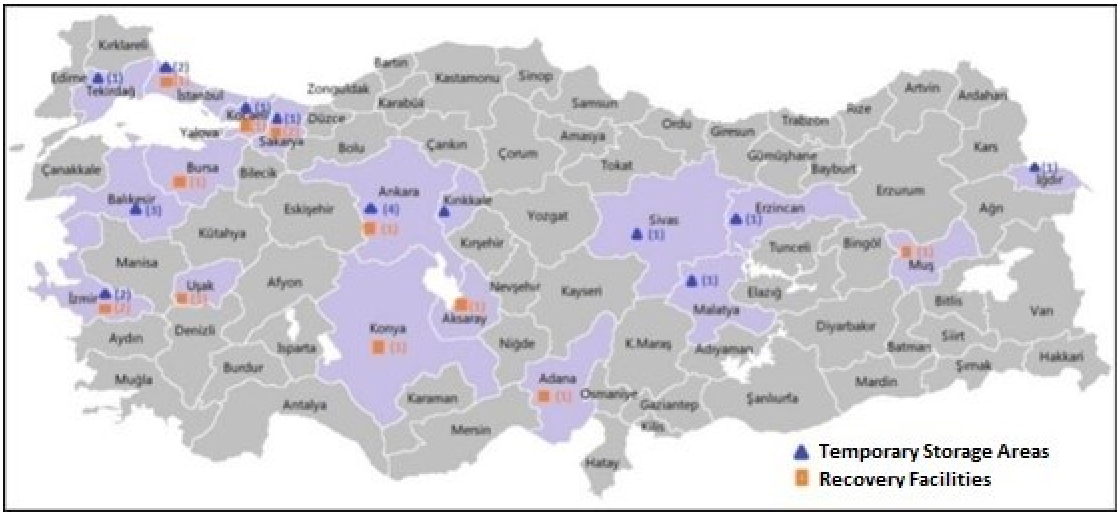

Figure 4.3 Licensed recycling facilities and temporary storage areas
(Ministry of Industry and Technology, 2014)

The Figure shows (Figure 4.3) the areas for obtaining Environmental Permit and License Certificate from the Ministry of Environment, Urbanization and Climate Change in Türkiye. It is noteworthy that licensed recycling facilities and temporary storage areas are insufficient, and it is thought that regulations should be made by the Ministry of Environment, Urbanization and Climate Change to monitor the use of recycled products and improve public use.

In order to make the economic analysis of the wastes generated in our country, first of all, the quantity of the construction elements considered for each building should be calculated. Secondly, the volume of demolition waste was calculated using these calculated quantities. Thirdly, the cost of the expenditures required for the demolition of the buildings in the Urban Regeneration area, the loading of the wastes to the trucks, their transportation to the area to be filled and the discharge of the wastes to this area have been calculated. Finally, the total cost of demolition works, loading-unloading works of construction wastes and transportation of wastes for Sürsürü Neighborhood was obtained over the item numbers and unit prices determined by the Ministry of Environment, Urbanization and Climate Change in 2022 (CSIDB, 2022).

At the stage of demolition works in the Urban Regeneration area, only the floors of the buildings, the inner and outer walls of the buildings and the garden walls remained. In the cost calculation method; The period and conditions in which it was built, the condition of the buildings and their construction systems were also taken into consideration. In this context; In the examinations made during the on-site demolition phase, the masonry and load-bearing outer wall thickness of the construction system was determined as 0.2 m. The highest building height in the Sürsürü District of the Merkez district of Elazig, where masonry structures are observed; 12 m from Ground + 3 Normal floors. In the concrete quantity taken at the building scale for the cost calculation, the floor slab was taken as the basis instead of the building foundation, and it was assumed that there was an uneaved roof slab equal to the building floor area.

Figure 4.4 An existing residence on zone 6192/1

Figure 4.4 provides data on the plan status, floor area in square meters, and number of exterior walls for both residential and commercial units across 396 building blocks. In assessing construction waste, the total floor area was calculated by doubling the floor area as the ceiling was assumed to be the same size. However, it should be noted that the floor slab is made of lean concrete, while the ceiling slab is reinforced concrete, but for the purposes of this analysis, both were treated as reinforced concrete slabs.

Figure 4.5 6192/1 Part of the zone

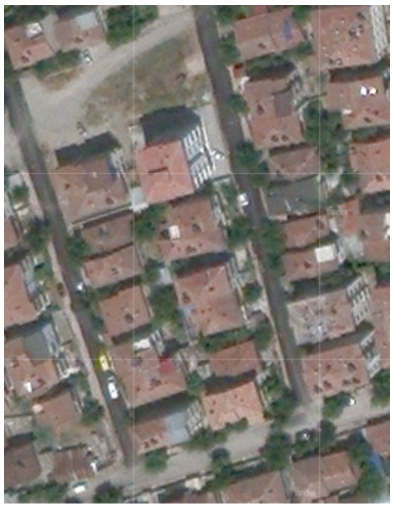

Figure 4.6 6192/1 Part of the zone

To determine the wall quantity, the sum of the outer load-bearing and inner walls of buildings was multiplied by the accepted building height of 3.00 meters. However, the dimensions of doors and windows were not factored into the calculations due to lack of information. The variations in building plans and floor heights were also taken into consideration. Figure 4.5 and Figure 4.6 depict 12 buildings and their sketches in the zoning plan, highlighting the impact of interior walls on demolition, loading-unloading, and transportation costs.

The average area of a residence in the Sürsürü neighborhood was determined using the formula x=a/b. The total floor area of all buildings in the neighborhood was divided by the total number of buildings (396) to calculate the average floor area per unit. The result was a value of 95.00 square meters.

$$\boldsymbol{x = \frac{a}{b} = \frac{37.630}{396} = 95}$$

x: Floor area of a building in Sürsürü district (m²)

a: Total area of the building (m²)

b: Total number of the units

The brick walls of masonry structures are typically 20 cm thick with an additional 5 cm of interior and exterior plaster. The waste calculation assumes a total width of 25 cm. The foundation beam is 50 cm thick and 30 cm high, while the ceiling and building floor slabs are both 30 cm thick. In the Sürsürü District, the average slab thickness is also 30 cm and the concrete density is assumed to be 2.5 tons/m³ in line with masonry building standards.

After calculating the total floor area and wall area in Sürsürü neighborhood, the waste generated from the demolition of walls and floors was considered as total construction waste. The cost of transporting this waste was then calculated. To determine the volume of concrete waste, the thickness of the concrete (0.3 m) was multiplied by the total area of floor and ceiling tiles (37.630 m²) to obtain the waste volume (11.289 tons/m³). The density of concrete was assumed to be 2.5 tons/m³.

$$y = c\ x\ hf$$

$$37.630\ x\ 0.3 = 11.289$$

y= Volume of concrete construction waste from neighborhood (ton/m³)

c: Building floor and top floor total quantity (m²)

hf: Slab thickness (m)

Next, the waste generated from external load-bearing and non-load bearing walls was calculated. The perimeter of all walls was measured and multiplied by the height of 3.00 m and the thickness of 0.25 m to determine the waste volume (21.384 tons/m³). As the buildings in the neighborhood were constructed using masonry, the density of the walls was assumed to be 1.00 ton/m³.

Figure 4.7 Sürsürü district– Sürsürü-2 conversion area demolition works

$$z = e\ x\ d$$
$$85.536x0.25 = 21.384$$

z= Weight of wall construction waste from neighborhood (ton/m³)

e: Quantity of building external bearing wall in the neighborhood (m²)

d: Total thickness of the wall and interior-exterior plaster (0.2+0.05=0.25) (m)

The waste generated from garden walls was determined by measuring the perimeter of the cadastral boundaries of 396 buildings and assuming an average height of 90 cm based on current zoning regulations. As garden walls are also constructed using masonry, their density was assumed to be 1.00 ton/m³. The waste volume was calculated by multiplying the length of all garden walls (12.847,23 m), their height (90 cm), and width (20 cm). Plaster thickness of the garden wall was not considered in the calculation.

Figure 4.8 2nd stage demolition works in Sürsürü

$$Q = f \; x \; i \; x \; h$$
$$12.847x0.2x0.9 = 2.312$$

q=Volume of garden wall construction waste from neighborhood (ton/m³)

f: Number of garden walls in the neighborhood (m²)

i: Total wall thickness (m): 0.20 m

h: Wall height (m) :0.9 m

The demolition of buildings in Elazig/Sürsürü resulted in the generation of various wastes including concrete, external load-bearing walls, garden walls, metal, joinery, timber, and glass frame waste. An economic analysis of these wastes was conducted in four stages. Firstly, the cost of demolishing the buildings was determined. Secondly, the cost of loading, unloading, and transporting concrete waste was calculated. Thirdly, the cost of loading, unloading, and transporting external load-bearing walls was determined. Fourthly, the cost of recycling metal was calculated. Fifthly, the cost of recycling glass/frame waste was calculated. Finally, the cost of loading, unloading, and transporting garden walls was determined.

When calculating the cost of demolishing a building, various unit values such as volume and tonnage are used as a basis. In this case, the total volume of 396 houses slated for demolition in the neighborhood was determined. The cost of using excavators and compressors per hour, as well as the hourly wage of workers and the cost of loading, unloading, and transporting debris waste on the construction site, were all factored into the demolition cost. A contractor's profit share of 15% was added to the unit price. The total cost of demolishing the 396 buildings was calculated to be 13.569.726,36 TL. Since the demolition and waste loading-unloading prices are listed under the same item number in the 2022-unit price of the Ministry of Environment, Urbanization and Climate Change, a separate calculation for loading and unloading was not performed. It is expected that the demolition costs for larger areas as part of urban regeneration will be much higher.

In Sürsürü district, the transportation expenses of the wastes were calculated by using the item number 07.005 of the Ministry of Environment, Urbanization and Climate Change for the year 2022, which includes the cost of transporting waste and the contractor's 15% profit share. According to this item number, the unit price of transporting 1 ton of waste within 1 meter of transportation distance is 0.05 TL. The unit price of transporting the waste within the neighborhood to a distance of 7 kilometers (7000 meters) was calculated to be 33.41 TL (as shown in Table 4.3). The weight of concrete waste (in tons) was calculated using the concrete density (ρconcrete=2.5 tons/m³) in the transportation cost calculation. The cost of transporting the concrete waste within the neighborhood (24.993 tons) to an area 7 km away was found to be 141.439,57 TL (as shown in Table 4.3). It should be noted that the cost of transportation will increase with an increase in the distance traveled and the number of trips made.

$$F = Ax0.00017xKx\sqrt{M}xGx0.04$$
$$1.25x0.00017x396x\sqrt{7000}x2.5 = 33.41$$

The transportation cost of wall waste was the third expense to be calculated in Sürsürü district. However, it was not possible to measure the interior walls on the site, and therefore, only the outer walls were considered in the analysis. The transportation costs of the wall waste were calculated based on the transportation costs listed in the 2022 Ministry of Environment, Urbanization and Climate Change, which includes the cost of transporting waste to an area 7 km away and the contractor's 15% profit share. The cost of shipping the wall waste was found to be 71.369,10 TL. In Sürsürü district, the transportation unit price value of the wall waste is 13.35 TL, and the contractor's profit at a 15% rate will be 2.01 TL.

$$F = Ax0.00017xKx\sqrt{M}xG$$

$$1.25x0.00017x396x\sqrt{7000}x1 = 13.35$$

Lastly, the cost of loading, unloading, and transporting was determined, taking into account the dimensions of the walls and building material. The cost of transporting the waste to an area approximately 7 km away from the site was calculated to be 13,569,726.36 TL (as shown in Table 4.3) using the unit prices listed by the Ministry of Environment, Urbanization and Climate Change for the year 2022. Using a single economic system, the total cost of the general selection items was 34,266,699 TL for the 396 building units. This includes the cost of transporting waste from a distance of 4.2 km per unit and loading it onto vehicles to be transported 7 km away, including the inner training walls. An average of three unloading works per unit was also calculated as a piece of agglomeration.

Table 4.3 Sürsürü district waste management cost calculation

Sürsürü District Value Calculation	**Formula**	**2022 CSIDB Unit Price (TL)**	**Total Cost (TL)**
396 Building Demolition Cost Calculation	Building ceiling/floor area x Building heigh 37.630,64 x 3.00=112.891,92	117.95	13.315.601,96
Shipping Cost of Concrete Waste (7 km)	$y=c \times hf \times \rho_{conc}$ 11.289,2 x 0.15x2.5=4.233,45	33.41	141.439,57
Exterior Wall Waste Shipping Fee (7 km)	$z=e \times d \times \rho_{wall}$ 21.384 x 0.25 x 1.00=5.346	13.35	71.369,10
Loading of Garden Wall Waste and Discharge Fee (7 km)	q=f x i 2.312,50 x 0.20=462.40	55.91	25.852,79
Shipping Cost of Garden Wall Waste	$q=f \times i \times \rho_{wall}$ 2.312,50x0.20x1.00=1.156,25	13.35	15.435,94
Overall Total			**13.569.726,36**

To analyze the impact of interior walls on transportation and loading/unloading costs, calculations were made based on a typical masonry building plan. A 90.00 m² (9.00 m x 10.00 m) house plan was designed according to today's masonry building regulations in the Sürsürü District, neglecting the door and window gaps and taking the height of the inner and outer load-bearing walls as 3.00 m. The total cost of the interior walls was calculated to increase the overall cost by 71%, and this was added to the total costs. The sample plan showed that the outer load-bearing walls are 37.2 m, the inner load-bearing walls are 23.8 m, and the interior partition walls are 2.6 m. The total walls in the building are 63.6 m, and the total interior walls are calculated as 26.4 m. The ratio of the interior walls to the total walls in this building is 71%, indicating that wall waste will affect loading, unloading, and transportation expenses at this rate. It is estimated that the inner walls of demolished masonry houses in Sürsürü will increase transportation costs by $141.439x0.71 = 100.422\ TL$.

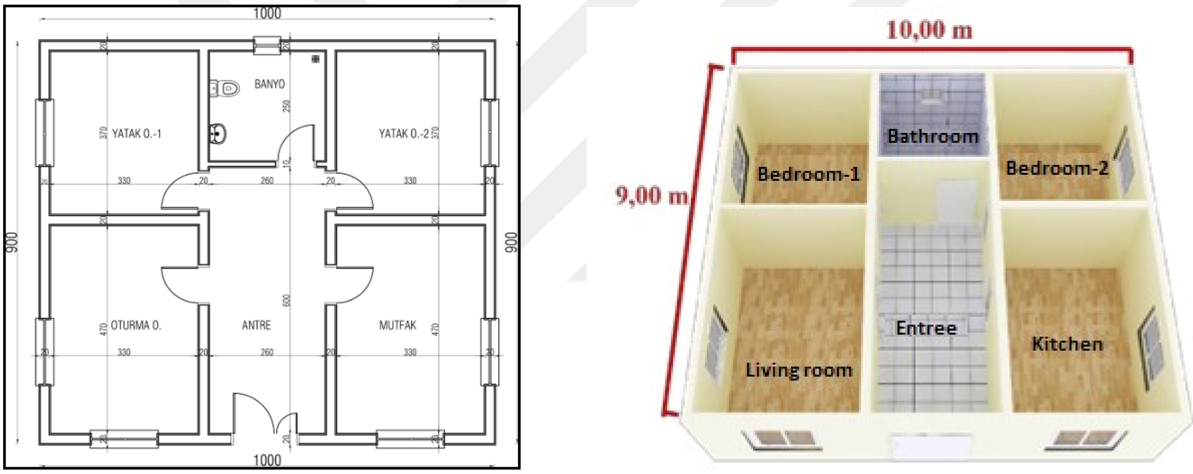

Figure 4.9 A typical masonry building plan and 3D visualization (Yarımçam & Parlak Biçer, 2020)

4.3. Economic Analysis of C&D Waste Recycling

4.3.1. Glass Waste Recycling

While only 10 percent of 1.2 million tons of glass waste released to the market in a year in our country is recycled, the remaining amount is buried in the soil. Glasses, swells, etc. produced from glass waste that can be recycled endlessly, are produced with lower carbon emissions and less energy consumption.

In Türkiye, approximately 1 million tons of waste is generated annually. 300.000 kg, 30% of which is becoming waste resulting from Urban Regeneration. (TOKI, June 2022)

Scrap Glass averages 1.79 TL per kg. The average price of 6 mm flat glass is 130-190 lira, 1 m² glass: $0.006x100x0.4 = 0.24\ m^3$. 8 mm flat glass price is 150-220 liras on average, 1 m² glass: $0.0008x100x0.4 = 0.32\ m^3$. 10 mm flat glass price is 180-320 lira on average, 1 m² glass: $0.01x100x0.4 = 0.40\ m^3$. The average price of 12 mm flat glass is 250-450 liras. 1 m² of glass: $0.012x100x0.4 = 0.48\ m^3$

Glass specific gravity: 2.5 g/cm^3. Average flat glass m² price: $\frac{500}{(0.24x2.5)} = 300\ TL$. Conversion cost: 57 TL/kg. When you buy 1 kg of glass, it is around 300 TL. When we recycle 1 kg of waste glass then 1 kg of waste glass price is 2.79 TL. (Field Price Study, 2022)

According to the June 2022 Price List of the CSIDB, the estimated cost of recycling 1 kg of waste glass is 27 TL, while the cost of recycled glass is 59.79 TL. Therefore, purchasing 300,000 kg of construction waste glass in Turkey, which produces the same amount of waste annually, can lead to economic recovery of $300.000 * 59.79 = 17.937.000\ TL$ per year.

This means that we will be able to cost the glass we need with $\frac{17.937.000}{75.000.000} = 0.24 = 24\%$. The income we will generate with the conversion is to be $75.000.000 - 17.937.000 = 57.063.000$ TL. By recycling the construction waste glass, we require, we can generate a significant amount of national wealth, estimated to be around 57.063.000TL.

4.3.2. Timber Waste Recycling

Timber is used in homes, workplaces, construction materials and many areas of our daily life. All kinds of sawdust formed as a result of home furniture, timber household goods, packaging pallets and crates, building materials and timber production are used as timber waste. Every timber waste used as recycling protects nature, prevents trees from being cut down and increases oxygen production. Any timber that is reused prevents trees from being cut directly. It reduces energy consumption and helps to protect nature.

When timber waste is generated, it is usually stored in a landfill and then collected by a waste disposal company and taken to a recycling facility. At this facility, waste timber is classified for transport for recycling or recovery, where appropriate. Construction and demolition sectors, along with industrial, commercial and household areas, are the largest producers of timber waste.

Globally, over 16 million tons of timber waste is generated every year, with only 15% of it being recycled. Therefore, it is crucial for industries to recognize the significance of recycling timber for environmental purposes. Türkiye produces 1.5 million m³ of timber annually, with approximately 10% being utilized in construction. However, only 15% of the timber used in construction is recycled, which corresponds to 22.500 m^3 based on data from the 2022 construction tables.

Table 4.4 Unit price list of ministry of environment, urbanization and climate change in 2022/2

Construction Timber Price - m³ - 2022	
Timber Types	**Price of 1 m³**
41x91 cm Construction Timber	3.250 TL
91x91 cm Construction Timber	3.250 TL
43x93 cm Construction Timber	3.400 TL
93x93 cm Construction Timber	3.400 TL
45x95 cm Construction Timber	3.500 TL
95x95 cm Construction Timber	3.500 TL
5x10 cm Construction Timber	3.750 TL
10x10 cm Construction Timber	3.750 TL
Construction Timber	3.400 TL

According to Table 4.4, the average price of timber used in construction is 3,500 TL. The cost of this timber can be calculated considering that only 15% of it is transformed, which corresponds to 22,500 m³. The average price of waste timber is between 250-400 TL per ton, and recycling 1 ton of timber costs around 550 TL. Based on these figures, the annual amount of recycled timber can be calculated, which shows that purchasing ready-made timber without conversion costs 78.750.000 TL, while recycling it costs 18.562.500.00 TL. This implies a profit margin of 26%.

4.3.3. Metal Waste Recycling

Metal waste recycling provides significant energy and raw material savings as it can be achieved without the need for ores used in the production of new products. Up to 95% energy savings can be achieved as a result of recycling a metal material. Regardless of the way a metal waste is used, it can be recycled again.

It is a material that can be reprocessed without deteriorating its metal properties. The salability of the scrap metal ensures that more investment is made in recycling resources. As with all wastes, metal waste recycling eliminates unprocessed raw material usage costs and provides energy savings. Thanks to metal waste recycling, greenhouse gases formed by metal production are prevented.

Metal scrap recycling saves up to 95% energy, o matter how much metal waste is used, it can be recycled. Converted metal accounts for 40% of the steel produced in the world. It is extremely easy to recycle compared to other wastes. More than 400 million tons of metal are recycled annually in the world. We can classify the metal recycling process as follows: Collection of metal waste, sorting of metal, processing, and shredding of metal, melting metal, purifying metal, solidifying metal, and accelerating by cooling.

Types of metal scrap that are recycled are iron scrap, steel scrap, stainless steel scrap, aluminum scrap, copper scrap, zinc scrap, yellow brass scrap, lead scrap. The average annual consumption of metal in Türkiye for the last 5 years has been calculated as 2.328.138.71 tons. (TUIK, 2022)

In Türkiye, metal is the most demanded material for recycling because it is more easily separated during construction demolition and is more valuable than other wastes. According to Table 4.5, the average annual money spent on metal in our Türkiye is $2.300.000x13.700 = 31.510.000.000\ TL$.

Table 4.5 Unit price list of ministry of environment, urbanization and climate change in 2022/2

Metal Price			
City	**Ø8**	**Ø10**	**Ø12-32**
Istanbul	14.000 TL	13.850 TL	13.600 TL
Ankara	14.100 TL	14.100 TL	13.650 TL
Izmir	13.900 TL	13.700 TL	13.550 TL
Konya	14.000 TL	14.000 TL	13.550 TL
Samsun	14.000 TL	13.900 TL	13.800 TL
Diyarbakır	14.100 TL	14.100 TL	13.650 TL
Van	14.200 TL	14.200 TL	13.750 TL
Kayseri	14.000 TL	14.000 TL	13.550 TL
Wire Mesh Metal	**Istanbul**	**Çukurova**	**Izmir**
Ø131-188	12600TL+ (tax)	12500TL+(tax)	12550+(tax)

Table 4.6 Unit price list of ministry of environment, urbanization and climate change in 2022/2

Scrap Metal Price	
Scrap Metal	7.25 TL
Extra Scrap Metal	6.90 TL
1.Class Scrap Metal	6.85 TL
2.Class Scrap Metal	6.80 TL
3.Class Scrap Metal	6.75 TL
Metal Shavings Metal	6.50 TL
Construction Demolition Metal	5.95 TL
Collection Metal	4.75 TL
Tin Metal	4.55 TL
Pik Metal Shavings Metal	6.75 TL

Around 90% of metal is recycled globally, and Türkiye produces and utilizes 2.3 million tons of iron annually, out of which a significant portion is recycled. The total annual expense for iron amounts to 31.510.000.000,00 TL, and the average purchase price for scrap iron is 7 TL per kg, as per Table 4.6. Recycling waste or scrap iron costs approximately 4440 TL, and recycling 1 kg of iron waste or scrap costs around 4440 TL. If we do not recycle iron annually, it would cost us 28.152.000.000 TL for 2.070.000.00 million tons of iron, which is equivalent to 18.961.200.000 TL remaining in our pocket and earned through recycling.

4.3.4. Concrete Recycling

THBB (2022) reports that there are 600 concrete production facilities and 1106 facilities in Turkey, with an annual production of approximately 110 million cubic meters of ready-mixed concrete. Typically, a concrete mix in the normal strength category contains 75% aggregate, 10% cement, and 15% water in terms of absolute volume, and chemical additives may be added in amounts up to 2% of the weight of the cement, as needed. Additionally, Turkey produces 300 million tons of aggregate, 78 million tons of cement, and 550 thousand tons of additives each year.

- 110.000.000 m^3: 75% Aggregate: 82.500.000 m^3
- 10% Cement: 11.000.000 m^3.
- 15% Water and additives: It consists of 16.500.000 m^3.

Table 4.7 Unit price list of ministry of environment, urbanization and climate change 2022/2

Concrete Price	
C14	870 TL
C16	890 TL
C18	910 TL
C20	930 TL
C25	945 TL
C30	960 TL
C35	980 TL
C40	1.010 TL
C45	1.020 TL
C50	1.050 TL
150 Doses Groconcrete	850 TL
200 Doses Groconcrete	870 TL
300 Doses Groconcrete	970 TL
500 Doses Groconcrete	1.070 TL

According to the Table 4.7, the cost of concrete produced in Türkiye is approximately 110.000.000*980=107.800.000.000 TL. (including transportation + fuel)

- $107.800.000.000x0.75 = 80.850.000.000\ TL$ for aggregate
- $107.800.000.000x0.1 = 70.780.000.000\ TL$ for cement
- $107.800.000.000x0.15 = 16.170.000.000\ TL$ for water and other additives.

Individuals in Turkey produce 20 kg of concrete construction waste each year, resulting in millions of tons of waste annually. Unfortunately, the recycling of 1.6 billion tons of this waste is severely lacking. However, these coarse materials can be recycled in facilities and utilized as aggregate. The economic cost of concrete production in Turkey is estimated at around 107.8 billion Turkish Lira per year. The cost of recycling construction and demolition waste through demolition, separation, and crushing in plants is approximately 300 TL per ton. Recycling concrete C&D waste into aggregate can result in significant savings that is equal to $82.500.000x300 = 24.75$ billion Turkish Liras as it can provide us with the necessary aggregate while recovering materials that would otherwise go to waste. In contrast, if we were to purchase all the aggregate needed for concrete production, we would end up spending 80.85 billion Turkish Liras. It corresponds to the ratio of $\frac{24.750.000.000}{80.850.000.000} = 0.306 = 30,6\,\%$. The profit we will get with the conversion is equal to $80.850.000.000 - 24.750.000.000 = 56.100.000.000\ TL$.

CHAPTER-5
RESULTS AND DISCUSSION

In Turkey, Urban Regeneration projects are undertaken for various reasons, including the need for total renovation and the desire to make the projects compatible with the environment and generate rental income. However, these projects often involve the demolition of large residential areas, resulting in significant waste generation. Unfortunately, there is a lack of research and planning on how to manage these waste materials, and this issue is prevalent across most urban regeneration projects in Turkey.

Although local governments have legal duties, authorities and responsibilities, it is not known what to do with the construction and demolition wastes generated as a result of Urban Regeneration in practice. However, construction and demolition wastes, which are separated, cleaned and shredded, can be converted into sustainable construction materials by turning them into re-building materials. In this respect, it is important to determine the construction and demolition waste management strategy and to develop recycling facilities. The efforts of the local government and private companies are not sufficient in this regard. The establishment of recycling facilities should be encouraged by determining the recycling strategies of construction, demolition and excavation wastes, which are solid wastes. These wastes, which are generally used as ground infrastructure filling, pose a danger to human health, environmental pollution and future generations. Negative effects on the natural environment will be prevented by improving the management of construction and demolition wastes.

Save Prompt

The owners of buildings constructed with a masonry system in the Sürsürü District of the Merkez district of Elazığ initially managed waste disposal. After evacuating the structures, various materials such as lean concrete, reinforced concrete, load-bearing walls, dividing walls, and garden walls remained. Urban Regeneration works occurred in phases, and the economic analysis of construction and demolition waste was divided into four groups. The Ministry of Environment, Urbanization, and Climate Change's unit prices were employed to calculate the costs of demolishing, transporting, and loading/unloading concrete waste, metals/reinforcements, interior/exterior load-bearing walls, and garden walls. Given the numerous masonry structures, average values were used to estimate the cost of inner walls. Using the Ministry's unit prices for 2022, the cost of demolishing, transporting, and loading/unloading concrete, external load-bearing walls, and garden wall waste was calculated at 13.569.726,36 TL. The cost of demolishing 396 houses and garden walls in the area, including waste transportation and loading/unloading, was 71.369,10 TL, with a cost of 21.339,00 TL for a single masonry house. By including interior load-bearing walls, the total cost was 34.616,65 TL for a single building.

The sample field study data is an indication of the high cost of Urban Regeneration works on parcel or island basis in Elazig/Sürsürü. The resulting cost is reflected as an additional cost either to the ministry, to the local administrations or to the contractor companies. Property owners who give their land or residence to private construction companies in return for flats are also indirectly affected by this situation. Within the scope of risky area urban regeneration projects, it is reflected as the decrease in the shares of the property owners in the buildings to be given as a result of urban regeneration or the increase in the purchase price of the new building unit to be acquired. This situation provides information on the economic situation of the construction and demolition wastes to be generated in the risky area urban regeneration projects numbered 6306 throughout our country, at a minimum scale.

By recycling the concrete and masonry wastes to be obtained from the Urban Regeneration works in our country, such as the Sürsürü district, the aggregate material that will be needed will also be met. The amount of concrete (11.289 tons), wall (21.384 tons) and garden wall (2.312 tons) waste in Sürsürü was calculated as 34.915 tons and the waste management cost as 13.569.726,36 TL. Here, the management cost of 1 ton of waste is 388.650,00 TL. This price, which is calculated with the unit prices of the Ministry of Environment, Urbanization and Climate Change in 2022, needs to be updated every year. In the recycling facility of construction and demolition waste, the waste management cost should be minimized by making profits at different rates depending on the quality of the sand and aggregate obtained by recycling 90% of this waste. These calculations show the importance of construction and demolition waste management and recycling facilities.

According to research conducted between 2001-2015, it is estimated that the number of slums and illegal structures in our country is approximately 2.400.000. In 2022, it is estimated that there are 12.000.000 residences in our country that are thought to be vulnerable to natural disasters. The earthquakes in Elazig and Izmir in 2020 also showed that our existing building stock needs urgent renewal. It has been tried to calculate how much the demolition, transportation and loading and unloading costs of the wastes that will arise as a result of the possible urban regeneration in our country will be. In a single building scale, it is estimated that the demolition, loading-unloading and transportation costs of a building built with a masonry construction system will be 34.616 TL, and the total waste cost of the buildings that will generate waste in slums across the country will be 415.399.440.000 TL. It is predicted that the country's economy will suffer from the lack of aggregate raw materials due to the increasing construction and road development activities necessary to accommodate population growth. However, recycling can provide a solution by generating aggregates that can fulfill this demand.

In order to establish a construction and demolition waste recovery facility to be made for recycling, financial resources are needed for the purchase of the land required in the first place, the design and design of the facility, the installation and operating costs of the facility, the maintenance of the facility machinery and all labor costs. Considering the cost of demolition and disposal, the recycling facility, which requires a large-scale investment, can meet the income needs of the facility with the sale of recycled materials, although it is not that much. In order for the recycling facilities of construction and demolition wastes to achieve their purpose, it is necessary to transport these demolished waste materials to the facility in a regular, stable and sustainable manner and to ensure the sustainability of the processing of these materials. In this respect, it is important to prevent the storage of construction and demolition waste materials, to establish a facility and to transport and convert wastes to these facilities. For the establishment of the facility, under the leadership of the Ministry of Environment, Urbanization and Climate Change, public institutions and the private sector should be accelerated to work on the subject.

Today, it is not possible to analyses the ratio of materials such as concrete, iron reinforcement, briquettes, bricks, glass, timber in the construction and demolition wastes in the demolitions made as a result of urban regeneration. The regional factors of our country and the effects of regional material use directly affect the rate of material use in construction and demolition waste. The preference of timber in construction in the Black Sea region and the high rate of timber in construction debris waste can be cited as an example to this situation. Waste rates in the construction and demolition waste mix also directly affect the profit rate in recycling. It is foreseen that the construction and demolition wastes proposed to be built in our country will have different profit rates in the regions where they are established in direct proportion to the capacity of the recycling facilities. In determining the amount of waste, both the ministry, local governments and construction companies in the private sector will report the qualitative characteristics of the wastes produced during the construction, demolition and renovation stages, on-site separation and selective transfer and selective storage will be provided. Finally, recycling methods, advanced technologies, waste management and waste economy should be developed by getting the support of academic studies conducted in 209 universities in our country and the academic people who carry out these studies. In order to develop and correct this situation, extensive studies should be carried out, the public should be blamed for the problem, awareness should be raised, and the problem should be clearly revealed. It is expected that the urban regeneration works in Elazığ that started with the 2020 Elazığ earthquake and the Sürsürü District risky area urban regeneration project progressing within this scope are examined, it is expected that the cost found in this study will be used as a guide and will shed light on the necessary studies to reduce it.

CHAPTER-6
CONCLUSIONS

Urban regeneration projects in Turkey are implemented with specific objectives in mind, and involve various stakeholders such as municipalities, ministries, private sector, and citizens. This thesis aimed to examine the statistical assessment of urban regeneration in Turkey, develop strategies for managing construction and demolition waste, and analyze the cost-effectiveness of recycled materials for a circular economy. The overarching goal of urban regeneration is to create better and healthier housing options and ensure more sustainable and liveable cities. This includes not only halting physical deterioration but also considering the economic, social, and environmental dimensions of sustainable development. Recycling waste generated by Urban Regeneration projects can promote circular economic life and promote mobility and vitality. Ultimately, strategies for managing waste and recycling materials can enhance the sustainability of urban regeneration in Turkey. The conclusions of the thesis are as follow.

a) The importance of recycling is undeniable on a global scale, particularly in regards to the millions of tons of construction waste generated annually in both Turkey and worldwide. Recycling metal allows for multiple reuses, while glass can be recycled infinitely. Additionally, recycling concrete waste can be utilized in concrete production and can produce aggregate as well.

b) A waste hierarchy, separating the wastes at their source through selective disposal, ensuring that the wastes are recovered and reused in a zero-waste cycle has been created for further studies.

c) During urban transformations, laws and regulations should be implemented for selective demolition, where glass, concrete, and wood are each demolished separately. Recycling facilities should be established for each material or incentivized support should be provided.

d) To ensure that the process is implemented by the local government, the municipality should take necessary environmental safety precautions, identify suitable areas for facilities, and create plans for Urban Transformation. All demolitions, starting from the bottom to the top, should be periodically reported and analyzed for cities. The annual waste amounts of the cities should be calculated, and mobile or fixed collection facilities should be established accordingly.

e) An increase in awareness about sustainability and resource management for Türkiye has been examined and the reuse of C&D waste materials for the circular economy and zero waste approach (reducing, reusing, and recycling) was discussed in the thesis.

f) The current study provides guidance for C&D waste businesses, the recycling procedure, and the role of recycling waste in the circular economy.

g) The analysis of costs has revealed a significant contrast between the utilization of primary resources and recycled resources. The construction industry in our country spends billions of liras annually, and a large portion of this expenditure can be regained through recycling. Research indicates that a major portion of the materials required for construction can be obtained through recycling the waste generated from debris.

h) The recycling process of urban regeneration wastes yields a significant amount of environmentally conscious and sustainable building materials.

i) Every year, Turkey produces 80 million tons of waste concrete, which can be recycled at a cost of 300 Turkish liras per ton. This would amount to a total of 24 billion Turkish liras in recycled materials. When compared to the cost of producing the same amount of concrete from a plant, which is 78 billion Turkish liras, using recycled concrete can save up to 31% of the total cost.

j) At a recycling cost of 57 TL/ton, 300,000 tons of glass waste is produced from construction activities. Purchasing 300,000 tons of metal would amount to a cost of 75 million TL. However, recycling 300,000 tons of glass waste would result in a recovery of 17.1 million TL, indicating a profit margin of approximately 23%.

k) In Türkiye, metal is the most demanded material for recycling because it is more easily separated during construction demolition and is more valuable than other wastes. If iron is not recycled annually, it would cost us 28.152.000.000 TL for 2.070.000.00 million tons of iron, which is equivalent to 18.961.200.000 TL remaining in our pocket and earned through recycling.

l) This study showed that annually, 150,000 tons of timber is utilized in construction at a cost of 525.000.000.000 TL, based on a ton price of 3500 TL. By recycling the timber at a cost of 550 TL, a profit of 82.500.000 TL can be generated, which translates to a 16% profit margin from the recycling of timber material.

m) It has been observed that the recycling cost ratio of construction wastes is between 15-35%.

Thus, it is important to utilize all C&D waste materials until the end of their healthy life cycle. Proper waste management is crucial for ensuring health, environmental, economic, and future sustainability.

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