

We are IntechOpen, the world's leading publisher of Open Access books Built by scientists, for scientists

7,000

Open access books available

186,000

International authors and editors

200M

Downloads

Our authors are among the

154

Countries delivered to

TOP 1%

most cited scientists

12.2%

Contributors from top 500 universities



WEB OF SCIENCE™

Selection of our books indexed in the Book Citation Index
in Web of Science™ Core Collection (BKCI)

Interested in publishing with us?
Contact book.department@intechopen.com

Numbers displayed above are based on latest data collected.
For more information visit www.intechopen.com



Construction and Demolition Waste Management in Turkey

Hakan Arslan, Nilay Coşgun and Burcu Salgın

Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/46110>

1. Introduction

Natural resources generally were consumed by the construction sector in huge amounts and have produced significant quantity of construction and demolition (C&D) wastes. C&D waste constitutes the largest volume of all solid wastes. Statistics from various studies have reported the high amount of C&D waste generated. For instance U.S. construction industry generated over 100 million tons of C&D waste per year [1], and approximately 29% of solid waste stream in the U.S. created by the construction sector [2]. Also, C&D waste contributes more than 50% of all landfill volume in the UK, [3] and 70 million tons of C&D waste is discarded each year[4]. Craven et al. [5] have reported that construction activities generated approximately 20–30% of all waste in Australia which were entering to the landfills. The annual generation of C&D waste in Hong Kong between 1993 and 2004 doubled and have reached the amount of 20 million tons in 2004 [6]. Nearly 23% of the solid waste in Hong Kong comes from the construction sector activities [7, 8]. The huge amount of construction waste streams in different countries has revealed the importance of local actions in order to manage, recycle and re-use the wastes generated through the lifecycle of buildings.

C&D waste was generally defined as a mixture of inert and non-inert materials arising from construction, excavation, renovation, refurbishment, demolition, roadwork and other construction-related activities. Inert materials can be comprised of whether soft inert materials such as soil, earth and slurry or hard inert materials of rocks and broken concrete. Non-inert materials has also included wastes of metals, timber, plastics and packaging [6]. The negative environmental affects of C&D debris started by dumping them into forests, streams, ravines and empty land that has resulted and caused erosion; contaminates wells, water tables and surface waters. They also attracted pests and had a potential to create fire. All these large volumes of construction in many countries have contributed primarily in increasing waste strain landfill capacities and then have resulted to lead environmental

concerns. It can also be pointed out that to disposal of construction waste is quite difficult because of its content of hazardous materials such as asbestos, heavy metals, persistent organic compounds and volatile organic compounds (VOCs). These wastes threaten the human health and the natural/artificial environment with various effects. The overall impact of the C&D waste not only had an impact on the environmental but also on the economical sustainability of the countries because of the fact that the construction sector as a base and crucial variable that was related all the other sectors.

The rise in the amount of C&D waste has caused serious problems both globally and locally. In this context, the management of C&D waste has become one of the major environmental issues in the construction industry. The environmental and economic effects of C&D wastes can be reduced by rational management. The aim of construction C&D waste management is waste minimization and appropriate disposal, both of which help to reduce negative environmental impacts. As C&D wastes are considered an important environmental problem in many countries and many regulations on these issues have been introduced. C&D waste management is adopted as part of state policy and specifications and guidance about these issues have been prepared. There are studies and documents on determining targets for the management and recovery of C&D waste management for member states of the European Union.

Construction sector in Turkey can be regarded as the main engine considering the whole economic activities. In the last decades, the role of construction sector has drastically increased by the new housing and infrastructure investments countrywide. Also, due to high earthquake risks the intensive works such as retrofitting, reinforcement and demolition have continue for those which were under serious risk. 66% of Turkey's land is in the first and second level earthquake zone where this reflects nearly 71% of the countries population. When the existing building stock of Turkey is considered, it is obvious that most part of the housing stock must be transformed through demolition, retrofitting and reinforcement activities which should be applied in the short term due to high earthquake risk [9]. Thus, all these activities will increase the C&D waste and the need for efficient waste stream management will be more important during this transformation process to sustainable housing stock with legal building codes.

This study briefly focused on C&D waste generation and C&W management issues in Turkey by giving information about the general framework of C&D waste management with legal aspects. Management policy on C&D waste is discussed through the municipality actions and implementations. The case study of Istanbul Metropolitan Municipality aims to identify the current situation in construction and demolition waste management in Turkey by demonstrating a better understanding of the actual waste management strategy implementations in local level.

2. Construction and demolition waste generation

Waste materials have started to be generated during the construction phase and go on throughout the lifespan of the building such as usage, renovation and demolition. The

generation of C&D waste differs depending on the type and function of the building in each phase of construction, usage, demolition and reconstruction stages. As an example it can be figured out that 10% of the materials used during the construction stage become waste. These were described as clean wastes that were relatively easy to classify for recycle and re-use. It is estimated that demolition and renovation operations produce ten times more waste than generated in construction phase [10]. The classification of these wastes generated during these stages were difficult as they were contaminated, complex.

The amount and type of waste materials varies during the production of construction materials, including wastage due to cutting or reformation during production and losses due to non-standard or defective products. Factors such as design defects, erroneous designation data, detail deficiencies, production preference defects, lack of communication between designers, lack of information during the design phase (management, preliminary works, pre-designing, application/detail design) may all result in wastage during production, usage and demolition stages.

During the construction stage, wastage is caused by many factors, including unused materials, incorrect materials; surplus stencils or nails, packages of construction materials or components; surplus concrete materials due to fractures or deformations due to improper storage or preservation of construction materials and components arriving at the construction site; necessary disassembly due to production errors; erroneous cuttings; improper equipment; bad weather conditions; relocating materials; and erroneous measurements [11]. The level of wastage caused during the construction stage depends on the construction system, the project and the variety of construction materials and components.

Due to renovations and refurbishments for reasons such as deterioration, corruption, alteration of needs, or fashion, many construction materials and components are changed and the old materials become wastes. These processes sometimes occur frequently. The usage stage is the longest stage of the construction lifecycle. Therefore, significant levels of wastes are generated during this stage. It is estimated that 30-50% of overall construction waste results from renovation activities [12]. A previous study determined that very frequent renovations are made in construction materials and components in Turkey, and that 74% of these materials are dumped [13].

During the demolition stage, when buildings have completed their operational life, the entire building, entire materials and components become wastes and thus the amount of waste material generated increases. Planned and systematic debris removal is of great importance. Structural problems of individual buildings may include collapsing entirely, due to earthquakes, illegal structuring, urban transformation processes etc. For example, after the Marmara Earthquake of 1999 in Turkey, the removal of approximately 13 million tons of debris created problems. These wastes were left in empty spaces and fill areas and some of them were dumped at sea [14]. Construction sector were aware of the waste management system during the intensive construction process and actively involved in a more efficient organization structure to reduce the negative impact of C&D wastes.

3. Construction and demolition waste management

The management of C&D waste has become one of the major environmental issue in the construction industry because of its long term affects. Uncontrolled dumping of C&D wastes not only represents a significant environmental burden but also a financial cost as well. Environmental and economic effects of C&D wastes can be reduced by a rational management policy. The aim of construction C&D waste management is based on waste minimization and appropriate disposal, which both two help to reduce negative environmental impacts. The specifications of European Union can be evaluated under three principles of waste management [15].

- **Waste Prevention:** This is a key factor in any waste management strategy. The aim is to minimize the waste before construction by detailed frame design and material use plans
- **Recovery:** This stage aims to reduce the environmental effects of unavoidable wastes, through reuse and recycle strategies.
- **Proper Storage:** This stage involves storage options in an appropriate way for non-recoverable wastes generated at registered sites. Easy access path will help to increase the efficiency and help the participation of building users.

Waste management is evaluated through its economic benefits but also the options of waste prevention not only have helped the reuse and recycling money savements but also generate broader environmental benefits such the conservation of natural resources. Reuse and waste prevention reduce the air and water pollution associated with materials manufacturing and transportation that indirectly is an asset for human health. This also saves energy and reduces attendant greenhouse gas production. The recycling of many materials requires less energy than production from virgin stock, and can also reduce transportation requirements and associated impacts.

3.1. Preventing and reducing C&D wastes

Waste prevention and reduction begins during the building materials production stage. Recuperation of wastes generated during the producing process has a crucial role in prevention of waste during subsequent stages of the construction lifespan. Design phase is very crucial part of the building production process in order to consider the generation of building waste and determination of the re-use and recycle options and features of building materials. The design phase prevention directly affects the volume of construction waste stream in construction, use and demolition phases. It is estimated in some international researches that nearly one third of the waste generated could be derived from the designers' inability to manage the waste reduction preventions [16]. The following precautions may then be taken during the design phase:

- Designs of buildings optimized to meet the needs of users,
- Rather than designing places at unnecessary scales, designing places of adequate sizes, based on the principle of "Less is More" and reducing the amounts of materials that will become C&D waste,

- Utilizing durable and repairable construction materials and components that reduces the need for frequent replacement during the usage stage,
- Creating flexible design solutions to reduce the amount of C&D waste when buildings are modified to meet the changing needs of occupants,
- Preferring standard modules at design phase to reduce material losses during construction phase,
- Selection of products based on lifecycle, production technology of the construction material and the effects of this technology on environment and health,
- Extending the economic lifespan of a structure by regarding the quality and resilience of construction materials,
- Utilizing reusable and/or recyclable materials,
- The use of local materials to reduce waste and energy consumption,
- Devising renovation project instead of demolition projects for old buildings in order to reduce wastes,
- Specifying water-based adhesives and paints.

Purchase and storage conditions should be carefully controlled during the construction stage in order to minimize wastage of surplus raw material and to provide financial savings. Precautions that can be taken during the construction stage include:

- Providing proper transportation of construction products,
- Using construction materials of appropriate sizes and amounts for the design,
- Specifying materials in appropriate sizes to prevent waste resulting from cutting and fracturing of materials,
- Purchasing materials in large quantities to reduce packaging waste associated with smaller quantities,
- Favoring material suppliers that retrieve product packaging,
- Favoring material suppliers that retrieve surplus materials from production,
- Purchasing materials with toxic constituents (when their use is necessary) in small amounts in order to reduce problems when disposing of surplus materials,
- Controlling material deliveries before use and/or storage to prevent on-site waste generation and the return of damaged materials,
- Storing season- sensitive materials appropriately,
- Taking security precautions against vandalism,
- Taking necessary precautions to prevent potential damage to natural habitats during excavation activities,
- Raising awareness among construction workers and making them responsible for the results of their task,
- Mentioning material and waste management issues in agreements with contractors.

The users and implementers should be informed about these issues in order to reduce changes/renovations during the usage stage. During renovation, disassembly of components and transportation of materials should be carried out carefully, to maximize the potential re-use of construction materials.

Before demolition, disassembly of materials to be recycled and reused should be carefully planned. This may prolong the demolition process. However, this is important to maximize economic and environmental benefits. The demolition should cover the following precautions:

- Reduce waste by suggesting appropriate demolition methods,
- Suggesting recycling or reusing the construction materials taken out of constructions completing their life,
- Determining reusable or recyclable materials before demolition (water and electrical system, doors, windows, sanitation systems, etc.),
- Instructing construction staff about the materials that will be disassembled and creating proper strategies to ensure the disassembly of undamaged elements,
- Determining the users and recyclers to whom disassembled materials will be given,
- Paying attention to materials that can contain hazardous constituents (lead-based paints, asbestos insulation materials etc.). Technical assistance should be sought for such issues [13].

3.2. Recovery of C&D wastes

Increasing the recycling and re-use of C&D waste within the industry will help to conserve the dwindling landfill resources. There are growing interests in many parts of the world in recycling and reusing C&D waste by the construction industry. Effective waste management has enabled recovery of 90% of C&D wastes [17]. The Netherlands has the highest rate of construction recycling, at 90%, followed by Australia (87%) [18] and Denmark (82%) [19]. Total C&D waste for England was estimated at 86.9 million tonnes in 2008. 53 million tonnes were recycled and a further 11 million tonnes were spread on exempt sites (usually land reclamation, agricultural improvement or infrastructure projects) [20].

C&D waste management and recovery will enable:

- Reducing environmental effects of obtaining further raw materials, their transportation and processing,
- Reducing the dependence on natural resources,
- Reducing emission rates related to production and transportation of building materials,
- Reducing costs associated with new material purchases,
- Reducing the need for disposal sites for C&D wastes,
- Reducing the negative effects on environment through removal and disposal processes,
- Creating a source for the sector by recycling C&D materials to secondary salvaged materials,
- Creating new employment fields.

Reusing and/or recycling of concrete wastes, which represent the highest proportion of C&D wastes, offers both a solution to waste disposal problems and enables preservation of natural resources. While 40% of globally used rocks, pebble stones and sands are consumed in structuring activities each year, the availability of good quality aggregates decreases [21].

In addition, European Union members produce approximately 50 million tons of concrete waste each year, compared with 60 million tons in the United States 10-12 million tons in Japan. Japan has reduced the use of aggregates by 2.5 million m³ by recycling concrete wastes in ready-mixed concrete plants [22]. Netherlands recycles 93% of concrete and Germany 18% [23].

In the recycling of steel, it is observed that 74% of the energy and 90% of the raw material are preserved, water consumption is reduced by 76% rate, air contamination is reduced by 86% and mining wastes by 97% [24]. Water consumption and emissions are reduced when recycling aluminum compared to extraction. Approximately 52% of steel wastes and 65% of aluminum wastes are recovered in the U.S. According to data from 1994, aluminum recovery was 85% in Switzerland and 91% in Sweden [25]. Doors and windows acquired as a result of demolition or renovation are ideal components for reuse. Even though kitchen and bathroom equipment if not be worn out, they are among reusable components.

3.3. Storage of C&D wastes

When recovery of C&D wastes is not possible, construction wastes should be stored in a controlled way. Storage facilities should not be established in primary farmland and areas of high agricultural production potential. Also these fields should not be close to drinking, irrigation and water reservoirs such as ponds. Distance to settlement areas is an important factor (at least 200 meters). Storage facilities should include units to accept arriving C&D wastes, an operation building and weighbridge, and the storage field should be separated by a proper divider.

An effective control, monitoring and tracking system should be created in the storage area, to enable segregated storage of different waste materials.

In order to prevent environmental contamination that can occur during transportation of C&D wastes to the storage location, vehicles should be covered with appropriate materials. Vehicles should not be overloaded and they should operate after cleaning mud or similar debris from their wheels. Vehicles should also carry signals indicating the C&D waste being transported [26].

Where the capacity of a storage area is exceeded, the area should be rehabilitated appropriately with the natural topographical features that allow for their reuse. For example, the Sidney Olympic Village was constructed on the site of a neglected industrial area in Homebush Gulf. The site was previously used for brick kilns, a military arsenal, state slaughterhouse and municipal garbage.

4. Research objectives and methodology

The research methodology of the study is based on the analysis of Turkey National C&D waste management general framework based on legal regulations and Istanbul Metropolitan City as a local case study. Brief information is given about the general framework of waste management in Turkey with legal aspects. The case study aims to

identify the current situation in construction and demolition waste management in Turkey. The study also tries to highlight the actual implementation in local level.

5. The current state of construction and demolition waste management in Turkey

This section will give some brief information about the general framework of building waste management in Turkey with legal aspects. Management policy on construction and demolition waste will be discussed through municipality actions and implementations.

5.1. General national framework: Regulations regarding construction and demolition wastes in Turkey

Many developed countries have introduced legislation and strategies to reduce the environmental effects of C&D wastes. Turkey also has several legislations regarding the management of C&D waste.

In Turkey, the issue of debris produced by disasters is covered by Article 4 of the “Law Regarding Assistance and Precautions for Disasters Occurring in Public Life” (Number 7269, dated 1959) and Article 4, 14/b and 24 of the “Regulation Regarding Immediate Support Organization and Planning Principals of Disasters” (Number 88/12777, dated 1988) [27].

The issue of C&D wastes is briefly included in Article 23 of the “Regulation Regarding the Control of Solid Wastes” (Number 20814, dated March 14th, 1991 under the title “Storage of Excavation Soil” [28].

The Report of Sub-Commission of 8th Five- Year Development Plan Solid Waste Control suggests the regulation of “Regional Debris Management Plan and Waste Management System” under the title of Construction- Demolition and Excavation Wastes [14]. While 9th Five- Year Development Plan includes articles regarding reduction and disposal of wastes generally, in its Article 471, it involves a statement that “the generation of non-domestic wastes shall be reduced, collection, transportation, recovery and disposal systems shall be creates appropriate for country conditions”.

- Laws and codes related with C&D waste in Turkey
- Environment Act (Number 2872 and dated 09/08/1983),
- Physical Development Planning Law (Number 3194 and dated 03/05/1985),
- Metropolitan Municipality Law (Number 5216 and dated 10/07/2004),
- Misdemeanors Law (Number 5326 and dated 30/03/2005),
- Regulation of Mining Activities with the Regain of the fields (Number 2747 and dated 23/01/2010),
- Regulation of “Pertaining to Regular Storage of Wastes” (Number 2753 and dated 26/03/2010),
- Forest Law article 16 (Number 27715 and dated 30/09/2010),

- Also, there are some regulations related with asbestos [29, 30] and after the regulations come into force in 31/12/2010 date it was totally prohibited [31].

The most comprehensive regulation in Turkey regarding the control and recovery of C&D wastes is the “Regulation of the Control of Excavation Soil and Construction and Demolition Waste” number 25406 enacted by the Ministry of the Environment and Forestry which came into force on March 18th, 2004. This regulation includes general rules about administrative and technical subjects on the reduction, collection, temporary storage, recovery, evaluation and disposal of excavation soil and construction and demolition wastes [26]. C&D waste grouping were given according to the regulation (Figure 1).

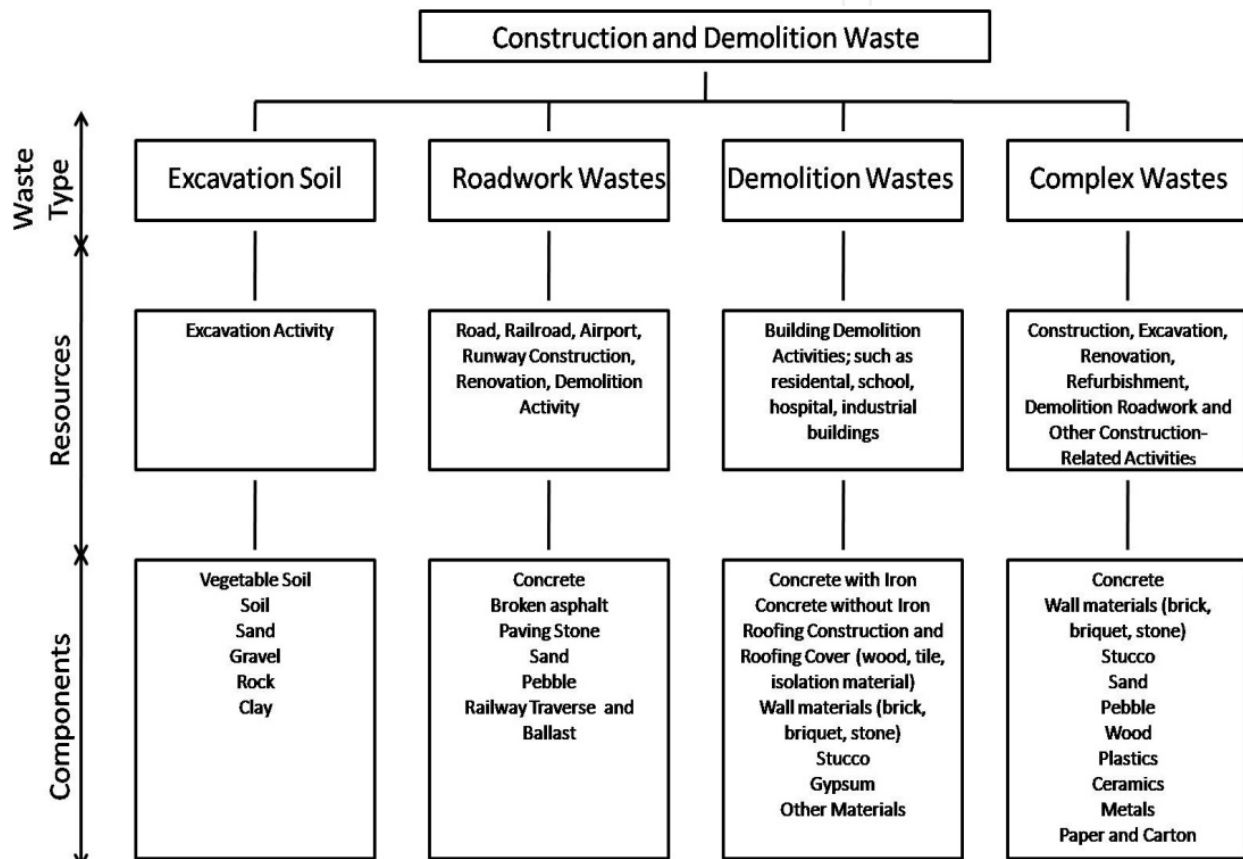


Figure 1. C&D Waste Grouping

5.2. Case study

The case study tries to show and gives a better understanding of the existing implementation in Istanbul Metropolitan Municipality in a local level and ongoing activities related the improvement of the waste management system and strategies.

- The study has evaluated solid waste management practices of the municipalities in Turkey in the context of the Istanbul Metropolitan Municipality works that were related and reflected the Istanbul city which connects the Asia and Europe has the highest population and had the highest population increase rate in Turkey. It is also city that

has generated the highest C&D waste because of the high construction and demolition activities. Thus, the city had the comprehensive C&D waste management works. It is estimated that the annual increase/decrease of C&D waste generated from infrastructure, road, bridge, maintenance/repair, construction and demolition is 3% according to the population. The construction, excavation soil and demolition generation were determined as 1500 kg/person/year for excavated soil and 200 kg/person/year for C&D waste [32].

- Until 2002 there were no regulation related with C&D waste management and all the waste generated were disposed randomly without any project and permission to the private or public land in different parts of the city. The landfill areas location and the amount of landfill was unknowable as it can not be prevented from unplanned construction in those landfill areas [33]. On 8th February 2002, in order to prevent from illegal spillation and escapillay to determine the landfill areas the central government – governorship the “Directive of Excavated Soil and Construction Debris Control” has put into action. But, short time consequences show that because the directive could not be able to block the deficiencies in illegal disposal [34].

According to code issued in 2004 “Regulation of the Control of Excavation Soil and Construction and Demolition” Metropolitan Municipalities are responsible to take the actions such as preparing plans for excavation, construction and demolition waste/debris management. For example the “Building and Demolition Waste Management Plan for Istanbul City” has prepared by the municipality on March 2006. The municipalities are also responsible to determine, establish and operate all the recycle facilities and storage areas. So, it can be pointed out that the site activities related with all types of waste were managed by the local government. But the collection and transportation of the excavated soil, construction and demolition waste services can be private. The role of the municipality for the collection and transportation were limited to announce and inform the list, addresses and phone numbers of these private firms. Also the monitoring and controlling of these firms were the responsibilities of the municipality.

- The responsibility for transportation of solid wastes including C&D, production of composted fertilizer, waste recycling, waste disposal in regular storage, electricity generation from storage areas, transportation of medical wastes and their disposal by incineration, recycle centers management were given to the newly established municipality firm ISTAÇ A.Ş. (Istanbul Metropolitan Municipality Environmental Protection and Waste Materials Evaluation Joint-Stock Company) [35].
- Totally 7 storage area with 54.343.676 m³ were determined for C&D waste generated in the city where the natural ground deformed such as quarries and open mine sites within the Istanbul province boundary. Additionally, excavated soil were reused as landfill for parks, gardens, open-space areas production, recreational areas, infrastructure and landscaping in district municipalities [33]. The C&D waste disposal and recycling amounts in Istanbul city between 2006-2011 can be seen in Table 1 [36].

	2006	2007	2008	2009	2010	2011	Total Amount
The amount of excavation soil disposed (gross ton)	2.999	18.354	16.796	16.257	24.100	47.709	126.215
The amount of C&D waste disposed (ton)	2.818	4.577	4.439	4.258	5.361	5.680	27.133
The amount of excavation soil recovered (ton)	-	1.389.986	102.421	175.540	34.356	35.996	1.738.299
The amount of C&D waste recovered (ton)	-	-	12.819	77.826	73.200	116.952	280.797

Table 1. Recycled and disposed waste generated from excavation, construction and demolition activities in Istanbul City (Population: 12.573.836 people in 2009) between 2006-2011) [36].

- 200 ton/hour the capacity Mobile C&D Waste Recycling Facility consisted of two sieves and one breaker were established in 2008 (Figure 2-3).
- Necessary measures have been taken for the factors related with these facilities such as dust and noise which may affect environment and human health.
- Excavation and debris were taken from the original place with an EPL (Environmental Phone Line). Building waste from renovation works divided into 40 kg package(s) and firstly sent to stopover stations then to the authorized disposal areas which belongs to İSTAÇ A.Ş. This service approximately cost 13 Euro per package between 1-20 packages and 0,65 Euro per extra package after 20 [37].

Waste Management Automation Project (WMAP) allow electronic web based control of all types of transportation vehicles that carry wastes (excavation, construction and debris, household, medical, industrial) within the İstanbul Metropolitan Municipality boundary (Figure 4). On the other hand, the works are going on in order to prevent illegal disposal with "Vehicle Control System" [35]. C&D waste collection and disposal processes illustrated as schemas in Figure 5-6 [35].



Figure 2. Construction Waste Recycle Facility [35]



Figure 3. Demolition Waste Recycle Facility [35]



Figure 4. WEB Based Control Unit [35]

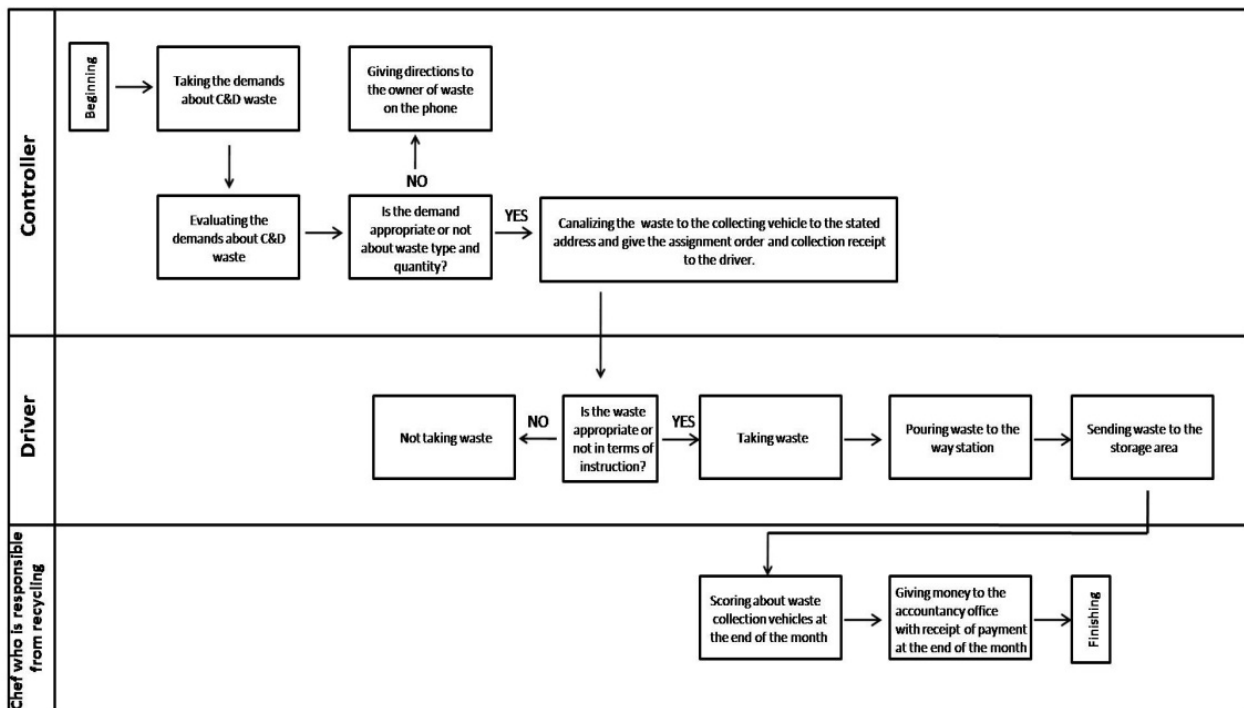


Figure 5. C&D Waste Collection Process

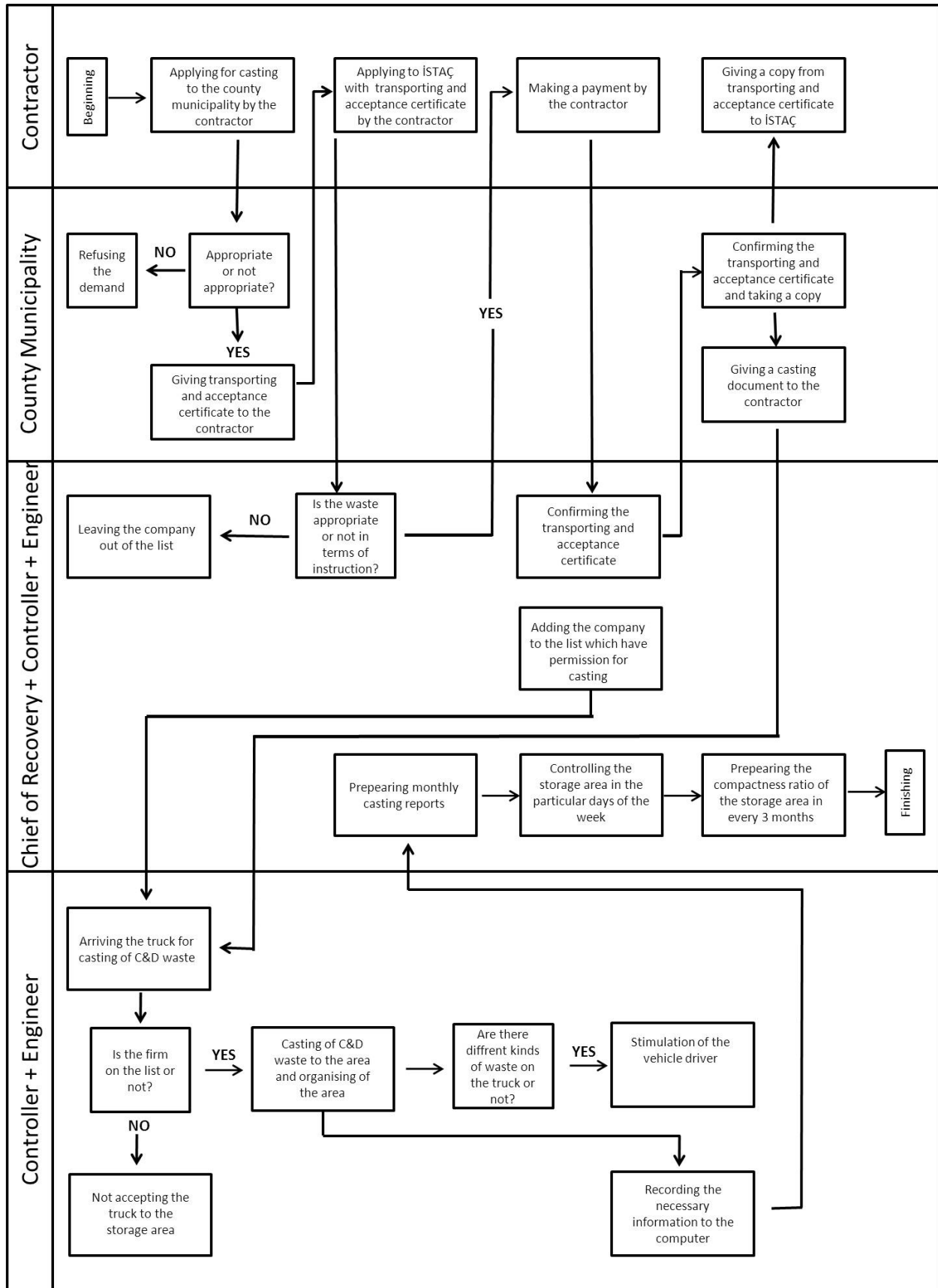


Figure 6. C&D Waste Disposal Process

The design phase has a very important role in reducing/preventing C&D waste during building production. In this context a research were conducted in order to understand and question the designers approaches to C&D wastes. Generally most of the respondents stated that the wastes occurred in the construction site can be controlled in design phase but contrarily most of them did not characterize it as a responsibility of the designer to reduce. Also most of them stated that main waste produced during the construction. Most of the respondents also think that building waste management can be possible by waste materials recycle [38].

Because the necessary organizations that can recycle construction waste have not developed in Turkey, large economic losses occur. However, the reuse of construction waste does occur at certain levels albeit quite irregularly. Mostly in Istanbul's outlying suburbs there are building material collectors. The collected salvaged building materials are sold in open and semi-open markets that could be named as "salvaged building material outlets." At these outlets, wood and PVC doors and windows, kitchen and bathroom components (closet, wash-bowl, kitchen sink, kitchen counter and cupboard), strips, tiles, plastic pipes, asbestos roofing sheets, wooden lath, etc., various materials and items that are in good and bad shape that can be salvaged are sold mostly to low income wage earners or those building squatter homes [Figure 7-8]. While the collecting and selling of material from modifications by collectors is a positive application of reusing, it is not a system that functions at an efficient level [39].



Figure 7. Salvaged Building Materials Outlet



Figure 8. Salvaged Building Materials Outlet

6. Conclusion

Architect(s) and/or designer team(s) need to focus on understanding the importance of wastestream. Because their central role in design decision(s) determine the type of building materials. So, the higher they have knowledge about building materials and optimum sizing that may refer the lower the construction waste produced. Even the brief information they may give about wastes to their clients may boost recycle and re-use options of generated waste in the construction site. Also, use of modular systems, selecting nature friendly and high durability materials, considering salvaged and recycled building materials in material selection and detailing processes will result with a decrease in the wastestream. The role of the architect(s) and/or designer team(s) must not be limited with design and go further to construction phase and by means of providing a good coordination and communication with the contractor and/or the builder they may obviously contribute to reduce/prevent from building wastes generated during the building production process.

A “Construction and Demolition Waste Management” (C&DWM) plan should be created in every stage of the building production processes in order to take the necessary precautions to minimize the negative effects of construction wastes on the environment and human health. A C&DWM System can be created through the integration of waste management plans with construction production within lifecycle process in every stage. By creating a C&AWM System as part of the construction lifecycle, solutions at the national, local,

institutional and individual scale will become clearer. The stakeholders role in each process can be summarized as;

- **Legal Base for Waste Management Hierarchy:** Laws and regulations should be made at a national scale; effective monitoring and control should be introduced; a measurement and verification system should be developed to establish the potential of C&D wastes; integration potentials of C&DWM system and present implementations in Turkey should be determined; incentive policies should be developed, Regulations should be introduced to reduce the negative environmental effects of obtaining and using raw materials, their transportation and processing. Minimizing the raw material use will contribute to lower the global warming impacts through the production of these materials and their transportation to the construction site. National, regional and local standards and codes should be established for recycled and salvaged materials.
- **Central and Local Government Initiatives and Role Distribution:** Although the legal base will identify the role of government bodies it is important to implement and clarify the roles of the local and central government. Waste management need a governmental level approach for determining national goals but apart from that it is based on the local governments (municipalities) capacity and capability to manage the process. Decisions taken at local level should be implemented effectively, a database should be created to determine the potential of C&D wastes, and effective supervision and instruction should be implemented,
- **Sustainable Construction and Demolition Waste Management Systems:** Recycling systems should be developed and supported at the national scale. The use of recycled and/or salvaged materials should be encouraged. Tax reductions should be used as a mechanism to encourage the use of recycled and salvaged materials. Reasonable price policies should be implemented for C&D wastes and classified waste materials should be charged with lower prices than the unclassified ones. Services for classifying and disassembling C&D waste should be created for better management of wastes. Quarries and open mines may be unsightly and unsuitable for immediate reuse, and should therefore be considered as sites for excavated wastes to also enable their rehabilitation. Dumping procedures of C&D wastes should be regulated and illegal dumping should be prevented.
- **Institutional and Individual Action Plans:** At an institutional scale, especially in construction/demolition organizations (including local recyclers and haulers), functional waste management departments should be created, wastes should be classified and properly disposed of, and effective supervision and instruction should then be developed. At an individual scale, waste management plans should first involve reducing the waste with source control optimization. Latterly, classifying waste (for salvage, recycle or donation) and appropriate disposal of wastes is important in the construction site or in an existing building site by adhering to the decisions of local administration.

- **Clarifying Contractor(s)/Builder(s) Responsibilities:** Contractors' responsibilities for wastes should be clearly determined in pre-construction phase in contracts and supervised /controlled during construction. Contracts should require contractors responsibility to follow the waste management plan at least results with 50% recycle and salvage option during construction for sustainable building(s) goals.
- **Educational and Research Activities:** Interdisciplinary training programs should be developed and encouraged to raise awareness of construction waste management at a national scale for all of the construction sector bodies. Research and development studies should be supported by the energy and construction related governmental organizations at a national scale in order to revise and sustain the existing waste management strategies.

Author details

Hakan Arslan

*Department of Architecture, College of Engineering, Technology and Architecture,
Hartford University, West Hartford, USA*

Nilay Coşgun

Department of Architecture, Faculty of Architecture, Gebze Institute of Technology, Kocaeli, Turkey

Burcu Salgın

Department of Architecture, Faculty of Architecture, Erciyes University, Turkey

7. References

- [1] Mills T.H, Showalter E, Jarman D. (1999) A Cost Effective Waste Management Plan. *Cost Engineering* 41 (3): 35–43.
- [2] Rogoff M.J, Williams J.F (1994) Approaches to Implementing Solid Waste Recycling Facilities. Noyes, Park Ridge, NJ.
- [3] Ferguson J, Kermod N, Nash C.L, Sketch W.A.J, Huxford R.P (1995) Managing and Minimising Construction Waste: A Practical Guide. Institution of Civil Engineers, London.
- [4] Sealey B.J, Phillips P.S, Hill G.J (2001) Waste Management Issues for the UK Readymixed Concrete Industry. *Resources, Conservation and Recycling* 32 (3–4): 321–331.
- [5] Craven D.J, Okraglik H.M, Eilenberg I.M (1994) Construction Waste and a New Design Methodology. In: Kibert, C.J. (Ed.), *Sustainable Construction*. Center for Construction and Environment, Gainesville, FL, pp. 89–98.
- [6] Poon C.S (2007) Reducing Construction Waste. *Waste Management* 27: 1715–1716.
- [7] Environmental Protection Department (EPD) (2006) Available: www.info.gov.hk/wfbu/whatwehavedone/wms/cd01.htm. Accessed 2006 Nov 01.

- [8] Lu W, Yuan H (2011) A Framework for Understanding Waste Management Studies in Construction. *Waste Management* 31: 1252–1260.
- [9] Türkiye İnşaat Malzemeleri Sektör Görünüm Raporu (2011) Türkiye Odalar ve Borsalar Birliği. (In English: Report of Turkey Construction Material Sector Outlook, The Union of Chambers and Commodity Exchanges of Turkey) Available: <http://www.tobb.org.tr/Documents/yayinlar/Türkiye%20İnşaat%20Malzemeleri%20Sektör%20Görünüm%20Raporu.pdf>. Accessed 2012 March 6.
- [10] Higgins T.E (1995) *Pollution Prevention Handbook*. Lewis Publisher. A CRC Press Company.
- [11] McGrath C (2001) *Waste Minimisation in Practice*. Resources, Conservation and Recycling 32 (2001): 227–238.
- [12] *Construction and Demolition Waste Practices and Their Economic Impact (1999) Report to DG XI, Symonds*. Available: <http://europa.eu.int/comm/environment/waste/report.htm>. Accessed 1999 February 01.
- [13] Esin T, Coşgun N (2005) Ecological Analysis of Reusability and Recyclability of Modified Building Materials and Components at Use Phase of Residential Buildings in Istanbul. UIA 2005 Istanbul XXII World Congress of Architecture - Cities: Grand Bazaar of Architectures, 3-10 July 2005, Istanbul.
- [14] DPT, 8.Beş Yıllık Kalkınma Planı 2000–2005 (In English: State Planning Organization of Turkey, 8th 5 year Development Plan 2000–2005) (2000) Solid Waste Control Sub Commission Report –Ankara. Available: <http://ekutup.dpt.gov.tr/icmesuyu/oik524.pdf>. Accessed 2006 February 01.
- [15] European Commission Environment (2011) Available: <http://ec.europa.eu/environment/waste/index.htm>. Accessed 2011 February 01.
- [16] Osmani M, Glass J, Price A.D.F (2008) Architects' Perspectives on Construction Waste Reduction by Design. *Waste Management*. Volume 28. Issue 7: 1147-1158.
- [17] Öztürk M (2005) İnşaat Yıkıntı Atıkları Yönetimi (In English: Construction Debris Management, Ministry of the Environment and Forestry). Ankara.
- [18] *Construction Waste Recycling Exceeds Target (2000)* Available: <http://eied.deh.gov.au/minister/env/2000/mr22jun00.html>. Accessed 2000 February 01.
- [19] European Commission, Directorate-General, Environment, Directorate E-Industry and Environment, ENV.E.3 - Waste Management, DG ENV.E.3 (2000) Management of Construction and Demolition Waste. Working Document N°1.
- [20] Department for Environment, Food and Rural Affairs (2012) Available: <http://www.defra.gov.uk/statistics/environment/waste/wrfg09-condem>. Accessed 2012 April 6.
- [21] Ngowi A.B (2001) Creating Competitive Advantage by Using Environment-Friendly Building Processes. *Building and Environment* 36: 291-298.
- [22] Hansen T.C (1992) *Recycling of Demolished Concrete and Masonry*. Rilem Report 6. Taylor&Francis Group London. New York.

- [23] Corinaldesi V, Moriconi G (2004) Reusing and Recycling C&D Waste in Europe. Construction Demolition Waste. Ed. M.C.Limbachiya, J.J. Roberts. USA.
- [24] Öztürk M (2004) Kullanılmış Çeliğin Geri Kazanılması (In English: Recycle of Used Steel). Ankara.
- [25] Öztürk M (2005) Kullanılmış Alüminyum Malzemelerin Geri Kazanılması (In English: Recycle of Aluminium Materials). Ankara.
- [26] Hafriyat Toprağı, İnşaat ve Yıkıntı Atıklarının Kontrolü Yönetmeliği (in English: Regulation of the Control of Excavation Soil and Construction and Demolition Waste) (2004) Tarih: 18 Mart 2004. Sayı: 25406.
- [27] Umumi Hayata Müessir Afetler Dolayısıyla Alınacak Tedbirlerle Yapılacak Yardımlara Dair Kanun (in English: Law Regarding Assistance and Precautions for Disasters Occurring in Public Life) (1959) Sayı: 7269. / Afetlere İlişkin Acil Yardım Teşkilatı ve Planlama Esaslarına Dair Yönetmelik (in English: Regulation Regarding Immediate Support Organization and Planning Principals of Disasters) (1988) Sayı: 88/12777.
- [28] Katı Atıkların Kontrolü Yönetmeliği (in English: Regulation Regarding the Control of Solid Wastes) (1991) Resmi Gazete Tarih: 14 Mart 1991. Sayı: 20814.
- [29] Asbestle Çalışmalarda Sağlık ve Güvenlik Önlemleri Hakkında Yönetmelik (2003) Resmi Gazete Tarih: 26/12/2003. Sayı: 25328. (In English: Regulation of "Health and Security Preventions Regarding Asbestos Works, Number: 25328 and dated 26/12/2003)
- [30] Regulation of "Pertaining to Regular Storage of Wastes" (Number 2753 and dated 26/03/2010).
- [31] Bazı Tehlikeli Maddelerin, Müstahzarların ve Eşyaların Üretimine, Piyasaya Arzına ve Kullanımına İlişkin Kısıtlamalar Hakkında Yönetmelikte Değişiklik Yapılmasına Dair Yönetmelik (2010) Resmi Gazete Tarih: 29/08/2010. Sayı: 27687. (In English: Regulation of "Changing the Regulation about Amendments and Restrictions on the use and placing on the market for certain dangerous substances, preparations and goods", Number 27687 and dated 29/08/2010).
- [32] Istanbul Technical University, Faculty of Civil Engineering, Department of Environmental Engineering (2006) İstanbul için AB Çevre Mevzuatı ile Uyumlu Entegre Katı Atık Yönetimi Stratejik Planı, İstanbul. (In English: Integrated strategic solid waste management plan with EU Environment legislation for İstanbul)
- [33] Altındağ S (2011) İstanbul'da Hafriyat Toprağı, İnşaat ve Yıkıntı Atıklarının Tersine Lojistik Yöntemiyle Alternatif Yönetim Planı (in English: The Alternative Management Plan of Excavation Soil, Construction and Demolition Wastes with Reverse Logistics Method in İstanbul). Master of Science. Istanbul Technical University, Graduate School of Natural and Applied Sciences.
- [34] İstanbul için AB Çevre Mevzuatı ile Uyumlu Entegre Katı Atık Yönetimi Stratejik Planı (2006) Istanbul Technical University, Faculty of Civil Engineering, Department of Environmental Engineering. İstanbul.
- [35] İSTAÇ A.Ş. (2012) Available: www.istac.com.tr. Accessed 2012 April 6.

- [36] Istanbul Metropolitan Municipality, 2012, Excavation soil, construction and demolition waste data, Istanbul
- [37] Alo Çevre Hattı'ndan Serkan Öztürk ile yapılan görüşmede edinilen bilgiler (In English: Interview with Serkan Öztürk from EPL (Environmental Phone Line), 10th April 2012).
- [38] Coşgun N, Güler T, Doğan B (2009) Yapısal Atıkların Önlenmesinde/ Azaltılmasında Tasarımcının Rolü (In English: The role of designer in reducing/preventing the construction waste). Mimarlık, Chamber of Architects Publications. Volume 348: 75-78.
- [39] Esin T, Coşgun N (2007) A Study Conducted to Reduce Construction Waste Generation in Turkey. Building and Environment, 42(4): 1667–1674.