

## Utilization of solid waste for use in technical projects

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**Abstract:** The aim of this paper is to research and describe ways of utilizing Excavations, Constructions and Demolition Waste (ECDW) in technical projects in Greece. The main characteristic of ECDW is its large volume and embodied resource. It constitutes a large fraction of the total waste produced worldwide. Therefore, both Greece and the European Union, have implemented legislation in order to address the issue of the proper management of this type of waste. The recycling goals set by the European plans are considered quite advanced for the Greek state. Even though the collection, transfer and treatment infrastructure system has been growing rapidly the last decade, recycling and re-use in Greece is still minimal. Research and application examples, which are presented in this research, aiming to reduce the volume of waste which is disposed in landfills or the environment.

**Keywords:** Excavation, construction and demolition projects, waste management, ECDW solid waste, Greek construction industry, management systems, alternative solid waste management, CDW.

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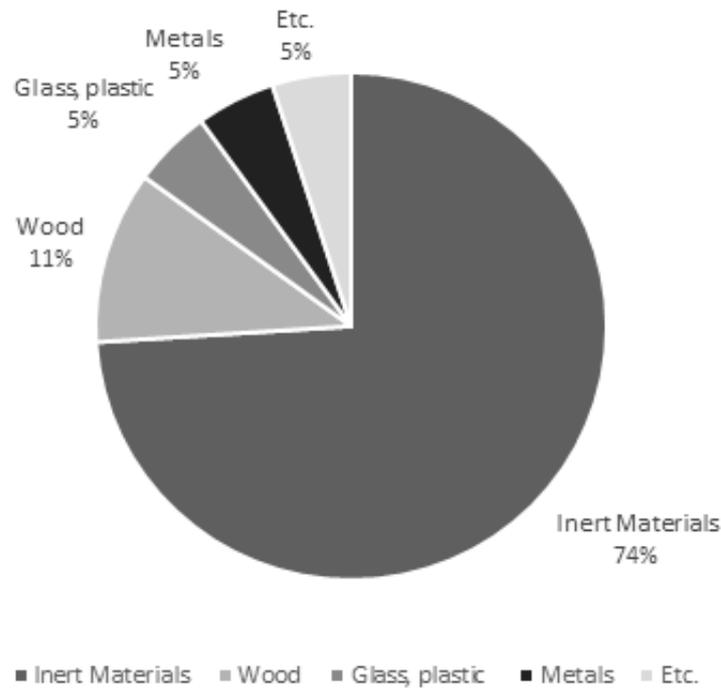
### I. INTRODUCTION

Climate change, depletion of natural resources and pollution of the environment with countless tons of waste, have resulted in the search for sustainable ways to grow the economy. Sustainability also applies to the construction industry (Oh et al, 2014). The technical works of the construction industry produce very large amounts of waste, which is estimated to occupy a very large percentage of all waste, municipal and non-municipal. Globally, the amount of construction waste exceeds 3 billion tons (Akhtar & Sarmah, 2018). The amount produced in Greece is estimated at 6 to 7 million tons per year (Study of Ministry of Environment, Spatial Planning and Public Works, 2006). However, it is very common that this type of waste is discarded in the environment and illegally landfilled, while recycling is minimal. The aim of this thesis is to describe efficient management practices of the waste produced in the construction industry. Information will be extracted from the international literature and from existing waste management units in Greece. The aim is, also, to provide safe conclusions and suggest realistic methods which can be applied in Greece, and to avoid theoretical models which could not be implemented in this country's construction industry.

### II. EXCAVATIONS, CONSTRUCTION AND DEMOLITION WASTE

Excavation, Construction and Demolition Waste (ECDW) is the waste resulting from activities such as the construction of buildings and public infrastructure, the total or partial demolition of buildings and infrastructure, the renovation of buildings or apartments and the construction and maintenance of them. They consist of materials such as concrete, bricks, iron, plastics, plaster, glass, wood, metals, asbestos and soil (eoan.gr). The main materials are shown in Figure 1. ECDW also includes either materials which are considered dangerous or materials which have been contaminated with dangerous substances. There are also materials which can become either dangerous, toxic, flammable or corrosive under certain conditions of pressure, temperature and humidity. Finally, there are materials which are not dangerous, but are not inert like the vast majority found in this type of waste.

Figure1. Composition of ECDW in Greece (eoan.gr).



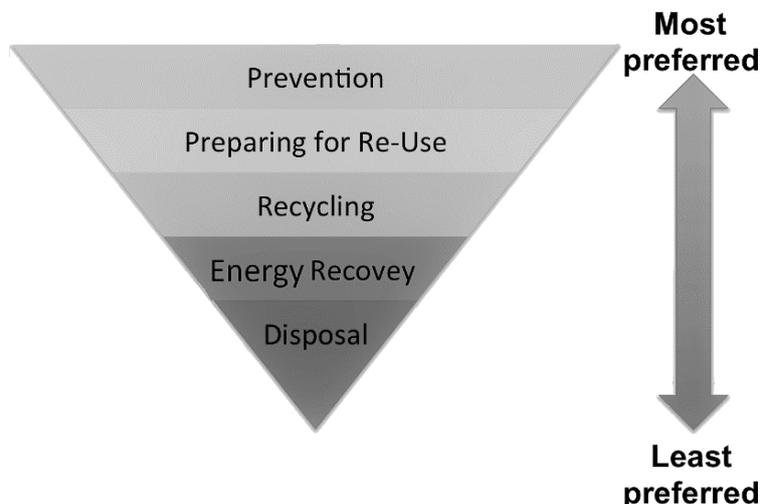
### 2.1 Categorization

The waste which is produced during construction industry activities, as already mentioned, is extremely inhomogeneous. The most practical way to categorize it, is according to their origin (waste streams). The main categories are: (a) excavation waste, meaning the excavated soils which are not used directly for embankment or supplementation at the same worksite, (b) demolition waste such as concrete, bricks, stones, tiles, metals and wood, (c) road construction waste, mainly consisting of asphalt and also materials of the sub-base of the roads such as gravel, bitches and sand and (d) building and construction site waste, which constitutes of the left-over and defective materials, packages and small quantities of various types of solid waste (Bandeira et al, 2019).

### 2.2 Management methods

The European Union and Greece, as well as all agencies and organizations dealing with the issue of reducing the disposal of waste in the environment, recommend 5 methods. These are: (a) prevention, (b) reuse, (c) recycling, (d) energy recovery and (e) disposal of various materials. The planning of most states, use a combination of these methods. Nevertheless, they are ranked in a range of preference according to their effectiveness and environmental friendliness, as shown in Figure 2.

Figure2. Hierarchy of waste management methods.



### III. RESULTS AND DISCUSSIONS

#### 3.1. European management framework

The study of the Greek legal framework can only be carried out, if only the European management framework is analysed. The management framework is defined by Directives 2001/118 / EC, 2004/31 / EC, 1994/62 / EC, 2008/98 / EC, and 2018/98 / EC, as well as by Regulation 2150/2002 of the European Parliament. Under Community law, EU Member States specific compliance guidelines must be followed in this context. Directive 2008/98 / EC is, the so-called, Waste Framework Directive. The Waste Directive includes Recycling and Recovery Objectives to be achieved by 2020. For construction and demolition waste, 70% of their weight must be prepared for re-use, recycling and other kind of recovery. The directive requires Member States to approve waste management plans and waste prevention programs in order to achieve this goal (European Commission, ec.europa.eu). Moreover, the provisions on End of Waste Criteria are specified. These criteria define when and under which conditions, certain waste ceases to be waste and acquires a product status (or secondary raw material). It is also important to be mentioned (in 2000) the European Waste Catalogue is formed, which is a useful tool for any EU Member State, public authority or individual, which seeks to properly manage with any kind of waste. The Chapter 17 of this catalogue appears in Table 1. Excavation, Construction and Demolition Waste are included in Chapter 17.

**Table1. Chapter 17 of the European Waste Catalogue.**

CONSTRUCTION AND DEMOLITION WASTES (INCLUDING EXCAVATED SOIL FROM CONTAMINATED SITES)	
17 01	concrete, bricks, tiles and ceramics
17 02	wood, glass and plastic
17 03	bituminous mixtures, coal tar and tarred products
17 04	metals (including their alloys)
17 05	soil (including excavated soil from contaminated sites), stones and dredging spoil
17 06	insulation materials and asbestos-containing construction materials
17 08	gypsum-based construction material
17 09	other construction and demolition waste

#### 3.2 Greek waste management legislation.

Concerning the Excavation, Construction and Demolition Waste (ECDW), the first time a European directive was incorporated into Greek legislation was in 1986 with the Joint Ministerial Decision (J.M.D) 49541/1424/1986. After that, numerous laws have been enacted until today.

The National Waste Management Plan, with a horizon to 2020, was formulated in 2012 with Law 4042/2012, incorporating the directive 2008/98 / EC. While the Greek state has been pursuing policies since 1964 (and more specifically after 2001), it was only after 2010 when they became essentially mandatory for waste producers.

In 2001, the National Organization for Alternative Packaging and Other Products Management, was founded, which is responsible for the realization of the objectives of law N.2939 / 2001. The principles on which the policy of the Greek state has been based since 2001 with the law L.2939 as amended in 2010 with the law L.3854 are the following:

- The principle of preventing waste generation by reducing their total volume and hazardous components.
- The principle "the polluter pays".
- The principle of responsibility of all stakeholders, public and private.
- The principle of publicity to users and consumers, in order to highlight their contribution to the reuse or recovery (alternative management) of packaging and other products (eoan.gr).

In 2012, National Organization for Alternative Packaging and Other Products Management was renamed to Hellenic Recycling Organization. This organization is the competent body from the Ministry of Environment and Energy for the planning and implementation of the policy for the prevention and alternative management of packaging and other products - including the ECDW - and monitors and controls the progress of the National Waste Management Plan.

The National Waste Management Plan had set the following goals in relation to the management of ECDW with a horizon to 2020:

- Panhellenic coverage by Alternative Management Systems. Application of the alternative management of ECDW in public and private projects, by adapting the relevant legislation or procedure where required.

- Rationalization of the operation of Alternative Management Systems and adjusting cash contributions. Separate collection for excavation waste and their rational management, which are excluded from the objectives of the ECDW, as well as for the excess concrete which results during the construction projects. In particular, the excess of excavated waste from public works should be collected separately from any materials from demolition, dismantling, etc., and the terms and conditions for their management should be included in the Environmental Reports of the project and in the contract with the contractor. The above should be included in all stages of implementation of public works, such as notice, contracts, etc.
- Development of markets for the secondary materials of ECDW processing.
- The quantitative targets concern the percentage of the produced waste leading to preparation for reuse, recycling and recovery and are: a) at least 50% by weight of the produced waste until the end of 2015 and b) at least 70% by weight of the produced waste by the end of 2020.
- For the collection of excavation waste, there must be mandatory sorting and transport (with corresponding pricing) in public works and formulation of economical motives for private projects.

### 3.3 Alternative waste management system.

The waste management in Greece is carried out by organisations called Alternative Waste Management Systems. Their operation is approved by the Hellenic Recycling Organisation. Their purpose is to coordinate and control the work of the treatment units, the collection of waste and all kinds of operations concerning waste management. The Alternative Management Collective Systems, during their approval, geographically covered a very small part of the territory. Today, the geographical coverage of the system is shown in Figure 3 and which is estimated at 61 regional units, ie 82% of the 74 regional units, as formed in the Kallikratis 2011 plan. Practically, the systems do not interfere in the treatment of waste from constructions. The enterprises which are contracted with the systems, carry out the collection, transfer and treatment of the waste. Their numbers, around the Greek territory, are shown in Table 2. With this infrastructure, the quantity of waste which is processed each year, is shown in Table 3.

**Figure 3. Alternative waste management system coverage.**



**Table2. Collectors / carriers and treatment units in Greece.**

REGION	COLLECTORS / CARRIERS	TREATMENT UNITS
Central Macedonia	113	25
East Macedonia and Thrace	39	39
West Macedonia	21	7
Thessaly	78	11
West Greece	36	7
Epirus	6	1

Ionian Islands	34	4
Central Greece	71	11
Attica	367	27
North Aegean	23	7
South Aegean	107	16
Peloponnese	101	9
Crete	17	6

**Table3. Ingoing and outgoing quantities of waste and materials.**

YEARS	OUTGOING QUANTITY OF MATERIALS (TONNES)	INCOMING QUANTITY OF WASTE (TONNES)
2014	59,315	176,112
2015	126,218	176,783
2016	247,802	525,276
2017	667,177	963,516

### 3.4 Utilization of waste in technical works.

There are many possibilities of utilization of the various materials which exist in the Waste of Excavations, Constructions and Demolitions (ECDW) (Galvez-Martos, Styles et al., 2018). According to the international and greek literature, there are many methods that the waste can be processed (Papatzani & Paine, 2017). In this research, data have been collected about the basic materials which are used in Greek construction industry. These are concrete, cement, metals, wood, gypsum, asphalt and glass. It has been attempted to present solutions which can be applied in our country where the recycling of building materials is minimal.

### 3.5 Excavation and Contraction waste in the Construction of House.

The construction of a ground floor house with an area of 94.50 sq.m. which was built in the area of Agrinio in the region of Aitolokarnania is a miniature of a technical project regarding the management of generated waste. The basic building materials used for the construction of the building were concrete, bricks, tiles and wood. The quantities and type of (ECDW) are presented in Table 4.

**Table 4. Quantity of ECDW.**

WASTE DESCRIPTION	QUANTITY PRODUSED (TONNES)	REUSABLE QUANTITY (TONNES)	RECOVER QUANTITY (TONNES)	DISPOSAL QUANTITY (TONNES)
Concrete	4.36	1.76	0.20	2.40
Bricks	5.67	4.40	1.07	0.20
Wood	0.40	0.25	0.10	0.05
Tiles	2.89	1.00	0.95	0.94
Soils	220.00	200.00	20.00	0.20

From the table we can understand that in technical projects of this type the main waste is the soil. In addition it is obvious that the main goal of the engineer is to reuse in the same project as much as possible waste. This drastically reduces the cost of waste management, a key element in the construction industry. Another element which can be mentioned is the difficulty of handling materials such as concrete as most of it goes for immediate disposal without further processing.

## IV. CONCLUSION

Waste management from Excavations, Constructions and Demolitions (ECDW) is an issue unknown to the majority of the people. With the help of schools and municipalities, society should learn about the problems which arise when producers and managers of ECDW are acting illegally. Also, professionals and businesses, as well as society as a whole, need to be informed about the country's progress and the opportunities which are opening up in the circular economy of building materials.

The ultimate goal is not for the state to force producers to respect the environment and do good management indefinitely. What is needed is a framework in which recycling and reuse of materials emerge as the most advantageous solutions. At the moment, there is an acute situation where a manufacturer, contractor, etc. have a greater economic interest to waste natural materials and then to dispose of waste illegally in the environment. Indeed, in some cases the competition imposes these practices on producers.

The possibilities of utilizing the materials identified in the waste. they are plenty. The question arises as to what measures should be taken to develop circular savings for specific materials. Especially for materials such as concrete, cement, steel and aggregates which are widely used and also produced in Greece, but are not recycled. It is estimated that, if there is research on the specific possibilities which exist for these materials and the necessary infrastructure is developed, the advantages for the industry, financially and environmentally, could be great. It would be of real interest to study how the new scientific and technological findings of the science of materials can be used and how they could be applied more widely in Greece.

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