Construction waste disposal practices: the recycling and recovery of waste

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Abstract

The rate of recycling and recovery of construction and demolition waste for the year 2020 is set at 70%. Currently in Romania, the waste recovery level is far below the set value, the collected waste is mostly disposed of by storage in landfills, without any other recovery or reuse. This paper presents practices in recycling of waste obtained from the construction of new buildings and demolition of existing buildings, with the potential of recovering large amounts of construction waste as filling material for road infrastructure or for heavy loaded industrial floors as well as possible other applications for using construction waste to substitute natural resources in concrete composition, obtaining material embedding waste with low energy consumption. The presented solutions might lead to an important increase of the recycling and recovery percentages, contributing to the fulfilment of the targeted and recycling, recovery and reuse rate. The viability of the possible applications is demonstrated with practical examples.

Keywords: construction waste, road infrastructure, recycling, recovery and reuse, natural resource substitution.

1 Introduction

The built environment in which we live has a substantial impact on the natural environment. The construction industry represents a major energy consumer domain, with a value of about 40% from the total energy consumption at EU level,

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generating 30% of the total CO_2 emissions [1]. The same source highlights the fact that the building sector shows an increasing trend over the past years [1]. At the same time, the construction sector is one of the pillars of economic development, accounting for 10% of the gross national product in developed countries and 20–30% in developing ones [2]. In 2012 the construction sector generated 8.6% of Romania's gross domestic product [3], not including the results of the building materials industry, e.g. cement production. At the same time due to the large number of employees in the construction sector it also has a substantial social impact when it upholds tens of millions of jobs. The quality of the built environment has a considerable impact on energy and material resources, implicitly being a decisive factor that affects inhabitants' health, comfort and productivity.

The construction industry demands approximately 3–4 tonnes of material per capita every year and generates over 1 tonne of waste per capita [4]. The national waste management policy should be in line with the goals of the European policy in order to prevent waste generation and should aim to reduce resource consumption and practical application of the waste hierarchy. The Frame Directive 2008/98/EC on waste, transposed into national legislation by Law No. 211/2011, sets up the basic principles of waste management: no hazardous effects on people and environment, no ill-effects for water, air, soil, plants or animals, no disturbances by noise or smells and with no negative impact on the landscape and special interest areas. These principles are to be applied in their hierarchical priority: prevention (reduction), preparation for reuse, recycling and other recovery operations [5, 6].

The rate of recycling and recovery of construction and demolition waste (recycling and other material recovery, including waste disposal on landfills using non-hazardous waste to substitute other materials) for the year 2020 was set at 70% [7]. By definition, construction and demolition waste derive from activities like the construction of buildings and infrastructures, total or partial demolition of buildings or infrastructures, road construction and maintenance.

The data made available by the Ministry of Environment [8] show that even if the recovery of waste from construction and demolition has increased in recent years (Figure 1), it has been made by landfill, almost the entire quantity of waste being disposed of by storage with no other real recovery.

Most of the waste management practices adopted in the past were oriented to short-term solutions, without taking into account the long-term effects on the environment. Therefore, palpable actions should be taken to apply the best available technologies for reducing, recovering and reusing waste. The first step in this manner is to develop the relevant code/norm provisions in order to allow extensive reuse of construction and demolition waste and/or to develop new materials from waste, usable at a similar rate to the existing generated waste volumes, which can ensure the possibility of further re-use and which is able to ensure the desired continuity for the life cycle of the construction materials, especially of those obtained from waste (Figure 2).

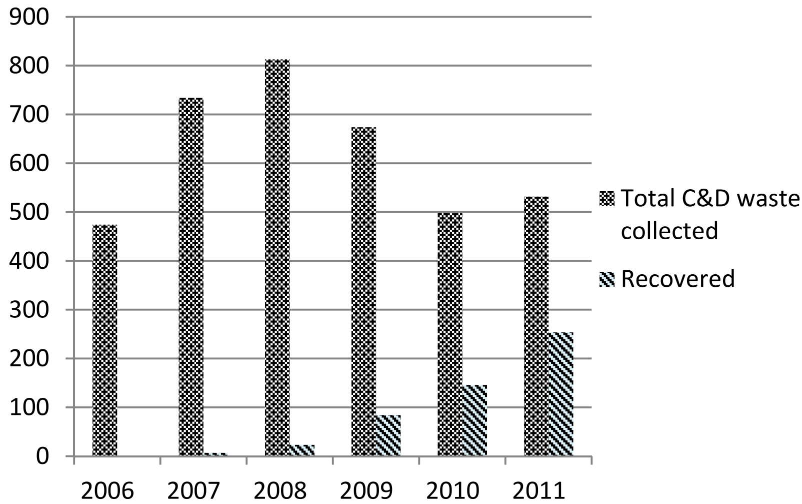

Figure 1: The situation of the construction and demolition waste (thousand tons) in Romania [8].

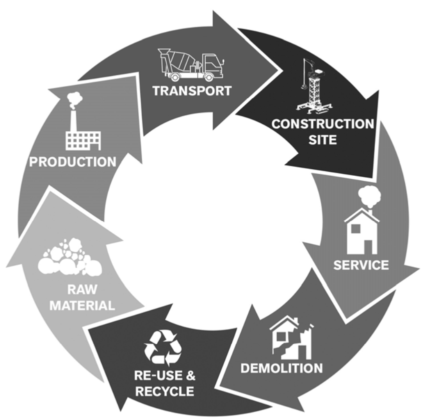

Figure 2: Desired life cycle of construction materials.

2 Construction and demolition waste management practices

In the European Union annually about 850 million tons of construction and demolition waste is generated, which represents 31% of the total waste generated in the EU [2]. In the composition of construction and demolition waste there are materials like concrete, bricks, wood, glass, metals, plastic, solvents, asbestos and excavated soil, many of them being recycled by various processes.

According to the European Topic Centre on Sustainable Consumption and Production (Eionet) [2], from the entire construction and demolition waste, the concrete, bricks, tiles and ceramics wastes amount to approx. 78% (Figure 3).

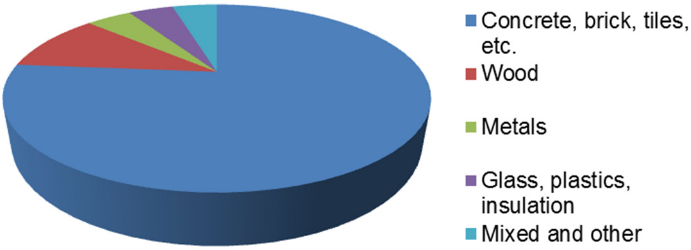

Figure 3: The weight of various types of materials in construction and demolition waste [2].

The same source concludes that this type of waste can be a source for recycling and reuse in the construction industry, being established as a priority management direction by the EU [2]. Due to the very large quantities of construction and demolition waste, they occupy important storage areas in landfills. Moreover, if they are not separated at source they might contain traces of hazardous substances (Figure 4).

Figure 4: Demolition wastes as landfill – with potential for recovery.

The potential resource for recovery of construction and demolition waste includes the large number of deteriorated or abandoned buildings, most of them built in a previous period, whose life stage approaches the demolition phase, the existing waste having resulted from already performed demolition works, which is temporarily stored or abandoned, and also high quality waste resulting from on-site construction activity or other redundant materials, with quality below the imposed standards values.

According to the European Aggregates Association (UEPG), in 2009 the European aggregates market totalled approx. 2.9 billion tons, dropping by 17.1% against 2008 levels (extracted and processed in about 23,000 facilities), out of which the secondary and recycled aggregates amount to as low as 7% [9]. For the next years the forecasts indicate an increase of the aggregates market to 4 billion tons per year, therefore it is imperative to enhance mineral waste recycling degree with a view to achieving effective aggregates, and to use mineral waste to replace non-renewable resources.

The realisation of concrete using recycled aggregates might present an important deviation with regard to the one realised using natural aggregates, therefore further research is necessary in the field in order to use mineral waste as aggregate in concrete composition.

3 Demolition waste for heavy loaded floor infrastructure

3.1 Presentation of the building to demolish

Abandoned industrial areas became of high interest for new industrial developments. These areas often include structural skeletons as a challenge to complete, but due to their advanced deterioration they represent only potential waste (Figure 5).

Figure 5: Structural skeletons in industrial areas in advanced deterioration.

When existing buildings are condemned to give space for new ones, their waste potential can be salvaged locally (Figure 6) mainly as filling material. Due to further development plans of the client, to the low quality and variability of the filling on the existing land, to the low bearing capacity of the soil as well as to the existence of underground foundations in order to level and to improve the existing area, a significant quantity of filling material becomes necessary (Figure 6). The three storey reinforced concrete frame building with masonry fill-in walls (Figure 7) became unnecessary for the client, also disturbing the path of the proposed new building. It has been used for decades as a social building, deserving the plant activity, being renovated from time to time to ensure the minimum comfort for employees. Therefore it presented not only limited possibilities for material retrieval, but important quantities of hazardous waste. Due to the environmental commitment of the client, demolition of the building with waste separation was chosen, also targeting the maximum reuse of the generated waste.

Figure 6: Structural skeletons in industrial areas in advanced deterioration.

Figure 7: Multi-storey building to demolish.

3.2 Demolition and reuse of the waste

The challenge to complete is to comply with the requirements of the client in order to maximise waste reuse. Priority in the works has been to remove and collect all the hazardous waste (like roof insulation, mechanical equipment, etc.) according to the specific waste management norms, representing only a minor percentage of the total produced waste. All architectural materials have been collected as waste, while all the PVC doors and windows have been retrieved for further incorporation in other buildings, with attention to the labour quality. According to the labour statistics during the retrieval of the PVC doors and windows, the labour cost is increased by circa 15% with regard to the usual demolition techniques, caused by high attention to the retrieved material handling and protection. Bricks from the masonry walls have been recovered, as well as all the metallic parts including the reinforcing bars of the structures.

The structure has been demolished using special equipment (Figure 8) and then crushed locally (Figure 9). Difficulties appear with the separation of the structural concrete of the rendering and masonry, the resulted filling material presenting a significant percentage of impurities (Figure 10).

The filling material obtained by crushing the structural waste had to be sorted after the crushing but prior to using it for the heavy loaded floor infrastructure, involving extra labour and cost. All the complication could be avoided with an appropriate demolition technological process and care for the size of the recycled aggregates. In the case shown, due to exaggeratedly large sizes of the recycled aggregates interlard of the filling bed has been almost impossible to obtain.

Figure 8: Demolition equipment on site.

Figure 9: Crushing of the structural concrete locally.

Figure 10: Filling material with impurities obtained after crushing.

The cost of obtaining the crushed recycled aggregates is comparable with the price of the ballast if the optimum technological process is established in order to obtain recycled aggregates reused locally. When the recycled aggregates do not contain impurities as a result of the appropriate technological process and the recycled aggregates' size is optimal, the cost of the recycled aggregates is justified to lay between the cost of ballast and of the crushed stone.

In order to replace the ballast and the stabilised ballast layer, the complete filling has been done using recycled aggregates (Figure 11). Due to the size deviations of the recycled aggregates, the compaction phase takes longer compared to the ballast or crushed stone. In the compaction phase, if the recycled aggregates have been properly splashed, the dust and small parts of the recycled aggregates act like a binder, creating an almost compact layer. Results obtained for the deformation modulus of the industrial floor substructure have been surprisingly good, showing more than 10% higher values than in the case of using natural aggregates.

Figure 11: Filling with recycled aggregates.

4 Conclusions

Using recycled aggregates locally could represent an adequate solution for roads or heavy loaded industrial floor substructures, comparable with the natural aggregates and also in the cost and deformation modulus obtained, also solving the problem of significant quantities of construction and demolition waste. Lack of code provisions for reusing aggregates is still raising doubts with regard to the rightness of the solutions. Solving the problem of construction and demolition waste is the responsibility of all the parties involved in the construction industry.

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