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## CHALLENGES OF CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT IN THE SOUTHERN SERBIA REGION

**Zorica Eraković**

University of Niš, Faculty of Technology, Leskovac, Serbia, [zookaa.trajkovic25@gmail.com](mailto:zookaa.trajkovic25@gmail.com)

**Ivana Mladenović-Ranisavljević**

University of Niš, Faculty of Technology, Leskovac, Serbia, [282ivana@gmail.com](mailto:282ivana@gmail.com)

**Abstract:** The paper presents the management of material waste flows in Southern Serbia through the analysis of techno-economic and ecological status. Waste generated during the construction and reconstruction of facilities is planned, whereby the place and method of its disposal must be provided. The construction waste life cycle analysis method uses recorded data on stored waste at a landfill in South Serbia, as well as the number and locations of wild landfills in 2016. For the selected time period, data on the total cumulative amount of waste, as well as the partial cumulative amounts of concrete, brick and asphalt that can be reused or recycled, are presented. The amount of wood waste could not be estimated because the separation of such waste is done at the source and has not been recorded.

According to the statistical reports from 2015, there are 184 registered, unregulated and mixed landfills, while going forwards 43 landfills were cleaned, with 141 still remaining unclaimed. In Donja Jajna landfill, owned by the public utility company “Komunalac” from Leskovac city, there is a solid waste dump. On average, about 10 trucks arrive at the dump in Donja Jajna, which amounts to 50m<sup>3</sup> of construction waste, 20m<sup>3</sup> (i.e. 40%) of which consists of concrete. The calculated amount of construction waste annually amounts to 18250m<sup>3</sup> of construction waste, of which the concrete itself is 7300m<sup>3</sup>. Considering that the landfill is 10 years old, it is estimated that it currently obtains 7300m<sup>3</sup> of concrete.

The current state and perspectives of the management of construction waste in the Southern Serbia region are assessed in this paper. The previous practice in the management of construction waste indicates that there is only one active landfill of construction waste that operates without any engineering principles. Estimations of material flows are done on a database obtained from a public utility company. Analysis of flows for wild landfills is excluded from this research since the share of construction waste there is negligible.

Currently no further treatment of the waste is performed at the observed landfill, so concrete as well as other construction waste, is permanently disposed of by burial. Considering the landfill and the estimation of the amount of permanent inflow of new waste, it can be concluded that the reuse and recycling of concrete, bricks and asphalt in construction units would be a cost-effective investment with stationary recycling equipment.

**Keywords:** construction waste, management, future perspectives, South Serbia.

### 1. INTRODUCTION

Natural aggregates (gravel, sand, technical and construction stone) are the main non-renewable resources used in construction. In addition to the new member states of the European Union and in Eastern Europe, it is estimated that the construction industry will grow by 4.2% in the coming years. This expected growth will likely complicate the overall market supply aggregates, and therefore the exploitation itself, which is extremely disproportionate to the needs and still associated with local phenomena of illegality and/or significant negative impacts on the environment. In addition, another important issue associated with the industry's aggregate inert waste mostly coming from construction works: construction and demolition and is deposited in landfills, sometimes illegally. The aim of the paper is to report that such inert waste can be recycled in technically available, sustainable and socially acceptable recycling facilities and become recycled aggregates, which can be used as a complementary resource in the total supply of aggregates.

### 2. THE MAIN TARGETS OF CONSTRUCTION WASTE MANAGEMENT

Construction waste in the EU is a priority for recycling. The practice of recycling and reusing construction waste has not started in Serbia, although it is estimated that around 80% of this waste can be reused. In the coming period, it is crucial to establish an efficient and environmentally responsible construction waste management system (Directive, 2008). It is necessary to adopt the most important regulations that would allow the further development of this area. Also, it is necessary to initiate the recycling of construction waste. Finally, construction waste dumps should be set up to properly dispose of non-recyclable waste. The goal is to recycle 70% of the generated construction waste in our country until 2035 (Law, 2016).

### **3. CONSTRUCTION WASTE TREATMENT FOR THE PRODUCTION OF RECYCLED AGGREGATE**

Nowadays, there are different technological methods available in the production of high quality recycled aggregates, useful in the construction industry as recycled products or raw materials, with stable technical characteristics comparable to those of natural aggregates. These technologies are in use in fixed installations and mobile installations, in order to achieve the different demands of quality (Krstić & Milenković-Kerković, 2017). Regardless of the applied technology, the plant must be able to separate the input material into stone materials that can be reused, light fraction (paper, plastic, wood, dirt, etc.) and metal fractions (Shen & Worrell, 2014). The main stages that mark the construction waste treatment processes can be divided into:

- Crushing, in order to obtain micronized particles favorable for final use,
- Screening, aimed at separating work fragments of crushed material to the grain size for the sake of obtaining homogenized fraction of grain;
- Separation, for removing unnecessary material.

Two basic principles are commonly in use: separation according to magnetic characteristics, i.e. magnetic separation and separation according to differences in specific gravity, i.e. gravity separation.

### **4. RECYCLING PLANTS**

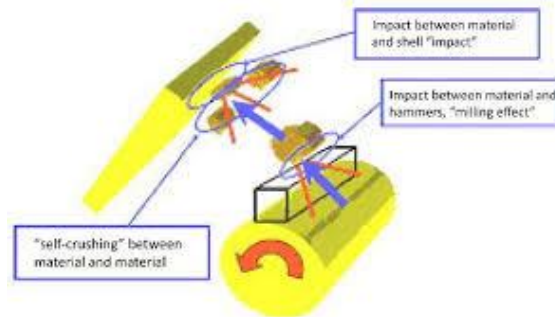
Recycling plants for aggregates can be mobile and stationary. The technology involves the production of recycled aggregate concrete crushing pieces of waste to the appropriate grit grains, which means that the two basic operations - crushing and sieving. Depending on the contamination of the waste material and the purpose of the aggregates being produced, the technological process further comprises the separation of metallic material by a magnetic separator, manually or mechanically removing foreign substances and air blowing or washing of the final product (Vučijak et al, 2016).

#### **4.1. Mobile recycling plant**

Mobile recycling plants are typically lower levels of processing waste material in relation to the stationary recycling plants because they do not allow for additional processing in terms of washing and air blowing, so that the quality of aggregates depends solely on the homogeneity of the waste material. Because of this limitation, it is mainly used in case of demolition and rebuilding in the same place, when it is expected a large amount of waste, for example during the demolition and re-construction of large industrial facilities, roads and so on. The capacity of these plants can be significantly different - from 200 t·h<sup>-1</sup> to 1,500 t·h<sup>-1</sup> of recycled materials. Their movement is usually secured with tracked propulsion device, although there are models equipped with pneumatic device for movement. Installations with a tracked device for movement have robust structure and are mostly equipped with heavier machinery and equipment, while plants with pneumatic movement device must be equipped with easier machinery and equipment, therefore with small capacity. The structure of a typical mobile plant is comprised of:

1. Loading silo, i.e. recycle acceptance of waste material,
2. Sieve for primary screening of fine materials,
3. Device for crushing,
4. Oscillating dispensing device,
5. Chassis with a device to move,
6. Supply unit - aggregates,
7. Electrical controllers,
8. The magnetic separator made of strong natural electro magnet which removes all metal parts from crushed material and
9. Sieve for the final screening - separating the different fractions (Efendić, 2008).

Crushers are the most important part of each plant, and therefore all related devices are in compliant with their characteristics (Figure 1).



*Figure 1. The mechanism of fracture in the crushing process by impact crusher*

#### 4.2. Stationary recycling plants

Stationary concrete recycling plants are complex mechanized structure in which it is possible to achieve a controlled level of product quality, i.e. it does not depend exclusively on the homogeneity of the material exploited, since the space for pre-sorting and temporary storage is available. Afore mentioned impacts on reducing processing costs, because the costs of recycling achieve a significant increase with heterogeneity, and the presence of aggregates of harmful materials. Furthermore, the separation of different types of waste allows recycling of not only the typical construction materials, such as concrete and ceramic materials, but also of wood, plastic, glass and metal sectors in their use. Also, unlike mobile plants, they must be located in densely populated areas (still taking into account the site, because of the noise and dust, as supporting factors of such plants), and can work with the production rate and capacity up to 200,000 tons of recycled aggregate per year. Figure 2 is showing the largest stationary recycling plant for demolition waste in Europe, located in Amsterdam, Netherlands, which has a production capacity of 700 t·h<sup>-1</sup>.



*Figure 2. Stationary recycling plant in Amsterdam, Netherlands*

Technological procedure of a typical stationary concrete recycling plant usually has two stages of crushing. Waste material in the first, primary screening stage separates the material through the grate (coarse screen), opening size of 40 mm, the larger pieces that are delivered to the conveyor belts primary, jaw crusher and the material smaller than 40 mm, which after passing through the oblique grid still separated, so that even in the primary screening removes fine material size of less than 10 mm, such as soil, plaster, mortar, etc. It is important that the so-called "feeding" machines are evenly arranged, to avoid overloads at the expense of quality and homogeneity. Also, regulators are provided, due to connection of a large number of machines (Robu & Mazilu, 2015). The remaining material is further processed by crushing double (first, as already mentioned, jaw, or a subsequently striking cone crushers) and double magnetic separation, followed by final removing of the remaining hazardous materials (wood, plastic, paper, plaster, glass), washing or air blowing, and less frequently, using thermal (sintering). If used, the process of dry removal of harmful substances by air blowing (that may allow manually removing of the backlog of large pieces) is the least efficient, because large amounts of dust require special protection measures. Wet washing is more suitable primarily for the removal of harmful substances soluble in water, where it is necessary to take into account that the residual gypsum can hardly be removed by this process, since it tends to expand in contact with water. Overall, the best results in the removal of undesirable impurities can be achieved by combining the above methods. The final product can differ in sizes in comparison to those shown in the scheme of operations, which depends exclusively on the size of the mesh openings (Pareek et al, 2019).

## 5. RESULTS AND DISCUSSION

At the landfill in Donja Jajna, shown in figure 3, owned by a public utility company "Komunalac" from Leskovac, arrive about 10 trucks daily in average, which would dispose amount of 50m<sup>3</sup> construction waste, of which approximately 40% of concrete, that would amount up to 20 m<sup>3</sup> of concrete.



*Figure 3. Landfill in Donja Jajna*

Currently, concrete and other construction waste have been buried on the landfill without any further treatment. The landfill has a lot of material that could be further exploited and brought into use. This would prevent a negative impact on the environment and reduce surface area of Landfill (Stumpf et al, 2011). The construction of the plant at the landfill could prevent the dumping of waste, and it could be re-used again. According to a research conducted by Banjad Pečur et al (2015), it was concluded that the recycled aggregate has got a 2 or 3 times higher absorption capacity than the natural aggregate and somewhat smaller density. Table 1 shows physical properties of recycled aggregates.

*Table 1. Physical properties of recycled aggregates*

Fraction (mm)	Apparent particle density $\rho_a$ (g/cm <sup>3</sup> )	Density of dry particle $\rho_{rd}$ (g/cm <sup>3</sup> )	Density of saturated surface dry particles $\rho_{ssd}$ (g/cm <sup>3</sup> )	Water absorbing $WA_{24}$ %
8-16	2,63	2,43	2,50	3,08
16-32	2,63	2,43	2,51	3,13

The share of pore in fresh concrete, as well as density is approximately equal to that of concrete without the use of a recycled aggregate. Banjad Pečur et al (2015) came to the conclusion that the strength and modulus of elasticity coincided with the literature data, but with increasing percentage of the recycled aggregate their values were reduced. By increasing the share of the recycled aggregate, the modulus of elasticity is reduced. Results of monitoring the waste stream in 2016, according to the data obtained in our research, are presented in Table 2.

*Table 2. Total amount of construction waste in the period from 21.12.2015 to 25.08.2016*

	The number of unloading	The amount of construction waste [m <sup>3</sup> ]	The amount of concrete [m <sup>3</sup> ]	The amount of asphalt [m <sup>3</sup> ]	Quantity of bricks [m <sup>3</sup> ]	Others [m <sup>3</sup> ]
Total	1187	11676.5	4667.6	2357.3	3257.72	1398.98

The landfill has a lot of material that could be further utilized and put into use. This would prevent the negative impact on the environment and the reduction of landfills. The construction of a facility at the landfill would prevent the disposal of waste. It would find its new application.

## 6. CONCLUSION

Depending on the time of the year, different amounts of construction waste reach the landfill. On an annual basis that would be 3650 trucks with at least 5 m<sup>3</sup> of construction waste. 18250 m<sup>3</sup> of construction waste in total, of which concrete is about 7300 m<sup>3</sup>. Construction waste management has been completely neglected, so a strong turnaround is needed in this area. Only a reduction in the consumption of natural resources resulting from the use of recycled aggregates has significant implications for the environment itself, as well as on the viability of reducing the economic cost of product costs. The current situation in construction waste management can be characterized as unsatisfactory by all indicators. Although the need for proper treatment of construction waste has been recognized in the 2009 Waste Management Strategy, nothing concrete has been done since then. Only a reduction in the consumption of natural resources resulting from the use of recycled aggregates has significant implications for the environment itself, as well as on the viability of reducing the economic cost of product costs.

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