

Quantitative Analysis of Construction Waste in the City of Novi Sad, Serbia

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Abstract—This paper introduces a method of calculating the quantities of construction materials and construction waste on site in city of Novi Sad. In buildings is about 40% of the total weight of materials that are in circulation in the world economic space. The best solution for this waste is to be stored at source, at the point of generation. There are several treatment options for this type of waste, reduction at source, reuse, recycling. Beside its negative effects on the environment, construction waste can be and resource. Novi Sad is divided in 16 single family resident zones and 10 multi family resident zones. For every zone of the city, quantities of used construction materials and construction waste were obtained. Rational use of natural resources is an essential factor in applying the principles of development with savings.

Keywords—Construction materials, Construction waste, Novi Sad, Recycling

I. INTRODUCTION

THE development of industry, mining and agriculture, unsystematic and irrational use of natural resources, population growth, pollution and climate change have caused major disruptions in the environment, leading to the vulnerability of natural resources and caused the disappearance of many animal and plant species. Therefore, the improvement of global environment is a problem of modern mankind, and an indispensable part of economic development and, through the rational use and conservation of natural resources, the imperative of sustainable development and survival including harmonization of economic growth on the one hand and the use of natural ecosystems and resources on the other. The settlement appeared in various forms, so it is impossible to describe it with just one definition. Settlement is not easy to describe, because it is constantly changing: in the beginning from the embryonic social nucleus, and then come complex stages of its maturity, and eventually grew old and started to fall apart. The origin of the undefined, since the greater part of his past, buried or removed so it can be reconstructed, and it is difficult to assess what would be his future [2].

II. CONSTRUCTION

Presented in the global scale, in buildings is about 40% of the total weight of materials that are in circulation in the world economic space. Most of this amount ends up on landfills. Construction waste is in fact a significant resource that is often found in the wrong place and its quantity can be reduced by establishing and implementation of fully developed site management procedures.

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Management decisions that could have influence on the reduction of construction waste generated on-site are:

- Availability of accurate project information and use of plans in order to eliminate potential ambiguities and discrepancies occur,
- Consultation with local authorities formed Council on materials that are recyclable or reusable,
- Informing all employees and staff working on site with efforts towards reducing the amount of construction waste generated and what is expected of them in terms of achieving this goal,
- Clear marking of separation and disposal of waste materials that can be reused or recycled, or those whose recycling is impossible,
- Adequate protection of the material while it is stored,
- Develop a plan for waste management [2].

III. CONSTRUCTION WASTE

According to the origin, construction and demolition waste is divided into the following categories:

- Waste that is allocated in the performance of new construction-construction waste,
- Waste generated during the renovation of existing buildings-waste from renovation,
- Waste that remains after demolition of buildings-demolition waste.

The first category makes construction waste and it is classified as "surplus" in the quantity ordered for building materials, waste generated during processing and preparation of materials for installation, as well as the material that is damaged before or during their delivery. Also, the materials left behind at the site immediately after the work of construction of buildings can be considered as construction waste.

Responsibly managing waste on a construction jobsite is a vital component of sustainable building. In this context, managing waste means minimizing the construction waste that leaves the jobsite for reuse, recycle or landfill disposal.

A. Construction Waste Categories

- Concrete, bricks, tiles and ceramics,
- Wood, glass and plastic materials,
- Bituminous mixtures, coal tar and tarred products,
- Metals and metal alloys,
- Copper, bronze, brass,
- Aluminum,
- Lead,
- Zinc,
- Iron and steel,

- Tin,
- Mixtures of metal,
- Soil, stone,
- Asbestos,
- Building materials on the basis of plaster,
- Construction waste contaminated with mercury and polychlorinated biphenyls – PCB,
- Other construction waste.

B. Waste Materials Treatment Hierarchy

- Reduction: always ordering the quantity of material that is really needed,
- Reuse: to use those materials-products that can be used several times in its original form and purpose, provided that it is safe,
- Recycling: applied when reusing the same purpose is not possible,
- Revitalization: to extend its life span.

C. Reducing the Construction Waste

Proper materials management practices may result in cost savings. Assure that precise estimates are made prior to purchase of materials, and that accurate measurements are made prior to cutting materials so that excess scrap and end cuts can be avoided.

D. Reuse of Construction Waste

Encouraging the reuse of products and materials that are suitable for it shall never be interrupted, because there is no more direct way of preventing the generation of waste. In cases where construction and demolition sites are located on a small mutual distance, it should be insisted on the revitalization and then their use as suitable building materials and elements. If not, an acceptable option may be to consider storage of reusable materials until their resale or redistribution. Installation of reusable materials can be significantly facilitated if they managed during the construction of the modular principle.

E. Recycling of Construction Waste

All the attention is focused on recycling of inert materials from construction waste. The main stages in the process of recycling are sorting, crushing and screening, and the final product is a unit that can be used in construction. There are at least two benefits of recycling process, with the engine as its final product:

- Significant reducing the amount of construction waste,
- Saving natural resources [2,3].

IV. ESTIMATING METHODOLOGY

In this study is presented analysis of construction waste in Novi Sad, which is city in Serbia with 280000 inhabitants. Novi Sad is divided in 16 single family residence zones, and 10 multi family residence zones [1]. Experimental test which is performed to calculate quantity of used construction materials

per square meter of one multi family building and one single family house shown that quantity of used construction materials for one multi family building was 2812 kg/m² and the quantity of used construction materials for one single family house was 2087 kg/m².

Quantity of used construction materials for each zone of Novi Sad is calculated as:

- For single family houses:

$$QCM = TAF \times QCM_{osfh} \quad (1)$$

QCM – Quantity of used construction materials

TAF – Total area of flats in zone

QCM_{osfh} – Quantity of used construction materials for one single family house (2087 kg/m²)

- For multi family buildings:

$$QCM = TAF \times QCM_{omfb} \quad (2)$$

QCM – Quantity of used construction materials

TAF – Total area of flats in zone

QCM_{omfb} – Quantity of used construction materials for one multi family building (2812 kg/m²).

Quantities of used construction materials by Novi Sad city zones are presented in Table II and Table III.

In order to determine the amount of construction waste compared to the quantity of used construction materials, a questionnaire is done with 10 construction contractors. The questionnaire is organized to estimate the percentage of construction materials which are noticed as construction waste. The result is presented in Table I.

TABLE I
QUESTIONNAIRE RESULTS REGARDING QUANTITIES OF CONSTRUCTION WASTE
COMPARED TO CONSTRUCTION MATERIALS ON SITE IN PERCENTAGES

| Contractor Company | Quantity of construction waste compared to construction materials on site (%) |
|-----------------------|--|
| Erker | 5 |
| Buducnost | 5 |
| Prezident | 4-5 |
| Proconing NS | 1-3 |
| Zlatibor Invest | 3 |
| Artec Group | 12 |
| Dom Company | 7-10 |
| Kimex | 1-3 |
| Kovacevic | 5 |
| Dijagonala | 7 |
| Average | 5 |

As it is shown in Table I, average value is 5%. Quantity of construction waste can be calculated as:

$$QCW = QCM \times 5\% \quad (3)$$

QCW – Quantity of construction waste

QCM – Quantity of construction materials

Results are presented in Table II and Table III.

TABLE II
ESTIMATED QUANTITIES OF CONSTRUCTION MATERIALS AND CONSTRUCTION
WASTE IN SINGLE FAMILY ZONES OF NOVI SAD

| City Zone | Estimated quantity of construction materials(kg) | Estimated quantity of construction waste(kg) |
|-----------------------------|---|---|
| Adice | 328868352 | 16443417 |
| Bukovac | 33278927 | 1663927 |
| Cardak | 71303112 | 3565155 |
| Karagaca | 18940248 | 947012 |
| Kip i Bocke | 72438984 | 3621949 |
| Klisa | 519156144 | 25957807 |
| Mali Beograd- Veliki Rit | 118310256 | 5915512 |
| Miseluk II | 76241232 | 3812061 |
| Sajlovo | 97595208 | 4879760 |
| Salajka | 134045424 | 6702271 |
| Sirine | 167040 | 8352 |
| Staroiriski Put | 67087440 | 3354372 |
| Sumice I and II | 61451928 | 3072596 |
| Telep | 707696280 | 35384814 |
| Veternicka | 38490192 | 1924509 |
| Rampa | | |
| Vidovdansko | | |
| Naselje | 70265376 | 3513268 |
| Total | 2415336143 | 120766782 |

TABLE III
ESTIMATED QUANTITIES OF CONSTRUCTION MATERIALS AND CONSTRUCTION
WASTE IN MULTI FAMILY ZONES OF NOVI SAD

| City Zone | Estimated quantity of construction materials(kg) | Estimated quantity of construction waste(kg) |
|---|--|---|
| Podbara | 316350000 | 15817500 |
| Grbavica with street Cara Dusana | 1016838884 | 50841944 |
| Area between streets Bulevar Oslobođenja and Petra Drapsina | 803427768 | 40171388 |
| Area between streets Futoska and Novosadskog Sajma | 753213884 | 37660694 |
| Nova Detelinara | 373996000 | 18699800 |
| Area between streets Novosadskog Sajma and Kralja Petra I | 863683304 | 43184165 |
| Salajka | 130153420 | 6507671 |
| Zitni Trg | 521223884 | 26061194 |
| Novo Naselje | 1850737484 | 92536874 |
| Telep | 231855924 | 11592796 |
| Total | 6861480552 | 343074026 |

V. CONCLUSION

All construction works have a negative impact on the environment, raising the buildings, with a geological standpoint, the use of natural resources, air quality and water, releasing pollution gases and liquids, power consumption and "production" of solid waste on construction sites. Rational use of natural resources is an essential factor in applying the principles of development with savings. Construction of infrastructure and buildings require the consumption of large amounts of non-renewable natural resources.

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