

Economic Expediency of Building Waste Recycling

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ABSTRACT: The economic aspect of recycled building waste use is observed. Technical and economic conditions providing the economic profitability of the recycling facilities, as an investment project realisation, are formulated. The condition, which provides the market competitiveness of the recycled aggregates against the natural ones, is drawn up. The production costs of aggregates recycled from building waste as well as of natural aggregates are grouped. They reflect also the costs of building waste transport to landfills and the disposal fees. Relations between prices of recycled aggregates and of natural ones in some European Union countries are indicated. Accent is put on some of the reasons, causing skepticism in the potential users about recycled building waste and recommendations are given for their better market presentation.

1 INTRODUCTION

The existence of large quantities of building waste in the industrialised countries is a fact which is dictated by a number of circumstances – dynamic new construction or restructuring of urban areas, whereby old buildings are being demolished; building of new infrastructure facilities, whereby old ones are being demolished too; availability of produced and not implemented quantities of various reinforced concrete elements, like sleepers, panels, etc.

Another source of building waste are buildings and structures demolished by earthquakes and other natural disasters as well as during war operations. In parallel to this, the demand of construction materials and particularly, aggregates for concrete mixes and various mortars is constantly growing. Very often, the natural aggregates used in the construction process are extracted at growing costs and transported to a great distance, which complicates the new construction and raises the unit price of construction works.

The availability of large quantities of building waste has a negative effect on the environment, since they lead to dust pollution, troubles in sewer systems when raining, and risk of contamination of people being around. Besides, they occupy a lot of space and impede the rational use of the respective sites.

The proximity of building waste to real estates lowers their market price and worsens the quality of life in the respective habitat. In the course of time, the existence of building waste from the civil, indus-

trial and infrastructural construction turns out into a serious technological, economic, social and ecological problem.

Technologically, the problem of building waste recycling is already solved. In EU countries, U.S.A., Japan, Canada and Australia the recycling of building waste obtained from demolished buildings and old road pavements is a profitable business.

The heavy machine-building industry in these countries produces stationary and mobile equipment for recycling and it is easily marketable. This offers two possibilities – to erect plants for building waste treatment or to drive the mobile equipment to the places of heavy concentration of such waste.

The first option needs a higher initial investment, while the second one benefits from the more efficient use of the equipment and lower transportation costs. The stationary facility provides a higher productivity and respectively, a lower unit cost per ton of recycled aggregates. However, the decision for its location depends not only on building waste transport analysis but also on a number of other limitations of administrative, planning or ecological nature.

Within the economic environment in the Balkans it is difficult to prove the economic efficiency of a stationary option from purely financial point of view (Radeva at all, 2003). This is due to both the relatively small concentration of building waste and financial sources availability for such an investment project. At the same time, the building waste quality is hard to be predicted and consequently, the quality of the obtained recycled aggregates.



It is difficult to predict also the market response of the potential users because there are no traditions in this business and only more attractive prices would have made it more attractive. There are still no problems so far with the natural aggregates supply and their prices are lower than the average ones in Europe. Nevertheless, the building waste recycling is an up-to-date problem, its importance will grow in the course of time, and the conditions here will become closer to the ones in the industrialized countries. All this requires proofs for the expediency of the recycled building waste use under the local economic conditions

2 ECONOMIC PROFITABILITY OF THE RECYCLING FACILITIES

First of all, the conditions providing the economic profitability of the recycling facilities should be formulated. They depend, to a great extent, on the local conditions but could be limited to:

- availability of a vast amount of building waste with a tendency of increasing;
- building waste sources of the same kind (demolished reinforced concrete buildings, damaged road pavements, damaged panels, etc.);
- possibility of separation of the building waste components – concrete, steel, glass, etc.
- convenient access of heavy vehicles for loading and transport;
- availability of a collection site for building waste – preferably in the immediate vicinity of an existing landfill for industrial and/or municipal waste;
- existing high fees for the disposal of the existing building waste;
- shortage of high-quality natural aggregates for the needs of the building production;
- relatively high prices of natural aggregates at the market – sand, gravel and crushed stone (rubble);
- the users at the aggregates' market should have the adjustment to implement recycled aggregates.

Taking into account the above factors, it is not surprising that the biggest stationary facilities for building waste recycling are located in heavily populated areas in the industrialized countries where a large-scale construction is realized, usually on the place of old buildings being demolished. A typical example of this is Berlin, which has been transformed into an enormous construction site where high-productivity recycling facilities are disposed. The industrial recycling of building waste is also well developed in the Netherlands, Belgium, Japan and around the big urban agglomerations in the U.S.A. – New York, Chicago and other cities. A

specific peculiarity exist in the U.S.A. – due to the large number of buildings with steel structures, including the ones erected in the 1920s and 1930s, their recycling is performed after the disassembly of the structure in steel plants.

From macroeconomic point of view it is very difficult to determine the quantity of the building waste per capita in the respective country. In U.S.A., per example, this amount is estimated to be 270 kg per capita. A number of economic and natural factors may influence this value. It is closely connected with the investment activity, its growing and the subsequent building in areas where buildings-subject-to-demolition exist. The types of structures of the demolished buildings also have an effect on the building waste volume. If the source of waste is road pavements, their type is of importance for the waste composition. Sometimes, the source of building waste is an earthquake that has caused demolitions.

All this outlines the scope of the problem of the economic efficiency of the recycled building waste use. One more technological condition has to be taken into account here – the physical and mechanical properties of building waste (estimated in lab tests) should conform to the norms being in force. Particular attention should be paid to the separation of the building waste components and possible unwanted chemical reactions stemming from this process.

If the physical and mechanical properties of natural aggregates and recycled aggregates become close to each other, it is necessary to investigate the competitiveness of recycled aggregates. This is of great importance before initiating investments in stationary or mobile facilities for recycling, which should be preceded by a number of technological, economic and market studies. Besides, the market adjustment of the future users of such recycled construction materials should be carefully studied and even stimulated. This can be realized in an appropriate way – through an advertisement campaign, demonstration of individual construction products or buildings, in the erection of which recycled aggregates have been used. Assistance in research works in this field is also a useful form of stimulation. This is important, since the physical amortization of buildings and structures could be forecasted, which could lead to an estimation of the building waste volume that is subjected to recycling.

The condition, which provides the market competitiveness of recycled aggregates against natural aggregates, is that the sum of all costs for recycled aggregates production should not exceed the cost of natural aggregates extraction. This condition is given in (1).



$$\sum_{i=1}^7 S_i \leq \sum_{i=1}^4 N_i \quad (1)$$

where: S_i – costs for recycled aggregates and N_i – costs for natural aggregates.

In Table 1 and Table 2 are shown the individual costs for recycled aggregates and costs for natural aggregates respectively.

Table 1. Individual costs for recycled aggregates production

Recycled aggregates production	
S_1	Additional activities for treatment of waste from demolition
S_2	Waste disposal (with reverse sign)
S_3	Transport to a landfill for building waste (with reverse sign)
S_4	Transport of waste to a recycling site
S_5	Processing
S_6	Transport of aggregates to a construction site
S_7	Additional costs for control, storage and sale

Table 2. Individual costs for natural aggregates extraction

Recycled aggregates production	
N_1	Extraction of aggregates from a quarry
N_2	Processing
N_3	Internal transport
N_4	Transport of aggregates to a construction site

3 DETERMINING OF COSTS FOR RECYCLED AGGREGATES PRODUCTION AND NATURAL AGGREGATES EXTRACTION

Four groups of costs can be distinguished in the process of extraction of natural aggregates – for their extraction from a quarry, for processing, for the internal transport and for the transport of aggregates to a construction site. These groups of costs are comparatively easy determinable because the extraction of aggregates and their processing are made in a mechanized way.

The machines used for this purpose have a fixed delivery price, which is supplemented with all costs related to putting them into operation, the current operational costs and the profit. Then, the unit price can be fixed on this basis, taking into account the productivity of the extracting facility. If natural aggregates need processing, similar steps are undertaken. The processing is performed by appropriate machinery.

The internal transport within the site for natural aggregates extracting raises additionally their production price. In order to correctly compare the

natural aggregates costs with the recycled aggregates ones it is necessary to add the transport costs of natural aggregates to the respective construction site. It is necessary to note, that the quarries for natural aggregates become increasingly far off the construction sites and this are one more argument in favor of recycled aggregates.

The group of costs fixing the unit price of recycled aggregates is larger. It includes, first of all the costs of the additional operations for treatment of waste, which are a product of demolition. The way of demolition and the respective associated costs are not taken into account because we consider the building waste as an available one. This group includes also the costs for separation of the demolition site but an additional separation is also possible to be carried out at the recycling site.

Table 1 and Table 2 indicate two items, which are with a reverse sign – these are the costs for transport to the building waste landfill and the costs for the disposal itself. In case of starting the waste treatment, the cost of transport to the recycling site should be taken into consideration, which is mainly true for a stationary facility. Following are the real costs of building waste treatment and they are fixed for the facility as a whole.

The cost of recycled construction materials transport to the construction site is added, as well as one more group of specific costs. It includes the additional costs for control, storage and sale, the control being realized in licensed laboratories.

There exists very big difficulty to reach an identity of values from (1) in practice. Therefore, it is important, in case of inequality, to establish to what extent we can deem that the use of recycled aggregates is economically justified. Beforehand, however, it should be estimated which group of costs dominates, although this is a very difficult task.

The object of demolition should be carefully evaluated and especially, in terms of possible selective demolition. In the West European countries the selective demolition costs have reached 25%. Besides, the building waste disposal fees depend significantly on the local conditions – they can vary up to 10 times in different locations, ranging from 1.35 EUR to 14 EUR for a cubic meter of building waste.

In the EU countries the additional costs for preparation, production, testing and control, storage and sale of recycled aggregates are around 5.5 EUR per ton. If the fee for building waste disposal is neglected, recycled aggregates can not be competitive to natural aggregates. Practically, this is not possible in the EU countries, since the legislation related to environmental protection is to a great extent compatible and includes very severe sanctions if such waste is not disposed by a fixed term.



In the construction materials market, natural aggregates are still preferable for concrete mixes, but if the price differs with 25% in favor of recycled aggregates, European users will prefer them. In the U.S.A. the market realization of the recycled construction materials is even more difficult – with equal technical parameters they have to be at least 50% cheaper in order to be preferred by the users.

One serious obstacle to the wider distribution of the recycled construction materials is the skepticism about their building qualities. This skepticism is due to a lack of enough experience in their use while lab tests show that their physical and mechanical properties are not worse than those of natural aggregates. The construction companies do not have proofs so far that, in a long term, the erected structures that have used recycled aggregates are durable enough. At the same time, there are some troubles and additional costs involved when recycled aggregates are used in concrete mixes. They are connected with the use of chemical additives and possible increase of the amount of cement, the complicated treatment of the concrete mix, the steps undertaken against shrinkage and taking care of concrete in its early age. Nevertheless, the use of recycled aggregates in most countries is profitable.

The relationships between prices of recycled aggregates and natural aggregates in some European countries are shown in Table 3, where are indicated the average sale prices.

Table 3. Price relations between recycled aggregates and natural aggregates in some EU countries

Country	1	2	3
France	4.4 – 9.0	3.6 – 6.5	1.2 – 1.4
Spain	3.0	6.0 – 14.4	0.5 – 0.2
Belgium	2.4 – 7.2	2.4 – 10.8	11.0 – 0.7
United Kingdom	3.3 – 8.4	4.4 – 15.2	0.5 – 0.6
Germany	4.8 – 8.4	6.5 – 8.8	0.7 – 0.95
The Netherlands	8.7	11.4	0.76

where 1 - Average sale price for recycled aggregates;

2 - Average sale price for natural aggregates;

3 - Price relation between recycled aggregates and natural aggregates;

After the analysis of the production costs of natural aggregates and recycled aggregate and the relations between them, the economic efficiency of their use can be determined. It should be, however, preceded by forecasts for the existing volume of building waste, review of prices and investigation of operational costs of stationary and mobile recycling facilities as well as the provisions of the local ecological legislation with respect to waste disposal. The increase of building waste volume in the future, taking into account the ever expanding scale of building activities, will lead to more extensive use of them and certainly will raise the trade interest to

them in parallel to the reduction of their market prices.

4 CONCLUSIONS

An approach for economic expediency of building waste recycling is concerned. Technical and economic conditions providing the economic profitability of the recycling facilities, as an investment project realization, are formulated. The condition, which provides the market competitiveness of the recycled aggregates against the natural ones, is drawn up. The production costs of aggregates recycled from building waste as well as of natural aggregates are grouped. Relations between prices of recycled aggregates and of natural ones in some European Union countries are indicated.

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