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Ivan HYBEN[1]
Marcela SPIŠÁKOVÁ[2]
Technical University of Košice

WAYS OF DEMOLITION WORKS vs. FINAL PRODUCT OF RECYCLING

The civil engineering is one of the significant holders of permanent value to society. On the other hand, construction and demolition waste (CDW) generated during this activity presents 22% of the total waste stream in European Union [1]. However, this waste can be recycling through the existing technological methods and processes. Considering this fact, is necessary to begin to understand the waste as a source of secondary material, which allows the sawing of natural raw materials. The ways of treatment and subsequent use of construction and demolition waste (CDW) depends strongly of the demolition waste realization, because the construction and demolition waste arises mainly at this works. This paper deals with the possibilities of realization of demolition works and the consequent ways of recycled material use.

1. Introduction

Construction waste presents a huge source of secondary raw materials, which is needed by appropriate technological methods to use. One of the waste material utilization ways is recycling, which brings to savings of natural sources, treatment of construction and demolition waste and prolonging of the life cycle of particular kinds of materials. In the last decade, the recycling of construction and demolition waste is emphasized not only from an environmental aspect, but also from an economic aspect, which is currently one of the main criteria of success of the activity. The realization of demolition works has a significant impact on the treatment options of construction and demolition waste and the quality of recycled materials.

The waste generated in the construction industry can be divided into the following groups [2]:

- waste form the operation of construction equipment and objects,
- waste from the preparation, auxiliary and transport activities,

[1] ivan.hyben@tuke.sk
[2] marcela.spisakova@tuke.sk

- waste from the realization, implementation and exploitation of the buildings,
- waste from the reconstruction and demolition of construction objects.

However, the renovation and demolition works of buildings present the biggest share in the production of construction waste. Currently it is interesting the issue of old prefabricated houses, which were designed at the 50 or 60 year life cycle. The demolition or renovation works of these objects is the source of mineral construction debris predominantly composed of the inert minerals, eg. bricks, concrete, mortar, concrete building components, roofing, etc and the concrete debris, particular reinforced concrete. Similarly, a large proportion of the CDW present a demolition and renovation works in the road and bridge construction, namely the old bridges and roads, where are created the recyclable materials, mainly the mixture of asphalt and materials from the layers of roads and highways, reinforced and prestressed concrete.

2. Building structures demolition and deconstruction works

The quality and composition of construction and demolition waste can largely influence the realization of demolition of building structure, construction or their parts. The reason for demolition (removal) of structures can be a disposal of unsuitable adaptations and extensions, the changes of dispositions or the removal and demolition of the entire construction object. Demolition works of non-load bearing of infill parts of construction is not usually difficult. Much more difficult is the demolition of load bearing parts of construction, respectively whole construction. The working method for the demolition, especially the exact demolition procedure of individual constructions in the building is necessary to design in advance. There stability of the structures has to be ensured. Therefore it has to be proposed the gradual demolition or load bearing parts of construction – those that have lost their load bearing function of which the load bearing function is transferred to other elements and parts of construction. The proposed working procedure must be regularly and carefully monitor in according with the Notice SÚBP and SBÚ No 374/1990 about the safety of occupational and technical equipment in construction work.

In the past, the ways of the demolition of construction were depended on the type of construction material and the type of construction. Until the mid-19 century, the most building were built entirely of stones and bricks connected by the mortar. These objects were manually demolished and materials were re-used for new construction. This procedure presents a reasonable re-use of materials. The new construction materials – concrete and reinforced concrete came with the use of cement. The demolition works presented the disconnection of much stronger materials, which require higher standards for their demolition [3].

The choice of the optimal demolition technology always depends on the particular case. Consideration has to be given to the impact of the demolition on particular reconstructed structure, nearby objects and the surroundings [4].

The demolition works can be carried out in particular:

- manually,
- by mechanized way,
- by explosive way.

1. *Manual demolition of structures* (Fig. 1a) – should be used where is it not possible or suitable to apply the mechanization, particularly in small demolition works, for example in the creation or extension of the holes, in some preparatory works for the reconstruction, in the remote locations or in the deconstruction of structures. The advantage of this demolition way is the opportunity to regulate the amount and extent of demolition material.
2. *Demolitions through the mechanization* (Fig. 1b) – the continuous of dividing joints, grooves, bores by which the structural components are divided into separate parts are created by the work of demolition mechanisms. The disadvantages of this technology are the significant shocks that can destroy the surrounding construction and the small sensitivity of demolition, because the quality and composition of waste cannot be regulated.

This realization method of demolition works was previously used for disposal of brick constructions. Firstly, there was provided a demolition of construction by the ropes pulled by the trucks or excavators. This method requires the gradual laying of the roof deck after its manually deconstruction, laying of the roof and then the pulling of vertical and horizontal parts of structures. The advantage of this procedure is that the building material be easily split and used [4].

The existing reinforced concrete structures are characterized by the large amounts of steel reinforcement. The crushing jaws of mechanization disturb the structural elements and move to the foot of construction. During the mechanical disconnecting of reinforced concrete construction it always begins from the top to down floors gradually cutting the reinforced concrete walls. Mechanisms cut the surface of the walls in the vertical and horizontal direction. Similarly, the demolition of reinforced concrete construction can not work without the supplementary hand demolition [3].

3. *Demolition works by explosive* (Fig. 1c) – is used mainly for the sanitation works, where is needed to demolish the whole constructions, eventually their complete parts, which usually means to demolish and remove at once the massive units of structures. By the explosion it is achieved a partial destruction of construction with the following manually or mechanized

disconnection, or the total disconnection – the destruction of structure with the removal of individual units by the heavy machineries. The use of explosives in the industrial demolition of construction has been successfully used form the 50s of last century. This method of demolition is mainly applied for the high buildings, where the mechanisms cannot be use, for example – chimneys of factory, cooling towers, bridges, as well as all types of reinforced concrete and steel structures.

Fig. 1. Demolition and deconstruction of building structures: a) manual demolition of structures, b) demolitions through the mechanization, c) demolition of construction by explosion, d) deconstruction of structures

Another possible approach to the demolition and destruction of structures and their parts is the deconstruction of buildings elements – *deconstruction of structures* (*dismantle of structure*) (Fig. 1d). The deconstruction is a relatively new method, where the construction is carefully dismantled to save of its components for their reusing. Major application of this procedure is in Germany. During dismantle of objects the manual and mechanical deconstruction construction elements are used. Later these construction elements should also be

reused in the construction of new structures or in the reconstruction of older buildings. The dismantled parts of building structures have to be properly transported by the lifting machines and stored in such way that even during longer duration the damages under atmospheric or biological influences can be avoided.

According the presented survey of the ways of construction demolition works, we can claim that in term of the subsequent use of construction and demolition waste the most acceptable way of demolition work is the deconstruction of building structures into the individual construction elements. On the other hand, we can say, that this method is used in our conditions at least, although the obtained components do not require major adaptations.

In terms of the waste management it would be appropriate to apply the manual demolition, or mechanized demolition combined with manual, where already at the building site would be provided a primary pre-sorting of particular construction waste. On the other hand, this demolition is difficult and ultimately ineffective. The least suitable demolition method is the demolition through the explosive, that presents a complete destruction of structures parts that cannot be subsequently sorted to types of waste.

The part of each demolition technology must be a careful separation of individual waste components in terms of its future use. It is clearly shown that the separation of particular types of waste already on the building site is far more effective and cheaper than in the recycling centre. During the demolition works it is easier to separate the mineral debris from other materials, especially wood, plastics, tar cardboard, metal etc.

During the demolition works it is important to emphasize [5]:

- separation of contaminated materials from uncontaminated,
- separation of foreign materials from mineral debris intended to recycling; it is closely connected with the creation of sorting logistics system already on the building site, where is providing the separation of these parts in the several separate containers; there are particularly the metals, organic materials – the used wood, some minerals materials – stones, mortar, and other mainly hazardous waste – paints, asbestos,
- separation of inert mineral debris at least the basic types – brick rubble, concrete rubble, bitumen debris and excavated soil.

The treatment and disposal of construction and demolition waste depend on the way of carrying out of demolition works and subsequent separation processes already on the building site, quality and quantity of generated this waste.

3. Recycling of construction products

The recycling of building materials is analyzed in many publications; therefore we will deal with the recycling of building products in the next part of paper.

The recycling of construction products has a crucial importance, because the created values are preserved. Given that, the used materials (mass and energy) are largely or fully exploited. The energy saving arises from the substitution for the concrete parts (blocks), which could be necessary produced. In addition, recycling of construction elements prevents of the further generation of construction waste. This means that it prevents the origin of construction waste, so energy and materials streams are decreasing.

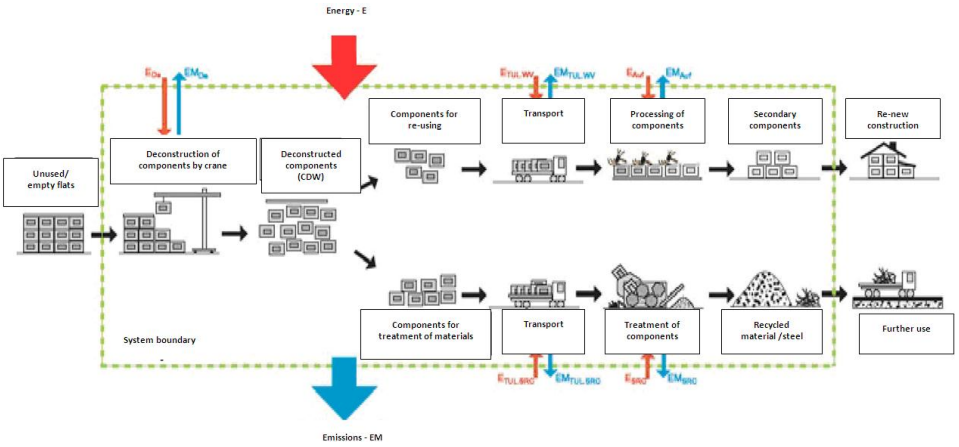

Fig. 2. Deconstruction and reuse of construction and demolition waste and origin of waste of first shape [6]

Through the deconstruction of structures creates *the wastes of the first shape*, which presented the recycling products. They consist of the prefabricated elements, which have been carefully dismantled (deconstructed) for the preserving of their original shape. During the deconstruction it is possible to use several ways of disposal with the obtained prefabricated block from the deconstruction of structure. According to the scheme (Fig. 2), after the dismantle of prefabricated blocks (the precast) by the crane; there are two possible directions for the waste management:

- direct use of wastes of the first shapes – components (precast) obtained by the deconstruction are reused without complicated processing; the processing phase consists only of their adjustment; these products are defined as secondary components, which are suitable for the subsequent use,

- indirect use of wastes of the first shapes – in this case, the precast are processed (sorted, adjusted and crushed) in the recycling centre. The resulting product is not recycled product, but recycled material, which can be used in civil engineering.

4. Recycled materials and products from the treatment of construction and demolition waste

It is assumed that the recycled materials which are produced during the recycling of CDW will be used mainly in construction production. Directive of EU Committee 89/106 EEC demands the member countries to accept such measures, that the products for building and structures comply with the regulations and requirements of mechanical strength and stability, fire safety, safety in use, sanitation and health legislation, protection against noise, saving of energy and environmental protection [6]. These requirements are also implemented in the Act no 90/1998 about construction products. When using the recycled building materials, the following requirements increase, because of lower homogeneity in comparison with natural materials.

The suitability of recycled materials for the new using in construction is verified by the regular tests by carried out the accredited testing laboratory, in terms of environmental protection, as well as their use.

Recycled materials are created by the combination of crushing and sorting to fraction with respect of maximum use in construction production. The quality of recycled material arises from the sorting of crushed construction waste. According the grain thickness (size) is divided into various separate fractions, usually 0-8 mm, 8-16 mm, 16-32 mm a 32-63 mm. Different types of recycled materials are cost-effective substitute for the natural raw materials and have a wide application – whether as a filling-in materials to construction of roads, paved areas, forest roads, noise barriers, adjustment of area, and soon.

1. Concrete recycled material.

   The way of the use of concrete as a secondary raw material is mainly dependent on the quality of the original concrete, the method of processing and the amount of information about the properties of the new produced concrete. Concrete recycled materials, especially their bigger fraction (>4 mm) based on its known physical-chemical and mechanical properties are widely used in the road construction, mainly as a filling for the top and background load bearing layer, the load bearing layer connected by cement, drainage layers, construction of field roads or as aggregates in the railway construction.

   The adjusted recycled concrete can be successfully used as aggregate for concrete of lower classes (underlying or filling concrete) with low quality requirements to quality of raw material and as filler to the bituminous mixtures. Conversely, the recycled material of fraction 0-4 mm,

which is created mainly through the crushing of concrete construction, is not suitable for similar using, because it contains a large proportion of cement stone, which may already be partially corroded, thus changing its properties. This fraction is suitable for the manufacture of mortars or in the production of Portland cement [7].

2. Bricks recycled material.

   Within the using of brick debris as a filler into the construction mixtures for the production of structural components is necessary to ensure that they do not contain large amounts of unwanted additions. The basic requirement for its use as filler in the construction mixtures is that it does not break a process of bond strength and enable the creation of solid mass of the required physical and mechanical properties and harmless for the human health. Another option of its universal use is the production of mortars especially in central plants of dry mortar mixtures, where this recycled material is used as a filler [7]. Similarly as concrete recycled materials, the bricks recycled materials can be used in the stabilized layers of roads and for the earthworks. In the areas of urban agglomerations, where there are considerable demands on the construction of local roads, paved areas (parking area) is necessary to use these secondary materials as a substitutes for natural sources.
3. Bitumen recycled material. The composition of bitumen recycled material is given by the particular construction and composition of the road. Its usage is similar as the usage of concrete recycling material, so as filler in the road construction. In addition, it can also be used as aggregate in the bitumen mixtures.
4. Aggregates of railway ballast. This type of recycled material can be reused in the reconstruction or construction of new ballast shoulder, eventually during the construction of the handling areas in the railway construction.

The using of the recycled products from the deconstruction of building structures is connected with their quality characteristics and properties and current market requirements. The durability of used concrete blocks has a crucial importance in assessment of appropriateness of reusing of these elements. In Germany, there were carried out the tests to determine the quality parameters of these elements, namely the depth of carbonation, concrete covering, permeability, compressive strength of concrete, strength etc. The test proved that structural components of the old concrete (age between 20 and 30 years) still have high productive properties. Analysis showed that it is suitable are mainly the former internal bearing walls and floor slabs. Moreover, there was verifying of reuse of external walls, sanitary cells, stairways and landings.

The wastes of the first shape can be used in the several areas, such as [8]:

- construction of buildings for housing (houses, duplexes, row houses, cottages etc.),
- agricultural buildings (silos, stables, hard surfaces),
- multipurpose buildings and industrial buildings (pavilions, warehouses, garages etc.),
- the landscaping of parks, as well as the surrounding residential buildings,
- the landscape (art elements),
- measures to protect the environment.

5. Conclusion

Current status in the production of construction and demolition waste at the global and regional level is forcing the company to deal with their recovery, respectively recycling. Slovak Republic and European Union aim to support the more dynamic progress in this issue by the legislative action. It should be noted that waste resulting from the construction is qualitative composition intended for further processing, treatment and recovery. On the other hand, the construction industry creates a space for the use of this recycled material in the building construction, road or railway construction. Finally, it should be noted, that in the future it is possible to replace the word „recycled material" by the „alternative building material" which can encourage the public to their higher use.

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