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2ND INTERNATIONAL SCIENTIFIC CONFERENCE

# REGIONAL DEVELOPMENT, SPATIAL PLANNING AND STRATEGIC GOVERNANCE

Conference Proceedings

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**REGIONAL DEVELOPMENT, SPATIAL PLANNING AND STRATEGIC GOVERNANCE**

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SESSION D

# SUSTAINABLE SPATIAL DEVELOPMENT UNDER CLIMATE CHANGE CONDITIONS

# TREATMENT OF CONSTRUCTION WASTE IN SERBIA AND THE LIFE CYCLE OF BUILDINGS

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## 1. INTRODUCTION

One of the greatest challenges of today's society that follows demographic as well as technical and technological development of communities is resolving the problem of waste that has been freely and progressively accumulating in the environment in different forms. Since unplanned and inadequate treatment of waste materials can cause severe damage to the environment, with unforeseeable consequences, both for users and the environment, at local and global level, it is obvious that systemized monitoring and management of waste streams on a certain territory is of great importance for its future sustainable development. Therefore, various waste management strategies have been developed and implemented in the developed world, aimed to reduce the amount of waste that is disposed of in landfills to a minimum.

In the context of contemporary architecture, perception and management of large quantities of construction waste that has been related to almost all phases of building's life cycle, represents a significant part of the global system of waste management. Having in mind scope, diversity and complexity of different activities, as well as engaged energy and material capacities and resources related to the construction sector, it is evident that monitoring and control of different activities and processes during the construction and exploitation cycle of a building is of great importance.

## 2. CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT BASED ON BUILDING LIFE CYCLE

Waste management in the construction field takes a special place within the global tendencies of waste management. Besides, construction sector with its various activities takes a leadership in a total energy balance of global industry. Different technological processes of resource exploitation and material production, transport, building technologies, as well as exploitation, renovation, demolition and reconstruction of a building, have a great merit for a number of negative consequences and changes in the environment, some of which may reach disastrous extent. In terms of generation and disposal of waste materials, it is evident that this problems refers to all phases of building's life cycle, from the earliest methodological operative procedures of planning and design

which predetermines the further course of the cycle, through preparatory phases that induce management of natural and created resource capacities, followed with construction, exploitation and final building life cycle phases personified by building decomposition and most often its demolition.

According to the official EU statistical data, 30 to 35% of total quantity of generated waste of the most developed countries are attributed to building sector activities, i.e. to building construction renovation and demolition processes (Eurostat, 2012). These data do not include waste material created in technical and technological procedures of resource exploitation, processing of raw materials and production of building materials and elements. Significant share of construction waste within the volume of total waste on the local and global level indicates the need for attention that this problem requires.

This is the reason why construction and demolition waste management strategies became one of the focusing areas of European architecture and engineering. Specific activities have been directed towards solving the problem of alarming depletion of resources and progressive environmental pollution caused by the generation and disposal of waste in the environment. Based on principles of sustainable development, this strategy is instrumentalized through ***3R concept***, originally introduced by G8 in 2004, aiming to establish control over the progressive depletion of resources and to reduce the burden of waste from the construction and demolition of structures by the means of simultaneous application of the basic reduce-reuse-recycle principles (G8 Information Centre, 2004). With a focus on reducing the production and consumption of goods, total reduction of energy and resource consumption during the whole life span of a building is required, as well as re-use of raw and building materials and components obtained from construction waste, increased use of recyclable and recycled materials in the construction process, and activation of buildings for their re-use.

Unlike the linear analysis of the life cycle of a product, meaning a building in this case, which primer focuss has been on the initial phases of the cycle, contemporary tendencies draw attention to the final stages of the life cycle (ISO, 2006). Exploitation, deconstruction and demolition of a building are considered as pottentially favorable phases for activation of principles of re-use and recycling, indicating the use of waste materials generated from the completion of a life cycle as the raw material for a new cycle. In this way, full potentials of a building could be used, in functional way through the process of adaptation and re-use, and in technical and technological way through the use of its system of elements as potential elements to be re-used or used as raw materials for recycling. Such an approach requires the proper management of potential waste materials already in initial stages, when preparation for proper completion of the cycle is done, ending with the ultimate waste management at the end of the cycle.

In the case of the European Union, the implementation mechanisms and enforcement of the principles of the ***3R concept*** were introduced into the legal system and precisely

defined by series of legal documents and directives, whose rapid adoption and compliance with local legislation is expected by all member states and the countries of claimants for a place in the Union (European Commission, 2008). The countries are expected to rapidly establish a system of environmental monitoring, followed by periodical reports, but also to establish accelerated adoption of crucial national documents that will regulate management of waste in all industries. In this sense, monitoring and making regular annual reports on the quality and structure of the waste materials in the environment is expected, as well as producing documents such as the National Strategy - Waste Management Plan, Law on Waste Management and a whole range of laws and regulations which would regulate the situation in the area. Another fundamental and necessary document to be made at the national level is the Catalog of waste. This internationally harmonized document contains a list of waste material sorted by country of origin, place of origin, structure and type, with a clear distinction between the dangerous and non-hazardous waste.

## 3. CLASSIFICATION OF CONSTRUCTION & DEMOLITION WASTE MATERIAL AND ITS ENVIRONMENTAL IMPACT

Analyzed at the level of building materials, the problem of construction & demolition waste in the light of effectiveness of the appropriate waste management strategy is closely linked to the problem of resources. In this context, as a basis for the development of sustainable resource management strategy, the European Commission takes data obtained from studies that address the exploitation of natural resources. With proper management, construction waste with great potential for recycling and/or re-use can lead to a significant reduction in the exploitation of natural resources. Therefore, EU's objective is to achieve 70% reuse of construction waste by 2020 (European Commission, 2008).

Table 1 - Ranges of composition of C&D waste per year for the European Union Member States (except Estonia and Finland), Source: based on European Commission (2011)

| Ranges | min. – max. (%) | min. – max. (mil. t) |
|---|---|---|
| **Concrete and Masonry - total** | **40,0 - 84,0** | **184 - 387** |
| Concrete | 12,0 – 40,0 | 55 - 184 |
| Masonry | 8,0 – 54,0 | 37 - 249 |
| **Asphalt** | **4,0 – 26,0** | **18 - 120** |
| **Other mineral waste** | **2,0 – 9,0** | **9 - 41** |
| **Wood** | **2,0 – 4,0** | **9 - 18** |
| **Metal** | **0,2 - 4,0** | **1 - 18** |
| **Gypsum** | **0,2 – 0,4** | **1 - 2** |
| **Plastics** | **0,1 - 2,0** | **0 - 9** |
| **Miscellaneous** | **2,0 – 36,0** | **9 - 166** |

As a first step in meeting these objectives, Member States are obliged to submit the data of the current situation concerning the amount of generated, re-used and recycled construction & demolition waste, as well as assessment of possible improvements. Analyses should include major obstacles and potential triggers in improving the rate of

reuse and recycling of construction waste. Another important step was to create categorization of construction & demolition waste. The criterion for the selection of categories that are further on analyzed depend on the quantity of shares of certain materials in the total amount of waste and the possibility for its contributions to achieve 70% recovery (European Commission, 2011).

In Serbia there has been no systematic research based on which the representation of a material in the total amount of construction & demolition waste could be determined. However, categorization of relevant material could be made on the basis of available data concerning the consumption of building materials in 2011 (Statistical Office of the Republic of Serbia, 2011).

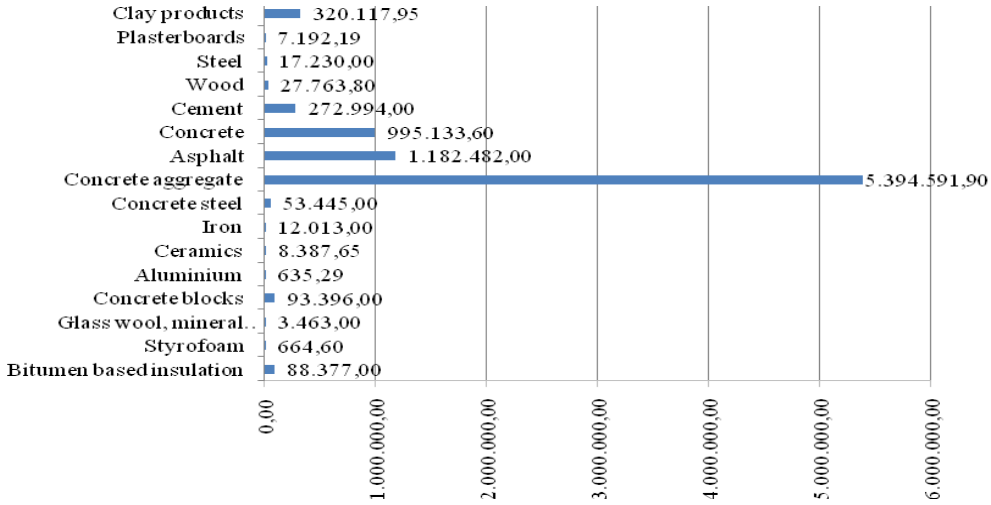


Figure 1 - Consumption of building materials in tones in Serbia in 2011, Source: based on Statistical Office of the Republic of Serbia (2011)

Additional argument in favor of the need for recycling or reusing of construction materials, which at the end of the life cycle of a building are transformed into a construction waste, is an environmental impact of materials. By analyzing the relationship between the quantities of materials consumed, the energy required for its production and $CO_2$ emission, it is possible to spot materials that, when being recycled or re-used, manifest significant energy savings, pollution reduction and landfill space savings.

Environmental assessment of building materials is closely related to characteristics of the economy of certain state. Climatic conditions, mechanical equipment, the level of technological development, transport and other factors have positive or negative impact at production efficiency in terms of energy consumption and $CO_2$ emission. Therefore, values

per unit of energy and material use and $CO_2$ emissions per kilogram of produced material are unique for each particular economy. Comparative analysis of data from the two environments may refer to these differences. Among rare sources dealing with this issues, available and comparable data were recognized in two independent researches, one from Spain (Zabalza Bribian et al., 2011) and another from case studies done in France (Roussat et al. 2009), referring to the energy required to produce 1t of certain materials. (Fig. 2)

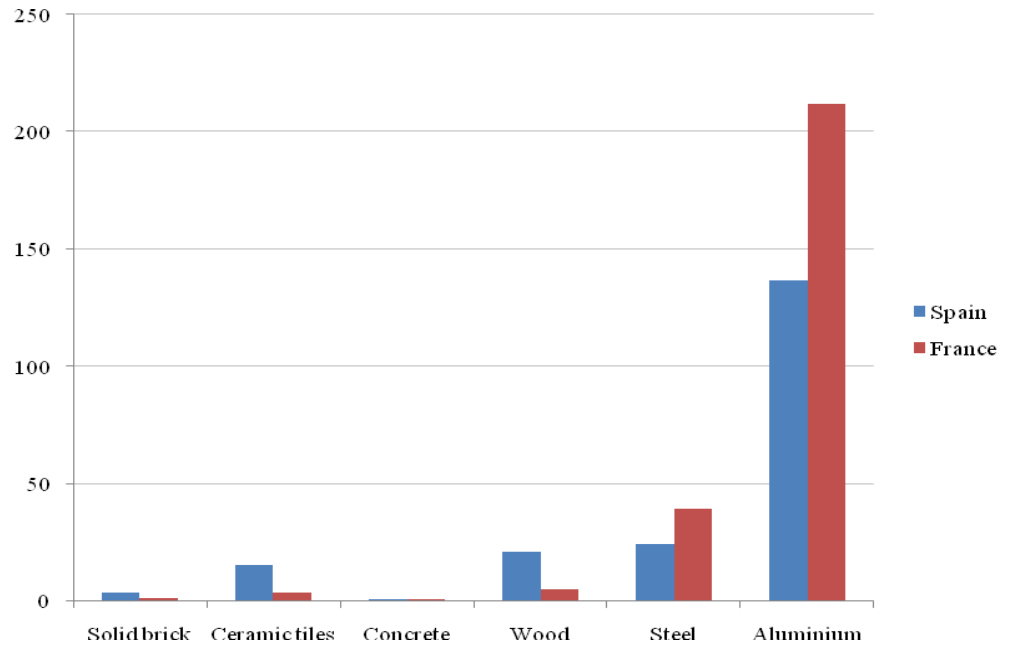


Figure 2 - Differences in material production embodied energy in two different environments (GJ/t), Source: Authors, based on Zabalza Bribian et al. (2011) and Roussat et al. (2009)

Since such investigation has not been conducted yet for the case of Serbian economy, for the purpose of estimation of environmental impact of building materials that are commonly used in Serbia, relevant data regarding material and energy flow for material production were adopted from the Spanish research (Zabalza Bribian et al, 2011). Although values of consumption of energy and materials were based on indicators from other region, the ratio between the actual amount of material, energy and $CO_2$ emission could be considered relevant, enabling the distinction of materials that require special attention when researching their recycling and re-using potentials in the stage of construction waste. The overview includes those materials for which data was available on their energy values and $CO_2$ emissions. (Fig. 3)

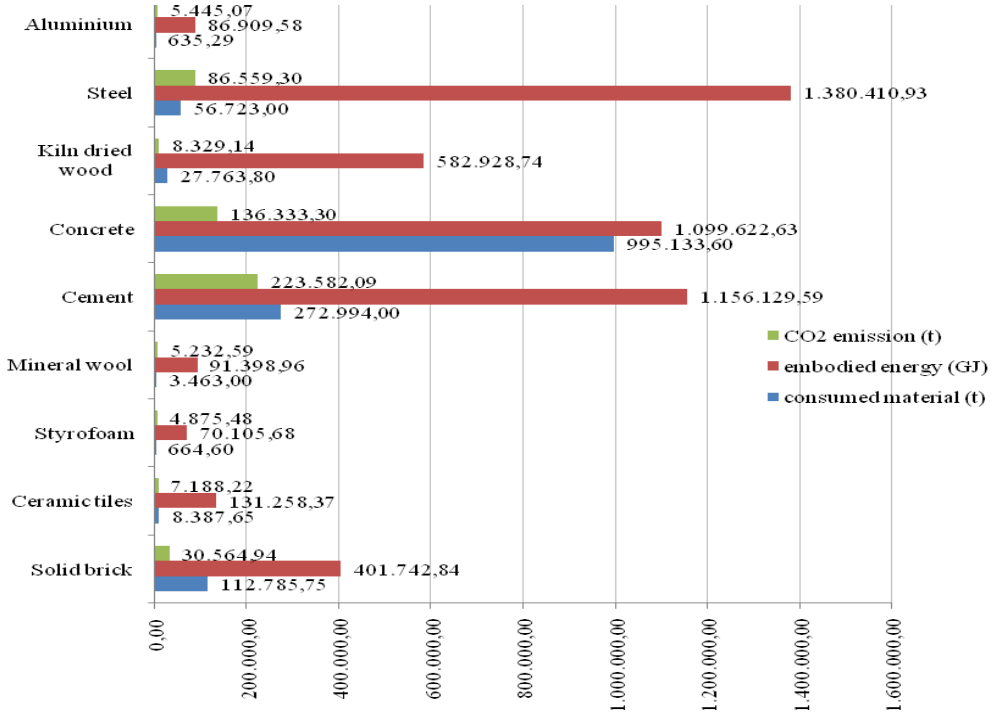


Figure 1 - Ratio between the amounts of material consumed, the energy required for their production and emission of $CO_2$ in Serbia in 2011, Source: Authors, based on Statistical Office of the Republic of Serbia (2011) and Zabalza Bribian et al. (2011)

In terms of consumption of energy and materials in the production steel, concrete and cement are distinguished, pointing out that their recycling at the end of life of a building could both, bring significant savings and contribute to environmental protection. Since the categorization is not based on the amount of waste material but the quantity of material used, with the assumption that high levels of consumption will have impact at the amount of waste, it is important to define appropriate indicators of our environment.

## 4. C&D WASTE MANAGEMENT IN SERBIA

The introduction of environmental management in the construction sector in Serbia is at the very beginning, since in the past these issues were regulated by the means of classical market mechanisms. Assisted by specific economic policy and social conditions in the region, planning and construction of buildings took place without clearly defined and developed regulatory policies and enforcement mechanisms, which enable the inclusion of

the domestic market in the global flows of sustainable architecture. It can be said that the exploitation of resources, processing of raw materials and production of building materials, as well as further management of building construction was entirely beyond the scope of contemporary global trends in green building. This refers to the perception and management of the entire life cycle of buildings, energy savings, reduced commitment of resources, re-use of components and materials, use of recycled materials, and so on.

Systematized monitoring and management of waste streams in Serbia has been launched during the last five years and is closely related to the current European integration processes. Within this process, through *The Stabilization and Association Agreement* (SAA), Serbia has taken a range of previous technical measures that have to be met on the way towards the final accession to the European Union. Only during 2009 and 2010, over twenty laws, regulations and rules in this area have been prepared and adopted, in compliance with the relevant documents of the European Union.

In addition to the *Waste Management Strategy, Law on Waste Management* and the *Law on Strategic Assessment of Environmental Impact* (Government of the Republic of Serbia, 2010a, b, c), passed a series of closely themed laws and regulations directed towards specific areas and activities in the waste management system. In accordance with the schedule defined by the SAA, there is an obligation to fully harmonize local legislation with the EU legislation till the end of 2014. Government Action Plan for the period 2010-2014, defined by a series of specific technical measures that need to be implemented in the process of implementation of the Waste Management Strategy and some of them are:

- development of regional and local waste management plans (deadline 2013),
- construction of 12 regional waste management centers (term 2010-2013),
- construction of centers for separate collection of recyclable waste (deadline 2011),
- raising public awareness on recycling (deadline 2010),
- the introduction of incentives for reuse and recycling (deadline 2011).

When C&D waste is concerned, the situation is rather serious since at present there are neither detailed regulations, nor waste management strategies developed for this type of waste. On the other hand, interest in collecting, sorting and recycling C&D waste is in its very beginning. This may partly be explained by the fact that, according to the *Waste Management Strategy*, the issue of management of construction waste is classified in the second group of long-term goals with the implementation period 2015-2019, which, together with the absence of suitable measures of state and local governments for the proper management of this type of waste results in current trends (Government of the Republic of Serbia, 2010c).

Despite the estimation of a very large amount of construction waste that is generated in the country (1 000 000 tons) (SEPA, 2011), the lack of both, regulation and individual initiatives, result in the fact that construction waste in most municipalities in Serbia goes

directly to municipal landfills without sorting at source. The lack of accurate data in the field of construction waste in Serbia is a consequence of the poor quality of monitoring and information system specified by law. Aggravating circumstance is the fact that only 60% of the total amount of waste in the territory of Serbia is disposed off in controlled way on the municipal sanitary landfill. (Government of the Republic of Serbia, 2010c)

Figure 4 – Illegal landfill of construction and demolition waste in one of the Belgrade suburbs, Source: Authors

It should be said that the collection of waste is mainly performed in urban areas. There is inconsistency in submission of data between local governments so the treatment of construction waste is mostly related to the landfilling. On the website of the Serbian Environmental Protection Agency there is a record on existing landfills that are under the jurisdiction of public utility companies, as well as that of illegal and the elderly ones, displaying the status of the 2005 year (SEPA, 2005). Taking into consideration the dynamic of filling in their capacity during the use, it can be concluded that some are already completed until now.

Construction waste is also used as an inert material for covering communal and other waste in landfills. At present, recycling of construction waste in Serbia has been reduced to fewer individual initiatives, despite the fact that almost 80% of such waste could be recycled. The Waste Management Strategy 2010-2019 provides a rough percentage representation of certain categories in the total amount of construction waste. (Fig. 5)

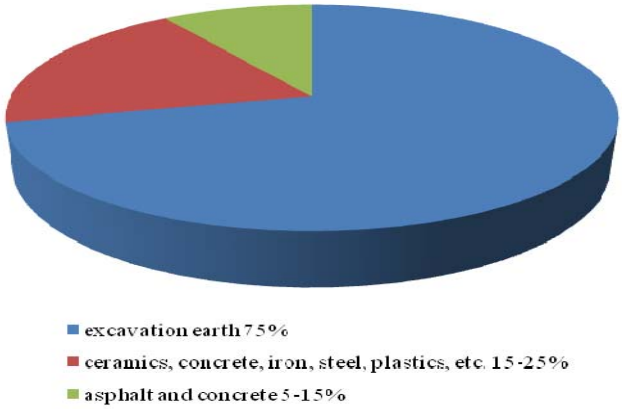


Figure 5 - Representation of certain groups of waste in the total amount of construction waste in Serbia, Source: Authors, based on Government of the Republic of Serbia (2010c)

One of the successful examples of implementation of the principles of management of construction waste is opening of recycling center in the vicinity of Kragujevac where from the year 2012 there is systematized collection and processing of this type of waste. This investment, carried out in cooperation with the EU, was assisted by the adoption of local regulations which regulate transport of construction waste in the municipality. Activities of the center will be focused on the processing and recycling of materials such as wood, stone, plastic, ceramic and clay products, iron and copper, for their further use primarily in road construction. For example, in the Kragujevac factory Fiat, calling for extensive works on freeing site for the construction of new capacity is expected to address the issue of acceptance and treatment of thousands of cubic meters of construction debris, generated as a product of construction activities at the complex.

On the other hand, about 50% of housing stock is dated from the period before, or almost immediately after the Second World War and is ready for a serious restructuring or removal. (Jovanović-Popović et al, 2012) It is assumed that more than 3.0 million of them are over thirty years old, which is the age that is considered as the final phase of the life cycle of facilities. On one hand, these data indicate the structure and the potential amount of construction waste that can be expected in due course in the region, while on the other, they open question of further strategic actions of state and local communities towards the timely development of necessary capacities and capability the recycling industry.

## 5. MECHANISMS OF STATE FOR ENHANCEMENT OF WASTE MANAGEMENT STRATEGY

The practice in the developed world indicates that landfill fees and incentives from the state play a key role in the creation of an artificial market of recyclable materials originated

from construction and demolition waste. Examples from different parts of the world confirm this experience. In the case of Hong Kong, the introduction of high fees for disposal of construction and demolition waste to landfills contributed that, within a year, amount of disposed waste decreased to almost one-third, with simultaneous stimulation of reuse and recycling (Hao et al., 2008). Different studies in United States indicate that high rates of waste disposal compared to the price of recycling of waste building materials encouraged the development of the recycling industry and the implementation of the concept of reuse (Lenon, 2005; City of New York, 2003).

In the Netherlands, as one of the most progressive countries in the field of waste management, recycling rate reached the target of 70% even before the year 2000, whereas today the rate of recycling of construction waste is 85% (European Commission, 2011). In contrast to the prohibition of deposit of certain categories of waste, fees offer a choice between the deposit and alternative solutions in the form of reuse and of recycling. The introduction of these economic policies had a positive effect on reducing the amount of disposed waste directing contractors to alternative solutions, which is confirmed on the example of the Netherlands that has one of the highest taxes on deposition. In addition, the amount of fees for mixed waste and further encouraged the waste separation, which led to the separation of waste at the source and improved capabilities for reuse or recycling (Oosterhuis et al, 2009).

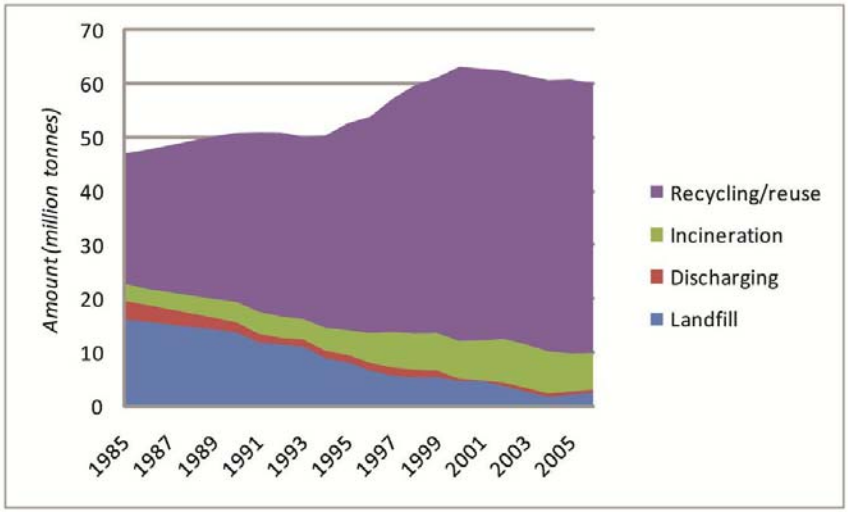


Figure 2 - Waste production and method of treatment in the Netherlands, 1985-2006 (in Mt), Source: Oosterhuis et al, (2009)

When it comes to the situation in Serbia, it is necessary to introduce various incentives at the local level to rouse the private sector and involve it actively in the waste management system in the republic (Government of the Republic of Serbia, 2010c). This primarily

refers to measures that would encourage the principles of reuse and recycling of building waste, which would directly contribute to further controlled exploitation of natural resources and determine structure and amount of waste. On the other hand, the current situation in practice is quite discouraging such goals, as the fees for the disposal of construction waste at the local landfill in the country is almost negligible. Compared with developed countries, much lower fees favor the disposal as an orientation in the process of waste management, which is in direct contradiction to the basic principles defined by the National Strategy. As a result of this situation, the "reuse" and "recycle" in the process of management of construction waste are marginalized and usually related to individual initiative. This confirms that, in Serbia, the issue of construction waste has not yet been systematically resolved. (Statistical Office of the Republic of Serbia, 2012)

## 6. CONCLUSION

Despite the great potential of building stock in terms of potential quantity of construction waste materials which can be reused or through recycling included in the next life cycle, the current situation in Serbia is unsatisfactory. It is evident that arrangement in field of environmental protection and waste management is a very complex and extensive work. On its way to the final regulation of these fields, Serbia has done small, but the most complex part of the work, linked to the establishment of the local legislative implementation of the 3R platform, and its harmonization with EU principles. At the same time, in the previous period the first steps were made in terms of technical realization of the planned objectives.

On the other hand, some concrete action have begun on the implementation of large-scale public and private projects, such as construction of public infrastructure and enterprises dealing with trade waste. Realization of this intensification is expected in the future with great technical and financial incentives of the state and foreign capital.

It can be said that Serbia is on a good way of effective implementation of the 3R platform, but that for the purpose of a fully success in regulating the domain of waste management, it must continue with multidisciplinary and responsible engagement of all members of the national community, with constant coordination and supervision of the state. Also, it is clear that the final effects of the implementation, as well as the desired results are very dependent on the economic status of society. Therefore, only the joint commitment of all members of society and pooling of capital can lead towards progress in this area.

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## SUMMARY

One of the most important areas towards which the European building sector turns is the waste management strategy. Based on the principles of sustainable development, this strategy is instrumentalized through ***3R*** concept in order to establish control over the progressive exhaustion of resources and reduce the burden of waste materials in the environment through a simultaneous application of three principles: reduce, reuse and recycle.

Modern tendencies of management of construction waste are based on assessment and evaluation of the life cycle of buildings, aimed at review the possibility of introducing new concepts of design and construction of buildings, based on the principles of reuse and recycling. In this sense, the environmental characteristics of building materials and identification of their impact on the environment during the life cycle, become of great importance and one of the main instruments in the field of waste management.

Enforcement of the ***3R*** principles and waste management implementation mechanisms are introduced into the legal system of the European Union, whose rapid adoption and compliance with local legislation is expected by all member states and the countries of claimants for a place in the Union. On the way to regulate this area, Serbia has done a more complex part of work related to the formation of the local legislative framework for waste management and its harmonization with the basic principles of the EU. Simultaneously, in the previous period the first steps in technical realization of set goals were made.

On the other hand, on the way to the final regulation of this area, Serbia expects additional efforts and involvement of all stakeholders in the promotion of basic principles of waste management, and the introduction of appropriate incentives, after the model of developed communities. This would determine further development of the construction sector, and put the problem of waste materials finally under control.

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