

# Implementation of 3R Principle in Construction and Demolition Waste Management



B. Vidyasekar, K. G. Selvan

**Abstract:** Building and demolition of structures are common in developing nations owing to fast urbanization taking place. These operations produce an enormous quantity of waste products that are detrimental to the environment, requiring an efficient method of waste management. Construction and Demolition Waste Management (C&DWM) methods frequently embrace the 3R (Reduce, Reuse, Recycle) principle for suitable waste management in construction sites. Managing different waste in separate areas of the industry seems very important nowadays. Most contemporary Western countries around the globe set separate laws to reduce and handle the quantity of waste in various areas of their industries as well. However, waste manufacturing is inevitable in the building sector, and no building site is less waste. Different kinds of waste in building sites can cause infinite social and environmental issues. It seems crystal clear that there is a huge need for waste management in such a scenario. A fresh idea on building waste management has been suggested in latest years is "3R" concept, which is based on three key waste management concepts such as reuse, recycle and reduce. Waste management was discussed in the introduction chapter. Then Construction type of waste was evaluated after Managing was reviewed, then various kinds of waste followed by how to do energy recovery through "3R" principles and lastly how to execute energy recovery through the "3R" principles mentioned. Hopefully the content of this article will benefit various individuals in charge of building projects.

**Keywords:** 3R principle, construction and demolition, Waste Management, Reduce, Reuse, Recycle

## I. INTRODUCTION

The most significant source of worldwide waste production is the building industry (Fuentes et al., 2013) and it accounts for 30% of landfill waste that contaminates the earth's surface (Robert H. Crawford et al., 2017). Building and demolition waste is a combination of different products including hazardous waste, non-hazardous waste, inert and non-inert waste from building, demolition and refurbishment operations (Maria Menegaki and Dimitris Damigos 2018). Construction waste is produced at different phases of the building process, so without recycling process it is not feasible to use the waste products. These waste not only pollutes the land assets but also creates damage to the environment so that the natural landscape, soil and water is destroyed (Coelho and Brito, 2012). Developing nations lag far behind in C&D waste management methods compared to advanced nations (Lu and Yuan, 2010).

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There is, therefore, a need to correctly handle the C&D waste to prevent environmental degradation. The study is focused on analyzing present waste management practices in distinct areas of the globe and on classifying C&DWM practices for future research purposes based on their functional aspect.

## A. Construction Waste Scenario Around the World

According to Mazumdar (2009), In Scotland 63% of waste was reused in 2000; the remaining 37% waste was dumped in land. The government is developed waste management regulations with code specifications. There are number of trials to establish connections with the planning system, computerization of transfer note scheme to promote numerical analysis and to encourage dialogue between organizations for advisors and contractors to adopt secondary aggregates. According to Danish Environment Protection Agency (DEPA) the construction waste produced in 2003 is about 30% of total waste. In construction waste 70-75% was generated due to demolition of buildings, 20-25% was generated due to refurbishment of buildings and the remaining 5 % waste generated from fresh buildings. Recycling is the main problem for Denmark due to landfill site limitations. There have been statutory orders, action plans and voluntary agreements, e.g. asphalt reuse (1985), building waste sorting (1995), etc. Mazumdar (2009) reported that around 40 million construction waste is produced. Out of this 80% waste is concrete and brick. The number of measures adopted since 1993, such as waste prevention, stimulation of recycling, promotion of long-lived building materials, products that can be readily disassembled, separation at source and prohibition of building waste at landfill sites. The factors that led to elevated levels of recycling are 1. Source 2 separation. Good recycled product market 3. Prohibition of landfill 4. Guidelines for the use of building waste instead of new aggregates Building waste is about 22 % of the waste produced in the nation, according to Mazumdar (2009). One element of a WM practice is sustainable or green building practice which adopts reuse and recycling of building waste. Green building methods may include recovering timber , using broken aggregates from crushed concrete, drywall scraps are grinded for using at the site to promote 'deconstruction' rather than 'demolition.' Deconstruction implies the designed breakdown of building with the primary motive being the reuse of materials. Much of Japan's research and development is concentrated on materials that can resist earthquake and prefabrication. The primary building materials are concrete and composite.



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In 2000, 85 million tons of construction waste was generated in which 95% of these wastes was reused in the construction of highways in the form of crushed concrete. Asian countries currently define the C&D waste in terms C&D waste components of construction industry. Most of the countries have been practiced 3R principles in construction sites, especially in urban settings. Such nations include, among others, Hong Kong, Japan, Special Administrative Region (SAR), Sri Lanka, India, Singapore, and Malaysia. In some of these nations, there is also a growing awareness of C&D waste management.

### II. RESEARCH BACKGROUND

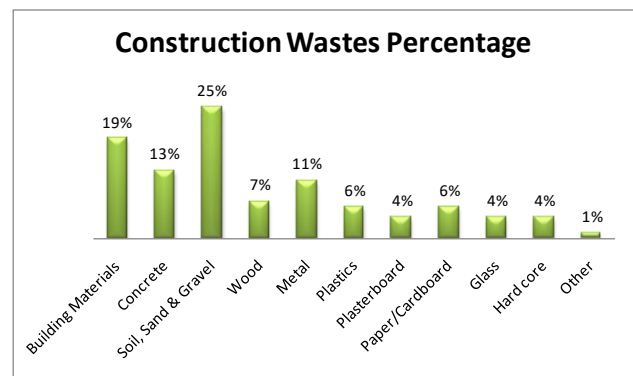
A literature review was made to evaluate the different C&DWM methods practiced. The following familiar keywords have been selected for this research: waste from construction and demolition, circular economy, life cycle assessment, and 3R principle. We have sparse studies published between the year 2011 to 2017. Abstracts, material and adopted methods in C&DWM in the screening phase were investigated. Building and demolition waste is generated during the renovation of structures in the building industry. The amount and composition of these waste products may differ across the region depending on the country's population growth, legislation, regional planning, and building industry. It is understood that the circular economy is the best-adapted model that by intention and design helps retrieve or regenerate the waste products. Circular economy replaces the notion of end-of-life with restoration, eliminates toxic chemicals that influence reuse, use renewable energy in moving bases, and seeks to eliminate waste through superior designs and business models (Ellen MacArthur Foundation, 2016). The circular economy is implemented in the building industry to eliminate and maintain C&D waste through recirculation in closed loops (Smol et al., 2015). The adoption of a circular economy is the step towards optimum management of C&D waste. Assessment of the life cycle is a technique of visualizing C&D waste from the starting zone to the ending zone and categorizing waste based on its strategic stage to analyze waste (Ardavan Yazdanbakhsh 2018). The 3R principle is the fundamental basis of a circular economy. It includes reducing, reusing and recycling. This paper's main objective is to define the environmental and financial effects of the C&DWM technique application of 3R principles. The Categorization of construction and demolition wastes is shown in table 2.1

### III. ENERGY RECOVERY BY MEANS OF "3R" PRINCIPLES

Shuanggui et al. (2011) suggested a framework for energy recovery based on the 3R principles with five phases mentioned in this chapter

**Table 2.1 Categorization of construction and demolition wastes (Anna Sobotka and Joanna Sagan 2016),**

Construction Wastes		Demolition Wastes	
Type	Percentage	Type	Percentage
Building Materials	19%	Building Materials	6%
Concrete	13 %	Concrete	16%
Soil, Sand & Gravel	25%	Soil, Sand & Gravel	33%
Wood	7%	Wood	19%
Metal	11%	Metal	10%
Plastics	6%	Plastics	2%
Plasterboard	4%	Plaster board	4%
Paper/Cardboard	6%	Paper/Cardboard	4%
Glass	4%	Hard core	6%
Hard core	4%	-	-
Other	1%	-	-



**Figure 1: Construction Waste Percentage**

The concept of "3R" principle was suggested to carry out some operations in the construction industry with regard to the reduction, reuse and also recycling of waste. All the distinct building project procedures engaged in the design, manufacture and manufacture of the building sites are directly related to waste generation, so it is necessary for a green economy to follow "3R" values in the building sites. The "3R" principles are related to the components of construction such as activities, society, people and sources. Due to its wide implementation in management fields of waste generation locations, studies based on the 3R principle are growing day by day. The following table 3.1 presents the figures for papers released in the period 2008 to 2018 based on the 3R principle. Reuse rates of construction and demolition wastes is shown in table 3.2.

**Table 3.1** Number of articles related to 3R Principle (2008 to 2018)

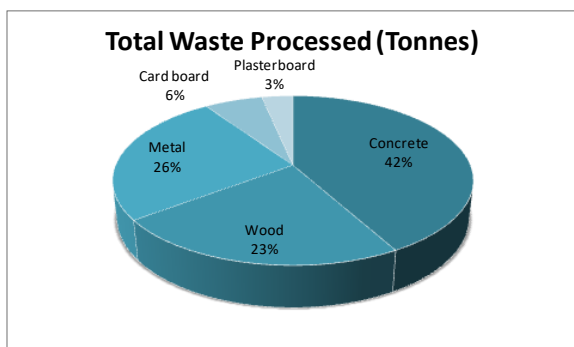
Year	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
No of Articles	10	13	10	17	17	24	18	26	38	48	58	201
Average	8.0											

at these building locations. Recovery rates of waste is illustrated in figure 5

**Table 3.2** Reusing rates of construction and demolition wastes (Abioye A. Oyenuga and Rao Bhamidimarri 2015)

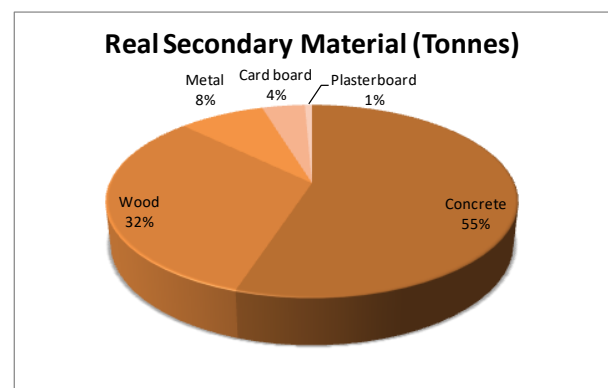
Case studies	2012			2013			
	Total Waste Processed (Tonnes)	Real Secondary Material (Tonnes)	Rate of Recovery	Material	Total Waste Processed (Tonnes)	Real Secondary Material (Tonnes)	Rate of Recovery
Concrete	880	820	0.93	Concrete	835	775	0.93
Wood	480	480	1	Wood	345	232	0.67
Metal	540	120	1.22	Metal	945	912	0.97
Card board	130	60	0.46	Card board	102	19	0.19
Plasterboard	70	10	0.14	Plasterboard	96	6	0.06

In Quantitative analysis total waste processed is depicted in figure 2, Secondary materials attained from the wastematerials is illustrated in figure 3. Demolition waste percentage is represented in figure 4



**Figure 2: Total waste processed in tonnes**

It is evident from the quantitative analysis that the application of the 3R principle at the construction sites reduced the illegal dumping of waste at the construction sites. At the same moment, the retrieval method offers better outcomes is not favourable from the table recycling method



**Figure 3: Real secondary material in tonnes**

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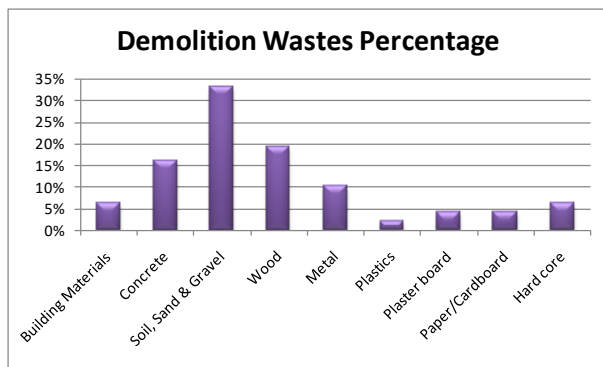


Figure 4: Percentage of Demolition wastes

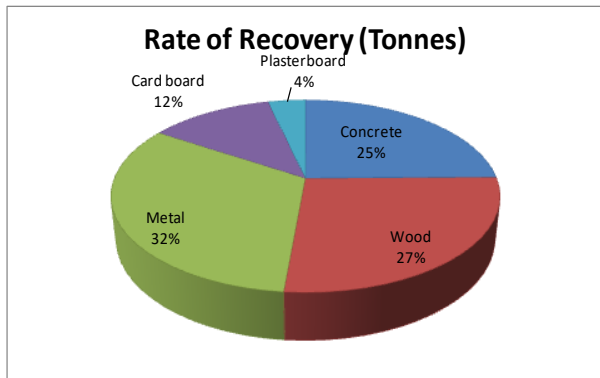


Figure 5: Recovery rate in tonnes

## IV. POLICY AND INSTITUTIONAL ASPECTS OF 3R PRINCIPLE

### A. Policies

Various policies have been practiced by national, zonal and local governments to attain the sustainable construction strategies. These policies aimed to minimize the construction and demolition wastes by adopting 3R principle. Adopting 3R principle in waste management strategy is demonstrated by developed nations such as the UK, Switzerland, Austria and the Netherlands, where non-renewable resources due to the shortage of landfill ability or sites are the main factors for the increasing realization (Addis, 2006). The Sustainable Building and Construction Initiative (SBCI) was launched by UNEP IETC (2006) to encourage and support sustainable solutions in the construction and building sector, including the C&D industry. In Japan more than 25 years demolished concrete is reused (Kawano, 2003 quoted in Rao et al., 2007), relatively a small amount of concrete was recycled because the project engineers don't want to compromise with the standards. To increase the recycling amount wastes generated in Japan recycling law was established by the Japanese government in 1991. This law needs the support of relevant ministries which nominate the materials under their responsibility. The former Ministry of Constructing (MOC) nominated the materials such as demolished concrete, soil, asphalt concrete and wood as by-products of construction. The nations such as India, China, Thailand, Sri Lanka, and Vietnam) do not have particular C&D waste regulations, besides some countries comprise sections in their

regulations on Construction and demolition waste management.

### B. Institutional Arrangements

IGES (2006) identified the 3R upgradation system and observed that the 3R legal systems have yet to be established in almost all developing countries. Insufficient institutional capacity is the main issue in adoption of 3R measures. Implementation of 3R principle policies are regulated by various government bodies such as Department of Environmental Protection (EPD) and the Environment and Food Bureau (EFB). Legal NGOs such as the Legislative Councils, the Housing Authority and task-oriented non-statutory bodies such as the Environmental Advisory Council and the Waste Reduction Committee all have an important role in the formulation and execution of waste policy. Other Asian nations such as Malaysia, Sri Lanka, India, and China are adopted 3R principles on construction sites, but there has been no institutionalization.

### C. Procedures

C&D waste management procedures are practiced mostly in Asia's developed countries. So, it is necessary to employ the green initiatives in developing countries to manage the construction and demolition waste. In some countries in Asia implementation of construction and demolition waste management has grown rapidly. Some countries are making efforts to implement an environmental management system (EMS) to attain sustainable development. Singapore and Hong Kong SAR research has emphasized that waste from C&D imposes a problem on the environment. The construction industry is responsible for waste pollution and has one of the highest resource uses. In Singapore, some global and local construction companies have already adopted the well-planned approach by ISO 14000 EMS (Ofori, 2000) to improve the environmental performance of construction.

## V. GREEN INITIATIVE IN 3R PRINCIPLE

There is a competitive race across the world, primarily in the construction industry, for sustainable development. Sustainable development of buildings is the necessity of green initiatives in construction. In the year of 2012 onwards, number of trials have performed to minimize the land filling by implementing "Halving Construction and Demolition waste to landfill" this is helpful to achieve sustainable buildings in UK (WRAP, 2012). The main target of the land fill is "Zero C&D waste" by 2020 as the UK Government continues to achieve on a long-term ambition to end landfill clearance of C&D waste as far as possible. The national policy of waste management was strengthened by sustainable approach such as reuse, recycle and material recovery methods (WRAP, 2012). Following the pursuit of a green initiative, several fiscal and regulatory measures are already driving resource efficiency, such as landfill dues, aggregate tax, Waste Management Plan for site, BREEAM standard (providing C&D landfill diversion credit 75% by weight and 65% by volume) (Aadal et al., 2013).

The standards for green initiatives and traditional waste management are clearly distinguished. Green C&D waste management initiative comprises project reduction methods, reuse methods, recycling methods and methods used for energy recovery from waste. This idea appeared to optimization of energy, minimize the usage of natural resources and maximize the full potential of waste reduction. The traditional approach for minimizing construction waste is unsustainable and its flexibility and reliability lacks in long term basis. The value of waste can be justified and re-evaluated in terms of long-term vision by minimizing the quantity of waste being dumped to landfill. There are also number of methods to be found by reducing C&D waste such as recognition and reward, generating high revenue and creating jobs. However, in terms of advanced technologies and providing critical knowledge of logistics, regulations and operations, green initiatives need to be re-evaluated.

## VI. IMPLEMENTATION OF 3R'S PRINCIPLE

(Peng et al., 1997) proposed the various stages required to manage waste based on a hierarchical model. These authors recommend waste management by reducing, reusing and recycling C&D waste. However, in addition to the recycling activities, certain events such as avoidance and minimization, which further depicts the reduction, are processed, which are considered desirable. The concept of WM is guided by the hierarchy level known as El-Hagggar's principle of the 3R (El-Hagggar, 2007).

This model creates a combined approach in which waste management options can be considered and thus serves as a systematic tool for those who generate and manage waste. This model depicted the waste management tools and provide the suitable managing methods of construction wastes (Hwang et al., 2011). El-Hagggar stated that the effective waste management in construction site, provide number of benefits from its generation to its end disposal throughout the whole life cycle of the waste (Hwang et al., 2011). Significantly, proper management of construction waste is believed to deliver economic and environmental benefits.

## VII. CONCLUSION

Waste management is the interested topic in society. Therefore, the current work provides a ground-breaking effort to some extent in that it is a suggestion for a changing opinion on waste management. The research findings revealed that the quantity of waste in the construction industry is quite large and that much of this waste can be predicted and avoided. The paper indicates that the amount of waste material is very high, but enhancing the industry's preference in this regard does not require much investment from the firms. Some overall waste reduction policies are suggested. Companies generally need to enhance their systems to make their waste more visible and easier to remove. Waste management methods based on 3R principle are analysed, and their implementation methods, energy recovery methods, green initiatives, policies and procedures were analysed from the previous studies. It is evident from the analysis it is evident that the application of 3R principle

in Waste Management techniques improved the system performance and thereby reducing the Construction and demolition wastes in the construction industry.

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