RETHINKING CONSTRUCTION MANAGEMENT PRACTICES TO ATTAIN SUSTAINABLE DEVELOPMENT GOALS

(VOLUME - 1)

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CONTENTS

S. No.	Chapters	Page No.
1.	Rethinking Construction Projects with Preliminary and Rational Planning: A Paradigm Shift Lalit Mohan Srivastava, Mohd Asim and Syed Aqeel Ahmad	01-17
2.	Integrating Vastu Principles with Griha in Construction Industry to Achieve Sustainable Development Goals Aditya Kumar Verma, Mohd Asim and Syed Aqeel Ahmad	18-25
3.	Application of Value Engineering in Residential Building Considering Sustainability Aspect Mariyam Khalid and Faraz Hasan Qadri	26-42
4.	Review on the Construction Project Team Relation with Csr: An Initiative to Attain Sdg6 (Clean Water and Sanitation) Muskan Yadav, Mohd Asim and Syed Aqeel Ahmad	43-48
5.	A Study on Impact of Risk Management Practices on Success of Construction Project Tafzeel Ahmad, Rajiv Banerjee and Mohd Asim	49-61
6.	Readiness Approach to Practice Onsite Sorting of Construction and Demolition Waste (An Initiative to Fulfil Sdgs) Mohd Muenuddeen, Mohd Asim and Syed Aqeel Ahmad	62-79
7.	Evaluation of Fire Safety Norms in Construction Projects of Lucknow Sonam Yadav, Rajiv Banerji, Mohd Asim and Syed Aqeel Ahmad	80-86
8.	Barriers and Opportunities in Administering Offsite construction in Latest Construction Projects of Lucknow (U.P) Arichandran. R, Mohd Asim and Syed Aqeel Ahmad	87-108
9.	Role of Project Management Consultant in the Construction Industry Shahbaz Siddiqui	109-132

10. Roles and Responsibilities of a Project Management Consultant 133-162
Shahbaz Siddiqui

11. A Critical Review of the Challenge Faced by Local Authority: Government in Remodeling of Ancient City in India 163-171
Priya Rai, Rajiv Banerji, Mohm Asim and Syed Aqeel Ahmad

12. Study And Application of Lean Concept in Construction 172-183
Safdar Imam, Faraz Hasan Qadri and Syed Aqeel Ahmad

13. Review on the Circular Economy in Construction Waste Materials: An Initiative To Achieve Sdg-8 (Decent Work And Economic Growth) 184-201
Bibidha Patel, Mohd Asim and Syed Aqeel Ahmed

CHAPTER 6

READINESS APPROACH TO PRACTICE ONSITE SORTING OF CONSTRUCTION AND DEMOLITION WASTE (AN INITIATIVE TO FULFIL SDGS)

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Introduction

Construction and demolition waste (CDW) generation drastically increased with exponential population growth and the allied urbanization trends in the 21st century around the globe. To accommodate the soaring urban population in large cities, replacing old and low-rise buildings with high-rise ones generates substantial CDW. Source reduction, recycling, and reuse are the common CDW management strategies, amidst which recycling has been adopted as the desirable practice worldwide. Only in the United States, 600 million tons of CDW generated in 2018 was over twice the municipal solid waste in the same year; encouragingly, more than 75% of that was reused. A large portion (36%) of the total waste consists of CDW in EU countries, whereas most of the countries achieved the set recovery goal of 75% by 2020. Conversely, 40% of municipal waste generated from urban areas in China is CDW and the country having 10% recycling rate lags the national target of 13% as of 2020. The Indian construction industry generates 150 million tons of CDW per year, and only 1.3% is recycled. Kim studied the present waste

generation and treatment methods, government policies, and stakeholder efforts toward aggregates recycling in Korea and found a motivational drive in all these aspects of CDW management. CDW in the United Arab Emirates (UAE) accounts for 30% of the total waste, most of which is landfilled. Due to inadequate recycling and reuse practices in the Kingdom of Saudi Arabia (KSA), 53 million tons per annum of municipal solid waste causes an environmental loss worth 1.3 billion dollars, whereas 30–40% of urban waste is CDW.

At the global level, the construction sector contributes to air pollution (23%), drinking water pollution (40%), climate change (50%), and landfill waste (50%). Most of the CDW components can be recycled or reused, but lack of infrastructure and technology limitations culminate the generated waste in landfills, leading to environmental concerns. Rosado et al identified the following important factors from reported literature that limit CDW recycling in most cases, low fees for landfill disposal, readily available low-cost aggregates, inadequate quality of the recycled aggregates, and ineffective sorting practices at the source. CDW can impact the environment (e.g., climate change, land utilization, impeded ecology, energy resource consumption, natural resources depletion, aesthetic nuisance, and air, water, and noise pollution), economy (international reputation and tourism losses), and public health and social life (e.g., hazards to health, use of public space, proliferation of pests and impact on safety at work). Inadequately managed CDW can lead to the violation of environmental protection and resource conservation undertaking of the United Nations 2030 agenda for sustainable development.

Underpinning the KSA's Vision 2030 of sustainable cities, extensive construction is augmenting the infrastructure and real estate projects. Advancing these ambitious targets, the transformation of the existing infrastructure along with new construction, particularly in large cities (e.g., Riyadh, Dammam, and Jeddah), generates a large amount of CDW in the country. A study reported the generation of 50–60 tons/1000 m^2 of waste from the new construction and 700–1200 tons/1000 m2 from demolishing aged buildings in KSA. In addition to the primary components (mixed soil, sand, and rock/gavel, concrete blocks, asphalt, clay bricks, and glazed tiles), the CDW in KSA contains some fraction of gypsum and plaster boards, painted timber, reinforced concrete, dirt, and steel (bars, poles, and brackets); this composition matches with the conventional CDW components stated in other case studies. Although most of these components are non-hazardous, high generation rates, on-site storage issues, landfilling impacts, and allied logistics complicate the management process of CDW. As per the Country Commercial

Guide of Saudi Arabia published by the International Trade Administration (ITA), KSA anticipates redirecting 60% (12% recycling, 35% reuse, and 13% treatment) of CDW from landfills [9]. However, the current CDW recycling rates are much lower than the established targets. For example, the Saudi Investment Recycling Company (SIRC) recycles 45% of collected CDW in Riyadh City, whereas most of the generated CDW (0.4 million tons per year) in Qassim is being disposed of in 40 landfills spread over the province. Another example is Qassim province where only 6% is being recycled and the rest goes to the landfall. Blaisi identified the following primary challenges, which different concerned sectors (academia, policy makers, generators, and landfill operators) are facing regarding CDW management in KSA. Academia is unable to effectively contribute to research on CDW due to limited data and their weak collaboration with the government organizations. Multiple regulators with the sector-oriented approach, duplication of efforts, and lack of clear strategic planning led to fragmentation at the policy-making level. At the generators' end, lack of interest, motivation, awareness, incentives, and promulgation of law resulted in ineffective source separation and handling practices. Landfill operators complain about the lack of infrastructure, treatment technology, absence of fee structure, and investment opportunities for sustainable landfill management. Some studies also attempted to minimize construction projects' waste by focusing on preventing waste during the project design phase (cf. Mak, et al., 2019; Wang, Li and Tam, 2015). These research endeavours have been focused either on generic construction management and the design phase or a scattered focus on project phases. However, there has been very little research on managing construction waste from the cradle to the grave (from the conception phase to the project's closing phase). Few studies have considered the project's characteristics, especially the transition of project activities from phase to phase during the project lifecycle - i.e., initiating, planning, building, and closing, given that each phase could generate different types of waste for different reasons. For example, Osmani (2013) presented a framework detailing source and causes of waste across the project lifecycle. However, and more importantly, amongst the very few research articles that aimed to provide a project lifecycle approach to waste management, there is no attempt to provide a readiness lens that shows how projects can be prepared at each phase to manage the various types of wastes that may arise and proactively tackle the causes of such wastes. Therefore, this study relies on the project management approach to analyse construction waste management across the phases of the project lifecycle to improve the management of construction waste by outlining causes for waste and strategies to tackle them at each phase along the project lifecycle.

Literature Review

Rawshan Ara Beguma et al. (2007) identified some waste minimization factors which are helpful for implementation for construction waste management system in the construction industry. And provided proof on the important stage of contribution and the stage of construction practices among the waste minimization factors the model of weighted average of factors and minimization and practiced index value of factors and analysed indicate the most important, less important and important factors that contribute to waste minimization and the maximum construction practiced, less practiced waste minimization factors in the construction industry of Malaysia. Effie Papargyropoulou et al. (2011) focused on Malaysian construction sectors current status of waste management and level of sustainable practices on construction sites of waste management and examined attitudes and response of Malaysian contractors towards waste management by interviews were conducted with Malaysian contractors. Concluded industry's level of awareness and commitment on waste management very low and disappointing. Al-Hajj A. et al. (2012) identified from data collection from two case studies of construction projects construction practices to reduce construction waste generation in the UAE construction sites by a literature review of research. and concluded that of people are lack of awareness, less importance towards the waste management on sites and showed that contractors are consider that waste management is extra cost of the project. Mansi Jain et al. (2012) focused on the economic aspects of waste minimization of construction waste materials in terms of cost savings of construction projects of India. And found that Due to lack of site waste management systems, lack awareness of waste minimization in Indian construction industry cause of generation of large quantities of material waste. This affects not only at environmental but also in terms of economically as waste materials handling cost. And found various causes for the waste generation like lack of awareness among owners and contractors, lack knowledge of labor, lack of proper training and education towards waste minimization system. Nitish Bagdi et al. (2013) used secondary data for the implementation of waste management practices in construction sector in India. Data based upon results from interviews of stockholders which focused on some of the significant issues and challenges and connected with the implementation of waste management system of India. And found that lack of awareness of contractors and the construction workforces are major challenges connected with the implementation of waste minimization practices in Indian construction industry.

Job Thomas et al. (2013) enlightened the waste minimizations 3R System of reduces, reuse and recycle for the construction waste management in India. And the resources from construction and demolition (C&D) wastes is yet other benefits for recycle materials for the construction industry of India. And also identified that some wastes are reduce by proper design in early stage .it can possible to minimize some level of C&D waste generated taking proper construction and demolition methods. Manal S. et al. (2014) developed a detailed process for to calculate construction and demolition waste management approaches by use of Decision Matrix technique. And introduced procedure helps the decision maker such as the C&D contractor or Transportation firms as well as the policy maker on strategic level to take the different influencing factors. Provided data, when planning; changing or implementing C&D waste management systems and approaches. And recommended to make a cost and benefit analysis for each stakeholder in the CDWM system considering weighing the discussed pros and cons of every approach. Shishir Bansal et al. (2014) concluded that there is less amount of natural construction resources so it is necessary to reduce C&D waste generation and increase reuse/recycling as the construction industry .in view of international experiences, shortage of aggregate from natural sources being discovered in many parts of the country, so now recycled aggregate can use in constructions processes. The government Municipal waste laws are required to modify and prepare effective plans and strict rules and regulations are important forget out of this problem. And recycled products are important to promote the use. Nuria Calvo et al. (2014) described a system based on rules measures which key factor in order to create a 3Rs model (Reduce, Reuse, Recycle) for incorporate universities in the C&D waste management for costs savings. By main objectives like restraint of idle wastes, reduction of unnecessary landfills and imitation of recycled C&D wastes and found a broad understanding of the socioeconomic factors implications of waste management over time and policies in the recycled aggregates market and got the goal of 30% C&D waste aggregates in 12 years or less then it. Abhijith Harikumaret al. (2014) suggested the reusing of the material waste is very good and helpful especially when it will be useful in minimizing demolition of earth's stone crust and green forest cover by aim of reduced mining. By proper reduce, reuse and recycling, these waste materials will not addition of wastes at dumping and disposal sites. Showed that Construction industry can help by encouraging use of recycled concrete stones and bricks. Towards its commitment to protection of environment.

Sadhan K Ghosha et al. (2015) proposed a model for transportation rates and resale value of recyclable materials which makes use of easily available

data that can provide an intuitive and simple optimization model for the basic principles of Reduce, Reuse and Recycle into action. Identified the most common causes of waste on site. And identified the advantages of construction waste management. Noraziah Wahia et al. (2015) conducted a review of existing waste control practices adopted by the responsible parties in Hong Kong and Malaysia in order to minimize the environmental impacts of construction activities. And also embraces the differences and similarities of waste control practices in both countries reviewed. And concluded, there are still many efforts that the Malaysian government can undertake by taking Hong Kong as a role model to tackle the C&D wastes issue. Suggested that there is future research on creating awareness by means of providing effective training on proper waste management method. And to providing Facilities to support waste management part in recycling need upgrading and improvement.

Sumit Arora et al. (2015) slated that natural resources are limited in nature and will be depleted with time. In order to conserve the natural resources, unnecessary wasting of natural resources should be restricted and regulated. Formulation and implementation of proper waste management plan throughout the life cycle of the projects can minimize C&D waste. With an integrated resource management scheme, most of the construction and demolition material can be recycled or reuse and more natural resources can be conserved for our next generations. The success of recycling requires promotion by means of education and information, in addition to judicial rules from the concerned governing body. Harish. P. Gayakwad et al. (2015) concluded that it is difficult to manage Construction and Demolition waste in the future. Data should be generated on the basis of Construction and Demolition waste generation on sites. And promote the. Separation of Construction and Demolition waste. The method for collection of waste should be discovered and modified it suitable for future. Reuse and recycling of waste materials also should be in method thus charges should be applied on generation of Construction and Demolition waste.

Markandeya Raju Ponnada et al. (2015) studied the sources and causes of demolition waste, its environmental effects and suggested the most effective waste minimization methods. Based on the research, construction Waste management plan was evaluated. For effective and proper use of C & D, it necessary that the governing bodies make the implementation practices of this plan regularly. And suggested increase methods of waste minimization. Questionnaire surveys and interviews were conducted to collect professionals' opinions on key issues and factors and found factors like better supervision,

human resources, knowledge, technology and policy to improve performance of waste construction management. Nur Najihah Osmana et al. (2016) slated that Improvement in construction waste management among industry stakeholders especially in Malaysia is crucial in ensuring the industry continues to remain relevant. In addition, developing countries like Malaysia are still lack of awareness of the importance of good waste management practices due to the issue of monetary profit that becoming main target to the industry stakeholders. Awareness of industry stakeholders are seeming important in order to minimize the gap between developing countries and developed countries. Milad Najafy et al. (2015) examined the most affected factors behind the waste management system the lack of awareness among different stockholders of industry about applications of waste reduction and recycle and demerits of an improper System and there is minimum technology available for recycling and reuse materials such as demolition waste recycling, aggregate recycling and mostly reusing methods for on-site construction in Northern Cyprus. And concluded that the most important results by the lack of knowledge were the reasons behind that to reduce waste materials, which is reported to be the lack of knowledge about the benefits and application. And suggested that local governing body should perform effective processes and promote C&DWM plans in the Northern Cyprus among lead contractors, designers and constructors. Thangam Somchand Singh et al. (2015) reviewed on systematic investigation on the management of construction materials and construction wastes are presented. Review revealed the requirement of a change in management processes of construction materials. Introduction of mechanized handling of construction materials will improve efficiency and cost effectiveness on the construction site. It revealed that minimization of wastage of construction materials during the construction phases is helpful for reduce the cost of the project. Sawant Surendra B. et al. (2016) slate the management of construction waste plays important factor in the cost of project. And it can estimate the cost of construction waste and its impact on cost of project. and also observed that by the generation of construction waste not only the cost of the project get increased but also high amount of valuable land is got occupied by waste generated in construction industry and it had negative impact on environment. And suggested that by reducing construction waste can help decrease the cost of project.

Noor zalik hasaadiet al. (2016) reviewed on current situation of construction waste management in Malaysia construction industry by literature. And invented that that have been implemented in the Malaysian construction industry is not serious on the construction waste management. And concluded that, an effective support by the government is needed and

providing a most effective policy in managing and reducing construction waste. Otherwise, the sustainability of resources and environmental problems will not be reduced and eliminated effectively. Roseline Ikauet al. (2016) defined a better understanding of the sources, causes and factors affect construction demolition wastes by current waste minimization practices on construction sites in Malaysia by determining various factors causing construction waste generation in the Malaysian construction sector and concluded that Lack of knowledge, lack of experience, poor supervision, improper inventories, lack of storage leading to damage and Rework. Concluded that Malaysian construction need world level awareness to construction waste management. S.M. Elgizawy et al. (2016) tried to provide an integrated solution for developing countries that combines efforts in slum development and zero waste management to get a higher impact on the local area and the national level. By providing job opportunities to the slum dwellers, enhancing the waste management mechanism and reducing the wastes sent to landfills hence moving towards the realization of the zero waste concepts and at the same time fostering the feeling of identity of the slum dwellers and solving the landownership problem. And concluded that Slum development through zero waste concepts is a comprehensive solution to the current slum development problem and waste accumulation problem and should be encouraged by the government. Saheed O. et al. (2016) suggested that site construction waste management practices could be important for reduce waste generation. Like strict construction waste management, project drawings, no design changes during construction process. And concluded poor knowledge, poor design documentation and lack of awareness towards waste minimization would increase construction waste generation. Site supervisors should be with the knowledge of waste minimization which could reduce of waste generation on sites. R. Shreena Shankari et al. (2017) highlighted the importance of waste management in construction, amount of waste generated in construction project, methods of minimizing waste and best methods involved in construction industries for minimize waste. Identified the factors that can contribute to materials that are minimum wasted. which is a need to concentrate even on materials that are least wasted as any small improvement in reduction of waste generated adds to the advantage in improving the overall efficiency of the project and enhance the construction industries performance with cost saving benefits. And suggested waste management plan which only minimizes the material waste but also improves the profitability and decreases the cost overrun. Eyong O. P.et al. (2017) assessed the perception of construction operatives, Tradesmen and Artisans on materials waste generation in the construction industry, with a view to encouraging better

performance of construction projects in Nigeria by employed questionnaire survey. And analysed that Design, Poor materials storage system and Theft and vandalism are the most important factors that influence material waste generation during construction and Proper site supervision and management techniques, adequate storage of material, and Staff training and awareness on waste management are the measures of minimizing construction material waste. Recommended that site operatives and craft men should be carried along in every management decision regarding waste management plan development as they constitute the major stakeholders on sites.

Objective

This study plans to apply readiness approach in sorting of C&D waste management. Organized sorting is considered to be helpful in demolition waste management.

Methodology

With professionals involved in construction projects, such as architects, contracting firms, and project administrators, thirty semi-structured interviews were performed. The research participants have knowledge and experience in construction projects spanning more than 6 years. Additionally, they have experience or understanding of decreasing waste in building projects and have been involved in a variety of construction projects during the past five years. The 30 participants' traits are depicted here according to the main types of building projects they were involved in.

Types of construction project	No. of Experts	Participants
General buildings, such as house building projects, commercial building projects & industrial construction projects.	17	8 Architects 2 Structural/Civil Engineers 4 Project Managers 3 Contractors
Engineered construction projects, i.e. public construction projects that are funded by the Jordanian government.	13	4 Architects 1 Structural/Civil Engineers 4 Project Managers 4 Contractors

Based on semi-structured interviews, data were gathered between April and May 2023. Due to the significant volume of both governmental and private construction projects in the region, face-to-face interviews were conducted in the central region. The interview questions were created to investigate the main causes of construction waste production at various stages

of the lifetime of a construction project. The 15-question interviews were divided into 5 sections: background information, sources and causes of waste during the project lifetime, construction waste minimization solutions, and further thoughts and opinions. The length of each interview varied between 50 and 90 minutes. The length of the total recorded interview is 10 hours and 24 minutes, with each session lasting an average of 1 hour and 8 minutes. The authors manually transcribed the data after manually recording it on a digital recorder.

Level	Factors
Environmental (Contextual)	Regulatory requirement Risk-based regulations Market Drivers Stakeholder awareness
Organizational	Learning and knowledge Top management support Business strategy Competitive advantage
Project	Project scope Project plan Value for money
Technology	Ease of Use Compatibility Availability

Four Levels of Readiness Model

S. No	**Causes of Construction Waste**	**Readiness Approach Indicator**
1	Poor site management and supervision Poor site management and supervision Poor site management and supervision Poor site management and supervision Poor site management and supervision Poor site management and supervision Poor site management inadequate supervision	• Organizational Top management support • Project Project plan
2	unplanned estimating	• Organizational Learning and knowledge
3	Poor planning and scheduling	• Project

		Project plan Project scope
4	Mistakes and Errors in design	• Organizational Business strategy
5	Mistakes during construction	• Environmental effect Weather • Project Insufficient labour and tools
6	Incompetent subcontractors	• Stakeholder awareness
7	Rework	• Organizational Learning and knowledge Business strategy Competitive advantages
8	Frequent design changes	• Project Project plan Project scope Value of money
9	Labour productivity	• Organizational Management
10	Shortage of site workers	• Organizational Management
11	Effect of weather	• Environment Improper scheduling
12	Lack of coordination between parties/construction team members	• Organization Top management

Discussion and Findings

S. No	Causes of Demolition Waste	Readiness Approach Indicator
1	Design and contract document (Frequent design changes and change orders, selection of low-quality materials)	• Organizational Competitive advantage Business strategy • Project Value for money Project plan
2	Procurement related- (Errors in contract documents, Design and construction)	• Project Project plan • Technology Availability
3	Handling related- (Damage during transportation to site, Materials supplied in loose form, Unnecessary material handling)	• environmental Regulatory requirement Risk-based regulations Market Drivers Stakeholder awareness • Organizational Learning and knowledge

		Top management support Business strategy Competitive advantage
4	Storage related- (Improper storing methodand inappropriate site storage area leading to damage and deterioration)	• Environmental Regulatory requirement Risk-based regulations Market Drivers Stakeholder awareness • Organizational Learning and knowledge Top management support Business strategy Competitive advantage
5	Workers related- (Poor workmanship, Time pressure)	• Technology Ease of Use Compatibility Availability • Organizational Learning and knowledge Top management support Business strategy Competitive advantage
6	Site management and supervision related- (Use of incorrect materials resulting in their disposal)	• Technology Ease of Use Compatibility Availability • Organizational Learning and knowledge Top management support Business strategy Competitive advantage • Project Project scope Project plan
7	External factors- (Weather conditions, Unpredictable local conditions)	• Environmental Regulatory requirement Risk-based regulations Market Drivers Stakeholder awareness

Causes/Barriers to Deal Construction and Demolition Waste

1. Policy and Governance

One of the biggest barriers to construction waste reuse in UP India is the lack of policy related incentive for companies. Current legislation for construction waste in UP India includes the Building Act (2004) and the Waste Management Act (2008). The Building Act (2004) implements the sustainability principles of the Ministry of Business, such as "the efficient and sustainable use of materials" and "the reduction of waste during the construction process". The Waste Management Act (2008) encourages the

reduction of waste by implementing a 6000 Rs. per ton levy for all waste products sent to landfill. The levy was used to incentivize waste reduction, whilst simultaneously generating revenue to develop new technology and practices in the industry. It should be noted that the imposed levy did little to change to landfill patterns, with construction waste continuing to rise.

2. Quality and Performance

Another barrier to the recycling of C&D waste is the need for it to be in quality condition. In order to make sure materials are of a high quality, they need to be manually sorted. Manual separation requires both time and money, hence increasing the pressure on an already strained system. Separation of materials is particularly important regarding hazardous materials, exemplary of this is timber. When regarding timber separation, it is important that contaminated wood be separated from non-contaminated wood which may be achieved on site or at transfer stations. If the material is sorted on site, then the associated cost is in terms of labor required to separate the material in addition to storage costs. If the material is not properly sorted, then it is unable to be recycled; thus, good separation practices need to be adopted for large amounts of material to be recycled.

3. Information

There is a lack of information within industry of the importance of recycling and the potential associated benefits. The construction industry is very dynamic, yet the practitioners have yet to understand the essence and importance of recycling the materials to avoid the waste.

4. Cost/Capital

In any construction project, the associated cost is of extreme importance as it is considered a major performance indicator and driver for success of the project. Unfortunately, in UP India, it is currently more expensive to recycle a material than it is to send it to the landfill.

5. Perception and Culture

Often, the value within C&D material is not fully realized, with many in the industry not considering it is as a potential resource. It is apparent that the majority of construction professionals consider waste as merely a waste and not a potential resource. Globally, there is increased focus on recyclable and renewable technologies in order to meet the sustainable development goals; therefore, it should be mandatory that construction practitioners update their perceptions and shift their focus from conventional methods to newer technologies.

6. Knowledge, Education and Lack of Technology

There are many companies and workers within the construction industry that do not have access to education on the circular economy. Education is a key factor to inducing change, with people traditional to the norm unless educated otherwise. It is the sole responsibility of construction professionals to learn the importance of recycling of materials and, subsequently, encourage their workforce to do the same. Nevertheless, governments and regulatory authorities are also responsible in conducting such educational seminars, meetings, workshops, etc., to update the knowledge and education of construction sector workforce. Generally, the absence of technology required for waste recovery and recycling results in contaminated, low-quality products. As such, the cost of acquisition of recycled materials is high, while the performance of the materials is relatively low and not up to the desired standards.

Conclusion

The construction and demolition waste management is very important to achieve environmental sustainability in its all aspects, for example, bringing positive social impact with opportunities and improvements of resources and work quality, preventing landscapes to get contaminated and reducing environmental degradation. Both economic and environmental interests are benefited, when optimizing the management and practical collection, treatment and recycling of waste.

Governments and municipalities have a crucial role to facilitate and employ sustainable measures. According to the collected data, the population is unaware of the environmental protection rules and has little respect for it, and several areas have been marked as irregular waste disposal. Therefore, it is necessary not only to create regulations and guidelines, but create ways to the population to absorb it.

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