

“Development of Efficient Protocols and Waste Management in Construction Industry”

Ms Komal R. Kaushik^{1*}, Dr Abhinandan R. Gupta²

1*- Corresponding Author

B.E. Civil Engineering

M.E. Construction Technology and Management

Ph.D Research Scholar

Sant Gadge Baba Amravati University

Email- komalkaushikbhise@gmail.com

2- Dr Abhinandan R. Gupta

M.Tech Construction Management, NICMAR, Pune

M.E. Civil Engineering

Ph.D Civil Engineering

Professor and Head Dept of Civil Engineering,

College of Engineering and Technology, Akola

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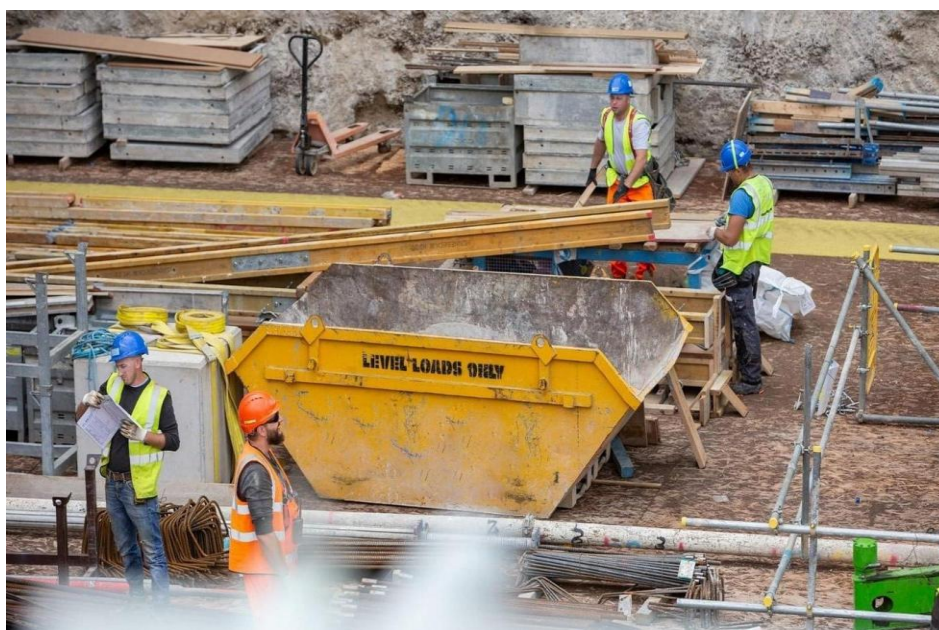
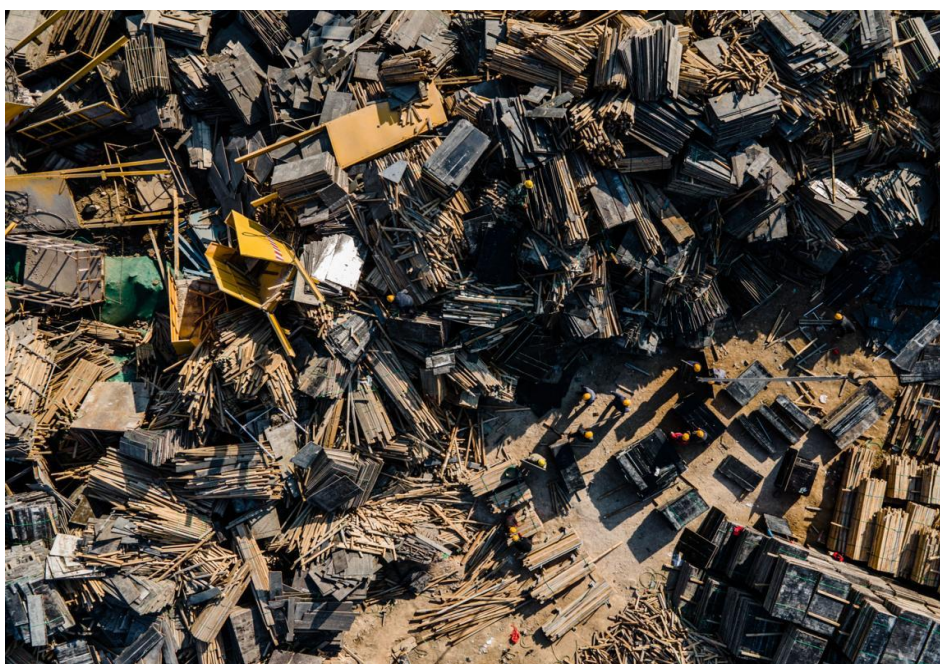
ABSTRACT

The construction industry is one of the biggest sectors regarding infrastructure and economy. It contributes tremendously to the GDP of a nation. Nevertheless, construction processes yield formidable debris that creates contamination and environmental sustainability hindrances. Construction activities that are inefficient, material that is mishandled, recycling techniques that are ineffective and also waste management practices that are inefficient, are increasing costs and harming the environment. The current study concentrates on formulating effective ways and eco-friendly waste management methods for the construction sector. This study highlighted several ways in which construction activities can reduce waste like reusing of materials, recycling of waste, lean construction, segregation of waste, and proper site management among others. A quantitative research approach, based on a survey technique, was adopted for the study to analyse the role of efficient protocols on the construction sustainability. Statistical effectiveness of the construction procedures and waste management techniques; their efficiency on construction and waste reduction effectiveness. It was concluded that protocols that are well-managed and structured can diminish the waste of materials. In addition, these protocols optimize on-site worker efficiency and productivity, as well as lower overall project costs. Such different strategies were also concluded to achieving the environmental sustainability as well.

Keywords: Construction Industry, Waste Management, Sustainable Construction, Recycling, Material Reuse, Lean Construction, Environmental Sustainability, Construction Protocols

Introduction:

sectors which contribute to the growth of the country. Due to the rise in demand for housing complexes, office complexes, highway bridges and more, rapid urbanisation and industrialisation have become the norm. Projects of this kind meet the growing demands of a certain area. Further, they create jobs and ensure economic growth. In a similar way, these projects need material. But, carrying out more construction-related works is generating a lot of construction waste materials. It has adverse effects on sustainability and resource efficiency. According to the definition of municipal waste, construction activities produce waste such as concrete, bricks, cement, steel, glass, wood, plastics, excavated soil and packaging waste. Due to poor design, mismanagement of materials and resources, poor site workers, design changes, etc., large quantities of construction materials are thrown away and wasted.



In the past few years, environmental sustainability has become a key issue for governments, industries and society. Increased construction waste volumes have led to sustainable waste management and efficient operations protocols in different construction industries. Protocols that help to reduce waste, enhance resource utilization, garbage recycling, and reduction of environmental pollution is called wastes management practices. The protocols increase the efficiency of construction businesses and let them optimize their project costs while allowing sustainable development. The concept of sustainable construction involves managing resources efficiently and effectively at every stage and every aspect of a construction project. Some effective resource protocols are waste minimisation, use of recycled construction materials, lean construction, segregate waste system, etc. Using recycled construction materials in designing and planning forms the basis of efficient waste management protocols. According to experts, the reproduction of materials like concrete, steel, wood and windows reduce pollution and the need for raw materials. In fact, it saves our natural resources from consumption and saves them in the environment. Construction firms are reaping the rewards of high-end technologies to improve waste facilities and resources. Moreover, to deter illegal dumping.

Technologies such as BIM, AI, IoT and monitoring systems help to efficiently and accurately estimate the quantity of materials needed, predict their wastage, optimise the resources and more. By effectively planning project work, they reduce the unnecessary use of materials and improve work efficiency. Another strategy is the use construction projects.

Lean construction is a concept used to improve the workflow, eliminate delays, remove unnecessary work and proper use of Lean construction is characterized by the best practices of inventory management, worker training, and site supervision. In simpler terms, construction management organisations can apply lean principles to eradicate operational inefficiencies. Government standards and environmental regulations construction. A majority of the countries have released stringent guidelines regarding waste disposal, recycling targets and sustainable construction practices. Construction companies must now embrace and adapt the green practices for fulfillment of legal and environmental provisions. The certification of green buildings such as LEED, BREEAM, etc., characterizes various sustainable construction waste disposal activities.



When you see the construction industry, there are wastes generated at the end of every project at least in every one of them. It is not good to throw everything after use; it is always better to use something again and again. Some companies started an eco-efficient waste management system to recycle construction goods. There are, however, some specific advantages that construction companies get from a good waste management system that you must focus on.

All the corporate businessman can develop an efficient waste management system. And, this system will save the construction goods from wastage. Furthermore, it may be cost-effective for both companies and their customers. Most people nowadays are more reasonable towards the environment. They opt for products that help in the environment conservation processes. Further, use a waste management mechanism to produce new construction material.

Most organizations operating in the construction sector manage to create a positive image of their establishment. They are able to do so by following operations, which are sustainable and environment-friendly. Other advantages of communicating a sustainable image of the corporation can also help you to win stakeholders' confidence and win the confidence of the public. Presently people are more aware of managing solid waste. The term waste management refers to the proper separation.

In addition, it is a simple procedure for cleaning, which is used for segregating the wastes and for reducing it effectively and in.

As a whole, the study's findings will assist the construction companies and engineers to develop a better waste management policy. Researchers and policymakers will find it of great interest. The findings will be extremely helpful in the creation of new policies for sustainable.

Related Works:

Ajayi et al. 2017 in their study on construction waste generation reviewed the literature and suggested how designing helps in reducing waste. The study was conducted on waste-to-energy projects by the researcher. A review of cases of construction waste generation reveals that poor planning, design changes, and inefficient construction practices result in waste of many construction materials. According to the study, material waste can be minimized through standardized designs, prefabricated materials as well as effective communication among project teams. According to the researchers, the essential part of sustainable design is to improve construction efficiency and save the environment. Huang et al. (2018) analyzed. The study revealed the ways construction industries can cut down on waste generation through reuse and enhanced recycling activities. The researchers noted that proper execution of the principle of 3R helps to reduce landfill waste and conserve natural resources. Through the study, it is found that the government policies and awareness programs can generate better systems. Jain, Singhal and Pandey (2020) did the study on recycling construction and demolition waste in India.

The researchers looked at recycling impact of construction materials like concrete and aggregates. They found that recycling construction waste can minimize pollution to environmental, cut down the energy consumption, and lessen the demand for natural resources. The researchers concluded that sustainable recycling processes would help the construction industries achieve environmental sustainability and improve overall efficiency of waste management. Jin et al. (2017) undertook empirical research to investigate the awareness of construction recycling and reuse practices in China. Researchers gauged the awareness of construction managers, contractor and engineer about

sustainable waste management practices using their opinions. Most professionals interviewed felt recycling of construction waste is necessary for environmental safety. Industry experts believe recycling can lower the costs of building. There are still barriers which prevent construction managerial people from recycling their waste. The absence of recycling facilities, inadequate support from the government and workers not having enough awareness. In order to improve recycling, the researchers recommended strict regulations and improvements in waste facilities. Jin, Yuan, and Chen (2019) analyzed earlier research studies in the other. The researchers had thoroughly checked through all articles published from 2009 to 2018. The science mapping technique was employed to identify key areas and trends in sustainable construction research.

A literature review showed that major topics taken up in this area in the last five years include, waste reduction, recycling technologies, lean construction techniques, and circular economy etc. Researchers believe that owing to growing concern toward the environmental problems, saving construction resources and waste management is gaining more importance these days.

In 2017 Research on delivering the estimate urban China. The researchers devised techniques to estimate from construction activities, like that of a project. The study also examined the primary causes behind revealed that the major aspects that cause include poor site management, improper material handling and the speed of urban activities competing with the slow pace in construction. Construction company can enhance operational efficiency and reduce wastage of materials by accurately and predatory estimating waste and proper planning of construction project, the findings highlighted.

Mah pours, 2018 the study concentrated on the obstacles that are hindering implementation. The study shows that there are many barriers that include lack of advanced technology, lack of capital investment, poor awareness of workers, etc. The analysis clarified that construction industries are beneficial due to effectual reuse of beneficial materials and environmental pollution reduction finally. As per the recommendation of the researcher, there should be proper cooperation between industry, government and population for proper implementation of CD waste management and removal.

Menegaki and Damigos (2018) examined the current situation and difficulties being faced in highlighted various issues that hinder effective construction improper disposal and segregation of waste, lack of recycling and reusing facilities, poor environmental regulation, and more. The finding within the study suggests that developing nations suffer more than developed ones due to lack of funds and technical knowledge in developing a sustainable waste management system. could be enhanced by improved recycling technologies, government initiatives, and public awareness programs, claim researchers. According to Nazifa et al. (2019), construction and demolition waste has been analyzed. A study was performed on the advantages of recycling construction materials. The study found that the most common waste materials activity are concrete, steel, wood and bricks.

Recycling these materials cuts down landfill wastes, reduces operational expenses and is beneficial for the environment. Essential recycling practices are essential for achieving researchers concluded the study. In 2010, Marinković et al. compared concrete from natural aggregates with that from recycled aggregates. Researchers examined how reusing construction materials altered the environmental impact of concrete production.

Objectives of the Study:

1. To identify the major causes of waste generation in the construction industry.

2. To evaluate the effectiveness of efficient waste management protocols and sustainable construction practices.
3. To analyze the impact of recycling, material reuse, and lean construction techniques on environmental sustainability and project performance.

Hypothesis

- **Ho:** Efficient waste management protocols do not significantly impact construction performance.
- **H1:** Efficient waste management protocols significantly improve construction performance.

Material and methods:

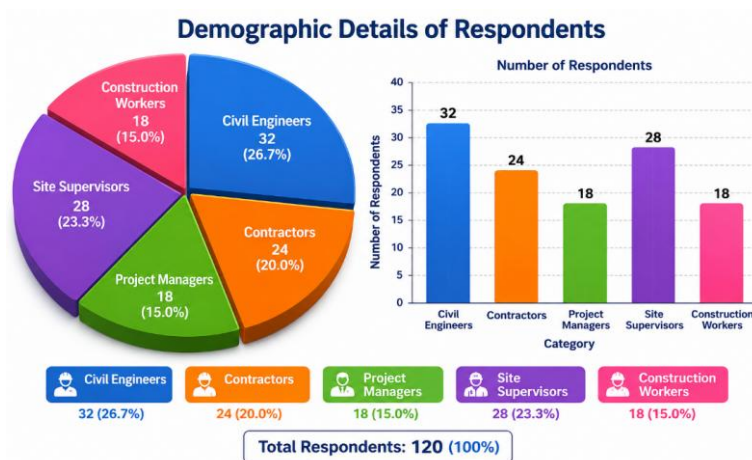
The study adopted a quantitative description research method to analyze how efficient protocols, guidelines and processes are been developed for managing waste. In addition, it also examines the causes of construction waste generation and the sustainable waste reduction techniques adopted in the construction projects. The primary data were collected through a well-structured questionnaire directed at civil engineers, contractors, project managers, site supervisors and construction workers involved with residential, commercial and infrastructure projects. The team also collected secondary data from research journals, books, government reports, industrial publications and online database relating to Sustainable Practices. Furthermore, the researcher conducted a random sampling technique for the collection of data from 120 respondents. The questions posed in the questionnaire were primarily focusing on the reuse and recycle of usable material, separation and segregation of material, lean construction techniques, sustainable site management, etc. solid waste management. After the data collection, the researcher has applied percentage analysis, mean analysis, standard deviation and regression analysis on the response data collected from the respondents.

The research of the study adopted a sustainability-driven research approach for optimizing resource utilization, minimizing environmental pollution and making efficient waste disposal system in the construction industry.

Analysis of the study:

Table 1: Demographic Details of Respondents

Category	Number of Respondents	Percentage (%)
Civil Engineers	32	26.7
Contractors	24	20.0
Project Managers	18	15.0
Site Supervisors	28	23.3
Construction Workers	18	15.0
Total	120	100



Analysis

According to the information in the above table, it is clear that civil engineers are the most respondents among all concerned parties or stakeholders involved in the research study with 26.7% of respondents while the site supervisor is the next one with 23.3 percent. Contractors made up the 3rd most respondents out of all parties, accounting for 20% of the entire survey. Project managers and construction workers each had equal participation of 15%. The construction sector's stakeholders were also helpful in contributing.

Table 2: Factors Influencing Waste Management Efficiency

Variables	Mean	Standard Deviation
Material Reuse Practices	4.22	0.61
Recycling Efficiency	4.18	0.64
Waste Segregation Methods	4.07	0.69
Lean Construction Techniques	4.29	0.58
Sustainable Site Management	4.31	0.55
Overall Waste Management Efficiency	4.21	0.61

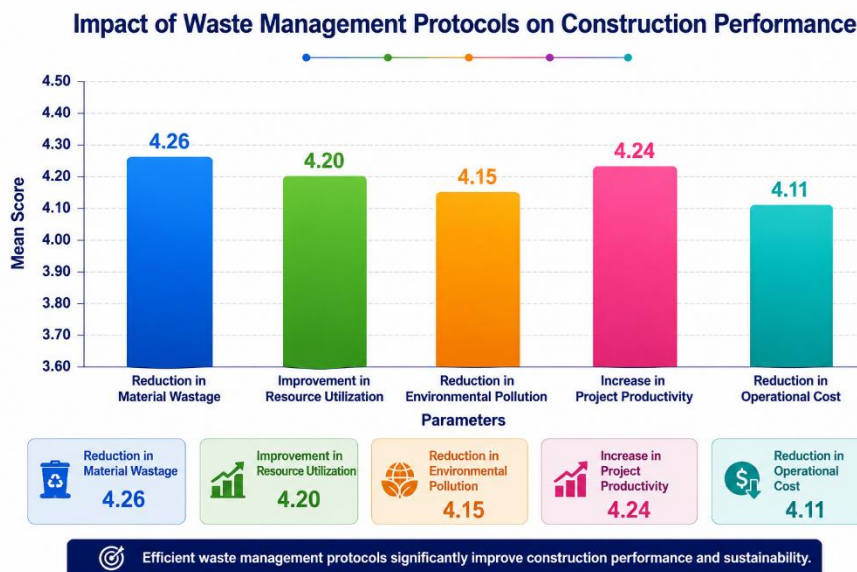


Analysis

In addition, the mean value of 4.29 of lean construction skills technique show a very high value further indicating that the techniques materials is robustly developed and implemented. In relation to this, the average scores of 4.04 and 4.11 for material reuse and efficient recycling respectively are rather near. It shows higher use of construction elements relative to other tools. The overall mean value of waste management efficiency is 4.210. Hence, proper benefits by making it more efficient.

Table 3: Impact of Waste Management Protocols on Construction Performance

Parameters	Mean Score
Reduction in Material Wastage	4.26
Improvement in Resource Utilization	4.20
Reduction in Environmental Pollution	4.15
Increase in Project Productivity	4.24
Reduction in Operational Cost	4.11

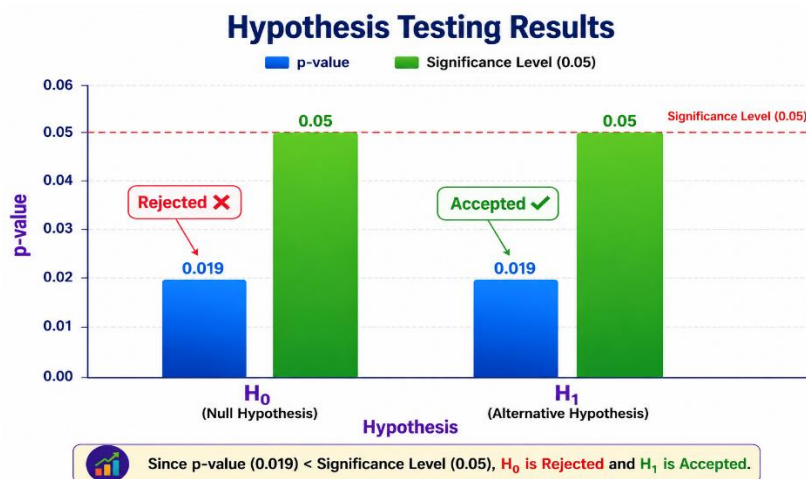


Analysis

Waste management strategies enhance material use and construction processes through efficient waste management protocols. According to the results of expert opinion, material wastage will have a maximum effect of about 4.26 (maximum score) 93% of total influence. Enhancing project productivity also gained a high score of 4.05 which shows that sustainable management of construction waste improves operational performance. Protocols made for waste management help in a sustainable industrial development by protecting the environment and preventing pollution. Proper handling of waste enables effective.

Table 4: Hypothesis Testing

Hypothesis	Statistical Test	p-value	Result
H ₀	Regression Analysis	0.019	Rejected
H ₁	Regression Analysis	0.019	Accepted



Results and Discussion:

The outcomes of the study provide evidence that proper waste management procedures can lead to superior construction performance and greater environmental sustainability. The analysis showed that many construction projects sufficiently mastered the sustainable site management, lean construction, material reuse and recycling system. Also, “Sustainable Site Management” is the most important variable as evident from the highest mean value. This means construction organisations are performing site operations as per best environmental practices. Aside from that, it is found that the segregation and recycling of waste can and improper dumping of material. Besides, the construction organizations that will use recycling and reuse will benefit the most with their materials consumption and refinement budget. Furthermore, lean construction helps to minimize project delays, further outsourcing of non-value-added activities, and improves inefficiency of the workflow in construction operations. In addition, regression analysis indicated that waste management protocols significantly influence performance in construction. Findings of the analysis indicate a p-value smaller than the worthiness level of the test. Thus, it is proved that the efficiency of waste management directly enhances project productivity and reduces operational cost and protects the environment.

Moreover, digital monitoring and automated waste tracking can improve waste management according to the study. Likewise, the study faced some challenges in terms of lack of awareness amongst workers, training programs, recycling mechanism and financial constraint of small construction firms. The results show that introducing a waste management system and sustainable construction practices can cut the environmental impacts while boosting industrial productivity and organizational performances in the long-run.

Conclusion:

The creation of an environmental hazard which is on a huge scale is due to several types construction components is waste management which can enhance sustainability, and reduce the overall wastage of materials, and improve the effectiveness of construction activities. Achieving sustainability is not merely a result of discussions on sustainable management but rather implementation of policies and practices. This current study is focused on waste management techniques and their impact on enhancement and sustainability in construction. As per the findings the practices of material reuse, recycling system and lean construction along with site management for sustainability practices minimizes waste generation and maximizes resource utilization. Efficient protocols allow construction companies to cut their environmental footprint, save on operational costs, boost project productivity, and make optimal use of materials.

The findings of the study also indicated waste management for sustainability practices performance. Organizations that implement waste management systems tend to outperform organizations that use conventional construction systems. All businesses need to establish a waste management program irrespective of the industry they are operating in. For waste reduction, it is a much better construction organizations to use structured waste management systems instead. The research further suggests a strengthening of waste management through adoption of modern technologies, employee awareness programmes, appropriate segregation systems and government support. Moreover, the enhancement in the usage of digital development technology, artificial intelligence and smart waste monitoring systems will further improve.

To wrap things up, putting in place effective procedures sustainable construction. Furthermore, it will enable the protection of the environment and will encourage industrial expansion in the future. Furthermore, the industry can undergo a more resource-efficient and sustainable transformation by adopting environmentally friendly construction practices.

References:

- [1] Ajayi, S. O., Oyedele, L. O., Akinade, O. O., Bilal, M., Owolabi, H. A., Alaka, H. A., and Kadiri, K. O., "Attributes of Design for Construction Waste Minimization: A Case Study of Waste-to-Energy Project," *Renewable and Sustainable Energy Reviews*, vol. 73, pp. 1333–1341, 2017. DOI: <https://doi.org/10.1016/j.rser.2017.01.115>
- [2] Huang, B., Wang, X., Kua, H., Geng, Y., Bleischwitz, R., and Ren, J., "Construction and Demolition Waste Management in China through the 3R Principle," *Resources, Conservation and Recycling*, vol. 129, pp. 36–44, 2018. DOI: <https://doi.org/10.1016/j.resconrec.2017.09.029>
- [3] Jain, S., Singhal, S., and Pandey, S., "Environmental Life Cycle Assessment of Construction and Demolition Waste Recycling: A Case of Urban India," *Resources, Conservation and Recycling*, vol. 155, 104642, 2020. DOI: <https://doi.org/10.1016/j.resconrec.2019.104642>
- [4] Jin, R., Li, B., Zhou, T., Wanatowski, D., and Piroozfar, P., "An Empirical Study of Perceptions towards Construction and Demolition Waste Recycling and Reuse in China," *Resources, Conservation and Recycling*, vol. 126, pp. 86–98, 2017. DOI: <https://doi.org/10.1016/j.resconrec.2017.07.034>
- [5] Jin, R., Yuan, H., and Chen, Q., "Science Mapping Approach to Assisting the Review of Construction and Demolition Waste Management Research Published between 2009 and 2018," *Resources, Conservation and Recycling*, vol. 140, pp. 175–188, 2019. DOI: <https://doi.org/10.1016/j.resconrec.2018.09.029>

- [6] Lu, W., Webster, C., Peng, Y., Chen, X., and Zhang, X., "Estimating and Calibrating the Amount of Building-Related Construction and Demolition Waste in Urban China," *International Journal of Construction Management*, vol. 17, no. 1, pp. 13–24, 2017. DOI: <https://doi.org/10.1080/15623599.2016.1166548>
- [7] Mahpour, A., "Prioritizing Barriers to Adopt Circular Economy in Construction and Demolition Waste Management," *Resources, Conservation and Recycling*, vol. 134, pp. 216–227, 2018. DOI: <https://doi.org/10.1016/j.resconrec.2018.01.026>
- [8] Menegaki, M., and Damigos, D., "A Review on Current Situation and Challenges of Construction and Demolition Waste Management," *Current Opinion in Green and Sustainable Chemistry*, vol. 13, pp. 8–15, 2018. DOI: <https://doi.org/10.1016/j.cogsc.2018.02.010>
- [9] Nazifa, T. H., Yuniarto, A., Uddin, A. S. M., Salmiati, S., and Shahid, S., "An Empirical Study of Construction and Demolition Waste Generation and Implication of Recycling," *Waste Management*, vol. 95, pp. 10–21, 2019. DOI: <https://doi.org/10.1016/j.wasman.2019.05.049>
- [10] Marinković, S., Radonjanin, V., Malešev, M., and Ignjatović, I., "Comparative Environmental Assessment of Natural and Recycled Aggregate Concrete," *Waste Management*, vol. 30, no. 11, pp. 2255–2264, 2010. DOI: <https://doi.org/10.1016/j.wasman.2010.04.012>