



“Understand the causes of material wastage on construction site and propose solutions to minimize the wastage - A Lean Approach”

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Abstract: It is widely acknowledged that there is a significant amount of waste in the construction industry. Because the construction industry has a significant and direct influence on many other industries through both purchasing inputs and providing products to all other industries, reducing waste in the construction industry could result in significant cost savings to society. Proposing the waste minimization techniques by understanding the cause of waste generation is the main motto of this project. For which the project will be initiated in 5 basic steps: Conceptual preparation, Onsite visits and observations, Onsite data collection, Data processing and propose the solution. Periodic onsite observation will be conducted for a period of over 2 months followed with a survey consisting of Project managers, architects and assistant engineers present on the site. Over the scope of this project 5 major causes of wastes on the construction sites have been identified as a result of the survey conducted among the engineers directly or indirectly associated with the construction site. They are as follows: Lack of onsite material control, Damage to materials on site during transportation, Poor handling of materials, Waste resulting from cutting uneconomical shapes, using excessive quantities of materials than required. This project will be throwing light on the importance of lean construction management in the construction industry and all the benefits of using the lean construction techniques on the construction site.

Key Words – material wastage, construction site, lean approach, lean construction, waste reduction, sustainability, productivity

I. INTRODUCTION:

The construction industry plays a crucial role in shaping the built environment, providing essential infrastructure, buildings, and structures to support economic and social development. However, the industry is also notorious for generating substantial amounts of waste, including material wastage, throughout the construction process. This wastage not only leads to financial losses but also contributes to environmental degradation and sustainability challenges.

Efficient management of construction materials is vital to minimize waste and optimize project outcomes. The traditional approach to material management often lacks effective control measures, resulting in excessive procurement, inaccurate estimation, inadequate inventory management, and poor coordination among project stakeholders. These factors collectively contribute to significant material wastage on construction sites.

To address this issue, adopting a lean approach in construction has gained recognition as an effective methodology to minimize waste and enhance project efficiency. Lean construction principles and practices aim to eliminate non-value-adding activities, optimize workflows, and promote collaboration among project participants. By applying lean principles to material management, construction projects can identify and eliminate the root causes of wastage, resulting in improved sustainability and productivity.

The objective of this research paper is to understand the causes of material wastage on construction sites and propose solutions to minimize wastage using a lean approach. By exploring the underlying factors that contribute to material wastage and investigating lean strategies, we seek to provide valuable insights and practical recommendations for construction industry professionals, project managers, and stakeholders involved in construction projects.

Through an in-depth analysis of causes, this research paper will shed light on key factors such as inaccurate estimation and procurement, poor inventory management, ineffective design and planning, lack of worker training and awareness, communication and coordination challenges, and equipment and machinery inefficiencies. Understanding these causes is crucial to formulating effective strategies for waste reduction.

The subsequent sections of this paper will delve into the core principles and practices of lean construction, highlighting their relevance to material management. Real-world case studies and examples will be examined to showcase successful implementation of lean strategies for minimizing material wastage on construction sites. Proposed solutions will be presented, encompassing improved estimation and procurement methods, enhanced inventory management, integrated design and planning

processes, training and awareness programs for construction workers, improved communication and coordination mechanisms, and the utilization of efficient equipment and machinery.

While implementing lean practices in the construction industry presents its challenges, this research paper will also discuss potential barriers and mitigation strategies to facilitate successful adoption. Furthermore, the paper will emphasize the impacts and benefits of minimizing material wastage, including cost savings, environmental sustainability, and enhanced project efficiency.

Ultimately, this research paper aims to contribute to the advancement of knowledge in construction management, sustainability, and lean practices. By providing a comprehensive understanding of material wastage causes and offering practical solutions through a lean approach, we aspire to empower construction industry stakeholders in making informed decisions and implementing efficient strategies to minimize material wastage and achieve sustainable project outcomes.

II. OBJECTIVE:

Following major objectives are identified:

- Identify the sources and causes of material wastage:
The wastage of material on any construction site has a definitely undefined reason behind it. Identification of which is very much important. Once identified the root causes, they can be easily eradicated to for a stable construction system.
- Identify the standard material waste reduction methods:
Once the root cause of material wastage is identified, the methods to reduce or eliminate the wastage come into the picture. Identification of the methods to reduce the wastage is also important as the implementation of wrong method to reduce the material wastage/usage may increase the future problems for the developer and customers.
- Propose the best suitable methods to reduce the waste on construction site:
Once the methods to reduce/eliminate the wastage are identified the synchronized study to of implementation of the wastage reduction method and the real root cause should be carries out to get the best and optimized solution out of the analysis.

III. LITERATURE REVIEW:

A)The foundations of lean construction, as presented by Lauri Koskela, Greg Howell, Glenn Ballard, and Iris Tommelein, assert that lean construction represents a significant advancement in the field. It is not merely another approach to construction but a transformative challenger to conventional construction practices. The development of lean construction thus far has led to two key claims: first, it is based on a superior theory compared to conventional construction, and second, it is more effective in achieving desired outcomes.

The authors argue that lean construction is a work-in-progress, indicating that there is still ongoing development and refinement within the approach. However, they emphasize the importance of recognizing the potential and benefits offered by lean construction. Its theoretical foundation and effectiveness in practice make it a compelling alternative for the construction industry.

Given these assertions, the authors suggest that all stakeholders in the construction sector should engage with lean construction, assess its principles and methodologies, and consider adopting this new way of thinking and practicing construction. By embracing lean construction, stakeholders can potentially unlock greater efficiency, improved project outcomes, and overall advancements in the construction field.

B) In their study on minimizing material wastage in the construction industry, K. Agyekum, J. Ayarkwa, and T. Adjei-Kumi focus on the Ghanaian context. They identify several factors contributing to material waste on construction sites, including materials storage and handling, operational factors, design and documentation factors, and procurement factors.

The study highlights specific causes of material waste, such as last-minute client requirements, errors by tradesmen or operatives, purchased products that do not meet specifications, and a lack of onsite materials control. Among the materials examined, timber, cement/mortar, concrete, and blocks were identified as having high levels of wastage on Ghanaian construction sites.

To address these issues, the authors recommend implementing proper storage and handling practices. Additionally, they propose the re-use and recycling of waste materials as effective strategies for reducing wastage on construction sites. The paper emphasizes that minimizing materials waste not only improves project performance but also enhances value for individual customers and positively impacts the national economy.

By adopting a lean approach and implementing these recommendations, the construction industry in Ghana can significantly reduce material waste, leading to more efficient and sustainable project delivery, increased customer satisfaction, and overall economic benefits.

C) In the paper "Lean Construction: An Effective Approach for Project Management" by Shariman Mustafa, the author addresses the shortcomings of existing project management models and strategies in delivering construction projects on time, resulting in waste generation within the industry. Through a comprehensive literature survey, the paper highlights the principles of Lean Construction (LC) and the prevalent wastes in the industry.

The author argues that LC offers a new and robust approach to addressing waste in construction. The importance of applying LC is discussed, emphasizing its potential benefits. By implementing lean tools and techniques, project teams and industry practitioners can minimize or eliminate waste, improve performance, and achieve significant cost savings for the industry and society as a whole.

The paper concludes by stating that the insights provided in the study will contribute to knowledge and practice regarding delay control and waste elimination. Furthermore, it is expected to serve as a benchmark for continuous performance improvement in the construction industry.

Overall, the paper advocates for the adoption of Lean Construction as an effective project management approach, highlighting its potential to reduce waste, enhance performance, and promote sustainable practices in the construction industry.

D) In the research paper titled "Application of Lean Construction Principles to Reduce Construction Process Waste Using Computer Simulation: A Case Study" by Amin Nikakhtar et al., the authors explore the implementation of lean production principles in construction processes with a specific focus on waste reduction. The paper presents a systematic approach to applying lean principles and highlights the importance of waste reduction in construction.

The researchers develop a reinforcement process model and utilize Arena 13.9 simulation software to conduct experiments and evaluate the effectiveness of lean construction principles in reducing waste. Through their study, they demonstrate the significant potential of lean principles in improving construction processes and minimizing waste generated during these processes.

The results of the study affirm the value of applying lean production principles to construction processes. The findings highlight the positive impact of lean construction on waste reduction and emphasize its potential for enhancing construction operations.

Overall, the research paper underscores the importance of adopting lean construction principles to reduce waste in construction processes. The study provides a systematic approach and simulation-based evidence supporting the effectiveness of lean principles in improving construction processes and minimizing waste generation.

E) In the article "Lean Construction – Eliminating the Waste" by Lauren Pinch, the focus is on the core objective of lean construction, which is the reduction of waste caused by unpredictable workflow. The article highlights that waste in construction can be categorized into seven main areas:

1. **Defects:** This refers to any errors, rework, or mistakes that occur during the construction process, leading to additional time, effort, and resources to correct them.
2. **Delays due to waiting:** Waiting for upstream activities to finish before starting another task can cause significant delays and disrupt the overall workflow, resulting in inefficiencies and increased project duration.
3. **Overprocessing:** Overprocessing refers to using more resources, time, or effort than necessary to complete a task or achieve a desired outcome. It involves activities that do not add value to the final product or result.
4. **Overproduction:** Overproduction occurs when more materials, components, or products are produced than what is actually needed, leading to excess inventory and storage requirements.
5. **Maintaining excess inventory:** Having excessive amounts of inventory ties up capital, requires additional storage space, and can lead to increased costs and potential waste if the excess inventory becomes obsolete or unusable.
6. **Unnecessary transport of materials:** Unnecessary movement or transportation of materials within the construction site adds to the overall waste. This can include moving materials between different areas without a valid reason or inefficient logistics planning.
7. **Unnecessary movement of people:** Excessive movement or unnecessary travel of workers within the construction site can waste time, increase fatigue, and reduce productivity. It is important to optimize the movement of workers and ensure that their activities are well-planned and streamlined.

By identifying and addressing these seven categories of waste, lean construction aims to eliminate or minimize inefficiencies, optimize processes, and improve overall project performance. The article emphasizes the importance of recognizing and actively working to reduce waste in order to achieve lean construction practices and enhance project outcomes.

F) In the paper "Six Sigma in Lean Construction Systems: Opportunities and Challenges" by Tariq S. Abdelhamidi, the author explores the potential application of Six Sigma methodology in the context of Lean Construction.

The paper begins by providing an overview of Six Sigma, tracing its origins back to its development at Motorola in 1985. Six Sigma is described as a methodology used by many organizations to achieve reductions in process variability. The definition and statistical origin of Six Sigma are discussed.

The DMAIC (Define, Measure, Analyze, Improve, Control) and DFSS (Design for Six Sigma) methods and metrics employed in Six Sigma are briefly presented. These methods provide a structured approach to problem-solving and process improvement.

The paper introduces a modification of the Last Planner System (LPS) using Six Sigma principles. The rolled throughput yield metric and sigma quality levels are proposed as tools to enhance the Last Planner System within the Lean Construction framework.

The author suggests that Six Sigma can find opportunities for application within Lean Construction, using the Lean Project Delivery System (LPDS) as a foundation. However, the paper acknowledges that it only covers a fraction of the potential applications of Six Sigma in the construction industry. Further research is needed to explore and investigate the implementation of Six Sigma methods in Lean Construction.

The author emphasizes that Six Sigma is one tool among many available and that its effectiveness depends on the specific business problems being addressed. Six Sigma is particularly suited for problems that are difficult to identify but relatively easy to solve. On the other hand, Lean tools are more effective for problems that are easy to identify but challenging to resolve.

In summary, the paper highlights the potential benefits of integrating Six Sigma into Lean Construction systems and calls for additional research to delve further into its implementation and effectiveness in improving construction processes. It also emphasizes the need for recognizing Six Sigma as a tool that is suitable for specific types of problems and that other tools may be more appropriate in different situations

IV. METHODOLOGY:



The Study and conduction of project was be carried in two parts.

3.1 Periodic Onsite Observation of the material wastage and data recording

3.2 Onsite survey for identifying the material wastage.

3.1 Periodic onsite observation of the material wastage and data recording:

An ongoing construction site was chosen to conduct data collection process with the prior permission of the developing authority. Regular visits to the site were conducted to collect the data observed about the actual material wastage and identification of the root cause of the material wastage. Total of four materials were found to be wasted heavily while the project was under construction. They are as follows: Timber, Cement/Mortar, Concrete making material and construction blocks.

1. Timber:



The timber on the site was found to be handled carelessly by the workmen thus, creating huge piles of timber wood difficult to contain in the site premises. Due to the improper handling of timber wood, there was huge loss of construction material and the reuse of timber formwork was nearly impossible.

1. Cement/Mortar:



The cement/mortar which was left half used was completely wasted as it was not handled properly. The proper use of cement/mortar was suggested on the site.

2. Concrete making material:



Major constituent of CMM (Concrete Making Material) sand and Gravel which was left over after the big pile was used up, was left unused and thus it was found to be a major cause of Material wastage.

3. Construction Blocks:



The blocks which were left after the pile has been used up were left aside and were complete waste as weathering of blocks makes them unfit for further use.

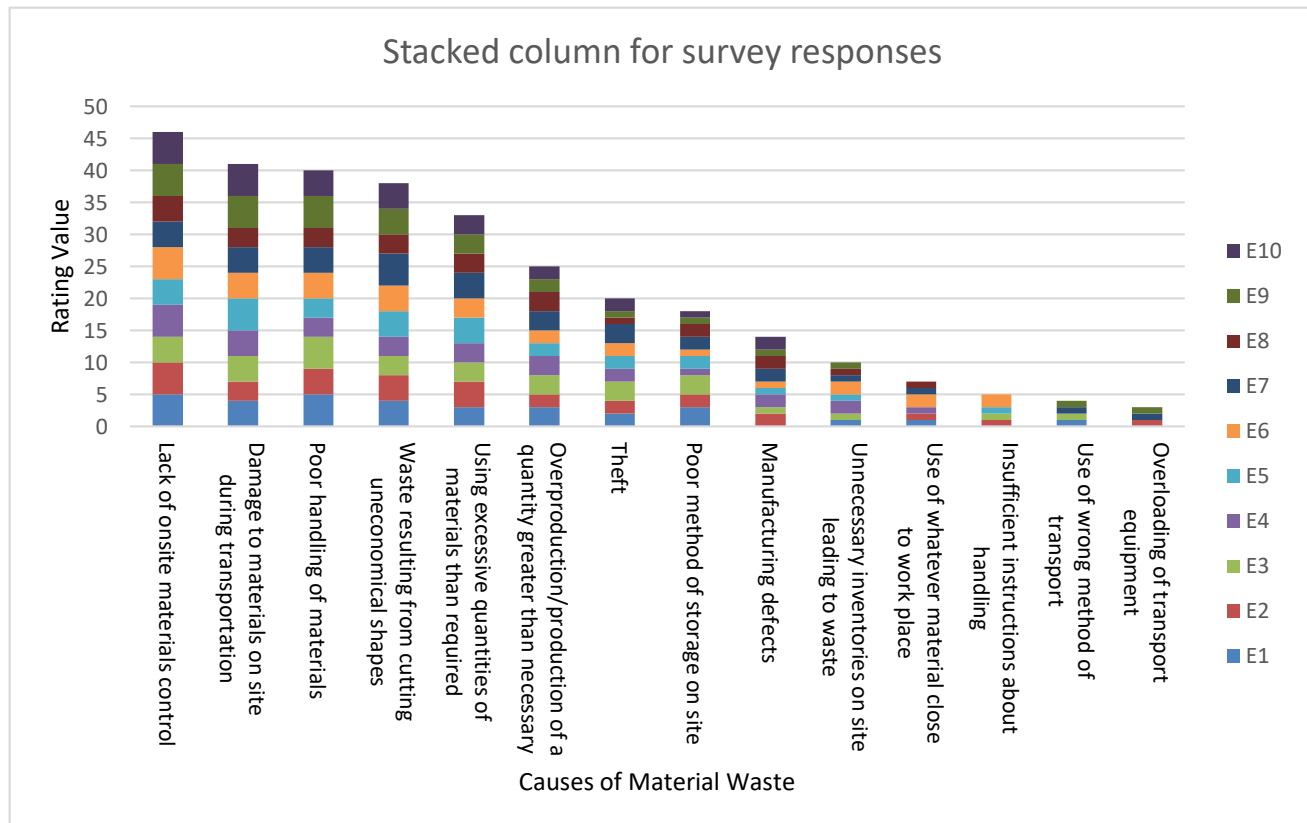
3.2 Onsite survey for identifying the causes of material wastage:

The survey will target the project managers, architects and assistant engineers employed on the site. The data obtained from both the methods will be processed and studied to find the pain point of the material wastage on the construction sites and suitable ways will be suggested to cope up the wastage using the Lean Construction approach.

10 factors majorly affecting the waste arising from material storage and handling have been identified by literature review and a survey for the same was conducted among 10 engineers who were directly or indirectly related with the site which was chosen for the project work.

From the 10 identified factors, the engineers were asked to rate the factors based on their experience and expertise on a scale of 0 to 5. And then out of the 10 factors identified, the major factors 5 were shortlisted on the basis of survey from engineers and solution for the rectification of these 5 factors are provided under the scope of this project.

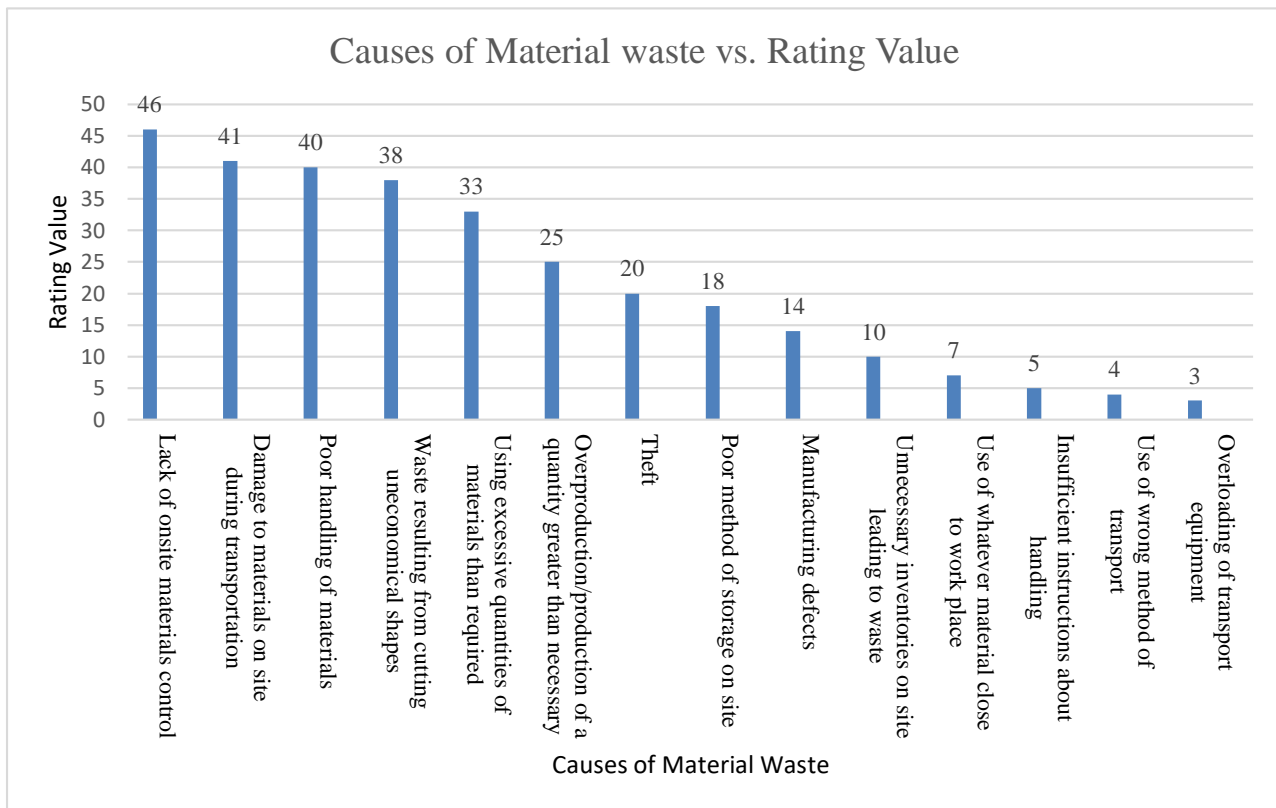
Sr. No.	Causes of Waste Arising from Materials Storage and Handling	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Total Rating
1	Lack of onsite materials control	5	5	4	5	4	5	4	4	5	5	46
2	Damage to materials on site during transportation	4	3	4	4	5	4	4	3	5	5	41
3	Poor handling of materials	5	4	5	3	3	4	4	3	5	4	40
4	Waste resulting from cutting uneconomical shapes	4	4	3	3	4	4	5	3	4	4	38
5	Using excessive quantities of materials than required	3	4	3	3	4	3	4	3	3	3	33
6	Overproduction/production of a quantity greater than necessary	3	2	3	3	2	2	3	3	2	2	25
7	Theft	2	2	3	2	2	2	3	1	1	2	20
8	Poor method of storage on site	3	2	3	1	2	1	2	2	1	1	18
9	Manufacturing defects	0	2	1	2	1	1	2	2	1	2	14
10	Unnecessary inventories on site leading to waste	1	0	1	2	1	2	1	1	1	0	10
11	Use of whatever material close to work place	1	1	0	1	0	2	1	1	0	0	7
12	Insufficient instructions about handling	0	1	1	0	1	2	0	0	0	0	5
13	Use of wrong method of transport	1	0	1	0	0	0	1	0	1	0	4
14	Overloading of transport equipment	0	1	0	0	0	0	1	0	1	0	3



The above table and the graph identify top 5 factors which affects the material wastage as given below:

1. **Lack of onsite material control:** This refers to the absence or inadequate measures to control and track materials on the construction site. Without proper control, materials can be misplaced, lost, or wasted, leading to increased material waste.
2. **Damage to materials on site during transportation:** During transportation from storage areas to the construction site, materials can get damaged due to mishandling or inadequate protective measures. Such damage results in material waste and can lead to delays and additional costs.
3. **Poor handling of materials:** Inefficient handling practices, such as rough handling, improper stacking, or incorrect use of equipment, can result in material damage and waste. Proper training and implementation of safe handling procedures are essential to minimize such waste.
4. **Waste resulting from cutting uneconomical shapes:** When materials are cut into shapes that are larger or more complex than necessary, it leads to wastage. Optimizing the cutting process to minimize waste and utilizing computer-aided design (CAD) software or prefabrication techniques can help reduce this type of waste.
5. **Using excessive quantities of materials than required:** Overestimating material quantities or inefficient use of materials during construction can contribute to significant waste. Implementing accurate material takeoff procedures, closely monitoring material usage, and promoting responsible consumption can help reduce this type of waste.

By addressing these factors through improved planning, effective material management, proper training, and process optimization, construction projects can minimize material waste, resulting in cost savings, environmental benefits, and improved project performance



V. RESULTS AND DISCUSSIONS:

- As the sources and the causes of the material wastage were detected, we can eliminate the root cause of issue so that it cannot persist anymore.
- As a result of survey conducted between the engineers, we got top 5 causes of material wastage as mentioned below
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 1. **Lack of onsite material control:** This refers to the improper management and control of materials on the construction site. It includes issues such as inadequate storage, disorganized inventory, and difficulties in tracking and locating materials. By implementing better material control practices, such as proper storage, labeling, and inventory management, the risk of material wastage can be significantly reduced.
 2. **Damage to materials on site during transportation:** Materials can be damaged during transportation from the supplier to the construction site. This can result from improper handling, inadequate packaging, or accidents during transit. To minimize this cause of wastage, it is crucial to ensure proper packaging and secure transportation methods that protect materials from damage.
 3. **Poor handling of materials:** Improper handling of materials on the construction site can lead to breakage, spills, or other forms of damage. This can occur during loading, unloading, or movement of materials within the site. By providing proper training to workers and implementing safe handling practices, the risk of material wastage due to poor handling can be mitigated.
 4. **Waste resulting from cutting uneconomical shapes:** Inefficient cutting or shaping of materials, such as timber or metal, can result in wastage. This occurs when larger pieces are cut into smaller sizes than necessary or when irregular shapes are created, leading to unused or unusable remnants. By optimizing the cutting and shaping processes, material wastage can be minimized.
 5. **Using excessive quantities of materials than required:** Overusing or overordering materials can contribute to significant wastage. This can happen due to inaccurate estimations, poor planning, or lack of coordination between different parties involved in the construction project. By adopting better estimating techniques, accurately assessing material needs, and improving communication and coordination, excessive material usage can be reduced.

 - A big amount of construction material will be conserved with scientific approach of Lean Construction Management Principles.
 - The construction cost of stakeholders will be reduced as the material will be efficiently used.
 - The overall Production cost of the project will be reduced and the stakeholders' money will be saved.

VI. CONCLUSIONS:

- It can be concluded that due to the use of lean methodology the material waste on the construction sites can be reduced up to substantial amounts provided that execution of the recommendations goes well.
- The study has identified materials storage and handling, Lack of onsite material control, Damage to materials on site during transportation, Poor handling of materials, Waste resulting from cutting uneconomical shapes, using excessive quantities of materials than required as the main sources of material waste on construction site.
- The study also identified that Timber, cement/mortar, concrete making materials and blocks as the major material wastes on the construction site.
- Also, proper reuse and recycle recommendations have been provided under the scope of this project. Which will help reduce the material wastage on the construction sites.
- The reduced material wastage will help in cost efficiency of the project.

VII. ACKNOWLEDGEMENT:

This is a great pleasure to express our deep sense of gratitude and thanks to our Project Guide Mr. Hardik Mandwe and HOD, Dr. Ashok B. More, for their valuable ideas, instantaneous help, effective support for publishing paper for project.

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