Identifying the Possible Measures to Minimize Material Waste Using Lean Construction

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Subject Area: Project Management.
Type of the Paper: Action Research.
Type of Review: Peer Reviewed as per |C|O|P|E| guidance.
Indexed In: OpenAIRE.
DOI: https://doi.org/10.5281/zenodo.7016112
Google Scholar Citation: IJAEML

How to Cite this Paper:
Madan Sharma, Mishra, A. K., & Janani Selvam, (2022). Identifying the Possible Measures to Minimize Material Waste Using Lean Construction. *International Journal of Applied Engineering and Management Letters (IJAEML)*, *6*(2), 47-64. DOI: https://doi.org/10.5281/zenodo.7016112

International Journal of Applied Engineering and Management Letters (IJAEML)
A Refereed International Journal of Srinivas University, India.

Crossref DOI: https://doi.org/10.47992/IJAEML.2581.7000.0145

Received on: 12/04/2022
Published on: 24/08/2022

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ABSTRACT

Purpose: *Continuous effort to assure material management is continued to identify the possible measures to minimize material waste in construction projects based on a lean construction approach.*

Design/Methodology/Approach: *The present study adopted Questionnaire Survey, Literature review, Study of project document for major sources of waste material, Possible Measures and Response in Scale of rating 1-5 using Relative Importance Index (RII).*

Findings/Result: *The discoveries uncover that Some of the significant places in the lean development approaches are: Adoption of legitimate site the board strategies, Accurate and great determinations of materials to try not to wrong request, Proper capacity of materials on location is additionally one of the actions for the waste material in the lean development, Purchasing unrefined substances that are simply adequate, Reduce Recycling and Reuse of a few waste materials on site. In this review, a few elements make issues in development ventures to execution of lean development approach for the undertaking's fruition. Because of various variables, the workers for hire can't finish the task successfully. This study gives proof fair and square of measure to conquer the obstructions to execution of lean development approach in development projects. The discoveries of this study are in concurrence with the impression of clients, experts, and workers for hire about the action to defeat the hindrances to execution of the lean development approach in development projects.*

Originality/Value: *The study contributes by assuring to Develop innovative practices and systems to control waste, delays, and cost overruns.*

Paper Type: Action *Research.*

Keywords: Material waste, Lean construction, Building, Construction site,

1. INTRODUCTION :

Nepal where foreign aid is one of the major resource as income part of budget needs to develop quickly with high efficiency to avoid the pit falls of foreign pressure [1 & 2]. Material waste is one of the major issue to maintain efficiency in construction sector as construction industry is under the trial of zero defects and zero waste though materials are found to be wasted due to storing condition, site conditions and operation conditions [3-7]. Because of the absence of information about the material waste produced during the development interaction, the development business has endured a ton. It has made either loss of benefit due exorbitant wastage of value issues because of the utilization of material underneath standard. Simultaneously, it significantly affects the climate. It is accepted that building material wastage on building locales represents cost overwhelms and any improvement in building materials the board on building destinations can possibly upgrade the development business' exhibition with cost-saving advantages (John and Itodo, 2013) [8]. Materials represent the biggest contribution to development exercises in the scope of 50-60% of the complete expense of a venture [9]. Accordingly, information about the size and reasons for materials squander in development is essential to work on the exhibition of the task. Until this point, there have been not very many examinations with respect to squander the board and lean development subsequently it is challenging to get exhaustively about the development material global positioning framework, kinds of

development squander, and its administration, and the way that squanders the executives is focused on in the Nepalese development industry. Thus, the requirement for research in this field is important to produce mindfulness on squander the board in the development business and the reception of suitable development ways to deal with limit squander.

2. LITERATURE REVIEW :

2.1 Impediments to Implementation of Lean Construction:

"Impediments to execution of lean turn of events" perceived from the assessments are presented as Lack of interest from clients, Waste recognized as certain, Poorly portrayed individual commitments, Lack of getting ready, Less commitment of undertaking laborers and specialists in the arrangement cycle, Delays in bearing, Lack of top organization support and obligation, Poor endeavor definition, Delay in materials movement, Lack of equipment, Materials deficiency, Unsuitable progressive plan, Lack of store network blend, Poor correspondence, Long execution period, Inadequate setting up, Lack of client and supplier consideration, Corruption, Poor master wages' Lack of standardization, Lack of specific capacities, High level of absence of training, Lack of care programs, Difficulty in sorting out thoughts, Inconsistency in government courses of action, Lack of buildable plans, Incomplete plans, Lack of agreed execution technique, High dependence of plan specifics on in-situ materials and parts rather than standardized and industrialized pre-collected parts, Extensive usage of subcontractors, Lack of long stretch commitment to change and advancement, Lack of long stretch relationship with suppliers, The partitioned idea of the improvement business, Lack of comprehensive execution, Inadequate receptiveness to necessities for lean execution, Lack of information sharing, Lack of social comforts and establishment, Unsteady expense things, Inflation and Uncertainty in store organization [10-13].

3. OBJECTIVES :

To identify the possible measures to minimize material waste in construction projects based on a lean construction approach.

4. HYPOTHESIS :

Null hypothesis: There is a relation between the ranking of Client and consultant i.e. $H_0 = 0$.
Alternative hypothesis: There is a relation between the ranking of Client and consultant, i.e., $H_1 \neq 0$.

5. METHODOLOGY :

5.1 Study Population and Sample Selection:

The study population was all the building projects which were in the commercial and residential operation and the working stage of construction in the Kathmandu valley of Nepal. However, construction projects were selected purposely for the study. Construction of new generator house in Airport, new pump house with underground water tank, Memorial Cancer Centre, Construction of Manmohan Centre ANNEX building, Residential building of Sanepa was constructed of three stories and which was privet sector building. And the projects of different developers which are in commercial and residential operation and the final stage of construction were selected based on a convenient sampling strategy to determine the major causes for material waste and identify the possible measures to manage waste. The total number of population is taken as sample size because the value of respondent population is less.

5.2 Sample Size:

Project Managers of these projects were consulted beforehand and found to have good knowledge about lean construction approaches so these projects were appropriate for collecting all the information required for the thesis. The parties related to the project such as the Client, Consultant, and Contractor were interviewed on the subject.

a. Client
b. Consultant
c. Contractors of the project
d. Project Supervisor

e. Experts who were related to the project construction and who were closely monitoring the activities of the project were also interviewed to find the causes of material waste in the project.

5.3 Method of Data Collection:

A questionnaire was developed in such a way to include representatives from clients, consultants, contractors, supervisors, and experts who were directly observing the project activities and to answer the research questions. Secondary data were collected from different sources like the internet and relevant articles and research papers.

5.4 Data Analysis:

After the assortment of essential and auxiliary information, this information was investigated efficiently. Material Reconciliation was done by contrasting the distinction between the store records. After the preparation of the list of causes of wastage, the analysis was carried out based on the comparison of opinions from the different stakeholders about the causes of wastage. Causes for the wastage were, then, ranked in terms of opinion from the stakeholders involved in the questionnaire and interview using the Relative Important Index (RII).

$$\mathbf{RII} = \frac{\sum \mathbf{w}}{\mathbf{AxN}} = \frac{(\mathbf{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1})}{(\mathbf{5xN})}$$

Where,
W is the mentioned scale for rating a factor by the respondents which range from 1 to 5
A is the highest weight on the scale
N is the total number of respondents
The methods of controlling the waste were determined using a different method of analysis. The information obtained from the analysis of data is presented in the form of chart, graph, table, and diagram.

5.5 Research Matrix:

Table 1: Summary of the methods

S. N.	Objectives	Data required	Sources of Data	Tools	Outcomes
1	To identify the major cause of waste material in construction projects.	Client, consultant, contractor,	Questionnaire The Survey, Literature review, Study of project document	Relative Importance Index (RII), Questionnaire survey,	Major sources of waste material
2	To identify the possible measures to minimize waste material in construction projects	Client, consultant, contractor,	Questionnaire The survey, Literature review	Relative Importance Index (RII), Questionnaire survey,	Possible Measures and Response in Scale of rating 1-5

6. RESULTS AND DISCUSSION :

The major causes/Factor affecting waste material in construction projects as shown in table 2.

Table 2: Significant factors affecting the material wastage in building construction

S. N.	Factor	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
		RII	Rank	RII	Rank	RII	Rank		
1	In adequate supervision	0.810	4	0.960	2	0.838	3	9.777	1
2	Change order	0.810	3	0.967	1	0.898	1	9.544	2
3	Damage of material in site	0.820	1	0.901	3	0.863	2	9.352	3

4	Lack of onsite material control	0.813	2	0.833	6	0.833	4	9.188	4
5	Poor storage of material	0.754	6	0.900	4	0.825	5	9.089	5
6	Storage and handling	0.738	9	0.883	5	0.738	9	8.877	6
7	Design change and revisions	0.800	5	0.717	9	0.813	6	8.591	7
8	Incorrect estimate quantity	0.742	8	0.750	7	0.791	7	8.371	8
9	Lack of waste management plan	0.750	7	0.710	10	0.775	8	8.195	9
10	Poor site layout	0.731	7	0.730	8	0.731	10	8.037	10
11	Changes in material prices	0.600	11	0.643	11	0.640	11	7.238	11

$$ARII = Si*\sum RII$$
$$Si = \sum Vi/Vi$$

Si= Scale factor of the this group;
Vi= Number of variables in this group;
ARII = Aggregate Relative Importance Index;
$\sum Vi = 11$ (Total number of variables)

The results of these parts of the study provide an indication of RII and rank of factors causing material wastage in building construction. Table 2 presents the ARII and the ranks of the major factor grouped into 9 different categories. The most important factors affecting the material wastage in building construction were: design changes and revision, incorrect estimate quantity, damage of material on-site, lack of onsite material control, poor storage of material, and lack of wastage management plan, inadequate supervision, and change orders. The findings of this study are in line with the study in Sri Lanka, Palestinian, Nigeria by Adewuyi and Odesol (2015) [14], who also reported the same factor like design changes and revision, site management, supervision, rework due to workers mistake and poor storage as the major factor responsible for waste generation in their study.

According to the aggregate relative importance index, it is found that the most effective factor for the cause of the waste in lean construction. Inadequate supervision was the most important waste causing factor as it has the first rank ARII =9.777 and adequate supervision in the site during construction from all parties significantly enhances the quality and reduces wastage. Proper Supervision of materials on-site plays a vital role to control the wastage in building construction by applying lean construction. The change order was the most important waste-causing factor as it has the second rank ARII =9.544. Damage of material in the site has been ranked the third position with ARII equal 9.352. Lack of onsite material control has been ranked in the fourth position with ARII equal to 9.188. Poor storage of material control has been ranked the fifth position with ARII equal to 9.089.

(1) Design and documentation related factors:

Table 3: RII and Rank of design and documentation related factors

S. N.	**Factors**	**Clients**		**Consultant**		**Contractor**		**ARII= ∑RII* Si**	**Rank**
	Design and documentation	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**		
1	Variations in the design while construction is in progress	0.810	2	0.783	2	0.838	1	15.833	1
2	Design changes and revisions	0.815	1	0.767	4	0.838	1	15.800	2
3	Incomplete contract documents at commencement of project	0.738	4	0.817	1	0.763	2	14.706	3
4	Poor communication leading to mistakes and errors	0.754	3	0.780	3	0.734	4	14.626	4
5	Poor site layout	0.731	5	0.730	5	0.750	3	14.613	5
6	Selection of low quality products	0.677	7	0.700	9	0.701	7	14.226	6

7	Lack of knowledge about construction techniques during design activities	0.676	8	0.727	6	0.675	8	14.206	7
8	Contractors non involvements	0.660	10	0.717	7	0.613	13	13.933	8
9	Poor/ wrong specifications	0.700	6	0.621	14	0.731	5	13.806	9
10	Designer's inexperience in method and sequence of construction	0.670	9	0.633	13	0.652	11	13.480	10
11	Lack of attention paid to dimensional coordination of products	0.613	12	0.683	10	0.651	12	12.98	11
12	Lack of attention paid to standard sizes available on the market	0.512	17	0.638	12	0.671	9	12.933	12
13	M Designer's unfamiliarity with alternative products	0.631	11	0.701	8	0.660	10	12.486	13
14	Complexity of detailing in the drawings	0.538	14	0.601	15	0.720	6	12.393	14
15	Error in contract documents	0.477	18	0.667	11	0.613	13	11.713	15
16	In complete contract documents	0.446	19	0.583	16	0.613	13	10.946	16
17	Lack of information in the drawings	0.610	13	0.400	19	0.610	14	10.8	17
18	Overlapping of design and construction	0.477	18	0.483	17	0.600	15	10.400	18
19	Last minute client requirement (resulting in rework)	0.513	16	0.421	18	0.613	13	10.313	19
20	Supplier's non involvement	0.523	15	0.483	17	0.438	16	9.626	20

$$\sum Vi = 20 \text{ (Total number of variables)}$$

Respondents were approached to score which elements are viewed as significant reasons for squander emerging from plan and documentation. At the point when the reactions of the experts (specialists and client and project worker) on the reasons for squander emerging from plan and documentation were looked at, the outcomes showed no tremendous distinction at a 5% importance level.

The ARII and position of plan and documentation gathering of variables are summed up in Table 3.Variations in the design, while construction is in progress, have been ranked the first position for the waste generation with an ARII of 15.833. Design changes and revisions have been ranked the second position for waste generation with an ARII of 15.800. Incomplete contract documents at commencement of the project have been ranked the third position for the waste generation with an ARII of 14.706. Poor communication leading to mistakes and errors has been ranked the fourth position for waste generation with an ARII of 14.626. The poor site layout has been ranked fifth position for waste generation with an ARII of 15.613. These are the factor for the generation of waste on lean construction.

(2) Material procurement related factors:

Table 4: RII and rank of material procurement related factors

S. N.	Factors	Client		Consultant		Contractor		ARII = ∑RII *Si	Rank
	Material Procurement	RII	Rank	RII	Rank	RII	Rank		
1	Incorrect estimated quantity	0.800	1	0.883	2	0.738	1	4.842	1
2	Changes in material prices	0.692	4	0.917	1	0.688	3	4.593	2
3	Unsuitability of materials	0.756	2	0.810	4	0.724	2	4.580	3

	supplied to site								
4	Poor schedule of material procurement	0.723	3	0.833	3	0.625	4	4.362	4
5	Ordering errors (e.g., ordering significantly more or less) Purchased products that do not comply with specification	0.800	1	0.713	6	0.625	4	4.275	5
6	Substitution of a material by a more expensive one (with an unnecessary better performance)	0.523	5	0.750	5	0.525	5	3.595	6

$\sum Vi = 6$ (Total number of variables)

Squanders emerging from material acquirement factors on building destinations were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and project workers) on the reasons for squander emerging from obtainment exercises were looked at, the outcomes showed no massive distinction at a 5% importance level.

The aggregate relative importance index (ARII) and rank of the material procurement group of factors are summarized in table 4. Incorrectly estimated quality holds the highest positing for contributing material waste with an ARII of 4.842. The same perception from all is mainly due to their experience of unskilled quantity estimators. Changes in material prices hold the second-highest positing for contributing material waste with an ARII of 4.593. The unsuitability of materials supplied to the site has third positing for contributing material waste with ARII of 4.580. Poor schedule of material procurement has been holding forth posting for generating waste material with ARII of 4.362. Requesting blunders (e.g., requesting fundamentally pretty much) Purchased items that don't follow the particular have a fifth posting for contributing material waste with an ARII of 4.275. This might be because of the absence of coordination among store and development teams or incorporated buying and it additionally cause because of unsound government. Over requesting or under requesting possesses the principal position from the view of the client in the acquirement bunch. This might be because of an absence of coordination among store and development groups or unified buying. Acquisition of materials that don't consent to the detail is evaluated the second-most elevated supporter of materials squander age by the project workers and third by specialist among the variables in the obtainment bunch.

(3) Material management on site-related factors:

Table 5: RII and rank of material management on site-related factor

S. N.	**Factors**	**Client**		**Consultant**		**Contractor**		**ARII= ∑RII* Si**	**Rank**
	Materials Management on site	**RII**	**Rank**	**RII**	**Rank**	**RII**	**Rank**		
1	Poor storage of material	0.803	2	0.951	2	0.867	1	9.610	1
2	Lack of onsite material control	0.854	1	0.967	1	0.713	3	9.291	2
3	Damage of material on site	0.700	5	0.901	3	0.800	2	8.803	3
4	Using Excessive quantities of materials more than the required	0.730	3	0.850	4	0.800.	2	8.726	4
5	Overproduction	0.706	4	0.813	5	0.704	5	8.705	5
6	Over size of building element during execution	0.585	8	0.783	6	0.710	4	8.305	6
7	unnecessarily inventories on site	0.692	6	0.717	9	0.688	6	8.151	7
8	poor quality of material	0.632	7	0.753	7	0.613	9	7.692	8

9	waste from uneconomical shapes	0.571	9	0.783	6	0.638	7	7.304	9
10	Manufacturing defects	0.523	10	0.750	8	0.525	10	6.592	10
11	Theft and vandalism	0.523	10	0.633	10	0.625	8	6.530	11

$\sum Vi = 11$ (Total number of variables)

Squanders emerging from material administration factors on building locales were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and workers for hire) on the reasons for squander emerging from material administration on location exercises were looked at, the outcomes showed no huge contrast at a 5% importance level.

The ARII and position of material administration on location gathering of elements are summed up in Table 5. Unfortunate capacity of materials is seen to be the most noteworthy supporter of material waste with an ARII of 9.610. Lack of onsite material control has been perceived to be the second position for material waste with an ARII of 9.291. Damage of material on-site has been perceived to be the third position of material waste with an ARII of 8.803. Using Excessive quantities of materials more than the required has been perceived to be the fourth position for the material waste with an ARII of 8.726. Overproduction has perceived to be the fifth position for material waste with an ARII of 8.705. There is always a high chance of damage of materials on site due to lack of knowledge or negligence is the factor for cases of waste material in construction.

(4) Material handling, storage, and transportation-related factors:

Table 6: RII and rank of material handling, storage, and transportation-related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	Materials Handling, Storage, and Transportation	RII	Rank	RII	Rank	RII	Rank		
1	Wrong and unnecessary handling of material	0.662	4	0.827	1	0.800	2	9.156	1
2	Poor and wrong storage of materials	0.753	1	0.753	2	0.750	3	9.024	2
3	Damage during transportation	0.692	3	0.733	4	0.867	1	8.200	3
4	Breakdown of equipment	0.728	2	0.750	3	0.733	4	8.184	4
5	Inappropriate storage leading to damage or deterioration	0.623	5	0.623	5	0.800	2	8.011	5
6	Poor technology and malfunction	0.692	3	0.610	6	0.688	7	7.915	6
7	Double handling of material	0.569	9	0.561	10	0.525	11	7.764	7
8	Insufficient instructions about storage, stacking and handling	0.585	8	0.600	7	0.638	8	7.723	8
9	Bad road condition	0.610	6	0.521	12	0.625	9	7.723	9
10	Inadequate stacking and insufficient storage	0.600	7	0.578	8	0.704	6	7.527	10
11	Accident	0.471	10	0.577	9	0.713	5	7.044	11
12	Inappropriate equipment	0.585	8	0.537	11	0.585	10	6.828	12

$\sum Vi = 12$ (Total number of variables)

The respondents were approached to assess the reasons for materials squander emerging from materials capacity and taking care of. At the point when the reactions of the experts (specialists, clients, and project workers) on the reasons for squander emerging from materials capacity and dealing with exercises were looked at, the outcomes showed no massive contrast at a 5% importance level.

The ARII and position of material taking care of, stockpiling, and transportation gathering of elements are summed up in table 6. Off-base and superfluous treatment of material possesses the principal position with ARII 9.156. Poor and wrong stockpiling of material has been positioned in the second situation with ARII 9.024. Harm during transportation has been positioned in the third situation with

ARII is equivalent to 8.200. Breakdown of hardware has been positioned in the fourth situation with ARII is equivalent to 8.184. Improper capacity prompting harm or disintegration has been positioned in the fifth situation with ARII is equivalent to 8.011.

These variables are unconventional elements of bound destinations because of absence of satisfactory extra room, troubles of moving material around the site, working environment becoming stuffed, and absence of sufficient space for the viable treatment of materials, harm happening because of unfortunate material administration, and absence of sufficient space to represent materials coming about to wastage of materials. Then again, a few investigations have likewise featured that huge destinations represent the most concerning issues because of the significant distance for which materials should be shipped, combined with the extra weight of observing materials. The normal allurement among project workers is to save material capacity regions around each structure to fulfill their singular requirements. This, nonetheless, will bring about inordinate material waste, Extra material taking care of expenses, and less mobility inside the site. Lacking stacking and deficient capacity can come about because of saying when materials are stacked without beds like blocks/blocks or packs of concrete; presenting materials to in component weather conditions, for example, steel bars which could rust and may get harmed; unloaded supply of materials like blocks, glass and tiles frequently increment wastage during transportation because of their delicate nature.

(5) On-site operation-related factors:

Table 7: RII and rank of onsite operations related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	onsite operations	RII	Rank	RII	Rank	RII	Rank		
1	Wrong construction method	0.753	3	0.800	2	0.800	1	8.554	1
2	Rework due to workers mistakes	0.712	4	0.827	1	0.788	2	8.484	2
3	Lack of skilled subcontractors	0.769	2	0.778	3	0.785	3	8.356	3
4	Use of incorrect material	0.792	1	0.750	5	0.753	6	7.784	4
5	Damage to work done caused by subsequent trades	0.710	5	0.710	3	0.750	4	7.560	5
6	Lack of coordination among crews	0.671	7	0.721	6	0.775	5	7.472	6
7	Using untrained labors	0.685	6	0.700	8	0.785	7	7.315	7
8	Accident due to negligence	0.592	9	0.633	9	0.625	9	6.783	8
9	Difficulty in performance and professional work	0.528	10	0.630	10	0.625	9	6.537	9
10	Poor workmanship	0.600	8	0.767	7	0.600	10	6.262	10
11	Interaction between various specialists	0.485	11	0.437	11	0.684	8	6.259	11

$$\sum Vi = 11 \text{ (Total number of variables)}$$

Respondents were approached to score the significant reasons for squanders emerging from functional exercises on building locales. At the point when the reactions of the experts (specialists and client and project worker) on the reasons for squander emerging from functional exercises were looked at, the outcomes showed no tremendous contrast at a 5% importance level.

The ARII and rank of the on-site operation group of factors are summarized in Table 7. The wrong construction method has ranked in the first position with an ARII of 8.554. Rework due to workers' mistakes has ranked in the second position with ARII of 8.484. Similarly, lack of skilled sub-contractors has been ranked in third ARII=8.356. This factor is somehow related to using untrained labor and reworks due to workers' mistakes. This shows there is no significant disparity among the perception of the client. Consultant and contractor on onsite-related factors for material waste. Use of incorrect material has been ranked in fourth ARII=7.784. Damage to work done caused by subsequent trades has been ranked in fifth ARII=7.560.

(6) Environmental condition related factors:

Table 8: RII and rank of environmental condition related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	Environmental condition	RII	Rank	RII	Rank	RII	Rank		
1	Severe weather condition	0.528	3	0.742	1	0.725	1	5.081	1
2	Site conditions significantly different from contract documents	0.712	1	0.633	2	0.638	2	4.286	2
3	Effects of subsurface conditions	0.685	2	0.630	3	0.584	4	3.945	3
4	Labor unrest	0.453	5	0.600	4	0.625	3	3.810	4
5	Difficulties in obtaining work permits	0.600	3	0.514	5	0.525	6	3.803	5
6	Government authority instruction/policy	0.442	6	0.507	6	0.523	7	3.721	6
7	Restiveness	0.472	4	0.430	7	0.580	5	3.693	7

$$\sum Vi = 7 \text{ (Total number of variables)}$$

Squanders emerging from Environmental elements on building locales were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and project workers) on the reasons for squander emerging from obtainment exercises were looked at, the outcomes showed no huge distinction at a 5% importance level.

The total relative significance list (ARII) and position of the natural condition gathering of variables are summed up in table 8. The extreme weather pattern has positioned in the principal position with ARII is equivalent to 5.081 as introduced in table 8. Adewuyi (2015) [14] uncovered that serious weather conditions is a critical calculate displaying development material waste for the zone. Waste might happen because of this component where the executed works are not as expected safeguarded against the weather conditions impact, particularly precipitation. Squander created because of this variable might be past the control of site staff. Site conditions significantly different from contract documents have ranked as the second position with ARII equal to 4.286. Similarly, the Effects of subsurface conditions have been ranked in the third position with ARII =3.945. The common knowledge of the two groups may be due to their experience of significant variation wastage during the contract period and after the real field execution. Labor unrest has been ranked in the fourth position with ARII equal to 3.810. Labor unrest has been ranked in the fifth position with ARII equal to 3.803.

(7) Site management and practices related factors:

Table 9: RII and rank of Site management and practices related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	Site management and practices	RII	Rank	RII	Rank	RII	Rank		
1	Lack of waste management system plan	0.812	1	0.842	1	0.775	3	4.048	1
2	Lack of a quality management system aimed at waste minimization	0.730	3	0.807	3	0.784	2	3.868	2
3	Incompetent contractor's technical staff	0.753	2	0.757	4	0.780	1	3.816	3
4	Lack of strategy to waste minimization	0.685	4	0.814	2	0.738	4	3.728	4
5	Poor site layout	0.628	5	0.730	5	0.725	5	3.471	5

∑Vi = 5 (Total number of variables)

Squanders emerging site the executives factors on building destinations were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and workers for hire) on the reasons for squander emerging from obtainment exercises were looked at, the outcomes showed no huge distinction at a 5% importance level.

The total relative significance record (ARII) and position of site the board and practice gathering of elements is summed up in Table 9. Absence of waste administration plan has seen as the most supporter of material waste in this gathering with ARII is equivalent to 4.048. Absence of a quality administration framework focused on squander minimization has seen as the second situation to material waste in this gathering with ARII is equivalent to 3.868. Clumsy worker for hire's specialized staff has seen as the third situation to material waste in this gathering with ARII is equivalent to 3.816. Absence of system to squander minimization has seen as the fourth situation to material waste in this gathering with ARII is equivalent to 3.728. The poor site layout has been perceived as the fifth position to material waste in this group with ARII is equal to 3.471.these are the cause of the waste material of the lean construction.

(8) Site supervision related factor:

Table 10: RII and rank of Site supervision related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	Site supervision	RII	Rank	RII	Rank	RII	Rank		
1	Inadequate supervision	0.812	1	0.730	2	0.875	1	3.449	1
2	Change orders	0.635	3	0.900	2	0.825	2	3.057	2
3	Slow response from consultant engineer to contractor in queries	0.615	4	0.677	3	0.784	3	2.768	3
4	Incompetent consultant's resident engineer	0.738	2	0.653	4	0.728	4	2.688	4

∑Vi = 4 (Total number of variables)

Squanders emerging from site management factors on building destinations were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and workers for hire) on the reasons for squander emerging from obtainment exercises were looked at, the outcomes showed no tremendous contrast at a 5% importance level.

The ARII and position of destinations management gathering of variables are summed up in table 10. Lacking management has been positioned in the primary situation in this gathering with ARII = 3.449. The outcome recommends that all gatherings feel that with enhancement for the nature of management on location, and fit bosses, the volume of material waste might be decreased. Change orders have been positioned in the subsequent situation in this gathering with ARII = 3.057. Slow reaction from specialist designer to the worker for hire in questions has been positioned in the third situation in this with ARII=2.768. Clumsy advisor's occupant engineer has been positioned the fourth situation in this gathering with ARII = 2.688.

(9) Delay related factors:

Table 11: RII and rank of delay related factors

S. N.	Factors	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
	Delay	RII	Rank	RII	Rank	RII	Rank		
1	In complete projects design	0.715	3	0.877	1	0.798	2	4.061	1
2	Due to unstable government	0.854	1	0.754	2	0.845	1	4.010	2
3	Changing documents and lack of arrangement of documentation	0.612	5	0.630	4	0.746	3	3.430	3
4	Misunderstanding data by	0.738	2	0.700	3	0.652	4	3.366	4

	engineer								
5	Design change by owner	0.635	4	0.583	5	0.620	5	3.063	5

∑Vi = 5 (Total number of variables)

Burns through emerging from postponement and time factors on building destinations were assessed by respondents. At the point when the reactions of the experts (specialists, clients, and project workers) on the reasons for squander emerging from obtainment exercises were looked at, the outcomes showed no massive contrast at a 5% importance level.

The ARII and position of postponement and time gathering of variables are summed up in table 11. In complete activities configuration has been positioned in the principal position in this gathering with ARII is equivalent to 4.061. Because of unsteady government has been positioned in the subsequent situation in this gathering with ARII=4.010. Changing reports has been positioned in the third situation in this gathering with ARII=3.430. Misconception information by the designer has been positioned in the fourth situation in this gathering with ARII=3.366. Misconception information by the architect has been positioned in the fifth situation in this gathering with ARII=3.063. Postponement of the ventures can be limited by the course of lean development approaches and it makes the development affordable. The request for position of the gathering of variables is introduced in table 11.

(10) Top 5 Major causes of waste material in selected construction projects:

Table 12: RII and Rank of the major cause of waste material in selected project

S. N.	Major Cause of waste material	Client		Consultant		Contractor		ARII= ∑RII* Si	Rank
		RII	Rank	RII	Rank	RII	Rank		
1	Material procurement related factors	0.715	2	0.817	1	0.654	4	3.643	1
2	Material management on site related factors	0.763	1	0.809	2	0.698	3	3.62	2
3	On-site operation related factors	0.663	4	0.732	3	0.723	1	3.530	3
4	Design and documentation related factors	0.665	3	0.646	4	0.643	5	3.436	4
5	Material handling, storage and transportation related factors	0.630	5	0.639	5	0.702	2	3.285	5

∑Vi = 5 (Total number of variables)

The ARII and position of deferral and time gathering of variables are summed up in table 12. Material obtainment related factors have been positioned in the primary situation in this gathering with ARII = 3.643. Material administration on location related factors has been positioned in the subsequent situation in this gathering with ARII = 3.620. On location activity related factors have been positioned in the third situation in this gathering with ARII is equivalent to 3.530. Plan and documentation-related factors have been positioned in the fourth situation in this gathering with ARII = 3.436. Material taking care of, stockpiling, and transportation-related factors have been positioned in the fifth situation in this gathering with ARII = 3.285. Different causes of waste material can be minimized by the different process of lean construction approaches in the selected project and it makes the construction economical.

(11) Aggregate relative importance index of material waste variables:

Table 13: Ranking of ARII of the group of factors

S. N.	Factors	Vi	Si	*ΣRII*	ARII	Rank
1	Site management and practices related factors	5	16.20	11.360	184.032	1
2	Site supervision related factor	4	20.25	8.972	181.683	2
3	Material procurement related factors	6	13.5	13.125	177.187	3

4	Material management on site related factors	11	7.36	23.049	169.640	4
5	On-site operation related factors	11	7.36	23.003	169.302	5
6	Delay related factors	5	16.20	10.04	162.064	6
7	Material handling, storage, and transportation-related factors	12	6.75	23.6761	159.779	7
8	Design and documentation related factors	20	4.05	38.990	157.909	8
9	Environmental condition related factors	7	11.57	12.148	140.552	9

To show the request for significance of the gathering of elements in their significance to material waste age, the summation of the RII of the variables in each gathering was gotten for the three gatherings of respondents; the scale factors (Si) determined; and the result of the two boundaries figured to show up at the worth of total relative significance list (ARII) which are in this manner positioned. The request for position of the gathering of elements is introduced in table 13.

ARII = Si*∑RII

Si = ∑Vi/vi

Vi= Number of variables in i^{th} group;

Si= Scale factor of the i^{th} group;

ARII = Aggregate Relative Importance Index;

∑Vi = 81 (Total number of variables)

Site the executives and practices are positioned in the primary situation as the main gathering adding to the age of material waste nearby. The site Supervision position is positioned second. Material acquirement on location positioned in the third situation by the respondents. Materials Management on location positioned in the fourth situation by the respondents. This might be because of the non-commitment of skillful staff with pertinent.

(12) Similarity among Clients, Consultant, and Contractor Views conformation:

(i) Hypothesis test for Correlation between Clients and Consultant View:

Null hypothesis: There is a relation between the ranking of Client and consultant i.e. $H_0 = 0$.

Alternative hypothesis: There is a relation between the ranking of Client and consultant i.e. $H_1 \neq 0$.

Spear's rank correlation coefficient between clients and consultant view is given by:

$$p = 1 - \frac{6\sum d^2}{n(n^2 - 1)}$$

Where,

d_i = difference between the two ranks of each questionnaire and

N = Number of questionnaires

Spearman's rank correlation coefficient (p) is 0.812 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p=0.7 to 1) positive relationship between the client's and consultant's views on the factors that cause the waste material in the construction site based on lean construction approaches.

The observed p=0.812 (greater than the critical value of p i.e. 0.217) so reject the null hypothesis at a 5% level and accept the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the client and consultant.

(ii) Correlation between Consultant and Contractor View:

Null hypothesis: There is a relation between the ranking of Consultant and Contractor i.e. $H_0 = 0$.

Alternative hypothesis: There is a relation between the ranking of Consultant and Contractor i.e. $H_1 \neq 0$.

Spearman's rank correlation coefficient (p) is 0.832 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p = 0.7 to 1) positive relationship between the Consultant and Contractor view on the factors that cause the waste material in the construction site based on lean construction approaches.

The observed p=0.812 (greater than the critical value of p i.e. 0.217) so it rejects the null hypothesis at 5% level and accepts the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the Consultant and Contractor.

(iii) Correlation between Contractor and Client View:
Null hypothesis: There is the relation between the ranking of Contractor and Client i.e. $H_0 = 0$.
Alternative hypothesis: There is a relation between the ranking of Contractor and Client i.e. $H_1 \neq 0$.

Spearman's rank correlation coefficient (p) is 0.804 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p = 0.7 to 1) positive relationship between the Contractor and Client view on the factors that cause the waste material in the construction site based on lean construction approaches.
The observed p=0.804 (greater than the critical value of p i.e. 0.217) so it rejects the null hypothesis at 5% level and accepts the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the Contractor and Client.

(13) Measures to minimize the wastage of materials in a construction project based on a lean construction approach:
(i) Wastage Minimization Measures on lean construction approach:
Table 14: RII and rank of Wastage Minimization Measures of lean construction approaches

S. N.	Measure	Client		Consultant		Contractor		ARII= ∑RII*Si	Rank
		RII	Rank	RII	Rank	RII	Rank		
1	Adoption of proper site management techniques	0.902	2	0.880	3	0.924	1	23.608	1
2	Accurate and good specifications of materials to avoid wrong ordering	0.910	1	0.890	2	0.921	2	23.582	2
3	Proper storage of materials on site	0.900	3	0.895	1	0.910	3	23.443	3
4	Purchasing raw materials that are just sufficient	0.840	8	0.870	4	0.910	3	22.706	4
5	Recycling of some waste materials on site	0.867	5	0.851	6	0.880	4	22.516	5
6	Checking materials supplied for right qualities and volumes	0.875	4	0.813	12	0.876	5	22.221	6
7	Minimizing design changes	0.782	14	0.850	7	0.790	15	22.152	7
8	Checking materials supplied for right qualities and volumes	0.862	6	0.832	9	0.820	9	21.788	8
9	Mixing, transporting and placing concrete at the appropriate time	0.803	12	0.865	5	0.840	8	21.736	9
10	Employment of skilled workmen	0.832	9	0.798	14	0.860	7	21.580	10
11	Careful handling of tools and equipment on site	0.832	9	0.845	8	0.812	11	21.571	11
12	Good construction management practices	0.842	7	0.832	11	0.798	13	21.415	12
13	Just in time operations	0.789	13	0.810	13	0.861	6	21.320	13
14	Encourage re-use of waste materials in projects	0.821	10	0.789	15	0.830	9	21.146	14
15	Weekly programming of works	0.762	15	0.810	13	0.860	6	21.077	15
16	Training of construction personnel	0.789	13	0.810	13	0.761	16	20.514	16
17	Good coordination between store and construction personnel to avoid over-ordering	0.754	17	0.789	15	0.810	12	20.392	17

18	Early and prompt scheduling of deliveries	0.821	10	0.865	5	0.798	14	20.528	18
19	Change of attitude of workers towards the handling of materials	0.751	18	0.775	17	0.820	10	20.332	19
20	Waste management officer or personnel employed to handle waste issues	0.752	17	0.820	10	0.756	17	20.176	20
21	Using materials before expiry dates	0..810	11	0.780	16	0.710	18	19.933	21
22	Vigilance of supervisors	0.712	18	0.756	18	0.830	9	19.916	22
23	Use of more efficient construction equipment	0.762	15	0.698	22	0.781	15	19.422	23
24	Adherence to standardized dimensions	0.698	19	0.712	21	0.810	12	19.240	24
25	Accurate measurement of materials during batching	0.652	21	0.751	19	0.810	12	19.179	25
26	Accurate and good specifications of materials to avoid wrong ordering	0.654	20	0.721	20	0.801	13	18.858	26

$\sum Vi = 26$ (Total number of variables)

To show the request for significance of the gathering of variables in their significance to material waste age, the summation of the RII of the elements in each gathering was acquired for the three gatherings of respondents; the scale factors (Si) determined; and the result of the two The aftereffects of this piece of the review demonstrate the general significance file and Rank of waste minimization measure in building development. The actions are introduced in add-on IV. Table 14 shows experimental proof of the levels of the critical commitment of the different measures to squander minimization in the execution of waste administration in building development. The waste minimization measure great coordination among store and development faculty to precise and great determinations of materials to Adoption of appropriate site the board strategies has been positioned as the principal measure with ARII 23.608. Precise and great particulars of materials to try not to wrong request has positioned the second situation with ARII is equivalent to 23.582 by the client, specialist, and project worker in course of lean development. Appropriate capacity of materials on location is likewise one of the actions for the waste material in the lean development has positioned the third situation with ARII 23.443. Buying unrefined components that are simply adequate has positioned the fourth situation with ARII 22.706, and Recycling of a few waste materials on location has been positioned the fifth situation with ARII 22.516. These are the significant direct that can be continued in incline development in the direction of limit the waste material in the building site.

Different measures having huge commitments to squander minimization are the work of talented laborers, appropriate capacity of materials on location, checking materials provided for right amounts and volumes, great development the executives practice, precise detail of materials to abstain from wrong requesting. As per research [15, 16, 17 & 18], utilizing materials before the expiry date, great coordination among store and development hardware, and reception of legitimate site the board strategies are the main estimates which can limit the wastage of materials on building locales.

It also suggests the waste management plan be implemented on-site providing training to employees, focusing on supervision, and implementing waste minimization strategy during design as most effective measures for waste minimization while insists owners visit the construction site at all the critical stage of the project period (during layout, bar bending, casting of the slab, beam, column), asking the contractor to prepare and submit waste management plan, consultant to pay attention during design and drawing and carefully estimating material during the design phase, recruit skilled and trained staff to prepare a waste management plan and stack the materials in the suitable place and good condition for the same:

The factors in this gathering are straightforwardly the exercises of the project worker's faculty which whenever oversaw may lessen waste as well as the other way around. Reusing of a few waste materials

on location bunch is positioned in the fourth situation by project worker, fifth situation by the client, and 6th by the expert. It proposes that reusing of waste materials on location is the training to further develop in the development business to reuse the volume of materials squander age by the most common way of reusing. It immediately infers that some gathering of elements might offer more to materials squander than others, proposing that partners in the development business ought to zero in on the more significant gathering without disregarding the others.

(14) Similarity among Clients, Consultant, and Contractor View on the measures to minimize the wastage of materials:

(i) Correlation between Clients and Consultant View:
Null hypothesis: There is a relation between the ranking of Clients and Consultants i.e. $H_0 = 0$.
Alternative hypothesis: There is a relation between the ranking of Clients and Consultants i.e. $H_1 \neq 0$.

Spear's rank correlation coefficient between Clients and Consultant view is given by:

$$p = 1 - \frac{6\sum d^2}{n(n^2-1)}$$

Spearman's rank correlation coefficient (p) is 0.845 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p=0.7 to 1) positive relationship between the Client's and Consultant's views on measures to minimize the wastage of materials in a construction project based on a lean construction approach.
The observed p=0.845 (greater than the critical value of p i.e. 0.388) so it rejects the null hypothesis at 5% level and accepts the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the Clients and Consultants.

(ii) Correlation between Consultant and Contractor View:
Null hypothesis: There is a relation between the ranking of Consultant and Contractor i.e. $H_0 = 0$.
Alternative hypothesis: There is a relation between the ranking of Consultant and Contractor i.e. $H_1 \neq 0$.

Spearman's rank correlation coefficient (p) is 0.712 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p = 0.7 to 1) positive relationship between the Consultant and Contractor view on measures to minimize the wastage of materials in a construction project based on a lean construction approach.
The observed p=0.712 (greater than the critical value of p i.e. 0.388) so it rejects the null hypothesis at a 5% level and accepts the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the Consultant and Contractor.

(iii) Correlation between Contractor and Client View:
Null hypothesis: There is the relation between the ranking of Contractor and Client i.e. $H_0 = 0$.
Alternative hypothesis: There is a relation between the ranking of Contractor and Client i.e. $H_1 \neq 0$.

Spearman's rank correlation coefficient (p) is 0.776 was within range from -1< 0 < 1. Hence, it was concluded that there was a very strong (p = 0.7 to 1) positive relationship between the Contractor and Client view on measures to minimize the wastage of materials in a construction project based on a lean construction approach.
The observed p=0.776 (greater than the critical value of p i.e. 0.388) so it rejects the null hypothesis at 5% level and accepts the alternative hypothesis. Hence, it concluded that there is no difference between the ranking of the Contractor and Client. Even a quantification of waste shows it is a critical issue (Mishra and Aithal, 2022) [19].

7. CONCLUSION :

This study gives proof to gauge the execution of the lean development approaches in the development project. A portion of the significant places in the lean development approaches are: Reception of appropriate site the board procedures, Precise and great details of materials to try not to wrong request,

Appropriate capacity of materials on location is additionally one of the actions for the waste material in the lean development, Buying unrefined components that are simply adequate, Decrease Recycling and Reuse of a few waste materials on location.

In this study, some factors create problems in construction projects to implementation of lean construction approach for the project's completion. Due to different factors, the contractors cannot complete the project effectively. This study gives proof fair and square of measure to defeat the boundaries to execution of lean development approach in development projects. The discoveries of this study are in concurrence with the impression of clients, advisors, and workers for hire about the action to beat the boundaries to execution of the lean development approach in development projects.

8. LIMITATIONS OF STUDY :

The study covers only four public organizations within Kathmandu district so, the result cannot be generalized.

9. ACKNOWLEDGEMENT :

The author is thankful to all the respondents and Master's students for helping to collect data and Dr. P.S. Aithal for mentoring the publication.

REFERENCES :

[1] Mishra, A. K., Jha, A. (2019). Quality Assessment of Sarbottam Cement of Nepal. *International Journal of Operations Management and Services. 9*(1), 1-22. www.ripublication.com/joms19/jomsv9n1_01.pdf. Google Scholar↗

[2] Aryal, R. and Anjay Kumar Mishra, (2020). In-situ compressive strength assessment of concrete in under-construction residential buildings at Gaindakot municipality, Materials Today: Proceedings, https://doi.org/10.1016/j.matpr.2020.10.630. Google Scholar↗

[3] Mishra, A. K. (2021). Operational Relation of Cement to Estimate Strength. *South Asian Res J Eng Tech, 3*(1), 1-7. DOI: https://doi.org/10.36346/sarjet.2021.v03i01.001. Google Scholar↗

[4] Mishra, A. K., Chaudhary, U. (2018). Assessment of Cement Handling Behaviour for Selected Construction Sites of Bhatbhateni Supermarket. *J Adv Res Const Urban Arch, 3*(3), 1-11. Google Scholar↗

[5] Mishra, A. K., Dinesh Gupta, & Aithal, P. S. (2020). Factors Identification and Conformance of Quality of Cement and Coarse Aggregate used at Gautama Buddha Airport Upgrading Component, Nepal. *International Journal of Management, Technology, and Social Sciences (IJMTS), 5*(2), 187-200. DOI: http://doi.org/10.5281/zenodo.4065739. Google Scholar↗

[6] Mishra, A. K., & Aithal P. S., (2021). Foreign Aid Contribution for the Development of Nepal. *International Journal of Management, Technology, and Social Sciences (IJMTS), 6*(1), 162-169. DOI: https://doi.org/10.5281/zenodo.4708643. Google Scholar↗

[7] Mishra, A. K., & Aithal, P. S., (2021). Foreign Aid Movements in Nepal. *International Journal of Management, Technology, and Social Sciences (IJMTS), 6*(1), 142-161. DOI: https://doi.org/10.5281/zenodo.4677825. Google Scholar↗

[8] John, A. O., and Itodo, D. E. (2013). 'Professionals' Views of material wastage on a construction site and costs overruns'. *Organization, Technology and Management in Construction; An International Journal, 5*(1), 747-757. DOI: https://doi.org/10.5592/otmcj.2013.1.11. Google Scholar↗

[9] Pheng, L. S. and Tan, S. K. L . . . . (1998). How 'Just-in-Time' Wastages can be quantified; CaseStudy of a Private Condominium Project. *Construction Management and Economics, 16*(1), 621-635. Google Scholar↗

[10] Garas, G. I., Anis A. R., Gammal, A. (2001). Materials Waste in the Egyptian Construction Industry. *Proceedings of ninth annual Conference of the International Group for Lean Construction 9IGLC-9), Singapore*, 22-29. Google Scholar↗

[11] Vidyasekar, B., Selvan, K. G. (2019). Identification of the Sources of Overall Waste Generation

that Affects the Well Being of the Environment. *International Journal of Recent Technology and Engineering (IJRTE), 8*(3), 6684-6687. DOI: https://doi.org/10.35940/ijrte.C5706.098319. Google Scholar↗

[12] Ferguson, J., Kermode, N., ash, C, L., Sketch, W. A. J., Huxford, R.P. (1995). Managing ad Minimizing Construction Waste; A Practical Guide, *Institution of Civil Engineers, London*. Google Scholar↗

[13] Polat, G. and Ballard, G. (2004). Waste in Turkish Construction- Need for Lean Construction Techniques, *Proceedings of the 12th Annual Conference of the International Group for Lean Construction*, pp, 3-5. Google Scholar↗

[14] Adewuyi, T. O., & Odesola, I. A. (2015). Factors affecting material waste on construction sites inNigeria. *Journal of Engineering and Technology (JET), 6*(1), 82-99. Google Scholar↗

[15] Rameezdeen, R., Ammar, M. A. & Ibrahim, M. (2008). Optimal Construction Site Layout considering Safety and Environmental Aspects. *Journal of Construction Engineering and Management, 134*(7), 536-544. DOI: https://doi.org/10.1061/ASCE0733-93642008134. Google Scholar↗

[16] Tam, Vivian W. Y. and Tam, C. M. (2006). A review on the Technology for Construction Waste Recycling. *Resources, Construction and Recycling, 47*(3), 209-221. https://doi.org/10.1016/j.resconrec.2005.12.002. Google Scholar↗

[17] Termine, Richard, J. (1994). Principles of Inventory and Materials Management. 4th.ed. New Jersey; Prentice-Hall. The reduction of construction waste. Masters research project. Department of Engineering and Technology Management, University of Pretoria, ISBN: 0-13-126484-2. Collation xvi, 591 p.; 24. Google Scholar↗

[18] Mishra, A. K., (2020). Implication of Theory of Constraints in Project Management. *International Journal of Advanced Trends in Engineering and Technology, 5*(1), 1-13. http://doi.org/10.5281/zenodo.3605056. Google Scholar↗

[19] Mishra, A. K., & Aithal, P. S., (2022). Assessing the Magnitude of Waste Material Using Lean Construction. *International Journal of Case Studies in Business, IT, and Education (IJCSBE), 6*(1), 578-589. DOI: https://doi.org/10.5281/zenodo.6717736. Google Scholar↗

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