Assessing the Magnitude of Waste Material Using Lean Construction

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ABSTRACT

Purpose: *Wastage of construction material always results in cost overrun not only for the construction cost of the project but also for the management and disposal cost of such construction waste. It is interesting to evaluate the magnitude of waste material based on the lean construction approach.*

Design/Methodology/Approach: *The present study adopted both primary as key informant interviews and secondary bills documents to analyze the Percentage of waste.*

Findings/Result: *The findings reveal that average wastage of material with standard deviation for five construction projects: rebar (2.096±1.09), bricks (2.56±0.77), cement (2.82±0.672), sand (3.634±0.5325), and aggregate (7.486±4.76). Compared with the other similar studies, waste percentages found are quite low because of adopting the lean construction approaches in the construction site. In the project, some of the wastage can be recycled and reused so the percentage of waste material is low due to the implementation of lean construction approaches. The practice of various reuse strategies like use of broken bricks in soling, cut a piece of rebar in the casting of a large number of manholes manhole grating, waste sand in Hume pipe bedding and backfilling, etc. Expire cement are used in unstructured work, cover block and aggregate are used for different purpose of construction..*

Originality/Value: *The study contributes by illustrating situation of wastage to implement lean construction. Governmental agencies, clients, consultants, and contractors are interested in waste management in building construction projects.*

Paper Type: Action *Research analysis*

Keywords: Waste, Lean construction, materials, buildings managerial, Bills,

1. INTRODUCTION :

Building and infrastructure construction, demolition, remodeling, maintenance, and repair are all part of the construction sector. It includes everything from planning and surveying through structural construction and finishing touches like painting and decorating (*nationalindustryinsights.aisc.net.au)*. The construction industry is backbone of a developing nation. Huge amount of budget is needed for infrastructure development.

Construction industry involves conversion of raw materials to the final assets passing through various steps, thus contributing to employment for various ranges of manpower and requirements of wide ranges of construction raw materials from locally available earth, sand to reinforcement bars and various sophisticated foreign materials.

In context of Nepal, construction industry provides employment for more than 10 lakhs people contributing just above 10% of total GDP and its covers about 60% of the total budget of the nation [1 & 2].

To make construction industry more efficient and profitable cost and time over run should be minimized. Wastage of construction material always results in cost overrun not only for the construction cost of the project but also for the management and disposal cost of such construction waste. In current scenario volume of construction waste is producing in large scale while building any type of construction projects [3].

To make construction project more beneficial for all concerns stake holders it is prerequisite to study the volume of waste currently producing, reasons behind the production of such wastes. After careful analysis of current trend of wastage, plan should be formulated and implemented to reduce such wastage from each step of construction activities ranging from storage, handling, designing, mixing and placing of materials [1 & 2].

2. OBJECTIVES :

To evaluate the magnitude of waste material based on the lean construction approach.

3. LITERATURE REVIEW :

3.1 Lean Construction:

Lean Construction (LC) is a technique for arranging creation systems to restrict abuse of materials, time, and work to deliver the most outrageous possible proportion of critical worth [4]. It is in like manner a comprehensive arrangement and movement prevailing upon a general-purpose in extending worth to all accomplices through methodical, synergistic, and consistent overhauls in the legitimately restricting game-plans, thing plan and procedure for decision, the creation organization, and the work cycle immovable nature of site undertakings (Abdelhamid, 2004) [5]. At the Design for Manufacture Competition (2005), LC was described as the constant course of discarding waste, meeting or outperforming all client essentials, focusing in the overall worth stream, and the journey for faultlessness in the execution of an errand. Lean thinking is inclining since it gives a strategy for achieving progressively more with less and less - less human effort, less stuff, less time, and less space - while almost giving clients definitively what they need. Sustainability is only possible through effective and economic operation and maintenance along with the comparison of new and old materials utility and winning the constraints [6, 7, 8, 9 & 10].

Lean improvement is a blend of useful investigation and sober minded improvement in plan and advancement with an adaption of lean collecting norms and practices to the beginning to end plan and advancement process. Not at all like collecting, improvement is an endeavor based creation process. Lean Construction is stressed over the course of action and complete mission for concurrent and tireless updates in all parts of the created and normal environment: plan, advancement, establishment, support, saving, and reusing [11, 12 & 13]. This approach endeavors to manage and additionally foster improvement processes with the lowest cost and generally outrageous worth by considering client needs [3 & 5]. This result is created when standard development approaches are converged with a reasonable and succinct comprehension of undertaking materials and data and two arrangements of the executive's originals, arranging and control. This might appear to be perplexing to comprehend, however the substance of this framework is to utilize what is vital without extra. This must be finished by essential preparation and activity by an administration bunch and with the assistance and help, everything being equal.

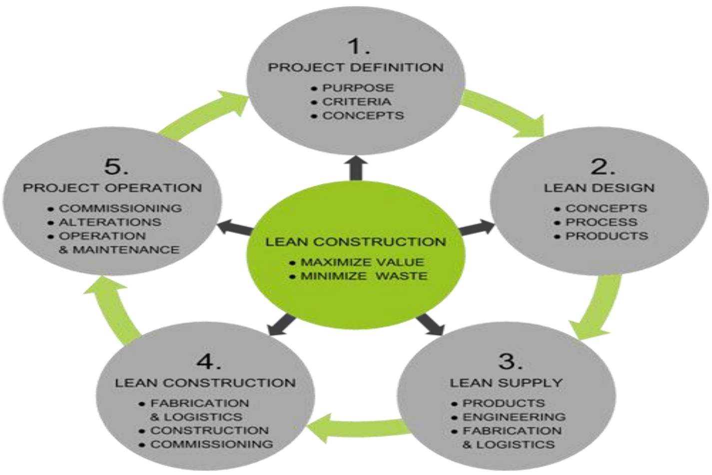


Fig. 1 Application of Lean construction
Quinn and Ulla Thorne, [14, 15, 16 & 17]

3.2 Points of Lean Construction:

The major point of Lean Construction is to design cautiously from the accessible information to limit squander, accordingly decreasing expense and adding an incentive for clients. It can work on quality and productivity through great correspondence among the partners. The fundamental standards are as per the following [18, 19, 20 & 21]:

Distinguish Value according to the Client's Point of View:

It's something past the idea of work or completing an endeavor on time and inside spending plan. This requires a client focused approach that can best be achieved by building a relationship with the client. In lean turn of events, this should consolidate all accomplices: owner, organizer, engineers, general task laborer, subcontractors, and suppliers.

Perceiving client values should begin at every turn in the determined orchestrating time of an endeavor and be carried on through improvement. It's connected to understanding what client needs, yet why they need it so the undertaking gathering can regulate suspicions and best advice the client. A nice level of trust ought to be spread out between all accomplices to execute lean practices really.

Perceive Processes that Deliver the Value Stream:

The value stream is basically what the client values. Whenever it is perceived worth as per a client's perspective, this present time is the ideal open door to recognize the cycles expected to convey the value stream. All means in the process should be meticulously illustrated to sort out what activities are involved. Think about work, information, materials, and stuff expected for each development. Any means in a cycle that don't add a motivator for the client should be cleared out.

Achieving Flow of Work Processes:

The goal in lean improvement is to achieve an endless work process that is strong and unsurprising. Each phase of creation is finished in arrangement. For instance, one wouldn't begin draping drywall in that frame of mind until all of the electrical and plumbing was roughed in. To accomplish stream all gatherings need to convey and cooperate to keep away from interferences. It ought to be borne as a primary concern to keep away from laborers hanging tight for work or the other way around. Sharing an undertaking into discrete creation zones can assist workers for hire with guaranteeing they can complete every responsibility on time. On the off chance that one phase of creation stretches out behind or beyond plan, it's critical to convey and make acclimations to stay away from the specialists sitting tight for work situations.

Utilizing Pull Planning and Scheduling:

While utilizing pull arranging or booking the work is delivered in light of downstream interest to make solid work processes since work is done successively and the consummation of one errand discharges work on the following undertaking. This requires beginning from a particular achievement or target fruition date and working in reverse to plan work when it very well may be performed.

In lean development pull arranging is finished by those playing out the work, normally the subcontractors, through correspondence and cooperation with one another to direct the timetable of errands. This is on the grounds that they are the most ideal for deciding their ability for playing out a given undertaking. They can work with the following subcontractor, or client, downstream to arrange timetables and handoffs.

Idealizing the Processes through Continuous Improvement:

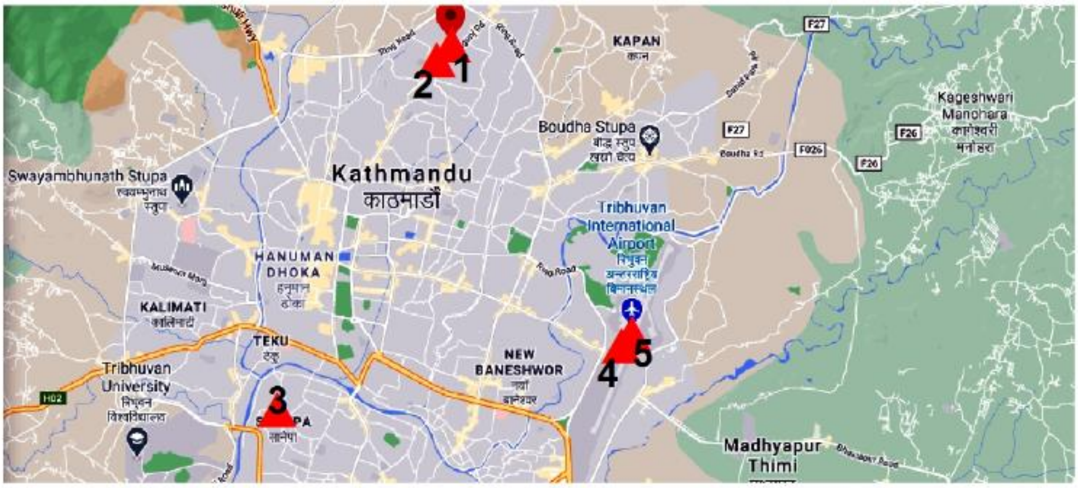
Endlessly making moves up to moreover kill waste and add regard is essential to perfect lean improvement processes. Notwithstanding the way that changes be should made all through the solitary endeavor to perceive and diminish waste anyway taking what is acquired from the dare to project will allow to diligently foster better ways to deal with add regard and kill waste.

4. METHODOLOGY :

In this study, a quantitative approach was used to determine the waste material and, to find the major factor affecting the waste material and possible measures to prevent it in building construction projects. For this, the researcher has collected the information by the questionnaires.

4.1 Study Area:

The study area of the research thesis was concentrated in the already constructed and ongoing project. Some government and private developer projects were considered as a sample to get overall information regarding waste material in the construction projects. Kathmandu Valley was selected for the study because such projects were easy and fast for gathering all the information and data from the construction site and related office. And the person who was involved in the project has good knowledge about lean construction approaches. Moreover, the project developed by the private and government developer has been chosen because the history of the construction project has shown that the cost of the project developed by the private developer is lesser than Government.



1. **Construction of Manmohan Centre Annex Building**
2. **Memorial Cancer Center**
3. **Residential Building**
4. **Air Transport Capacity Enhancement Project Package NCB 02,BO1,BO3**
5. **Air Transport Capacity Enhancement Project Package NCB 03 (B06)**

Fig. 2: Study area

Table 3: Salient features of projects.

S. N.	Project name		Location	Land area (ft^2)	Built-up area (ft^2.)
1	Air Transport Capacity Enhancement Project Package NCB 02		Tribhuvan International Airport		
	BO1	Unit 1		21341	21340
		Unit 2		4119	4118
		Unit 3		52346	52340
	BO3			1232	1232
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)		Tribhuvan International Airport	1421	1420
3	Construction of Manmohan Centre Annex Building		Teaching Hospital Maharajgunj	6996	5511
4	Memorial Cancer Centre		Maharajgunj KTM	6985	6921
5	Residential Building (3 Stories)		Sanepa. Lalitpur	6755	6727

4.2 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. The selected projects represent the different areas of Kathmandu Valley. Table 4 present the salient features of projects for the case study under consideration.

Table 4: List of projects with the total number of respondents

<table>
<tr><th>S. N.</th><th colspan="2">Project name</th><th colspan="3">Total no. of respondents</th></tr>
<tr><td rowspan="5">1</td><td colspan="2" rowspan="2">Air Transport Capacity Enhancement Project Package NCB 02</td><td>Client</td><td>Contractor Representative</td><td>Consultant Representative</td></tr>
<tr><td rowspan="5">1</td><td rowspan="5">6</td><td rowspan="5">9</td></tr>
<tr><td rowspan="3">BO1</td><td>Unit 1</td></tr>
<tr><td>Unit 2</td></tr>
<tr><td>Unit 3</td></tr>
<tr><td colspan="2">BO3</td></tr>
<tr><td>2</td><td colspan="2">Air Transport Capacity Enhancement Project Package NCB 03 (B06)</td><td>1</td><td>6</td><td>9</td></tr>
<tr><td>3</td><td colspan="2">Construction of Manmohan Centre Annex Building</td><td>1</td><td>3</td><td>3</td></tr>
<tr><td>4</td><td colspan="2">Memorial Cancer Centre</td><td>1</td><td>3</td><td>4</td></tr>
<tr><td>5</td><td colspan="2">Residential Building</td><td>1</td><td>3</td><td>3</td></tr>
<tr><td colspan="6">Total=54</td></tr>
</table>

4.3 Method of Data Collection:

Both primary and secondary data were required for the fulfillment of this study. Primary data was collected by questionnaires of the personnel related to the project. Research-related data was collected from their corporate office and site office from Kathmandu Valley.

4.4 Data Analysis:

After the assortment of essential and auxiliary information, these information were investigated deliberately. Material Reconciliation was done by contrasting the distinction between the store records and the genuine necessity of the material as per the work things of the Bill of Quantities. Standards of the rate examination were taken as the reason for breaking down the work things of Bill of Quantities. This is legitimate as most project workers use rate investigation for assessing and material demand. Wastage stipends are communicated normally with respect to the genuine amount of work. Appropriately, this study considers wastage as proportionate to the real work, as

$$\textit{Material Wastage} = \textit{Store Record} - \textit{Actual material Requirement}$$

$$\textbf{Material Wastage} = \frac{\textbf{Material Wastage allowance}}{\textbf{Actual Quantity of work}} * \textbf{100}$$

4.5 Mean and standard deviation:

Mean and standard deviation are used in the evaluation of the magnitude of waste material of the different projects. Standard deviations are calculated to know the position of the value i.e. closer or away from the mean value. Let us present the summary.

Table 5: Summary

S. N.	Objectives	Data required	Sources of Data	Tools	Outcomes
1	To identify the magnitude of waste material based on lean construction	Material reconciliation data	Questionnaire survey, Literature review	Percentage Of waste, Questionnaire Survey	The magnitude of waste material

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5. RESULTS AND DISCUSSION :

5.1 The Magnitude of wastage:

The magnitude of wastage of commonly used building construction materials i.e. rebar, brick, cement, and aggregate of five selected projects were determined through the material reconciliation report provided by the respective project and analyzed [22, 23, 24 & 25].

5.1.1 Reinforcement bar:

Table 6: Reinforcement

S. N.	Project Name	Store record (Kg)	Bill /WIP/ Progress payment record (Kg)	Wastage (Kg)	Wastage (%)
1	Air Transport Capacity Enhancement Project Package NCB 02 BO3 Unit 1 Unit 2 Unit 3	609399	598764	10634	1.75%
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)	328379	316768	11611	3.5%
3	Construction of Manmohan Centre Annex Building	465190	460170	5020	1.1%
4	Memorial Cancer Centre	437102	432165	4937	1.13%
5	Residential Building	142200	137931	4269	3%
Average Wastage ±Standard Deviation					**2.096±1.09**

Table 6 show the wastage of reinforcement bar in five different construction projects among which Air Transport Capacity Enhancement Project Package NCB 02 has minimum wastage of 1.75% and Air Transport Capacity Enhancement Project Package NCB 03(B06) has maximum wastage of 3.5% and an overall average of five projects is 2.096%which is within 5% as recommended by norm published by the government of Nepal for building construction. Compared to the result obtained from this study, the waste lies between 1 to 4% which is within the accepted norms of 5%. According to the concerned staff of the related sites, low wastage in rebar was mainly due to the use of cut piece bars in sill and lintel band during the brickwork. The wastage of rebar of all these projects was less.

5.1.2 Bricks:

Table 7: Bricks

S. N.	Project Name	Store record (Nos)	Bill /WIP/Progress payment record (Nos)	Wastage (Nos)	Wastage (%)
1	Air Transport Capacity Enhancement Project Package NCB 02	525623	512483	13140	2.5%

	BO3: Unit 1, Unit 2, Unit 3				
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)	402546	393287	9259	2.3%
3	Construction of Manmohan Centre Annex Building	337025	325000	12025	3.56%
4	Memorial Cancer Centre	225143	218473	6670	2.96%
5	Residential Building	92516	91131	1385	1.497%
Average Wastage ±Standard Deviation					**2.56±0.77**

Table 7 shows the waste quantity and percentage of bricks, where Construction of Manmohan Centre Annex Building has maximum wastage of 3.56% and Residential Building has minimum wastage of 1.497% and the overall average of five projects is 2.56%. Air transport Capacity enhancement project package NCB 02 and 03 has 2.5% and 2.3% respectively. As per the projects manager and supervisor of all projects, the reason for saving bricks was due to the proper use of all broken bricks in soiling and other measurable work in the project.

5.1.3 Cement:

Table 8: Cement

S. N.	Project Name	Store record (Bags)	Bill /WIP/Progress payment record (Bags)	Wastage (Bags)	Wastage (%)
1	Air Transport Capacity Enhancement Project Package NCB 02 BO3: Unit 1, Unit 2, Unit 3	45630	44673	957	2.1%
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)	37461	36210	1251	3.339%
3	Construction of Manmohan Centre Annex Building	29843	29116	757	2.44%
4	Memorial Cancer Centre	31241	30088	1153	3.7%
5	Residential Building	7256	7074	182	2.5%
Average Wastage ±Standard Deviation					**2.82±0.672**

Table 8 shows the waste quantity of cement in five construction projects, where Air Transport Capacity Enhancement Project Package NCB 02 has minimum wastage of 2.1% and Memorial Cancer Centre has maximum wastage of 3.7% and the overall average of five projects is 2.82%. The data presented in the table comprises both OPC (ordinary Portland Cement) and PPC (Pozzolana Portland Cement).

5.1.4 Sand:

Table 9: Sand

S. N.	Project Name	Store record (Cum)	Bill /WIP/Progress payment record (Cum)	Wastage (Cum)	Wastage (%)
1	Air Transport Capacity				

	Enhancement Project Package NCB 02 BO3 Unit 1 Unit 2 Unit 3	3560.24	3407.64	152.6	4.286%
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)	3212.51	3112.5	100.01	3.113%
3	Construction of Manmohan Centre Annex Building	1944.6	1882.52	62.08	3.19%
4	Memorial Cancer Centre	2103.28	2030.03	73.25	3.48%
5	Residential Building	1159.43	1187.32	47.5366	4.1%
Average Wastage ±Standard Deviation					**3.634±0.5325**

Table 9 shows the waste quantity of sand in five different construction projects among which the Construction of Manmohan Centre Annex Building has minimum wastage of 3.113% and Air Transport Capacity Enhancement Project Package NCB 02 has maximum wastage of 4.286% and an overall average of five projects is 3.635%. The maximum wastage on Air Transport Capacity Enhancement Project Package NCB 02 was mainly due to improper storage, double handling, and poor site layout as mentioned by the concerned staff of the project.

5.1.5 Aggregate / pebbles:

Table 10 Aggregate

S. N.	Project Name	Store record (Cum)	Bill /WIP/Progress payment record (Cum)	Wastage (Cum)	Wastage (%)
1	Air Transport Capacity Enhancement Project Package NCB 02 BO3 Unit 1 Unit 2 Unit 3	10254	9546	708	6.9%
2	Air Transport Capacity Enhancement Project Package NCB 03 (B06)	8235.4	7885.34	350.06	4.25%
3	Construction of Manmohan Centre Annex Building	2366.51	2315.23	51.28	2.167%
4	Memorial Cancer Centre	4885.27	4563.23	271.5	7.05%
5	Residential Building	5015	4743.5	467.5	5.72%
Average Wastage ±Standard Deviation					**5.219±3.76**

***Cum = meter cube**

Table 10 shows the waste quantities of aggregate /pebbles for five projects in which minimum in wastage of 2.16% on Construction of Manmohan Centre Annex Building and maximum in wastage of 7.05% on Memorial Cancer Centre has been recorded and average wastage determined for five construction project is 5.219%. The maximum wastage in Memorial Cancer Centre was mainly due to improper storage and negligence during mixing as mentioned by the concerned staff of the project in the case of Memorial Cancer Centre.

5.2 Discussion in Comparison of results with related studies in literature:

Table 10 shows the magnitude of wastage in percentage found out in the different countries from different research studies. Comparing the result from this study the average wastage for all materials i.e. rebar, cement, sand, aggregate, and brick is found to be lower than in other counties. For rebar, all listed countries have wastage at least 5% but in Nepal. It is only2.56%. Similarly, wastage of cement ranges from 3% to 20% which is found just 2.82% in the studies. Sand is 10.5% in Palestine and 9% in Egypt but 2.82% in this study. Similarly for aggregate, which is 8.9% in Palestine while 7.486% in Nepal. A study carried out by Rameezdeen and Kulatunga (200) in Sri Lanka identified the main material wastage as sand (25%), cement (14%), brick (14%), and steel (7%) which is also high as compared to the findings of this study. The result of the study by Sharma (2014) shows wastage as Concrete (2.91%), Reinforcement (4.76%), and brick (4.76%), and Mahato (2014) concrete (4%), Reinforcement (5.8%), and brick (4.2%) which are also high comparing with result of this study. The magnitude of wastage calculated in this study was found to be lower than the value reported in other studies. This might be because the private housing companies are always willing to maximize the profit controlling the wastage and also waste generated within mass housing sites have more options for reuse. Similarly, as no sub-contracting practice was involved in these projects, material and labor contract is provided by the same party. Therefore, the contractors of these projects seem to apply waste reduction and reuse strategies to minimize material wastage. Examples of reuse strategies at the construction site such as using broken pieces of bricks in works like soling, flooring, cut pieces of rebar in casting manhole cover, sill lintel band, metal grating, and using wastage sand in Hume pipe bedding. Cement is used in construction projects before its expiry. Some of the bags of cement were found to expire due to different reasons (Like lockdown). These bags of cement are used in places where less strength is required like in non-structural work, screeding, cover block, etc. Sieved sands are taken for the data collection so the waste data are less in comparison to others. Waste sand is also used in backfilling so the wastage gets less than others. In addition, the contractors were also keen on changing the design to minimize and avoid material wastage as reported by the contractor's representative during the personal interview. Regular preparation of material reconciliation report, material consumption report, an audit from top management, Site meeting, with storekeeper, supervisor and engineers and daily briefing to the worker is the best practices adopted by these projects for a low waste generation as said by site personnel and also experience of each country and company guide the actual amount of waste production.

6. CONCLUSION :

According to the findings of this study average wastage of material with standard deviation for five construction projects: rebar (2.096±1.09), bricks (2.56±0.77), cement (2.82±0.672), sand (3.634±0.5325), and aggregate (7.486±4.76). Compared with the other similar studies, waste percentages found are quite low because of adopting the lean construction approaches in the construction site. In the project, some of the wastage can be recycled and reused so the percentage of waste material is low due to the implementation of lean construction approaches. The practice of various reuse strategies like use of broken bricks in soling, cut a piece of rebar in the casting of a large number of manholes manhole grating, waste sand in Hume pipe bedding and backfilling, etc. Expire cement are used in unstructured work and cover block and aggregate are also used for different purpose of construction.

7. LIMITATIONS OF STUDY :

The study cover only selected reference projects.

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REFERENCES :

[1] Mishra A. K. (2020). Project Management: Theory and Practice from Different Countries. Project Management: Theory and Practice from Different Countries. Tamilnadu: DK International Research Foundation. 2020; 345. DOI: http://doi.org/10.5281/zenodo.481754222.

[2] FCAN, 2009, Construction Souvenir, Kathmandu, Nepal; Federation of Construction' Associations of Nepal (FCAN). 116, No; 19.

[3] Mishra, A. K. (2019). Implementation Status of Value Management in Project Management Practice in Nepal. *International Journal of Management Studies, 6*(1). 92-108. DOI: http://doi.org/10.18843/ijms/v6i1(1)/13. Google Scholar↗

[4] Koskela (1992), Transformation/Flow/Value. Lean Construction (IGLC-9), Singapore, 22-29.LCI Seminar, (2002). Comparison of Lean and Traditional Construction,

[5] Abdelhamid, T. S. (2004, August). The self-destruction and renewal of lean construction theory: A prediction from Boyd's Theory. In *Proceedings of the 12th Annual Conference of the International Group for Lean Construction* (pp. 3-6). Google Scholar↗

[6] Mishra, A. K. (2018). Sustainability and risk assessment of Salyankot water supply project in post-earthquake scenario. *International Journal of Operations Management and Information Technology*, *8*(1), 1–30. Google Scholar↗

[7] Mishra, A. K., & Aryal, B., (2021). Operational maintenance analysis of actively utilized road construction equipment. Materials Today: Proceedings. https://doi.org/10.1016/j.matpr.2021.01.051

[8] Mishra, A. K., Rabindra Kumar Yadav & Aithal, P. S. (2020). Economic Operation of Cement: A Case of Gautam Buddha Airport Upgrading Component Project. *International Journal of Applied Engineering and Management Letters (IJAEML),* *4*(2), 188-199. DOI: http://doi.org/10.5281/zenodo.4108233. Google Scholar↗

[9] Mishra A. K. & Rai S. (2017). Comparative performance assessment of eco-friendly buildings and conventional buildings of Kathmandu valley. *International Journal of Current Research, 9*(12), 62958-62973. Google Scholar↗

[10] 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↗

[11] Pheng, Low Sui and Choong Joo Chuan, (2001). Just-in-time Management in precast Concert Construction: A survey of the Readiness of Main Contractors in Singapore. *Integrated Manufacturing Systems*, *12*(6), 416-429. Google Scholar↗

[12] Picchi, F. A. (1993). Sistemas da Calidad: Uso em empresses deconstruction (Quality Systems; use in construction companies).

[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 in Nigeria. *Journal of Engineering and Technology (JET)*, *6*(1), 82-99. Google Scholar↗

[15] 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↗

[16] Formoso, C. T., Isatto, E. L., & Hirota, E. H. (1999, July). Method for waste control in the building industry. In *Proceedings IGLC* (Vol. 7, p. 325). Berkeley^ eCA CA: University of California. Google Scholar↗

[17] Garas, G. I., Anis A. R., EI 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↗

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

[19] 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. Google Scholar↗

[20] Tam, Vivian W.Y. And C.M. Tam. June 2006. A review on the Technology for Construction Waste Recycling. *Resources, Construction and Recycling*, *47*(3), 209-221. Google Scholar↗

[21] Fatta, O.O and Papadopoulos, A., Avramikos, E., Sgourou, E., Moustakas, K., Kourmoussis, F., Mentzis, A. and Loizidou, M. (2003). Generation and Management of Construction and Demolition Waste in Greece- an Existing Challenge. Elsevier Science Resources. *Construction and Recycling 40*(1). 81-91. Google Scholar↗

[22] Ganesan, S. (2000). Employment, Technology and Construction Development. Ashatye Publishing Limited, England.

[23] Gavilan, R. M., and Berold, L., E. (1994). Source Evaluation of Solid Waste in Building Construction. *Journal Construction and Engineering Management*, *120*(3), 536-552. Google Scholar↗

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

[25] 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, pp- 31-52. Google Scholar↗

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