Application of Lean Construction to Improve Material Management in Construction Project

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***Abstract*--Lean construction is as an effective management implement that improve the efficiency in constructing field. Research has revealed that construction materials and equipment found other than 70% of the total cost intended for a distinctive construction knowledge. Construction waste is extra severe problem in construction industry. To commerce active and cost in effect site capable material managing is very important. Tangible construction materials management is important to realisation for construction plan. One of the main problems in delaying construction developments is poor materials and equipment management. As questionnaire survey accomplished to determine most common causes of ineffective material management. Through study this it provides vibrant report of actual management in materials with aid of managing lean concepts.**

Key words: Lean construction, construction materials, construction waste, delaying construction, questionnaire survey.

1. INTRODUCTION

Lean is a manufacture management system for attaining important, continuous development in the performance of the whole business procedure over and done with elimination of all wastes like time and other resources that do not enhance value to the product or ability supplied to the customer. Materials management is a way for forecasting, performing and governing arena and work doings in construction. The aim of materials management is to lookout building materials are existing at their point of practice when wanted. The materials management system efforts to protect that the exact quality and quantity of materials are correctly nominated, purchased, transported and controlled on site in a timely manner and at a affordable cost. Materials management is the structure for planning and controlling all of the fights vital to confirm that the exact quality and amount of materials are properly detailed in a timely method, are obtained at a reasonable cost and most obviously are obtainable at the point of use when essential. This Materials management is an important element in project management. Materials characterise a major expense in construction, so minimalizing attaining costs improves chances for dropping the overall project costs. Poor materials management can consequence in enlarged costs during construction. Effective management of materials can result in considerable savings in project costs. If materials are bought first, capital may be held up and concern charges incurred on the excess list of materials. Materials could get worse during storage or get stolen without distinct care is taken. Delays and add-ons costs can be practiced if materials necessary for specific activities are unavailable. Ensuring a timely flow of materials is an important concern of material management. For successfully managing and governing materials, the performance of materials management should be measured. A appearance amount analyses the real operational of a duty. These turn activities may change from system to system. The dealings torn apart the materials management scheme in shares and make the working of the system more efficient. When joined, the measures make the complete materials management system.

2. STRUCTURE OF PROJECT

The project report flows from explaining the introduction of project in Chapter 1 to the structure of project in Chapter 2. Chapter 3 is the literature study for this project. Chapter 4 is dedicated to research methodology of the project. Chapter 5 shows the factors taken for findings for questionnaire survey and discussions. As a results and discussions from the questionnaire survey suitable for the material management is presented followed by the results from the suggestion of implementing of the Last Planner System in Chapter 6. Conclusions and recommendations are displayed in Chapter 7 followed by the references used in the research.

3. LITERATURE STUDY

A thorough study was carried out along with study of cases surveys and interviews to professionals involved in this area. As a result, a methodology for diagnosis and improvement was proposed. Effective construction materials management is a key to success for a construction projects. The first part based on conducting questionnaire survey in various construction companies. The improper handling and storage of materials in construction site has made it difficult to track and locate materials when the time they are needed. To maintain sufficient stock of raw materials in period of short supply, to protect inventory against deterioration and control investment in inventories and to keep it in an optimum level.

By several findings in literature it shows of some different and certain ways for material management.

According to journal, An Empherical Study on the impact of lean construction techniques on sustainable construction in UK [2017] shows the identification to improved process flow, improved production, waste elimination, value of money along with quality management. The questionnaire of that journal finding displays time, management process, discussion in terms of meeting. Stake holders involve in this are contractors, labours, engineers and tools used are SPSS 19.0 version using

percentile method, Cronbach's a reliability test. Results are improved corporate image, improved process flow & productivity [1].

Research article paper, Management for Construction Materials and Control for Construction Waste in Construction Industry [2015], identifies management of construction materials and construction waste, material management technique, existing situation of construction management and construction waste in industry. Tools used are wireless communication system, bar coding readers, RFID. Results on this are reducing poor handling of waste, pre-planning, and increased material efficiency [2].

Construction Materials Management on Project Sites [2011], giving identification of poor material management leads to increase in cost. Stakeholders are workers, project managers, contractors gives the results on centralised material management team co-ordination b/w the site and organisation, also increased efficiency by 35% [3].

Also in IJCER volume 7, [2016] Lean Construction Techniques in Indian Construction Industry: Some Analysis identifies unskilled labours, poor workmanship, lack of communication by contractors and stakeholders like contractor, site engineer, project manager and government employee. Results improve efficiency of value added service, improve work method of essential non-value added activity with help of lean technique. Improve in efficiency from 25-30% [4].

In paper The Impact of Material Management on Construction Project Delivery in Maldives [2017], Zaha Ahmed says about identification of unavailability of material, time spent for investigating non qualifies suppliers. Questionnaire like current material management practices, cost to overrun, delay. Also tools like questionnaire survey, delay. Tools like questionnaire survey, structures interview [5].

IJIR journal Vol-3, Issue-3, [2017] Waste Management Process for Non-Value Adding Activities using lean construction, identifies poor management of project, overproduction, transporting, inventory are maintained properly and tools like last planner concept, 5-S technique. Result identifies application of lean principle, importance of waste identification, waste evaluation tool [6].

Also in IJISME, Volume-1, [2013] paper Lean-Management approach to Construction Engineering & Management, it identifies running out material, improper storage, double handling. Contains area of approach in small and medium sites. As a result of this, it needs regular site clearing, proper arrangement of used material, layout site used for material management [7].

Improving Materials Management Practices in Construction Projects [2011], gives the identifications of paper based reports for materials management are problematic, error prone & inefficient also poor material management result in delay and wastage. Questionnaire based on reasons for delay & wastage of materials. Tools used are ICT, ABC. Results shows for implementation of ICT applications increases material efficiency [8].

An IRJET journal, Factors Affecting Material Management on Construction Site [2017], identifies improper material management leads to loss of money and delays the project. Also questionnaire the factors affecting material management, where the recommendations with use of ABC analysis for inventory management. EOQ techniques to reduce cost overrun [9].

4. METHODOLOGY

For every construction industry material is required. In construction projects material constitute major cost. Generally the cost of materials contains 50% to 60% of total cost of the project. In construction projects, material management is carried out to minimize wastage of material, shortage of material, damage of material, lack of storage space and delay in supply. The construction industry struggles with low profit margins and needs to increase productivity to lower production costs and increases profit. Material management is a scientific technique, concerned with planning, organizing and control of flow of materials, from their initial purchase to destination.

Fig. 1: Methodology

A. *Material Management*

Material management can be defined as a process that coordinates planning, assessing the requirement, sourcing, purchasing, transporting, storing and controlling of materials, minimizing the wastage and optimizing the profitability by reducing cost of material. Building materials account for 60 to 70 percent of direct cost of a project or a facility, the remaining 30 to 40 percent being the labour cost.

B. *Components of material management are*

- Material estimation, budgeting, planning and programming.
- Scheduling, purchasing and procurement. Receiving and inspection.
- Inventory control, storage and warehousing.0
- Material handling and transport.
- Waste management.

C. *Objectives & Importance of Material Management*

- Efficient use of the working capital.
- Lowering inventory investment. Increase in inventory turnover.
- Responding to the market changes related to any product.
- Ensuring the cooperation of all departments. Providing best services to the king of market i.e. customers.
- Buying or Purchasing.
- Procuring and receiving.

- Storing and inventory control.
- Supply and distribution of materials.
- Quality assurance.
- Good supplier and customer relationship.
- Improved departmental efficiency.

D. Functions of Materials Management

The functions of materials management are discussed below: In order to fulfil the objectives of materials management as stated above to meet the basic objectives and goals, the functions of the materials management are also categorized as primary and secondary functions.

(I) Primary Functions

To meet the primary objectives, the primary functions of the materials management are given as follows:

- Materials Requirements Planning (MRP)
- Purchasing
- Inventory Planning and Control
- Ascertaining and Maintaining the Flow and Supply of Materials
- Quality Control of Materials
- Departmental Efficiency

(II) Secondary Functions

- Standardization and Simplification
- Make and Buy Decisions
- Coding and Classification of Materials
- Forecasting and Planning

E. Benefits of Material Management

An effective material management system can bring following benefits.

- Reducing the overall costs of material.
- Better handling of material.
- Reduction in duplicated orders.
- Material is on site when needed and in the quantities required.
- Improvements in labour productivity.
- Improvements in project schedule
- .Quality control.
- Better field material control.
- Better relations with suppliers.

F. Process of Material Management

Material management process initiates from need generated from site then this information conveyed to store department and material is ordered in the store, indent is generated. Vendor selection is to be carried out for the least value and best items. Materials are received at store department and inspection is carried out. Special training sessions should be arranged on site to update the workers regarding the latest techniques. Plant and machinery should be updated regularly in order to avoid any break down. Workers and contractors should be guided for correct methodology to execute a particular task. Regular check should be kept on planning so as to overcome any error. Proper supervision should be done on site to improve the level of workmanship.

Fig. 2: Material management process

G. Lean Construction

The traditional method of project management has a long history. It is being used to manage all kinds of construction projects ranging from small residential to huge infrastructural projects like bridges and dams. However, in the recent years due to the growing domestic and international competition, development of highly complex and uncertain projects this technique of project management has often come under severe criticisms. The construction industry has been suffering from the problems of low productivity, poor safety, inferior working conditions and most importantly inferior quality. Many have attributed automation and increased computer integration as a solution to the above mentioned problem (Koskella 1997). Hence, there has been little progress in the field of Lean construction over the years. However, recently many parts of construction industry have started to shift towards the lean production theory like prefabricated housing.

The main characteristics of the traditional approach are as follows (Saied Kartam et. al 1997):

1. All activities are value adding activities.
2. No distinction is made between processing and flow activities.
3. The total cost is estimated on the basis of the WBS (work breakdown structure).
4. No emphasis is given to the importance of resource flows.
5. All activities are assumed to be independent of each other and it is assumed that reducing the cost of each activity will reduce the cost of the project.
6. It doesn't take into consideration the effects of poor quality output and effects of variability and uncertainty.
7. Another characteristic is that work passes linearly from one process to the other.

"Lean construction is the application of lean production principles in the construction industry" (Koskella 1998). However, the lean production principles cannot be applied directly to the construction industry. There is a marked difference in the construction industry from its manufacturing counterpart. The main problem that lies in the road towards lean construction is that most companies do not see construction as a flow and conversion based process. They believe that all activities are conversion based and hence they do not try to reduce the Wastes in construction. Past researchers (Serpell et al. 1997) have identified the following wastes in construction:

- Waiting for resources
- Travelling time movement (of operator or machine)
- Idle time (of operator or machine)
- Resting
- Rework

A classification of the main causes behind the wastes has also been provided by Serpell et al. (1997) and is shown in Fig. 3

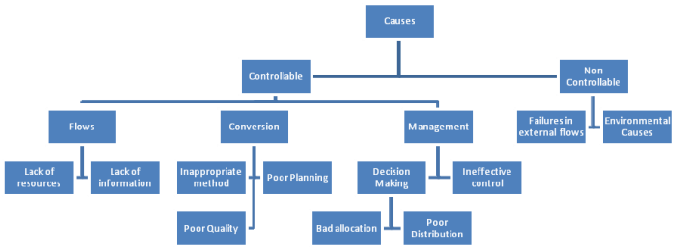


Fig. 3: Classification of causes of waste

Lean Production in construction in essence tries to reduce the wasteful activities in construction to deliver the product to the owner. Many tools are available to achieve this goal, but in this research we shall focus on Last Planner System developed by Glenn Ballard (Ballard 2000) to remove the wastes and to shield the downstream work from the uncertainties in the upstream construction processes.

Most of the wastes listed above are a clear demonstration of lack of adequate planning and management control. Information of the above mentioned wastes beforehand can help the project managers to take extra precaution during the execution of the project. One major solution to the above mentioned wastes can be increased emphasis on short term planning as most of the wastes mentioned above are a result of ineffective short term planning (Serpell et al. 1997).

H. Process of lean construction

This states that as soon as one activity is finished the other should start irrespective of the fact whether the other pre requisites of the activity like materials, labour and equipment are available. This model pressurizes the available resources to act fast thereby resulting in a compromise in the quality of the construction. On the other hand lean construction is a flow and conversion based model where a construction process is a collection of conversion processes involving flows of information and materials from one process to the other as depicted in Fig. 4.

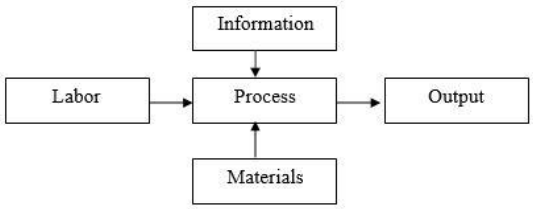


Fig. 4: Lean Construction

I. Tools for Lean Construction

Pull Approach

This concept is the same as that of lean production. Traditionally inventories are managed using the detailed scheduling techniques wherein the materials are ordered on the basis of the master schedule prepared. With the pull approach the concept of Just in Time is utilized in construction wherein the inventories are kept to the bare minimum and new inventories are ordered based on the current demand. Stocking of materials is wasteful. Its implementation however requires good relation with the suppliers (Ballard and Howell 1997b).

Multifunctional Task Groups

This concept contradicts the current belief that only specialized workers can produce good quality products. Instead of having a specialty group of workers a multifunctional task group should produce a number of different products. This makes it possible to produce a more complex or more completed product with one production unit. In multifunctional task groups the workers do not have to waste time in waiting for each other to complete the work. However, to achieve the principle of multifunctional task groups, personnel need to be trained intensively in recombining thinking and doing (Melles 1997).

Kaizen (Total Quality Improvement)

Kaizen means to continually look for new ways to improve the process by reducing costs and increasing efficiency. It might involve the management asking the

production teams to suggest new ideas regularly. A good implementation of Kaizen implicates cost reduction and zero defects in final products. It includes the 5S principle for site management which has been described earlier (Melles 1997).

Benchmarking

It is an important tool for standardization of activities, ultimately leading to good construction quality. New methods evolved by means of continuous improvement need to be benchmarked so that they can be implemented at similar situations and can be improved upon at all sites. This tool promotes achievement of high quality work (Tanskanen et. al 1997).

A3 Reports

This tool developed by Toyota helps in documentation of key results of problem solving manner in a concise manner. It involves mentioning the theme of the problem, current situation, any improvements / suggestions and the implementation and follow up plan, all on a single A3 sheet. The A3 method is an easy to use, comprehend method and can be implemented only with a paper and pencil. The size of A3 is assumed to be just enough to be able to highlight the important points for discussion.

J. ***Last Planner System***

This tool in simple words can be taken to be an assimilation of the above mentioned tools. It also has a number of other features which are explained below. The main objectives of a production control system like the Last Planner System are as follows (Ballard 2000):

1 Manage and mitigate the variability.
2 Assignments and schedules should be sound regarding their prerequisites.
3 The completed assignments should be monitored.
4 Causes for failure to complete the planned work should be investigated and removed.
5 There should be a workable backlog for each crew and production unit.
6 The prerequisites of upcoming assignments should be made ready.
7 The traditional push based construction process model should be incorporated with pull techniques.
8 Traditional project control focuses on hierarchical decision making and thus the decision making process lies in the hands of few and often decision makers are unaware of the ground realities. Decision making powers should be well distributed among the project team.

Developed by Prof. Glenn Ballard of the University of California at Berkeley (2000), itaims to reduce / remove the uncertainties plaguing the construction project processes. In CCPM there is strict adherence to the master schedule even when great obstacles lie in its path. Supervisors keep on pressurizing the subordinates to produce despite obstacles. Many a time these obstacles result in poor quality output which remain in the project supply chain throughout.

1. Last Planner System (LPS) aims to shift the focus of control from the workers to the flow of work that links them together. The two main objectives of LPS are to make better assignments to direct workers through continuous learning and corrective action and to cause the work to flow across production units in the best achievable sequence and rate as shown in Fig. 5.

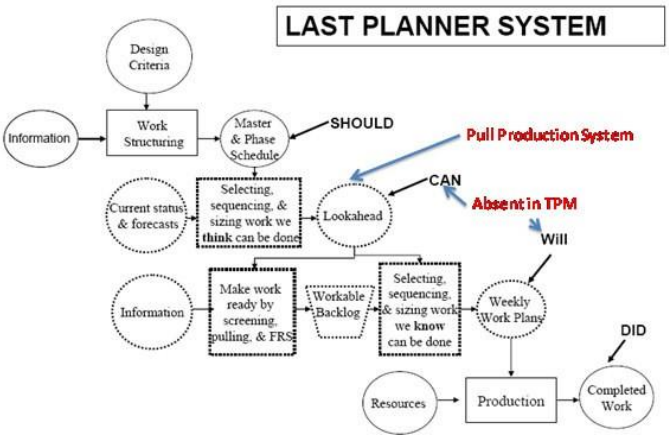


Fig. 5: Last Planner System

Application of Lean Construction Principles to the Construction to the Construction Process

The application of lean construction tools to the construction process will be explained in this section. The construction process is considered as a three phase process:

1 Design
2 Planning
3 Execution

Application of lean construction principles in construction execution

This stage involves utilization of the last planner tool (described earlier) of lean construction for execution of the project. In this section the meaning of the “pull process” for building up of the schedules and the workable backlog is described.

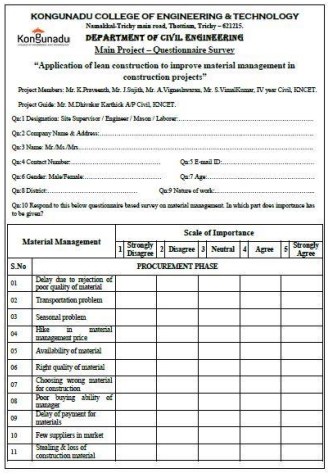
5. FINDINGS OF QUESTIONARY SURVEY

The wastes delays and interruptions were found to have similar meanings and the respondents remarked that they had difficulties in differentiating between them. They mentioned that interruptions led to delays and hence they should be grouped together. The respondents had similar difficulties while dealing with the waste defects, ineffective work, uncompleted work and rework; hence they should also be grouped together. Furthermore important waste categories from the point of view of Indian construction sector like space constrain and frequent changes in design were found to be missing from the questionnaire and should be incorporated in it.

It was also observed that some sources of wastes relevant to the Indian construction practices like abnormal weather, equipment breakdown and accidents were missing and should be incorporated in it. Furthermore, the management related sources – unnecessary requirement and excessive management control were found to have similar meaning and hence should be grouped together.

There were also suggestions on making the questionnaire more meaningful and less time consuming for the participants like keeping the questionnaire as a single

perform a instead of two separate performs. Based on the above mentioned feedback which was received from the participants a new simplified questionnaire has been formulated and presented.



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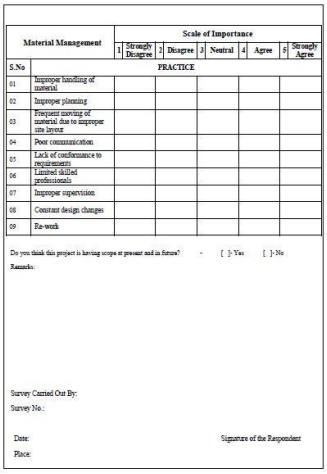
DEPARTMENT OF CIVIL ENGINEERING
Main Project – Questionnaire Survey
"Application of lean construction to improve material management in construction projects"

Project Members: Mr. K.Praveenth, Mr. J.Rajith, Mr. A.Vigneshwaran, Mr. S.VimalKumar, IV year Civil, KNCET.
Project Guide: Mr. M.Dhivakar Karthick A/P Civil, KNCET.

Qn.1 Designation: Site Supervisor / Engineer / Mason / Laborer
Qn.2 Company Name & Address:
Qn.3 Name: Mr./Ms./Mrs.
Qn.4 Contact Number: Qn.5 E-mail ID:
Qn.6 Gender: Male/Female Qn.7 Age:
Qn.8 District: Qn.9 Nature of work:
Qn.10 Respond to this below questionnaire based survey on material management. In which part does importance has to be given?

Material Management	Scale of Importance					
	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	
S.No	PROCUREMENT PHASE					
01	Delay due to rejection of poor quality of material					
02	Transportation problem					
03	Seasonal problem					
04	Hike in material management price					
05	Availability of material					
06	Right quality of material					
07	Choosing wrong material for construction					
08	Poor buying ability of manager					
09	Delay of payment for materials					
10	Few suppliers in market					
11	Stealing & loss of construction material					



Material Management	Scale of Importance					
	1 Strongly Disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly Agree	
S.No	PRACTICE					
01	Improper handling of material					
02	Improper planning					
03	Frequent moving of material due to improper site layout					
04	Poor communication					
05	Lack of conformance to requirements					
06	Limited skilled professionals					
07	Improper supervision					
08	Constant design changes					
09	Re-work					

Do you think this project is having scope at present and in future? - [ ]-Yes [ ]-No
Remarks:
Survey Carried Out By:
Survey No.:
Date: Signature of the Respondent
Place:

Questionnaire Used for Identification of Wastes and their Sources in Construction Practices

- Designation: Site Supervisor / Engineer / Mason / Laborer
- Company Name & Address
- Name
- Contact Number
- E-mail ID
- Gender: Male/Female
- Age
- District
- Nature of work
- **Respond to this below questionnaire based survey on material management. In which part does importance has to be given?**

Material Management

Procurement Phase

- Delay due to rejection of poor quality of material
- Transportation problem
- Seasonal problem
- Hike in material management price
- Availability of material
- Right quality of material
- Choosing wrong material for construction
- Poor buying ability of manager
- Delay of payment for materials
- Few suppliers in market
- Stealing & loss of construction material

Practice

- Improper handling of material
- Improper planning
- Frequent moving of material due to improper site layout
- Poor communication
- Lack of conformance to requirements
- Limited skilled professionals
- Improper supervision
- Constant design changes
- Re-work

6. ANALYSIS TOOLS & DISCUSSIONS

Relative Importance Index Technique:

It is used determine the relative importance of the various causes and effects of delays. The same method is going to adopted in this study within various groups (i.e. contractors, project engineers, owner and site supervisor). The five-point scale ranged from 1 (strongly disagree to 5 (strongly agree) is adopted and transformed to relative importance indices (RII) for each factor as follows:

$$RII = \Sigma W / (A*N)$$

Where, W is the weighting given to each factor by the respondents (ranging from 1 to 5), A is the highest weight (i.e. 5 in this case), and N is the total number of respondents. Higher the value of RII, more important was the cause of delays.

A. Importance Index Technique

In this technique, for each cause/factor two questions were asked: What is the frequency of occurrence for this cause? And what is the degree of severity of this cause? All were categorized on a five-point scale. Frequency of occurrence is categorized as follows: always, often, sometimes, rarely and very rare (on 5 to 1 point scale). Similarly, degree of severity was categorized as follows: strongly agree, agree, neutral, disagree and strongly disagree (on 5 to 1 point scale).

B. Frequency index

A formula is used to rank causes of delay based on frequency of occurrence as identified by the participants.

$$\text{Frequency Index (F.I.) (\%)} = \Sigma\, a\,(n/N) * 100/4 \ldots (4)$$

Where, a is the constant expressing weighting given to each response (ranges from 1 for strongly disagree to 4 for strongly agree), n is the frequency of the responses, and N is total number of responses.

C. Severity index

A formula is used to rank causes of delay based on severity as indicated by the participants.

$$\text{Severity Index (S.I.) (\%)} = \Sigma\, a\,(n/N) * 100/\ldots (5)$$

Where a is the constant expressing weighting given to each response (ranges from 1 for strongly disagree to 5 for strongly agree), n is the frequency of the responses, and N is total number of responses.

D. Importance index

The importance index of each cause is calculated as function of both frequency and severity indices, as follows:

$$\text{Importance Index (IMPI) (\%)} = [\text{F.I.} * \text{S.I.}]/100 \ldots (6)$$

As observed from the survey, the construction is affected by delays, interruptions and rework, which have been attributed to mostly the management related sources like poor management control and poor planning along with shortage and poor quality of resources. After discussion, it was decided to go for the implementation of the Last Planner System, which is an integrated tool for the implementation of lean construction, to reduce the wastes thus identified. It

was felt that since the Last Planner System is in essence a tool which promotes proper planning of the construction process and involves all the parties concerned with a construction project, it will help in mitigating the planning and management related wastes.

The last planner system was formally started as follows:

- Creation of a milestone based Master Schedule for the works.
- Selection of works to be noted in the Week Look Ahead Plan.

On the basis of the master schedule thus developed, activities were selected which were to be completed in the coming weeks. They were noted down in the prescribed format along with their completion dates based on the prevalent conditions.

- Identification of all prerequisites of the activities in the look ahead plan and their procurement.

All the prerequisites (pending activities, labor requirements, material requirements, equipment, specifications etc.) of the activities listed in the look ahead were identified so that they can be procured / completed before starting the work.

- Creation of a Weekly Work Plan (WWP) by selecting activities from the look ahead plan whose prerequisites had been procured.

The activities for which all the resources had been procured were enlisted in the WWP and were required to complete in the coming week.

- Weekly performance monitoring by calculating the PPC (Percent of Planned Complete) and taking necessary action to prevent reoccurrence of problems. This leads to continuous improvement.

The activities in the WWP which had not been completed were noted along with the reasons for non-completion so that they were not repeated again.

Problems during the Implementation of the Last Planner System

- No planning / scheduling techniques were being followed at the site.
- The construction wastes were mostly viewed as wastage of materials.
- Lack of interest on the part of the contractor to implement the Last Planner System (Lack of adherence to the weekly schedules and the look ahead schedules.).
- Lack of interest among all parties towards a joint weekly review meeting to monitor the progress of the work and to sort out the problems. This led to lack of coordination between the authorities and contractor.
- There was excessive rework at the site due to the failure on the part of the contractor / site engineers to understand the requirement of the authorities.
- There were acute problems in the supply chain management of the contractor, no effort was made to stick to the look ahead plan and order materials according to the date mentioned in it. This led to a huge buildup of activities in the look ahead plan.

There were problems of labor shortage at the site. It was felt that the contractor failed to pay the labor properly and this led to frequent inflow and outflow of labor from the site. Superficial labor shortage was also reported when the contractor failed to pay the labor on time which led to stoppage of work.

7. RESULTS AND CONCLUSIONS

At the end of the project work the major objectives have been achieved. Phase I of the project work involved the identification of the key wastes along with their sources using a questionnaire based survey. As obtained from the analysis of questionnaires collected, Delays and Rework were the most critical wastes plaguing the construction practices. Their sources as found by Poor Management Control, Poor Planning and Shortage of the Resources Used.

Phase 2 of the project involved the implantation of the Last Planner System at the extension to reduce / remove the wastes identified from the survey.

It was observed that much more improvement could have been achieved if the contractor would have taken keen interest in the implementation of the LPS. There was also lack of interest among all the authorities to sit for a weekly review meeting to solve the problems causing the plan failures.

Recommendations

The following recommendations are made on the basis of this research to improve the construction scenario.

- Weekly review meetings at all sites (1 site per day) in which all parties sit down and review the work done in the previous week, solve the problems to prevent reoccurrence, make look ahead plans and weekly plans using the LPS.
- As the Engineering cell is understaffed at the moment, it is recommended that a dedicated project management team be formed which will maintain the weekly plans to keep track of the project and organize the review meetings.

Future Work

As the implementation of the LPS was not completely successful owing to a host of reasons discussed in Chapter 6, it is hoped that the LPS be applied again to another construction site taking into consideration the problems faced while implementing it for this project. The only major problem which lies in the way is to make the people concerned change their mindset and be open to new ideas about managing the construction projects.

REFERENCE

[1] Oyedolapo Ogunbiyi Adebayo Oladapo Jack Goulding, (2013),"An empirical study of the impact of lean construction techniques on sustainable construction in the UK", Construction Innovation, Vol. 14, Issue 1 pp. 88 – 107.

[2] Management for Construction Materials and Control of Construction Waste in Construction Industry: A Review ISSN: 2248-9622, Vol. 5, Issue 4, (Part -1) April 2015, pp.59-64.

[3] Applying Lean Construction to Concrete Construction Projects, Aditi Javkhedkar, and December 2006.

[4] Construction Materials Management on Project Sites, National Conference on Recent Trends in Engineering & Technology.

[5] Lean Construction Techniques in Indian Construction Industry: Some Analysis, ISSN 2278-3652 Volume 7, Number 1 (2016), pp. 59-65.
[6] Analyzing Material Management Techniques on Construction Project, Ashwini R. Patil, Smita V. Pataskar, (IJEIT) Volume 3, Issue 4, October 2013.
[7] The Impact of Material Management on Construction Project Delivery In Maldives, Zaha Ahmed.
[8] Waste Management Process for Non-Value Adding Activities using lean construction, (IJIR) Vol-3, Issue-3, 2017.
[9] IJISME, ISSN: 2319-6386, Volume-1, Issue-4, March 2013, Lean-Management approach to Construction Engineering & Management, Sunil V. Desale, S.V. Deodhar.
[10] Impromng Materials Management Practices in Construction Projects, Narimah Kasim.
[11] Factors Affecting Material Management on Construction Site, Volume: 04, Issue: 01 | Jan -2017.
[12] Quantification of Delay Factors Using the Relative Importance Index Method for Construction Projects in Turkey, Murat Gündüz, Ph.D., A.M.ASCE.
[13] IRJET, Volume: 03 Issue: 01 | Jan-2016, RII & IMPI: Effective Techniques for Finding Delay in Construction Project.
[14] ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 3, and Issue 3, March 2013, A Methodology for Ranking of Causes of Delay for Residential Construction Projects in Indian Context.