Lean-Management Approach to Construction Engineering & Management

Sunil V. Desale, S. V. Deodhar

Abstract:- This paper was written to fill a vacuum of research on the fundamental principles of site construction management. Efficient material management is essential in managing a productive and cost efficient site. In his working career, the author has been observing inefficient labour productivity practices resulting from poor site material management and this paper attempts to rectify those using techniques such as zoning which have been construed with deductive logic and a heuristic approach. These zones being outside storage, staging areas, and inside storage. Each has a unique function in relation to site material management. Using these areas as the basis of the study, heuristic principles are deduced and illustrated with a case study project accompanied by numerous photographs.

Keyword: Construction material, lean management, cost control

I. INTRODUCTION

The wealth of a country is measured by its GDP; the monetary value of the output of goods and services produced by the nation annually. But what is the source of wealth? Although India might have rich natural resources such as mineral deposits, farm lands and forests these are only potential sources of wealth. A production function is needed to transform our resources into useful goods with minimum or zero wastage by the basic concept of **six sigma and lean construction measurement principle**. Production takes place in all forms of transformation such as extracting minerals from the earth, farming, lumbering, fishing, and using these resources to produce value added ones. Similarly in the construction sector quarrying, mining, brick-making, steel production build-up to construction and structures.

There are many stages between the extraction of resources material and final construction. At each stage leading to the final constructed product value is added, thus creating added wealth. For example if stone is quarried from the earth and sold, wealth is gained from this effort, but those who continue to transform the stone into slabs will gain greater wealth. Japan is a prime example of this. It has very few natural resources and buys most of the raw material which it needs. However, if India has to develop into one of the wealthiest economies in the world then translating the raw material purchased and adding value to them through manufacturing (i.e. constructing) is the route to be adopted.

Construction farmers are in the business of converting raw materials to a form that is of more value and use to the consumer (client/ owner) than the original raw material. e.g. Iron ore to steel, Steel into steel structure, cement/sand into concrete, wood/ plywood into furniture, stones as ornamental and decorative flooring or cladding purpose and so on and so forth. This conversion process is called as construction or build, which makes a society wealthier and create a better standard of living.

To get the most value from our recourses, we must design the process and set certain principle that makes the construction process most efficient. Once the process is finalized, we need to manage and control the resources by adopting minimum wastage or zero wastage of material practices at the contractors site which will effectively save the labor and capital costs increasing productivity to ensure that the construction process becomes economical.

If the right metric in the right quality is not available at the right time, the construction process cannot proceed as it should. Labour and construction machinery will be inefficiently utilized. The profitability and even the existence of the construction company would be threatened.

The discipline of project management is often ill defined, particularly when it comes to side operations. A " Black Box" of data on what can go wrong and on the consequences of ineffective decision making exists but not enough published material specifying and segmenting construction zone-wise and bringing out algorithms to avoid cost over-runs has been brought out. This is particularly true of site material management practices and can be reduced by using **Lean management** tools.

II. OBJECTIVE AND SCOPE

The objective of this paper is to present fundamental (guiding & strategic) principles of managing materials on the construction site. The goal is to begin developing suitable active approaches and procedures that will define the generalities on material management approach heuristically. Site material management is defined as the allocation of space to delivery storage and handling of resources for the purposes of supporting the labour force and minimizing inefficiencies due to congestion and excess material movement and lastly rubble management. *In fact, on the 5th of November, a GoAir plane almost crashed into the rubble left on site at the intersection of the two runaways which were being repaired*.

This paper focuses only on material management for medium and smaller size projects and is not intended as a complete guide for all aspects of material management. Many other topics related to material management are not addressed which includes information management risk and uncertainty, supply chain management, integration and others.

The paper covers two broad categories:

1) Site layout and planning
2) Heuristic principal to site management

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Site layout and planning

The paper discusses the factors considered during site layout and planning. The factors include layout zones, access and traffic routes, material storage and handling, administration buildings and welfare facilities, equipment workshops and services. The published literatures on developing a site layout can be characterized as "black box". Some of these have an extensive knowledge base, where as others are limited to a narrower knowledge base. Most algorithms address the positioning of lay down facilities and storage areas and the remaining cover staging areas such as the best location of the mixture machine and vertical lift or cranes.

For practicality's sake, the most comprehensive algorithms use the selection criteria as the minimum travel distance or minimum transportation cost. The algorithms concentrate on positioning facilities to satisfy the constraints while achieving the objective. While applying multiple criteria and addressing other features of the layout problem it is perhaps possible that the problem can quickly become quire complex. Further, for a small site, where the site layout is critical due to space constraints the distances and transportation costs might be of secondary importance. The adherence to principles that assure safety, project schedule and good labor productivity occupy primary importance, so the link between site layout and material management would be secondary. Yet none of the articles in published seem to adequately address this issue. This could be due to the fact that these objectives are not expressed mathematically easily. This paper therefore takes "***A Heuristic Approach***" allowing the planner to adapt to the uniqueness of each site and therefore the focus is on broad principles of site management.

III. SITE MATERIAL MANAGEMENT

Site management involves storage, identification, retrieval, transport and construction parameters. Each is indelibly linked to safety, productivity, and schedule performance. Doing so also saves on-site storage costs and eliminates most double handing as well as saving the cost in essence. Just –in-a time material delivery are preferred in this instance, but does require more co-ordination with the others.

In another article on site material management practices, it is shown that effective site management practices can have a significant effect on schedule (CPM of the project). The schedule slippage on the installation of steel window precast lintels, precast concrete block masonry ranged from 50-120% of the time. Thabet 1992, Tommelein et al, 1992, Riley and sanvido 1995, 1997 used case studies to define work area patterns as linear, random, horizontal, vertical, spiral and building face (Riley and sanvido 1995). He argued that space need patterns changed over-time and that for effective use of resources, space needs must be predicable and rationally planned.

Lean Construction Principle

In recent years, many researchers have propounded and backed lean construction as offering principles related to material management. Unfortunately, many of these principles are difficult to comprehend, and hard to implement at the site level (Thomas et at 2006). However, one aspect is clear. Any interruption to the normal flow of materials will result causing serious degradations on performance and labor productivity (Thomas et at. 2002a). In studies that involved a number of projects, the most frequently documented cause of disruption was problems associated with material management.

IV. RESEARCH METHODOLOGY

Over the years, the author has been measuring waste material and site labor productivity. The productivity database for this paper contains projects form six different sites at Khandesh Region. In the process of measuring labor productivity, site conditions affecting the work were documented. In particular, material management deficiencies have been observed that, in general, for all types of material management deficiencies, there is a reduction in daily productivity of about 40% (Thomas and smith 1992). Deficiencies include running out of materials, improper storage, double handing, poor housekeeping, and others which are reduced by using Six sigma and Lean management Tools.

It has been documented that when these deficiencies occur, there are negative impacts on labor productivity. Using deductive reasoning, it is concluded that these deficiencies must be avoided, and principles are proposed for doing so. The principles have been intentionally kept general so as to assure applicability to the widest range of site reconditions.

Some principles are illustrated with a single case Study project. The case Study project is ideally suited for this purpose because it was a small site and is representative of the type of project found in many locales.

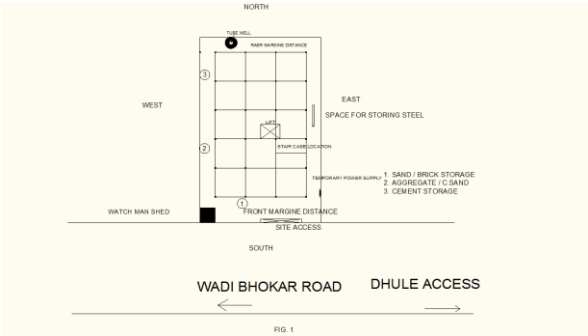
The principles of Heuristic approaches to site material and labour management are summarized.

1. *Out site storage area* - these are areas. Sometimes called lay down areas, where materials are stored prior to being used in the project.
2. *Staging area*- this area is next to the outside of the facility. It is from this area that materials are lifted into the facility. Materials that are off loaded directly into the facility also use this area.
3. *Inside storage area* - this is the area inside the facility where the work of the craftsmen takes place. Each of the above areas has a different use and must be managed differently and different principles will apply.
4. *Vendor Relation and deliveries*- as far as possible deliveries should be taken directly from trucks, assure that they are properly planned accordingly to work progress with the use of PERT and CPM must be used. Make sure that both quality and quantity should be checked. Following the above will save on- site storage costs and eliminate most double handling,
5. *General*- makes use of cutting edge machinery. Avoid unstable and temporary platforms.

V. SITE CHARACTERISTIC

The site plan of the project is shown in fig. 1. It shows that the site had limited space for material storage and lay down areas and other facilities. Fig.1. shows how the contractor utilized the limited space. The use of storage and lay down areas was based on a "***first come first served"*** (FCFS) philosophy.

When the story began, steel reinforcement, structural steel burn bricks, material comprising of aggregate, sand, cement and other material were already stored on site. There was congestion and interference due to entering tractor and trucks on site.



Construction Methods: - Case study description 1

As the excavation work started there is ample space available for doing the excavation work but for proper utilization & planning purpose, we had decided to commence the excavation work from the Road side. Excavation pits were dug for front row columns. The material excavated was collected at the front at a marginal distance and at a vacant plot without disturbing the heavy traffic over the Road and the collected material was disposed off. We then started the excavation for the second row columns. Prior to this the front side foundation was filled & work was taken up to the G.L. level column respectively and then the material excavated from 2nd row was transferred directly to front row column pits for filling purpose .So far we have found that no excessive material is required for filling the trenches the excessive material was then spread evenly along the peripheral of the plinth to prepare a leveled working and storing space for stacking of raw material like steel, sand, aggregate. The site was very small and site access was from the front side S-E corner only. After construction of the 1st floor slab the construction material was transported into the building area. The building area was also used to stock and store miscellaneous material because of the limited site spare space. This aspect is shown in Photo No.1.

Several activities were done simultaneously as per PERT chart. There were numerous disruptions caused by congestion, interference and out-of –sequence work when PERT wasn't followed. Over all the labor performance of the work was poor. When examining this and other projects in hind- sight it is possible to formulate a heuristic approach which forms the principles of site material management using deductive reasoning. The heuristic approach was summonsed in Table-1.

Out Side Storage Area: - Case study description 2

Outside storage areas are where materials are stored for an extended period of time say for a month or several weeks or days. Importantly, material should not be stored next to the building as these can hamper the activities of the staging areas and close the normal access for easy movement of the material, cladding, scaffolding and the next material deliveries Care should be taken that the reliable store space showed in tube accepted by tools & planks. Some judgment must be applied for the separate storage for tools & planks. These should be clearly marked or distinguished separately from other similar materials e.g. when steel is being cut for reinforcement the remaining cutting bar should be separated as per the diameter as well as it length. This segregation helps when there is a need of a smaller piece and the required piece is readily available eliminating the need to cut a new bar .It is also easy for the foreman to identify the reusable material, and hence wastage can be reduced on site.

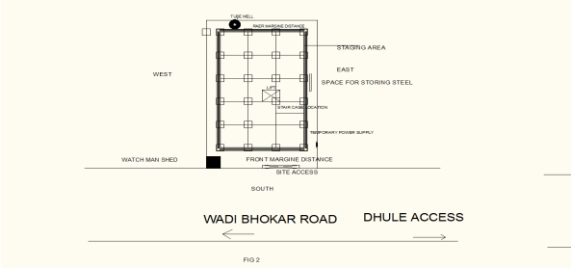
Photo No.2 shows very poor storage practices. The labor productivity of the steel reaction crew on this project was much worse than on comparable project and the cause was the material storage practices.

Material should be stored in such a manner that will allow access by lifting and transportation equipments such as fork-lifts. This is clearly not possible in the project as seen in ***photo No. 3.***

The performance on both projects relatively to time and cost was below average with cost over runs poor.

VI. STAGING AREA

This is the area immediately near or adjacent to the building. The area is shown by hatched / dotted line. This area is needed for many different activities, functions in aiding in site operations e.g. planning, painting, cladding, fixing windows plumbing, etc. It is also needed to assure easy access for deliveries of equipments and materials and for waste removal. The material stored in this area are more likely to undergo double handling of material which might cause damage & optimally more wastage takes place, if not handled properly.



Generally for small sites care should be taken in stocking material. If not the work face area can become cluttered with excessive material and waste, which also spoils the healthy, productive working environment as the tendency of the laborers is to be wasteful. Clean the site periodically by collecting unpacking, cutting and reshaping material. This should be limited in workface area. Also assign these sub-operations to other locations which can be interior as well as outside.

Housekeeping is an important function that should be given close attention. Poor housekeeping tends to check indented productivity.

VII. CONCLUSION

This paper has attempted to bring out systematically all the problems encountered in site material management on the site and to ensure that there is a smooth co-ordination amongst site factors of production and lay out site space use for material management for a well co-ordinate and timely execution of project and minimizing project costs at the same time by heuristic principles learnt after years of on-site experience. However, a mathematical algorithm should be attempted in the future after testing out algorithms over a number of site sizes.

VIII. CASE STUDY DESCRIPTION

The case study project is a three storied gyanack hospital building at wadi bhokar raod,deopur ,dhule .The structure frame of the building is R.C.C and parking at ground floor level the site area is 15m x 25m and the 1st floor plan area is 15.5 x 25.5 (395.25m^2) the project estimated cost is about Rs. 50,00,000 and the planned construction schedule was 18 months.

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