

Improvement of Manpower and Equipment Productivity in Indian Construction Projects

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Abstract

Major Construction Projects are completed by huge input of manpower and equipment resources. Successful completion of these projects depends on efficient utilization of these resources. The profitability and effectiveness of the project are the outcome of better management and control of the manpower and equipment resources. Monitoring and maintaining the productivity of manpower and equipment resources in line with the standards determined is a challenge for the top management of the project and it makes or breaks the project. Better productivity management will produce significant improvement in meeting the predetermined targets of the project. Better productivity management includes measuring the actual productivity, comparing with bench marks, identifying the factors affecting the productivity and implementing management tools for improving and increasing the productivity. Productivity Management has to be followed in every level with push from the top level of the project. Productivity hence is a driving force in a construction project.

Keywords: Resource, Productivity, Bench marks

1. INTRODUCTION

During the last few decades, the growth in Construction Industry is phenomenal. The Government is concentrating in the development of Infrastructure by constructing roads, airports, sea ports and power plants such as Hydro-Electric plants, Thermal Plants and Nuclear Plants. The advent of Information Technology in the last decade and its massive growth has shrunk the globe. This growth of Information Technology has also prompted the requirement of buildings with hi tech facilities for the Engineers and hence Construction of Software parks and allied buildings have also assumed importance. The growth rate sustained by the Government in the last decade has also enhanced the quality of life of the individual and thereby shopping malls, Educational institutions with modern teaching gadgets and Hospitals to accommodate sophisticated medical equipment are also being constructed across our country. The concept of Residential Buildings has undergone a sea change with individual houses paving way for multi storied apartments. The need for raw materials, cement etc has led to the construction of multi-dimensional factories.

The other important aspect of construction is that the duration of the projects has also reduced significantly. All the above stated construction is carried out in a project concept. A

project is a unique endeavor with a definite start and finish. Project is a specific activity on which money is spent (in form of resources ie men, materials and equipment) in the expectation of returns.

Most of the modern construction projects are multi-disciplinary and complex in nature; both in Technical and managerial point of view. Such projects require expert knowledge in various fields and require more attention to the construction process.

Construction projects involve huge input of resources which are primarily materials, manpower and machinery. While materials assume maximum importance (nearly 40% to 60%) of the project costs, more or less standardization of specifications and material quality can be obtained by scientific methods and relevant codes.

Manpower and Equipment being the other input account to nearly 30% to 40% of the project outlay. However the product of the input of Manpower and Equipment is still under the process of Standardization and study is still continuing both in the International and Domestic Domain.

It has been observed in the various literatures from all over the world that the productivity of workers has been a concern and is on the declining trend. This is due to the huge dip in the skills of the workers and their ability to learn physical work. Since the world is moving towards mechanization and more people are turning towards education about mechanization including Information Technology, the traditional skills such as carpentry, bar bending and mason skills are not popular.

Further the workers will also have to execute the works as per the quality and time stipulations and this should not be comprised on flimsy grounds. One has to put in all efforts to see that the requisite men and equipment are mobilized and deployed for timely completion of the job. If the work is completed in time to appropriate standards it will give a sense of satisfaction to all the parties and also contributes to the national economy. As explained earlier, the cost overruns and schedule slippages may have many reasons one of them being the lack of attention towards productivity.

This productivity management not only ensures timely completion and cost advantages to the project but also provides comfort to the investors, mitigate risks, and fix liabilities and responsibilities in the construction phase. It may be noted that in a construction project the bench mark productivity also needs to be adjusted to suit the conditions and complexity of the project. Major projects have many

complexities and coordination issues which have to be addressed as compared to smaller projects. Solutions to the problems particularly productivity in this major projects has also become more complex. So while dealing with complex and sophisticated major projects there can be shortages of the manpower and equipment which again affects productivity. If there are more resources, then there is underutilization, which in turn also affects the productivity.

This paper, aims at the study of Manpower and Equipment productivity in Major Projects carried out by direct observation in two major projects over a period of time. The factors affecting productivity are also observed simultaneously. The observed productivity is then compared with standards and the variance is summarized. The various factors resulting in variance in productivity are established and the financial impact on the project due to the variance in productivity is estimated. The improvement factors and management tools are recommended to achieve target productivity and thereby efficiency in project management.

BACKGROUND OF STUDIES

Randolph Thomas and Carmen Napolitan, (1995) studied quantitative effects of construction changes on labour productivity. They identified a 30% loss of efficiency when changes were being performed. Lower labour performance is strongly related to the presence of change work, disruptions and rework. They find the most significant types of disruption are the lack of materials and information and having to perform the work out- of sequence it resulted in a daily loss of efficiency in the range of 25%-50%.

Abdul Kadir et al (2005) found the factors affecting construction labour productivity for Malaysian residential projects. The five most important factors identified by them were: material shortage at site; non-payment to suppliers causing the stoppage of material delivery to site; change order by consultants; late issuance of construction drawing by consultants; and incapability of contractors' site management to organise site activities. On the other hand, the five most frequent factors were: material shortage at project site; non-payment to suppliers causing the stoppage of material delivery to site; late issuance of progress payment by the client to main contractor; lack of foreign and local workers in the market; and coordination problem between the main contractor and subcontractor.

William Ibbs (2005) examined impact of change's timing on labor productivity. They reported reaffirms that project change is disruptive and detrimental to labor productivity. Data from 162 construction projects were statistically analyzed and a series of three curves are presented in this paper, representing the impact that change has on the labor productivity for early, normal, and late timing situations. The projects are a representative sample of the industry, involving a wide range of sizes, different delivery systems, and industry sectors. Late change is more disruptive of project productivity than early change, all other things being equal. The implications and benefits of this research are clear: if changes are necessary, they should be recognized and incorporated as early as

possible. Practitioners can use these data and curves for either forward pricing or retrospective pricing of changes.

Adnan Enshassi et al (2007) identified factors affecting labour productivity in building projects in the Gaza strip. Productivity remains an intriguing subject and a dominant issue in the construction sector, promising cost savings and efficient usage of resources. Productivity is one of the most important issues in both developed and developing countries. The developed countries are aware of the importance of economic growth and social welfare. The developing countries which face unemployment problems, inflation and resource scarcity seek to utilise resources and in such a way to achieve economic growth and improve citizens' lives. Productivity is an issue of particular importance to projects located within the Gaza Strip, as it is considered a newly-developed area, and a huge number of projects have been planned for the near future. The aim of this research is to identify factors affecting labour productivity within building projects and to rank these factors according to their relative importance from a contractor's viewpoint. The analysis of 45 factors considered in a survey indicates that the main factors negatively affecting labour productivity are: material shortage, lack of labour experience, lack of labour surveillance, misunderstandings between labour and superintendent, and drawings and specification alteration during execution.

Frank D.K. Fugar and Adwoa B. Agyakwah-Baah (2010) studied delays in building construction projects in Ghana. The study sought the views of clients, consultants, and contractors on the relative importance of the factors that cause delays in building construction projects in Ghana. The study showed that all the three groups of respondents generally agreed that out of a total of 32 factors the top ten influencing factors in causing delay arranged in descending order of importance are delay in honouring certificates, underestimation of the costs of projects, underestimation of the complexity of projects, difficulty in accessing bank credit, poor supervision, underestimation of time for completion of projects by contractors, shortage of materials, poor professional management, fluctuation of prices/rising cost of materials and poor site management. 32 factors were categorised into nine major groups and were ranked. The results show that clients, consultants, and contractors all agreed that the financing group of delay factors was the most influential factor. Material factors were considered the second most important factor causing delay in construction projects followed by scheduling and controlling factors.

Serdar Durdyev and Jasper Mbachu (2011) examined on-site Labour Productivity of New Zealand site Labour Productivity of New Zealand construction industry. This study has prioritised the constraints based on their relative levels of impact. 56 sub-factors have been identified under 8 broad categories of internal and external constraints. Compared to the external factors, the internal constraints were found to contribute far more to the onsite labour productivity issues in the New Zealand construction industry. In the order of decreasing influence, the internal factors comprise project management, project finance, workforce, project characteristics and technology/ process. The key subcomponents under each of the five broad categories of the

internal constraints are rework; level of skills and experience of the workforce; adequacy of method of construction; buildability issues; and issues around coordination, supervision and performance monitoring and control; respectively. Under the three external constraint broad categories, the key subcomponents are compliance with the Resource Management Act 1991; ground conditions; and the boom-bust cycles, market conditions and level of competition in the industry; respectively. In addition to understanding the nature of the identified constraints, some mitigation measures have been discussed for addressing the key subcomponent under each broad constraint category. It is believed that by focusing on the relative levels of impact of the identified constraints, the project team could be guided well in their efforts to addressing the constraints in a cost-effective manner.

Mostafa E. Shehata and Khaled M. El-Gohary (2012) examined towards improving construction labor productivity and projects' performance. They analyzed proper management of resources in construction projects can yield substantial savings in time and cost. This study focused on labor productivity in definitions, aspects, measurements, factors affecting it, different techniques used for measuring it and modeling techniques. They provided a guide for necessary steps required to improve construction labor productivity and consequently, the project performance. It can help improve the overall performance of construction projects through the implementation of the concept of benchmarks. Also, it gives an up to date concept of loss of productivity measurement for construction productivity claims. Two major case studies are presented to show construction labor productivity rates, factors affecting construction labor productivity and how to improve it.

Farnad Nasirzadeh, and Pouya Nojedehi (2013) identified dynamic modeling of labor productivity in construction projects. They found labor with high productivity at each stage of a project's development plays a significant role in project success. They used complex inter-related structure of different factors affecting labor productivity is modeled using system dynamics approach. The qualitative model of labor productivity is constructed using governing cause and effect feedback loops. Then, the relationships that existed between different factors are determined and the quantitative model of the labor productivity is built. The labor productivity is simulated considering the effects of all the influencing factors. The effect of labor productivity on different project performance measures is also assessed in terms of time and cost. Using the proposed model, the project manager may find the root causes of a decrease in productivity. Therefore, the labor productivity may be improved by implementation of proper solutions.

Parviz Ghoddousi and Mohammad Reza Hosseini (2013) analysed a survey of the factors affecting the productivity of construction projects in Iran. The intense competition between the Iranian construction companies has led them to take all appropriate measures to decrease the costs as much as possible. Hence, due to the pivotal role of human resources in construction projects cost, a major part of Iranian construction companies seek their profitability and survival in maximizing

the productivity of their operatives. Because of the widespread belief among contractors about the low productivity of daily workers and operatives with basic salary, they commit a major part of their projects activities to sub-contractors. Deployment of sub-contractors by construction firms has become largely conventional in country's construction projects. The aims of this paper is defined as determining the factors and grounds affecting sub-contractors productivity and evaluate their overall negative side effects on project productivity via a structured questionnaire. A total of 31 factors selected and were divided into 7 broad categories. The perceptions of companies managers were asked about the level of effect brought about by the mentioned factors and groups upon productivity on a time based criterion. The analysis indicated that the most important grounds affecting sub-contractors productivity in descending order include: Materials/Tools, Construction technology and method, Planning, Supervision system, Reworks, Weather, and Jobsite condition. Project managers should focus on the identified major grounds and relevant factors in order to improve productivity as long as they commit construction activities to sub-contractors.

David Ngwoke Mbazor and Sunday Okuoma Okoh (2015) have Productivity Improvement in Construction Project Delivery. Productivity is a complex phenomenon at all levels be it individual, organised private sector or government the world over and in all spheres of human endeavour particularly in construction project delivery. Low productivity in the construction industry is as a result of diverse identifiable reasons such as; high reduction in skill level of construction workers, shift work, shortages of materials and equipment, change orders, labour shortages, weathers, low level of monitoring and control of projects etc. key factors that leads to productivity improvement in construction project delivery were analysed. These comprise of project planning, productivity measurement, avoidance of construction site congestion, motivation of workforce and good communication among others. It was therefore recommended that time management, application of project management tools like pert master, precedence diagram, research and development, provision of new equipment, plant and machinery to replace the old ones, simplifying the product variety, increasing the overall effectiveness of the workforce through motivation and paying attention to details of the current best practices in the industry will no doubt lead to productivity improvement in construction project delivery.

PRODUCTIVITY MEASUREMENT

The nature of the construction process points to a need for measures of construction productivity at three levels

1. Task Level
2. Project Level
3. Industry Level

Task level productivity of Equipment and manpower gives the direct efficiency for each and every task being performed at

any particular construction project and hence task productivity is the measure for gauging project efficiency. The following methods are used in arriving at task productivity

- a. RS Means Method
- b. CII Method
- c. Productivity Index Method

• RS Means Method

In this case, the denominator is the number of hours associated with a designated "crew day". Thus for a designated crew day higher output is better. In this case higher output equates to higher task labor productivity. In such cases RS Means provides estimates of output that is produced by a designated crew in a 8 hour day along with the equipment they use and these measures can be considered multi factor.

• CII Method

The CII Benchmarking and Metrics program uses a different metric to measure task labor productivity. CII fixes the output and measures the labor hours required to produce that output. In this method the denominator is a fixed output and the numerator is the number of labor hours. Thus for a given amount of output, lower labor hours is better which equates to high task productivity.

• Productivity Index Method

A task productivity index is a dimensionless number, pegged to a reference data set, where the reference data set establishes the base line value for one or more components of the index. For example the denominator could correspond to the baseline value for the task's labor productivity and the numerator could be the value for a specific project.

Project and Industry level productivity are measures of overall efficiency of a project and the industry itself and are macro level observations which require a separate set of detailing and analysis.

PRODUCTIVITY STUDY & ANALYSIS IN INDIAN PROJECTS

Before starting the productivity study in the projects, a clear cut plan has to be made on how to carry about the study in major projects. Major projects involve input of resources in various activities and in various quanta. Care should be taken to select those core activities which involve input of more resources and any change in productivity in these activities affect the project as a whole. Smaller activities not having much significance can be omitted. Usually the important activities in a major construction are 1. Reinforced Cement Concrete 2. Formwork 3. Reinforcement work 4. Blockwork / Brickwork 5. Plastering 6. Painting 7. Piling 8. Flooring 9. Waterproofing 10. Structural Steel Work 11. Excavation and 12. Backfilling.

The above 12 activities involve nearly 70% to 80% of the project expenditure. A core team has to be formed to measure the productivity in these twelve items for equipment and manpower. Usually a list of locations where the productivity study is to be made and quantity of work to be carried out in that location is ascertained beforehand. The amount of resources to be engaged in that particular activity should also be predetermined. It is also important to observe the factors affecting the productivity while making the productivity observation. The researcher should note down all the factors that affect the productivity of a particular activity in a proper way. It may be noted that there will be multiplicity of factors which may be affecting the productivity. The researcher should use all the skills to ascertain the multiple factors and their impact on the productivity on that activity. The researcher shall not alter the resources in between which may not be the correct data in the productivity study.

A good videography and photography also may help in ascertaining the factors influencing productivity in a project site. A time motion study can also be conducted for many activities. The data should be collected over a period of time (at least 15 days for each activity) to account for variations in form of teething issues, learning curve etc.

In this research the study has been conducted in two major projects – One an IT park of 21 Lacs sqft area being constructed by a leading Engineering Company for a software firm in the outskirts of India. The work force involved was to the extent of 2500 nos and all major equipment like tower crane, Batching plant, Transit mixers etc were involved. The second project is a residential building being constructed by the same Engineering firm which involves 14.5 Lacs sqft built up area consisting of 8 blocks of G+13 floors with a labour force of 1500 nos and all major equipment. All the twelve activities mentioned in progress in these projects.

RESULTS AND DISCUSSION

It is clear from the observation and analysis of the data for various important activities from major projects that the productivity of both workmen and equipment is to the tune of 70% to 80% of the Standard productivity is presented in figure 1. This difference in productivity or lack of productivity is due to the following factors.

• Manpower

1. Non Availability of Clear Work Front (39%)

This is one of the major factors affecting the productivity of manpower. It is usually observed that manpower is deputed to the work place where as the front is not ready for them to work directly. Till the time the front is cleared, the workers are made to stand idle or do some preparatory works which are of no need.

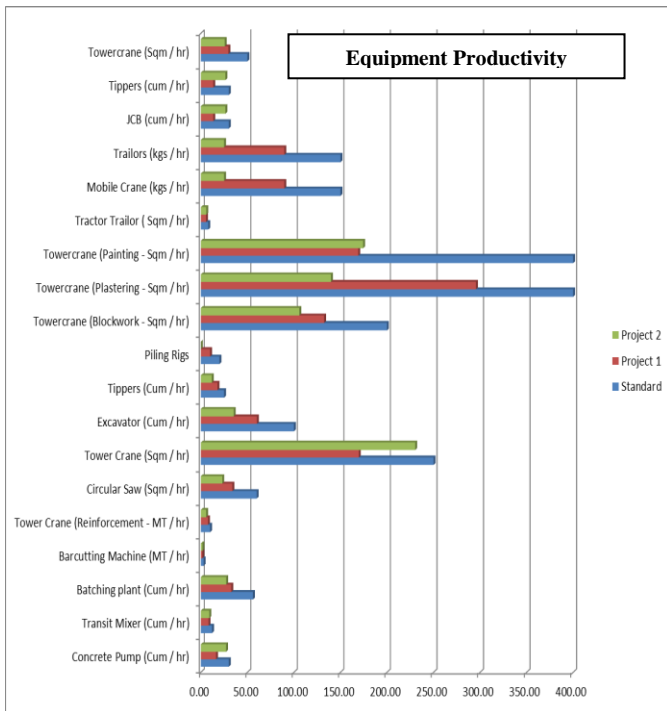
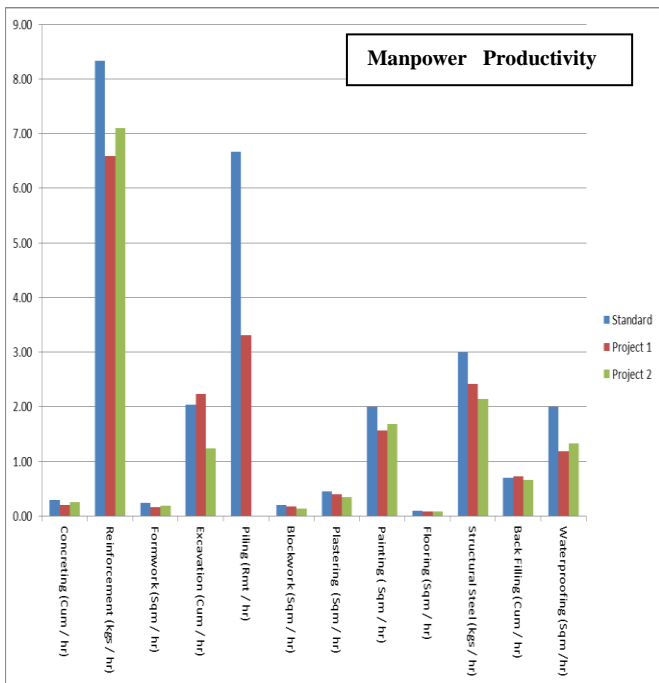


Figure 1: Labour and Manpower productivity

1. No proper Planning (17%)

For any successful work, there needs to be a proper plan in place. The lack of proper planning affects the productivity to a greater extent. Eg Concrete is requested from batching plant at 11AM whereas workers are called at 8.30 AM

2. Skill of the worker (17%)

The skill of the worker in executing the work with proper quality the first time and every time with the same accuracy plays a vital role in getting the work done with utmost

efficiency. Since modern day workers lack this skill, the productivity is affected abnormally.

3. No proper Supervision (15%)

Supervision is the important virtue of getting the work done in the proper speed, in the required quality and safely. It is observed that lack of supervision at crucial junctures has affected the productivity of workmen to the extent of 15% of the deficit.

4. Other factors such as Interfacing with different works (6%), Workers not interested (2%) and external factors like Climatic condition (2%) etc also affect the productivity of workmen to a major extent as per the observations.

• Equipment

1. Non availability of Work Front (28%)

As in manpower, this is the important factor affecting the productivity of equipment in construction projects. When an excavator is ready for starting excavation, it is observed that the live wires and pipe lines that are in that area are not cleared.

2. Coordination between Equipment (22%)

This is one important aspect affecting the productivity of equipment in a major construction project. Eg – Transit mixer with concrete loaded fully is waiting for pump to be placed in position and started. Excavator doing excavation but there is no tipper for hauling etc.

3. No proper planning and No proper supervision (34%)

As observed in manpower productivity, proper planning of the operations of the equipment and proper supervision to implement the plans provide the platform for increasing the productivity of equipment to a considerable extent.

4. Other factors like Interfacing of different works (6%), Skill of the operator(6%) and Climatic factors (4%) leading to less efficiency of using the equipment also affects the productivity of equipment to a greater extent.

MANAGEMENT TOOLS TO IMPROVE PRODUCTIVITY OF MANPOWER & EQUIPMENT

Productivity improvement is a management issue. If the productivity is more, the profits are more and less the problems. Management thinks of the following practices and tools to improve productivity of equipment and manpower

- Practice Productivity Management as any another aspect of the project (Planning, Safety, Quality etc.). When Management gives importance to productivity, there is control and desire for improvement right from top most person to the bottom most person and hence there is improvement of productivity.
- Incentives should be given to both staff members and workers for achieving increased productivity in their

work area. This can be extended to sub-contractors and supervisors also which highly motivates the team to achieve more productivity.

- A core team has to be formed to measure, monitor and improve productivity. The core team should consist of a mix of people from the top most managers to the bottom supervisor.
- The cost effect on the profit margins and the overall project objectives due to productivity or lack of productivity should be monitored on a real time basis. This information stands as the benchmark for improving productivity.
- Management should be in lookout for technological advances and implement them immediately which in turn increase the productivity.
- Idea generation workshops and soliciting opinions from the core team on improvement, implementing them and deriving benefits is one of the management practices to improve productivity.
- Analyzing data on past performances, competitor data analysis, considering productivity as one of the factors in vendor selection, reviewing productivity in top management meetings and consultation for productivity are some of the practices for productivity improvement.

CONCLUSIONS

Productivity is one of the important aspects of Project Management and it makes or breaks a project. Material productivity can be standardized to a greater extent. Manpower and Equipment productivity needs review at project level. Manpower and Equipment Productivity is in the decline all across the world particularly in Construction work. Task Level productivity in Construction projects has to be measured, analyzed and improved in every project. Better productivity management will produce significant improvement in meeting predetermined targets. The implication in project profits due to lack of manpower and equipment productivity in major construction projects is to the extent of 3% to 5% of the overall project value and hence needs to be constantly improved.

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