

# Applications of Management in Civil Engineering – An Overview with reference to Construction Projects

Dr.Udayashankar D.Hakari,

Associate Professor in Civil Engineering,

SDM College of Engineering and Technology (Autonomous Institute of VTU, Belagavi),

[Formerly Manager (Technical - Project Appraisals), Karnataka State Financial Corporation, Bengaluru]

DHARWAD- 580 002, Karnataka, India.

**Abstract**— The field of civil engineering is witnessing a tremendous growth in India and particularly more so in the past decade. Huge investment nearly to the extent of 50-60% of the planned budget is being made towards building infrastructure, which is essential for the sustenance and growth of economy. But however the construction industry yet needs to be developed on organized lines which are possible with the civil engineering professionals having managerial skill and knowledge. This paper is the result of study undertaken to highlight the applications of management concepts in the routine construction projects at its various phases of execution. It attempts to bring out the salient features of different forms of management as applied in the construction projects and tends to conclude attributing their success to the efficient management practices.

**Keywords**— *Management, Construction project, Civil engineering*

## I. INTRODUCTION

This Civil engineering being one of the oldest professions, has tremendous contribution to its credit for the growth and development of civilization since ancient times. Beginning with the simple tasks of construction of dwelling units, the field of civil engineering has now embarked upon the creation of manmade wonders including mega projects like construction of express ways, sky rise buildings, bridges, tunnels, dams, metro railways, airports, water supply so on and so forth. These projects involve large quantum of resources in the form of men, money, machines, materials and more importantly the time. This has led to the ever growing urge for the efficient and optimum use of these resources which calls for a better insight in the spatial and temporal patterns of resources and activities (Iyer and Jha, 2006). The parameters of civil engineering today are thus not only confined to the design and construction of structures, but are more concerned with the art of efficiently managing the resources used for the project execution and satisfactory competition. It is therefore necessary that considerable attention is required for the development of construction industry on scientific and organized lines; backed by management concepts (Kerzner, 2003). During past two decades, there has been substantial growth of budget, project and staff sizes, geographic areas etc. and these conditions have necessitated the demand for the civil engineers with managerial skills and expertise. The nature of large projects undertaken by the construction companies tend to transform a

civil engineer in to a project manager, who apart from the technical knowledge will then have to write proposals, make client presentations, negotiate contracts, hire staff and manage the resources at disposal – all leading to the successful execution of the project. The success of a construction enterprise thus largely depends upon a civil engineering manager having an equal blend of both technology and management (Turner, 1999).

This paper intends to present an over view of the importance of different domains of management relevant to the field of civil engineering and their applications in construction projects.

## II.CHARACTERISTICS OF CIVIL ENGINEERING PROJECTS AND CONSTRUCTION INDUSTRY

Globally the construction activity is observed becoming increasingly complex. Rapid improvement in design and technology have added new dimensions to the construction projects. Due to the steep escalation in the material cost and scarcity of some of essential materials, skilled and economic use of the same has become imperative. Inherent problems have been witnessed in adopting new techniques in construction. The need for better building practices, systematized work planning and effective management are hence self-evident. Unless the construction projects are managed by improved and most appropriate building techniques and management concepts, success in any project is difficult to ensure (Adnan et.al. 2009). This is because of the complexity and wide range of aspects that are associated with the project; both engineering and managerial; such as site investigation, market survey, bidding for the works, post tender negotiations and agreement, planning for the works, mode of construction and supervision, arranging the required finance, workforce, material, equipment, monitoring the progress of work till complete execution in the stipulated time and finally the realization of profits or benefits. Moreover each civil engineering project is normally unique in itself and a civil engineer needs to have the requisite capability and expertise in both the technical as well as managerial activities for enhancing his effectiveness for the success in project that has such a complex, variable and typical characteristics.

### III. OBJECTIVES AND FUNCTIONS OF MANAGEMENT

In its broad sense, management implies getting a task done. The basic role of management in civil engineering is to direct the efforts of others towards the optimum use of available resources. As classically defined by Henry Fayol, the management with reference to a construction project is the most important process in performing various jobs in the project such as planning, estimating, organizing, commanding, coordinating and controlling. Management of a project thus aims at facilitating the economical consumption of the available resources in the least possible time for successful completion of a project (Milorad, 1998).

#### Management functions

The basic functions of management viz. planning, scheduling, organizing, staffing, directing, controlling and coordinating are discussed in the following sections with particular reference to construction projects.

**Planning:** In a construction project it begins with the initiation of the process of selecting a particular method and the order of the work to be adopted for a project from all the possible ways and sequences in which it could be done. It essentially helps to minimize the project cost by optimum utilization of available resources. It reduces irrational approaches, duplication of works and internal conflicts. Planning encourages innovation and creativity among the engineers, thereby imparting competitive strength to the project. Fig.1 shows the variety of applications of planning in a construction project.

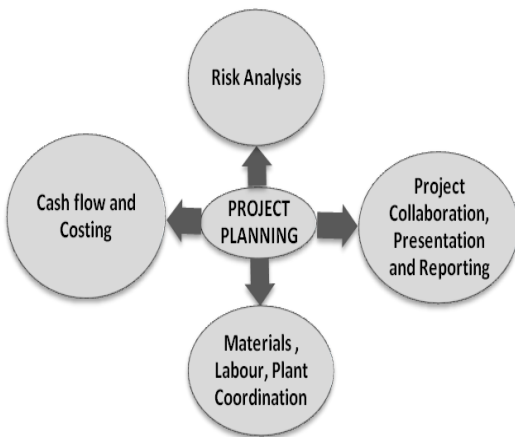


Fig.1 Pervasive applications of planning in a construction project

**Project scheduling:** It fits the final work plan to a desired time scale that shows the duration and order of various activities of the project. It is a vital tool in monitoring the project progress. Organizing a project means dividing the entire work into manageable units and managing the different operations by delegating specific tasks to individuals.

**Staffing, directing, controlling and coordinating:** While the staffing provides right people to perform the relevant tasks, the directing trains and supervises the work of subordinates thereby guiding their effort. The controlling facilitates a constant review of work plans to check progress and to

discover / rectify deviations if any through appropriate corrective measures. Finally the coordinating brings together the work of various sections of the projects.

The application of management concepts in a civil engineering project thus invariably lead to maximum production / output at least cost and completion of projects within the stipulated budget and time. The management principles provide to achieve the optimum utilization of resources, on time project execution with the much needed leadership and motivation to the project team.

### IV. FORMS OF MANAGEMENT PRACTICES IN CONSTRUCTION PROJECTS

As classically defined by Drucker, management is the 20<sup>th</sup> century story about success and is most realistic and acceptable in the present time as well. The story is continued in the 21<sup>st</sup> century and the management has taken the lead position in almost all arenas of modern life. Building being one of the most essential and creative activity, requires the applications of management for its success. In this process, the field of civil engineering, construction projects in particular, underwent various kinds of transformation with respect to technology, operations, resources, quality, safety, risk, environment, documentation etc. As a result the management was practiced in different forms in a project execution depending on the transformation needed for the project. Such various faces of management are discussed in the following sections with focus on their applicability and practice in the construction projects.

#### A. Technical Management

The nature and volume of the work, the time available for its completion and the sophistication required are a few major factors that decide the choice of type of technology to be adopted in any construction project. The major problem of selection of appropriate technology hinges round the optimum utilization of available resources apart from the maintenance of quality and minimization of cost; which are identified from the management decisions. Natural hazards may also be a cause for the increase in the project cost significantly by delaying or damaging the construction process.

The technical management thus essentially includes the cost and time estimations and prediction of natural hazards which may possibly take place at the project site. It also deals with ensuring and matching up the material standards to suit the project requirement and using them efficiently (Motwani,2001). It even associates in predicting various factors which may affect the cost, safety and completion time of the project. Technical management ensures efficient utilization of resources and construction personnel for various operations to accomplish the jobs.

#### Operations Management

The design and management of required tasks, services, supply chains and processes are incorporated in the operations management. It comprises of a wide range of decisions to be made by the project manager with regards to various aspects of a project such as design, capacity planning, forecasting,

process and technology selection, design of facilities, inventory, supply chain, quality and maintenance. The function of operations management thus ranges from strategic to operational and tactical level problems. The strategic problems may be with finalizing location and size of the project, deciding upon the infrastructure creation and ensuring the resource availability. Typical operational and tactical problems of the project may incorporate technology and material selection and work progress assurance (Sammerville, 1999).

**B. Resource Management**

Management of resources is one of the most strategic and essential exercise in any construction project. It is primarily concerned with efficiently organizing and allocating the project resources viz. men, material, money, machinery and time (Dho and Khaled, 2011). Fig.2 shows a typical resource wheel of a construction project.

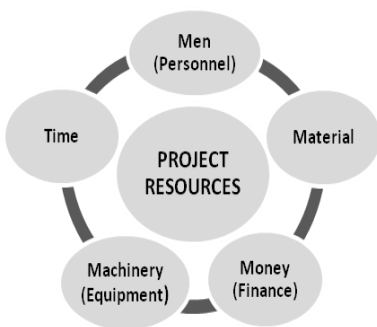


Fig.2 Resource wheel of a construction project

**C. Financial Management**

It provides an effective overall control of management in any kind of project facilitating better end results. This is more so with regards to construction projects which are rampant with variety of activities and ticklish problems. Finance being one of the most important resources and generally being in short supply, its proper and efficient utilization is of vital importance in a construction project (Augastin and Constanta, 2015).



Financial planning comprises of arrangement of required finance at the lowest possible cost and making its timely availability for the project. Visualization of the future financial scenario / difficulties forms an important base for the financial planning. Budgetary controls aim at ensuring proper utilization of the funds proposed to be invested for a project. They include cost accounting, profitability projections, break even analysis, profit/loss and cash flow statements and auditing. In view of large quantum of investments involved, an efficient financial system needs to be developed for tracking and managing the funds for successful completion of the project.

**D. Time Management**

The challenging phase of any construction project can surely be efficient and optimum use of time. Time management organizes the allotted time set for the completion of the task for the purpose of meeting or even beating the deadlines. It is in fact a strategy of organizing and implementing the course of actions within the time frame allocated to a particular activity in the project. It enhances the effectiveness, proficiency and productivity of the project (Hoffman, 2013). Time management entails a broad range of activities such as preparation, allocation, delegation, evaluation, supervision, scheduling and prioritizing of tasks of a project. Use of time management techniques can result in the timely completion of the project and can create a positive and impressive testimonial for the construction company. Time management is not just a tool used in construction project management but is like a key to achieve corporate profitability and success.

**E. Machinery Management**

With the advancement in technology and challenging construction projects, the mechanization of construction has become inevitable to meet the project demands. As a result huge capital investment is made in procuring various kinds of machinery and equipment such as earth moving/excavating equipment, material handling machinery, centering/shuttering/scaffolding equipment, compressors, boring equipment, crushers, batching/mixing plants etc. Buy, lease or rent of machinery forms the most important decision to be taken before proceeding with their management. High mechanization entails huge initial investment on the construction project which may be as high as 25-30% of the entire project cost as compared to that of mere 5-10% in case of conventional construction projects. However in the long run if the equipment or machinery are operated, maintained and managed efficiently it would prove to fetch satisfactory returns for the investment made. Owning cost, operating cost and depreciations are the three major cost factors to be considered while assessing the financial impact on the project on account of such investment. Fig.3 shows the typical cycle of events involved in the machinery management of a project.

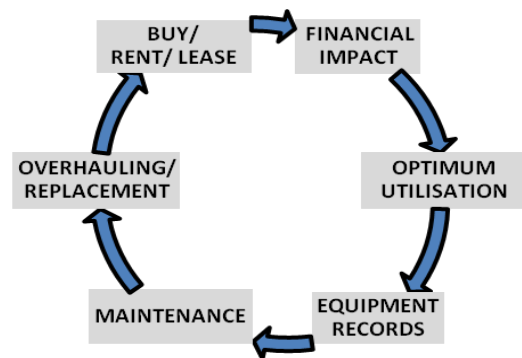


Fig.3 Cycle of machinery management

Once the equipment is acquired, it becomes important that the same is utilized to its full advantage and optimum capacity; as the idle equipment can not only add to the losses but as well is likely to be rendered unserviceable with the disuse (Prabhakar, 2002). Complete and accurate records of major equipment are necessary to have control and to meet accounting requirements.

Maintenance of plant and equipment ensures their perfect condition for use on the work at any time. Well-equipped field workshops become necessary for the purpose in case of remote project locations. The overhauling or replacement of the machinery and equipment largely depends on the judicious assessment of the construction project manager; which needs to be based on the evaluation of depreciation cost, resale value, maintenance cost, obsolescence and other related factors. The time of disposal of any equipment is equally important considering the interest of overall economics of the project.

**F. Material Management**

Depending on the type of project the construction materials account for nearly about 40-60% of the contract cost of the project. An effective material management can contribute substantially; not only towards the successful completion but also for widening the profit margins (Chandani, 2007). The material management of a construction project involves three major phases the salient features of which are highlighted at Fig.4 along with various courses of action in each phase.

project requirement. The prime objective of the HRM is to facilitate reaching pre-defined goals by satisfying, maintaining and managing the employees effectively (Kilby and McCabe, 2008). This can be achieved by having a clear personnel policy and service rules; which in turn inspires confidence among the employees of getting a fair deal from the project management. The chain of major functions and events of HRM can be depicted as shown at Fig.5.

The HRM in a construction project has to function primarily on the assumption that the employees, though a form of resource, are individuals with varying needs and goals and as such should not be treated as any other basic project resources such as money, machine or say material. The area does also need a positive view of workers assuming that practically they all wish and aim to contribute to the project productively. The human resource or personnel management in the construction industry is thus to be viewed in the context of the requirement of the job as also from the point of view of socio-economic needs and aspirations of the employees.

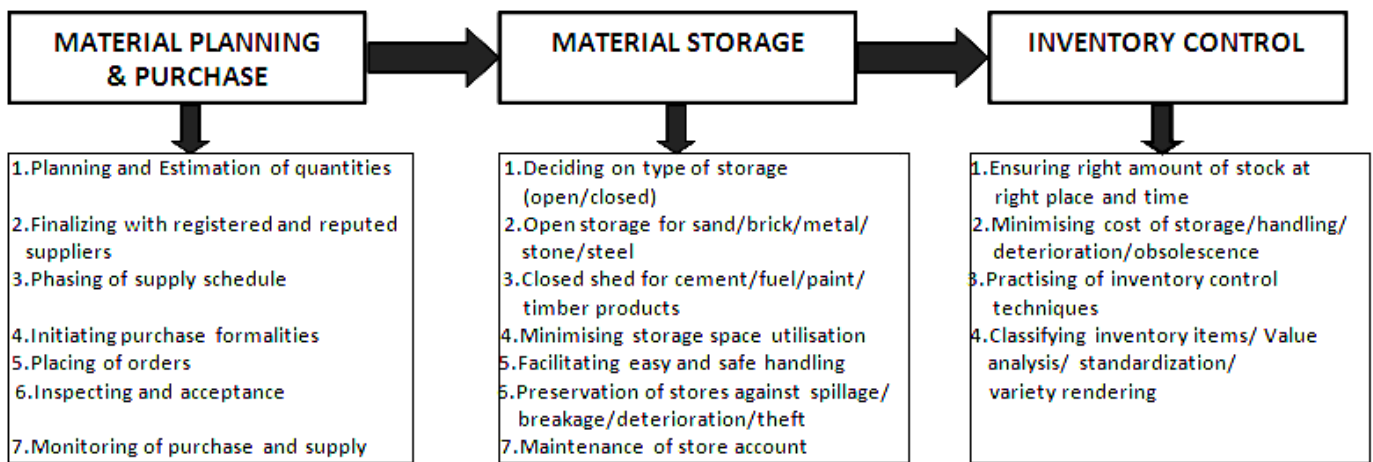


Fig.4 Major phases of material management in a construction project

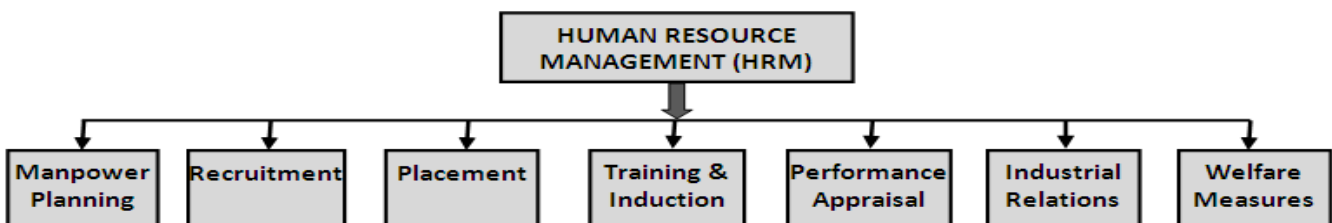


Fig.5 Functions of Human resource management (HRM)

**G. Human resource Management (HRM)**

Human resource or personnel management involves addressing various such issues of the project personnel right from their selection and placement to the performance appraisal, salary career management and training of the employees of the project. HRM thus deals with employing people, developing them as resource, utilizing, maintaining and compensating their services in tune with the task and

**H. Quality Management**

Quality means excellence and it provides the level of acceptability of any object or a task or a project in broader perspective. As such, if the maintenance of quality is one of the prime aspects of any activity then its management becomes still more important for the sustainability of reputation gained by the virtue of quality. Though the concept of quality management is commonly and extensively used



especially in the process and manufacturing industries, its application is as well becoming popular and also mandatory in construction industry in the recent times. Quality assurance and quality control are the two prime functions of quality management. While quality assurance is achieved by the use of appropriate and correct structural design specifications, proper materials and good workmanship; the quality control is exercised by the rational use of resources and procedural implementations.

The management of quality facilitates the construction company to remain viable by making it possible to meet two essential factors viz. client satisfaction and profit achievement. Quality management is achieved by adopting and applying the total quality management (TQM) process, a modern system that helps to assess the level of quality in a project/company and provides means to improve it if required (Motwani, 2001). TQM is one of the essential wings of project management with orientation on construction quality and is based on participation of all members focused towards long term success with customer satisfaction. There are numerous TQM models in use and every construction company can have its own model chosen on the basis of its needs and nature of activities.

#### *I. Health safety Management*

Management of health safety in a construction project is mainly concerned with deciding on the control methods to eliminate or reduce the impact of hazards at the project site or location. Hazards which cause risk to the health and safety of lives at site and which eventually lead to physical harm of work force; are due to the transfer of energy in one form or the other. They are created in the production process or at the construction project when the energy transformed is more than the withstanding capacity at the receiving end. The quantity of such energy at the tolerance level or threshold of human system or any other object or species requires to be determined in order to adopt any suitable control method for the project.

Health safety management decreases the chances of physical harm of employees by minimizing or if possible completely avoiding the hazards at site. A successful safety program can be developed by motivating and establishing communication with the people at all levels (Abdelhamid and Everett, 2000). An effective health safety management practice in a construction project facilitates to implement methods of safety program that may comprise of written circulars, reports, promotional activities, incentive or reward schemes and structural safety meetings at the work place level, where everyone including the contractors as well if they are part of work group at site can be involved. Enthusiastic participation of all staff in safety meeting should be regarded as long term objectives of the company and the conclusions/concerns arising out of such meetings should be documented for prompt and timely actions.

#### *J. Environmental Management*

Management of the environment surrounding any construction project site forms one of the major

responsibilities of civil engineers along with the planning and implementation of the target project. Environmental management as subjected to a construction project basically includes proper functioning of built environment systems like sewage systems, tunnels and water supply systems (Chen and Heng, 2006). Fundamental laws of nature like rule of gravity or the laws of thermodynamics, physics, chemistry, biology etc. play crucial roles in the design and maintenance of these built environment systems. The decisions regarding planning, design and maintenance of these systems should hence need to be on a strong basis of the basic laws and natural principles, so as to have a better and efficient management of the environment. This is particularly more so in case of urban development projects related to mass housing and industrial infrastructure wherein large quantities of water, energy, chemicals, supplies and disposable items are consumed; thereby generating lots of waste water and solid waste. Environmental management in any construction project thus encircles and involves all specialist professionals in the project for developing a systematic approach to find out practical ways to save water, energy, materials and reduce negative environmental impacts due to the project undertaken.

#### *K. Document Management*

The importance of documents of a project is beyond any deliberation and justification. The detailed project report(DPR), property documents, contract agreements, memorandum of understanding(MOU), Build-operate-transfer (BOT) agreements etc. are few to list the related documents of any construction project. The document management thus involves far more than simple data processing and file sharing. In fact it is concerned with the complete life cycle of a document as well as its content; right from its creation to the eventual storage and possible reuse and reference in future (Matheu, 2005). Well developed technologies offer electronic document management systems and various modern methods of security for preserving and controlling the documents of a project. An efficient document management can not only enhance productivity but also can increase security through a better control over document production and handling.

### V. CONCLUSIONS

In summary, the present study highlights the necessity and importance for civil engineering professionals to understand the management aspects and also the various modes of its application in construction projects. The paper offers scope for carrying out surveys and case studies for quantitative treatment of the topic.

Based on the study made and discussion presented here, following broad conclusions are drawn:

- i) The complex and diversified nature of construction projects invariably require the application of management principles for their efficiency and success.
- ii) The knowledge, expertise and skills of management techniques facilitate optimizing the use of massive resources invested in the project.
- iii) The various phases of the construction projects beginning right with planning till successful implementation pass through different facets of

management; with each phase being monitored and controlled by it.

iv) Construction projects /companies having civil engineers with managerial skills, knowledge and command can achieve accelerated growth with enhanced profit levels.

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