ABSTRACT

The present research work is an interdisciplinary study of Civil Engineering Construction and Business Management. When entire construction activity, is performed in an organised manner by applying principles of project management techniques, it would result in the highest possible efficiency. With this objective in mind, the present interdisciplinary research has been taken up.

The entire research work discusses technical as well as managerial features of under mentioned nine stages of construction activity.

1. Project Definition
2. Preliminary Planning
3. Hiring of Human Resource
4. Project Design and Development
5. Procurement of Material
6. Project Construction or Implementation
7. Project Completion
8. Project Commissioning
9. Winding Up or Divestment

After discussing techno-economic feature, an attempt has been made to optimise the construction activity at each and every stage.

On the basis of professional experience scholar has discovered that books and papers available in the present body of knowledge discuss only one aspect of the problem i.e. only technical or only managerial or commercial.

If we go through the books related with civil engineering design the word, “COST” is very much missing. In the books of structural optimisation, only optimisation of structural system is discussed that is too in mathematical terms, usually ignoring field conditions.

In books on operational research emphasis is on production part only. On examination of cost engineering and cost accounting books, one discovers that only commercial aspect has been discussed.

Scholar has discovered that not a single book covering technical as well as cost aspect of optimisation of civil engineering construction is available in the present stock of knowledge. In the present work scholar has tried to fill up this gap.
The present work is an aggregation of knowledge scattered in different books and journals. This aggregation of knowledge has been further reinforced with scholar's technical and managerial experience of construction practice and consultancy rendered in last twenty years. The data used in present work to support the study is secondary in nature to fulfill the following objectives.

1. To discover the area or various aspects of construction which affects costs and needs thorough investigation.
2. To discover total picture of construction industry in India.
3. To compile a document or a handbook which engineers, managers and layman also can use in reducing cost of construction.
4. To discover pitfalls in construction business and to discover causes for the failure of business.
5. Lastly, to present a philosophy or guidelines or model for those who want to earn maximum profit from construction business.

The cost optimization is a generalized concept. It has versatile application in all walks of life, involving cost. The application of cost optimization, in construction activity in India has been realized in recent years due to global competition in infrastructure development.

First chapter begins with the profile of construction industry. It points that construction industry is one of the oldest industries providing ample employment to the people from village level to metropolitan cities. The size of construction industry ranges from small company owned by one or two individuals to a large industry employing thousand of people.

In the present work inherent nature of construction industry has been discussed and concluded that it is infrastructure or capital formation industry, which directly and indirectly uses capital goods and all other types of resources.

It has been also highlighted that government agencies has direct interference in construction activity right from acquisition of land to commissioning of project and ways have been suggested to deal them.

To face the temporal variation of feast and famine state of business in construction industry, emphasis on systematized management has been suggested.

Like any other business, failure of construction companies is also very common. This issue has also been investigated. Incompetence, lack of experience, newness, smallness and financial handicap are the few reasons cited for such failures.
It has been concluded that lessons should be learnt from failures as success is never final and failure is never fatal. It is the courage of management that counts. At last it is not failure but low aim is a crime.

In second chapter, light has been thrown on the understanding of the inherent nature of construction project and project management technique specific to construction project has been highlighted. It has been pointed out that utility of construction project can not be assessed only on the basis of cost benefit ratio alone. It needs Social Cost Benefit Analysis (SCBA) approach for the rational evaluation of the project as it has become necessary for securing loans from international funding agencies like World Bank. At the end of the chapter, a list of project management software has also been given with comments.

Third chapter is devoted to concepts of cost. The concept of cost has been thoroughly discussed beyond the scope of direct material, direct labour, overheads and indirect cost.

The theoretical and practical implications, for all the stages of construction activity has been looked into, to reduce cost over runs by any means. It also discusses accuracy of estimate, performance indicators and variance. Once the phenomenon of cost is well understood, only then one can think of cost reduction. Finally it has been observed that estimate is an opinion, price is a policy and cost is a fact.

Theory of mathematical optimisation has also been given due place in the text because theory looks behind the curtain where human eye is unable to see. It has been concluded that physical interpretation of the optimisation result is necessary without which result is not of much use.

Fourth chapter is broadly based on literature survey. It discusses inherent nature of research in general, managerial research and research methodology in particular. It emphasises need and utility of managerial knowledge as industrial and business activity have achieved unprecedented growth in the second half of the 20th century. One of the reasons is, advances in information technology. The use of computer has changed the approach to manage the things. So large organization cannot be managed without knowledge. In the present work it has been suggested that acquisition of knowledge should be permanent feature for the managers of today but they should always remember that epistemology of management is approximate. A thorough literature review has been
given in the text to know what is available in the present stock of knowledge. Secondary data has been used in the present study.

In fifth chapter, need of cost consciousness at each and every stage of project; design, development and implementation has been emphasised.

Key human resource like architect, engineers and consultant play vital role in optimal design. This issue related with key design persons has been discussed in detail. It has been concluded that consultation fee of the consultants adds to sunk cost of the project yet it has to be reconciled as wrong decision at early stage will have multiplier effect.

Specifications need thorough analysis as over specification is a continuous hidden drain and under specification has disastrous effect. A thorough investigation of the issue has been done and it is recommended that specification should be most balanced, rational and appropriate.

Construction activity is basically a manufacturing activity. So it is recommended that principle of operational research should be applied as much as possible.

Implementation stage of the project is the most critical phase in the life cycle of the project. During this period, company suffers loss or earns profit. In this stage every day monitoring should be done to rectify deviations.

CPM is still most suitable network technique for the construction project. A list of project management software has been given. The manual handling of network is limited to small projects only. Big projects cannot be handled without computer but to have a feel of network analysis, user has to do few networks by hand computation.

Sixth chapter is about cost effective management of fixed assets i.e. land, building, equipment and machinery along with building economics.

Site selection and purchase of land is an important stage in life of an individual or company or country as sometimes it involves savings of entire life or big capital outlay.

Sometimes ecological and environmental awareness, social acceptability, complex legal processes and multiple plan reviews by various regulatory agencies, can reduce the efficiency of working team leading to delays in the start of the project.

To deal with such situation, a systematised approach has been suggested to simplify decision making process. This is necessary as a wrong decision at initial stage will affect continuing series of inter-related developments throughout the design process or in brief it will have multiplier effect.
Economics of planning directly affects the cost of the building. The square plan is the cheapest feasible plan. A detailed account has been given to optimise the cost of the building. Golden section approach has been suggested for the suitable plot sizes.

For the roof treatment *Mud Phaska*, has been in practice in India for last so many years. Scholar on the basis of his professional experience rejects this very technique and has suggested brick ballast with neat cement finish as the optimal solution of roof treatment. This theory is further discarded that presence of mud on the terrace reduces inside temperature of the building. It is also recommended that inside temperature should always be taken 2°C less than the outside temperature for designing the air conditioning system of the building.

Seventh chapter deals with various aspects of cost effective methods of purchasing of material or the materials management techniques needed for the construction project.

Purchasing of construction equipment is a critical decision as it involves huge sum of money and equipment depreciates quickly. Operating characteristics, engineering features, useful life, ease of maintenance and repair are few factors. which must be considered in selection of the brand of the equipment.

For accounting purposes it should be treated as non-current asset and its productivity should be judged by life cycle casting.

If a piece of used equipment can serve the purpose technically and on the analysis of pay back or return on investment reveals that a new machine happens to be not useful in terms of finances availability and economic use, then, it is a better buy than a new machine.

The present study concludes that groundwork is necessary in every purchase done. In Indian market, as there is no dearth of cheats and thugs in the market. This groundwork is necessary as radical changes are being done in equipments by taking the advantage of improved hydraulics, electronics, chip technology and computerised control systems. This makes decision making difficult.

In any construction, material cost ranges between 60 and 70 percent, of total construction cost. So materials management activity needs thorough investigation, firstly at technical level and secondly at managerial level, only then materials management activity can be optimised. Every rupee saved in purchasing is a new rupee of profit. Therefore, the group involved in procurement, distribution and logistics of material has
the responsibility to reduce the total material cost. Any cost control mechanism can work in totality only. Inefficient materials management is a direct loss, which cannot be discovered in cost accounting records of the firm.

In the parlance of everyday life quality means intrinsic excellence of material but in industrial use quality means suitability of material for specific purpose with lowest possible cost. Therefore, in industrial purchasing, quality comes first, price comes next or in other words quality determines the price.

Material is the lifeblood of construction. Right material should be procured at right time, in right quantity, at right place, at right price. In the field of construction, fixation of most appropriate quality for specific structure is really a difficult task as most of the materials are natural materials. So it has been suggested that relevant IS code should always be referred. It has been also concluded that all the properties of construction material cannot be quantified by immediate physical and chemical tests. The performance of such materials can be predicted by past experience and historical facts only.

Price of the material ordinarily depends on the market condition. Procurement of material at right price, which suits to both buyer and seller, is essential for the buyer company. The study reveals that evaluation of right price must be done in consonance of total circumstances surrounding a specific purchase at a specific point of time.

In construction industry materials manager operates in a sort of pure competitive market where forces of demand and supply alone govern the price. For bargaining, it is necessary to know margin of profit on a particular product, a seller earns.

The skill of price estimation is a science as well as an art. What is needed, a little wisdom and knowledge of different materials and processes and a knack of cost accounting.

In selecting a supplier, competitive pricing, reliable quality, timely delivery and good technical service should be the prime criteria. It has been suggested that company should always try to maintain a symbiotic relationship with supplier as it has real capital value, which is noticed during periods of short supply.

Too often buyers feel that consummating a contract with a carefully selected supplier ends their major responsibility but in case of construction material in India, scholar reports his experience that supplier should always be looked upon with suspicion, as suppliers are not much interested in maintaining a very long-term relationship. The
buyer should always search for new and better supplier and should always keep an alternate supplier in his pocket.

In present study, critical analysis of purchasing has been done and advice has been given to novice also. If the purchaser is novice then buyer can request to seller to submit a cost break up along with quotation at the time of negotiation. The simplest way to obtain such break up is inclusion of clause “quotations without cost break up will not be considered”. This is necessary to arrive at a price, which is reasonable and acceptable to both parties. A poorly equipped buyer in the field of cost concepts, hardly exploits price negotiation to its fullest potential. However, to pay higher profit margin for truly distinctive product is a good buying while paying higher profit margins for competitive product is a poor buying such precedents reflect a lack of fundamental purchasing analysis. After considering purchasing activity in totality, a buyer should try to purchase at prices as close as possible to the bottom of the estimated price range. Moreover, buyer should always explore possibility of various discounts.

In present study, due emphasis has been given on quality of raw material. Quality of raw material and performance of external suppliers have direct impact on the quality of product produced by the company. Conversion of raw material into a usable finished product involves, network of activities of different nature. A superb quality is possible when each activity is done in best possible manner.

Light has also been thrown on logistics of material. Physical inspection of material is needed to control the quality. In construction, inspection should be done while material is being unloaded because of weight and volume of the material, it becomes really trouble some to send back the defective material when delivered, in every purchasing contract, clause for delivery, return of defective material should be included. Penalties and deductions in payments should be explicitly written and told in advance in every purchasing contract.

Thus defective, unacceptable material should be detected as early as possible; otherwise supplier may misinterpret an order or a specification. At last frequently encountered ship shod or dishonest supplier may cut corners, jeopardizing the quality of construction. In all cases it is less costly to detect defective material at the initial stages rather than after its consumption.

It has been suggested that inspection of material should be done by methods of attributes. The supplier should be informed in advance about the procedure of inspection.
Buyer Company should always try for the reduction in inspection cost by suitable means as inspection cost adds to Sunk cost of the product.

A sound inventory management is necessary to reduce the investment in inventory. Inventory catalogue must be prepared with utmost care as inventory cost always encroaches profit. Today professional managerial skills are needed to control inventory, as sometimes inventory constitute 15 to 25 percent of its invested capital. Just In Time (JIT) manufacturing is the practice, basically developed for reducing production inventories. Therefore, it is suggested that prefabrication and JIT should be practised in construction activity too.

On Sundays and holidays one should avoid purchasing of building material in local market as on these days demands are more and prices are high. A keen observation and analysis of market condition are essential for good purchasing. This is the insight of purchaser which guides hand to mouth, forward and speculative buying.

Value analysis has also been discussed in the present work. Value analysis of product should be a regular feature of purchasing department. Value analysis always requires participation of persons from different background.

Purchasing department sometimes confronts with the problem of ‘Make or Buy’. Study concludes that, there is no straightforward rule exists for make or buy decision. Analysis of historical cost, review of present economic and labour considerations decide make or buy decisions with the sole objective of saving in cost.

Warehousing and store management or dumping of construction material at right place is essential for cost saving, safety and to have check on pilferage. An efficient store operation saves attendant cost in price, in paper work and in material handling. The specific responsibility of store’s function is to inspect, identify and receive the material only when found suitable. A capable person who can take decision should always supervise receiving operation. It is suggested that five minutes of inspection can save hours for rectification. Material received should always be placed at marked proper location and records should also be updated.

Eighth chapter is about cost optimisation of human resource management in construction industry. It discusses importance of labour economics and personnel management both for construction industry.
In construction activity also labour acts as a factor of production. The cost of labour in ordinary residential construction amounts to around 30 percent of cost of the building. Thus knowledge of labour economics is essential for the wage optimisation.

In present study it has been reported that, in construction industry, labour market has characteristics similar to competitive market.

Every construction manager faces labour shortage during harvesting period of April and May. It is obligatory upon him to schedule construction activity accordingly.

In present work advice has been given to construction manager that any deviation from minimum wage policy is direct violation of the law of the land. Money given in advance to any labourer and work being taken as repay, amounts to bonded labour which is an offence and cannot be ignored in the eyes of law.

Construction manager should not offer any opportunity for the activation of labour union and trade union.

It is further suggested that company should run incentive and welfare programmes to motivate the employees. Education, training and skill development should be the regular feature of the human resource maintenance.

What scholar has found that there is no readymade solution to tackle labour management conflict. It is the wisdom of manager who formulates the solution. Employees should be always treated as an asset not a liability. In dealing with the human resources one should not forget that man will not be happy just with bread and butter. Studies have shown that beyond a certain point productivity depends only on people.

In Indian context influence of behavioural feeling, emotions, empathetic perceptions, impressions have greater influence over people than anything else.

In present study it has been said that HR policy of the company should attempt to make a balance between boss and sub-ordinate relationship. Healthy uniform, transparent policies should be rendered at all levels of organisation for higher productivity and growth of the organisation to meet the challenges of 21st century. HRM strategies have to focus on better individual organization interface and greater emphasis on organizational effectiveness rather than on personal success.

The head of the business organisation must check that people in the organization are the right men for right job.

HRP should act as interface between a large range of external organizational factors and specific personnel policy. A company should try for symbiotic relationship
with employees rather than a commercial relationship. Need forecasting for human resource is an important part of HRP, as training of personnel has substantial cost.

Assessment of performance should be done on specific job rather than overall personality. Right talent is always in short supply. Therefore individual career development should be given greater importance. Full utilization and retention of talent should be preferred over external recruitment. It is suggested that HRP should develop every individual talent to its full potential and should arrange opportunities in which he fits best. However prospects of individual career development, largely rests with the employee himself. Companies must learn to manage employees career especially of managers of high expectations, on the other hand companies should offer voluntary retirement schemes for employees facing retirement or desirous of career change.

It is also emphasised that today the most fragile, living and critical asset in business enterprises is the human resource. This is the quality of human resource, which differentiates between a profit making and loss giving company.

The role of human resource is to help management in optimising the use of material resources. Therefore, presence of right people, at right place, at right time is necessary to obviate the failures of company’s strategic plan. Therefore, a continuous monitoring of human resource is necessary.

The issue of surplus manpower in organization has also been addressed. This problem is much more serious than the future manpower planning. This problem should be tackled very cautiously. The solution to such problem is redeployment in the form of transfer or long-term orientation or training or retrenchment or attrition. Every care should be taken to avoid industrial disputes and distaste, such situations are not desirable for business activity at all.

A good human resource management is essential for the success of project. A project should not be considered only as a technical entity. But study reveals that human side of the construction project has not received due weightage. It is unfortunate that Human Resource Management in the context of construction project is still very elementary in India.

Ninth chapter is about cost optimisation in maintenance and upkeep. Today because of complexity of equipment, material and the cost involved, in the maintenance activity has received paramount importance in pursuit of increasing economic life or reducing life cycle cost of capital equipments.
Maintenance practice has two orientations: one is managerial, which is concerned with the cost of maintenance and cost of loss in production caused by poorly or ill-maintained machines.

It is pointed out in the present study that preventive maintenance is a cheap insurance for breakdown maintenance as well as a time and cost-saving method for corrective maintenance also.

Proper lubrication of mechanical equipment is a must to avoid wear and tear of the parts. This should be the duty of the maintenance group to provide information to operators on specification and the doses of lubricants and explain the procedures and practices of lubrication and the inspection.

Scholar realizes that the fixation of size of maintenance crews is also a matter of concern. To have a realistic estimate, the amount for maintenance should be taken as a certain percentage of investment in machinery. The annual cost of maintenance may range between 3 and 5 percent of investment in tools, plants, and machinery. However, maintenance cost of a building may run between 3 and 8 percent depending on type, size, and use of the building. The labor cost may alone vary between 30 and 50 percent of total maintenance cost. It is suggested that a sinking fund should be generated for maintenance of buildings, etc.

Scholar has suggested that on smaller projects a few maintenance men who are jack-of-all-trades can be appointed without any problem. While in larger projects, separate shops may be set up for each craft.

Supervision is also an important part of the maintenance programme. It is obligatory upon the supervisors to train the craftsmen to save time for fixture planning and to improve the efficiency of the maintenance shop.

The scholar's experience is that the competence of the foreman and craftsmen plays an important role in achieving the objective of low cost and high productivity at all levels of maintenance.

Diversified experience and competence should be the main criteria for the selection of foreman and craftsmen. In scholar's opinion, the foremost quality to be judged in any candidate is 'the desire to learn, attitude towards cost consciousness and acceptability to new ideas.

Effectiveness of preventive maintenance can be judged by counting the number of breakdowns. Preventive maintenance gives many returns if the programme is run properly.
To make preventive maintenance programme a success: it is necessary to inculcate the value “preventive maintenance is the duty of every body”.

Scholar feels that in technical jobs, field training is more important than merely educating the people. So maintenance inspectors should be thoroughly trained about the parts, which are to be inspected during inspection and decide, what to inspect, when to inspect and how to inspect. Sometimes it has been observed that craftsmen who regularly maintain the equipment are, many a times better inspectors than the manufacturers. Service manuals received from the manufacturers must always be referred to, critical parts must be noted down and purchased along with purchase of new equipment.

A checklist should be prepared. Preventive maintenance manager must make sure that no item needing inspection is omitted. But at the same time he must be careful that inspection costs do not get inflated through needless checks and tests. Checklist should be revised on the basis of experience gained. Too much unscheduled work means, lack of preventive maintenance.

The frequency of inspection depends on amount of costs and saving from a preventive maintenance programme. Over inspection is expensive and under inspection leads to more breakdowns and quicker replacement. In this situation it has been suggested that only experience can give an optimal solution to preventive maintenance programme.

In spite of all complexities preventive maintenance remains an affective tool of maintenance management. Experience and development of new procedures make preventive maintenance administration easier. The executive, administering preventive maintenance must be technically skilled to highest level and should be a good manager as well.

The research work ends by suggesting following optimised model of construction company.
SIZE AND SPECIALITY OF THE COMPANY

SEARCH FOR OPPORTUNITY

OPPORTUNITIES AVAILABLE

OFFERED

OPTIMIZED SERVICES AND/OR PRODUCT

GOT THE CONTRACT

OPTIMAL PROJECT MANAGEMENT STRATEGY FINALISED

MANAGED

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<th>CAPITAL ARRANGED</th>
<th>HUMAN RESOURCE ACQUIRED</th>
<th>MATERIAL PROCURED</th>
<th>MACHINERY AND EQUIPMENT ARRANGED</th>
<th>CASH FLOW PATTERN PREPARED</th>
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MONITORED THE PROJECT PROFESSIONALLY

PROFIT

NAME IN TOP RICHES OF THE WORLD

OPTIMIZED MODEL OF CONSTRUCTION COMPANY
The study has been confined to workable limits as there are several issues like cost optimisation in paints or a discussion on the long list of materials used in construction could also not be incorporated due to the increasing volume of the thesis. The present study also has few limitations like:

1. The entire research work was to be completed in the stipulated time.
2. A thorough coverage on the working of major construction companies operating in India could not be incorporated due to inhospitable site location and lack of personal conveyance.
3. The scholar was always hard pressed for the finances, which was the primary requirement for such study.
4. The present study is based on the scholar's experience. So personal bias is always there.

At the end of the thesis, few possibilities of further research and advancement of the study has been given as under:

Like any other research work, present work, in spite of its limitations, has scope for further research and advancement of the study. Few possibilities are as under:

1. A management information system specific to construction industries in Indian context can be developed.
2. A document can be prepared on dealings with government agencies in construction contract in India.
3. SCBA packages for specific project in Indian context can be made.
4. There is a dire need of preparation of simple optimisation packages for cost optimisation in construction project.
5. A comparative study of schedule of rate and analysis of rate of various states and departments can be done to ascertain degree of accuracy with actual field data.
6. A document giving recommendation on optimal design of individual structural member and structural system can be prepared.
7. A detailed CPM network based on realistic field data specific to particular construction project like housing, bridges for India can be prepared.
8. A study on financial management in major construction companies in India can be done.
9. A document dealing in real estate management in India can be prepared covering all the aspects of real estate.
10. A document/software giving optimal plans for various types of building can be prepared.
11. A manual dealing with finance, selection, purchase, rental quandary, and maintenance of construction equipment based on life cycle costing can be prepared for heavy construction equipment.
12. A handbook covering all aspects of materials management of construction material in India can be written.
13. A study on labour economics of construction worker in India can be done.
14. A study on the productivity of construction workers in India can be done.
15. A study of strategic human resource management in construction companies of India can be undertaken.
16. Safety measures during execution of project always increase construction cost. This opens a new portal for optimisation of safety practices in construction projects. A manual can be prepared.