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Minimizing the Cost of Construction Materials through Optimization Techniques

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Abstract: *In construction industry the aim of project is to control the cost of the men, material and machineries and finish it on time, within the estimated budget. Reduction in cost of construction is a constant goal for construction industry.In this project we have performed the quantification of the structural elements with regard to dimensional and material properties in order to work out the cost per unit item for various design combinations.This project covers the optimization of design combinations to achieve satisfactory results for economical construction.*

Keywords: *Cost Optimization,Structural element,Economic Construction*.

I. Introduction

In the construction project, time and cost are the most important factors to be considered in the planning of every project. The aim of project is to finish the projects on time, within budget and to achieve other project objectives [2].

The result accomplished from the survey revealed that the major cause for time overruns are contract modification, material market rate, and high level of quality requirement and the major cause for cost overruns are , change in material specification, high transportation cost, and escalation of materials price[10].

Material has a dominating role in construction. If the material has controlled properly then the total project cost would be reduced. To achieve this objective, a research methodology has developed by author to control the material procurement and carrying cost[5].

In many construction projects, project managers and contractors find difficulties like poor planning of project, poor material, labour shortages, increased cost of material, delays in deliveries, wastage of material, over budgeting, unexpected weather changes, lapse in management and control, loss of material, poor communication etc. This results into cost and time overruns, conflicts in project. So there is need to study costs included in projects and to identify cost reduction or cost control techniques for carrying construction projects effectively. Reduction of cost of construction is a constant goal for construction industry. One way of reducing construction cost is to develop innovative technologies as well as methodologies to increase productivity. Due to cost reduction techniques cost of project is managed so that contractor does not suffer losses while carrying different activities of projects.

The cost optimization is a process that should be carried out throughout the construction period to ensure that the cost of the building is kept within the estimated cost limits. The cost optimization can divide into two major areas; the optimization of cost during design stages and the optimizing the cost by the contractors once the construction of project has started. Cost optimization of a project involves the collecting and measuring the cost record of a project and the work progress. It also includes the comparison of actual progress of project cost with the estimated. The main objective of cost optimization of a project is to gain the maximum profit within the design period and with satisfactory quality of work.

II. Construction Cost

The estimated cost for a contract to carry out the work is known as theconstruction cost and is composed of the direct cost of carrying out the work and the indirect cost. The construction cost then forms thebasis for determining the net cost for the contract. Cost is considered to be a commonparameter of resources expenditure on a project. In other words, the application and useof money, man, and machines, material and time for the performance of the variousactivities are allrelated to these common measures of cost.Net cost is the sum of two separate costs:

a) The Direct cost: Direct costs are those expenses which are directly chargeable and canbe identified specifically according with the activities of the project. They represent thecosts of the resources used by activities, such as the materials installed, labour, andsubcontractors.

b) The Indirect cost: Indirect costs (site overhead or on costs) are those that are not specifically identified but, they are being associated with a particular work item. Theyinclude site management and supervision, offices, canteen, storage sheds, cars and othertransport temporary roads and services, and general labour not assigned to production.

III. Factors Affecting Construction Cost

There are many factors which affect the construction cost estimate and have significant impact on project cost and they are as following:

1) Similar Construction Projects: For the construction estimate, the best reference will be similar construction projects. The final cost of those similar projects can give the idea for the new construction project cost calculation. The final cost of past project needs to be factored with current construction cost indices.

2) Construction Material Costs: Construction material cost consists of material cost, shipping charges and taxes applicable if any. So, it is important consider all these variations while calculating construction material cost.

3) Labor Wage Rates: Labor wages varies place to place. So, local wage rate should be considered in calculation. If the project has to be started after several months of estimating the project cost, the probable variation in wage rates has to be considered in the calculation.

4) Construction Site Conditions: Project site conditions can increase construction costs. Site conditions such as poor soil conditions, wetlands, contaminated materials, conflicting utilities (buried pipe, cables, overhead lines, etc.), environmentally sensitivity area, ground water, river or stream crossings, heavy traffic, buried storage tanks, archaeological sites, endangered species habitat and similar existing conditions etc. can increase the project cost during construction phase if these variations are not considered during estimation.

5) Inflation Factor: A construction project can continue for years before completion. During the construction period, the cost of materials, tools, labors, equipments etc. may vary from time to time. This variation in the prices should be considered during cost estimation process.

6) Project Schedule: Duration of construction project is affects the cost. Increase in project duration can increase the construction project cost due to increase in indirect costs, while reduction in construction cost also increases the project cost due to increase in direct costs. Therefore, construction project schedules also need to be considered during project cost estimation.

7) Quality of Plans & Specifications: A good quality construction plans and specifications reduces the construction time by proper execution at site without delay. Any vague wording or poorly drawn plan not only causes confusion, but places doubt in the contractor's mind which generally results in a higher construction cost.

8) Reputation of Engineer: Smooth running of construction is vital for project to complete in time. The cost of projects will be higher with sound construction professional reputation. If a contractor is comfortable working with a particular engineer, or engineering firm, the project runs smoother and therefore is more cost-effective.

9) Regulatory Requirements: Approvals from regulatory agencies can sometimes be costly. These costs also need to be considered during cost estimate.

10) Insurance Requirements: Cost estimation for construction projects should also need to consider costs of insurance for various tools, equipments, construction workers etc. General insurance requirements, such as performance bond, payment bond and contractors general liability are normal costs of construction projects. In some special projects, there can be additional requirements which may have additional costs.

11) Size and Type of Construction Project: For a large construction project, there can be high demand for workforce. For such a requirements, local workmen may not be sufficient and workmen from different regions need be called. These may incur extra costs such projects and also for the type of construction project where specialized workforce is required.

12) Location of Construction: When a location of construction project is far away from available resources, it increases the project cost. Cost of transportation for workmen, equipments, materials, tools etc. increases with distance and adds to the project cost.

13) Engineering Review: Sometimes it is necessary to carry out technical review of construction project to make sure the project will serve the required purpose with optimum operational and maintenance cost. This review cost shall also be added to the project cost.

IV. Cost Reduction Techniques

So, there are various cost effective techniques of construction. Lots of them are also energy efficient and easily adoptable. Since India is a developing country, the economy haves importance

There is a need for the adoption of strong, durable, environment friendly, ecologically appropriate, energy efficient and yet cost effective materials and appropriate technologies in construction.

In construction project reduction in cost can be achieved by some of the following techniques
a) Value Engineering
b) Material Management
c) Budgetary Control
d) Cost optimization Techniques
e) Cost Reduction Techniques at site

A) VALUE ENGINEERING

Value engineering is a systematic application of recognized techniques which identify the functions of the product or service, establish the worth of those functions, and provide the necessary functions to meet the required performance at the lowest overall cost. Application of Value Engineering(VE) to construction projects is a solution which emphasis the function of project which helps to team to make final choice and which results in cost effective design for project.

B) MATERIAL MANAGEMENT

To manage productivity and cost efficiency material management is essential. It contributes the major portion of expenses in construction projects. Controlling procurement, carrying cost can reduce total project cost and complete the project in a fast track method. ABC (Always Better Control) is the tool to identify those materials. By resource leveling, smoothing usage can be brought to optimum refined level so that much storage cost can be eliminated. Economic Order Quantity (EOQ) is arrived, then sensitivity of material is checked using what –if analysis. Then effect of project is checked to find optimum solution. This optimizes total project cost.

C) BUDGETARY CONTROL

For cost control on a project, the construction plan and the associated cash flow estimates can provide the baseline reference for subsequent project monitoring and control. For schedules, progress on individual activities and the achievement of milestone completions can be compared with the project schedule to monitor the progress of activities. Contract and job specifications provide the criteria by which to assess and assure the required quality of construction. The final or detailed cost estimate provides a baseline for the assessment of financial performance during the project. To the extent that costs are within the detailed cost estimate, then the project is thought to be under financial control. Overruns in particular cost categories signal the possibility of problems and give an indication of exactly what problems are being encountered. Expense oriented construction planning and control focuses upon the categories included in the final cost estimation. For control and monitoring purposes, the original detailed cost estimate is typically converted to a project budget, and the project budget is used subsequently as a guide for management. Specific items in the detailed cost estimate become job cost elements. Expenses incurred during the course of a project are recorded in specific job cost accounts to be compared with the original cost estimates in each category. Thus, individual job cost accounts generally represent the basic unit for cost control. The PERT and CPM techniques bar chart, Gantt chart relate to time and shows how to accelerate the project for the lowest possible cost.

D) COST OPTIMIZATION TECHNIQUES

In design, construction, and maintenance of any engineering system engineers have to take many technological and managerial decisions at several stages. So ultimate goal is to minimize the effort or to maximize desired benefit. Various mathematical programming techniques are used for optimization of construction cost of project. Some of them are non linear programming, dynamic programming, integer programming, stochastic programming etc

E) COST REDUCTION TECHNIQUES AT SITE

Contractor uses schedule to monitor the progress of the work which is related to cost. Inspection of work is done and comparison with budget is made. Meetings held to review the progress of work provides motivation to all workers and stake holders to improve their performance. Documentation of all activities or record keeping is important to enable detection of deviation from the set standards. Clients, consultants and the contractors use monitoring tools of budget, schedule and feedback to keep watch on cost performance. Quantification of work and comparing cost with bill quantities helps to evaluate the work and to check the progress of work.

COST OPTIMIZATION CONCEPT:

"The cost optimization is a process that should be carried out throughout the construction period to ensure that the cost of the building is kept within the estimated cost limits". In the construction field, time

saving can also be transformed into some kind of opportunity such as bonus of early completion or saving in overhead. Therefore,the lowest tender price may not be the only criterion for project success and thus concurrent optimization in both time and cost is highly encouraged and desirable.

V. Methodology

- Find out the dimension of structural elements
- Find out the material properties of structural elements
- Cost workout for various design combinations
- Select the optimum design combination.

DIMENSION OF STRUCTURAL ELEMENT:

COLUMN:

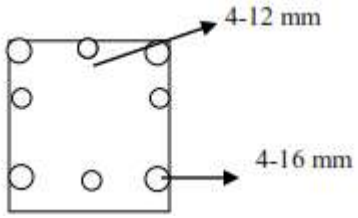

Fig 1 cross section of column

Size of column : 300 mm x 300 mm
Height of column : 4000 mm
Number of columns : 80
Volume of steel bars required for total columns : 0.4021 cubic meter.
Volume of concrete required for total columns : 28.32 cubic meter.

BEAM

BEAM:

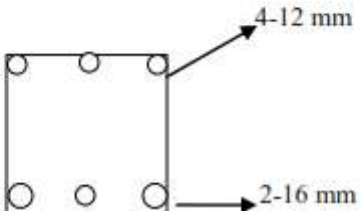

Fig 2: cross section on beam

Size of beam : 300 mm x 230 mm
Length of beam : 5000 mm
Number of beams : 124
Volume of steel bars required for total beams : 0.529 cubic meter.
Volume of concrete bars required for total beams : 42.16 cubic meter.
Total quantity of steel : 0.931 cubic meter = 7.448 tons.
Total quantity of concrete : 70.48 cubic meter.

Table 1: Cost of Steel and Concrete per Unit.

Specification	Cost
M 20	Rs.4420/cubic meter
M 25	Rs.4450/cubic meter
M 30	Rs.4700/cubic meter
Fe 415	Rs.42250/ton
Fe 500	Rs.46360/ton
Fe 550	Rs.47544/ton

Table2:Various Design Combinations

SL.NO	Various Design Combinations	Cost of steel	Cost of concrete	Total
1	M 20 , Fe 415	314678	311521	626199
2	M 20 , Fe 500	345289	311521	656810
3	M 20 , Fe 550	354107	311521	665629
4	M 25, Fe 415	314678	313636	628314
5	M 25, Fe 500	345289	313636	658925
6	M 25, Fe 550	354107	313636	667743
7	M 30, Fe 415	314678	331256	645934
8	M 30, Fe 500	345289	331256	676545
9	M 30, Fe 550	354107	331256	685363

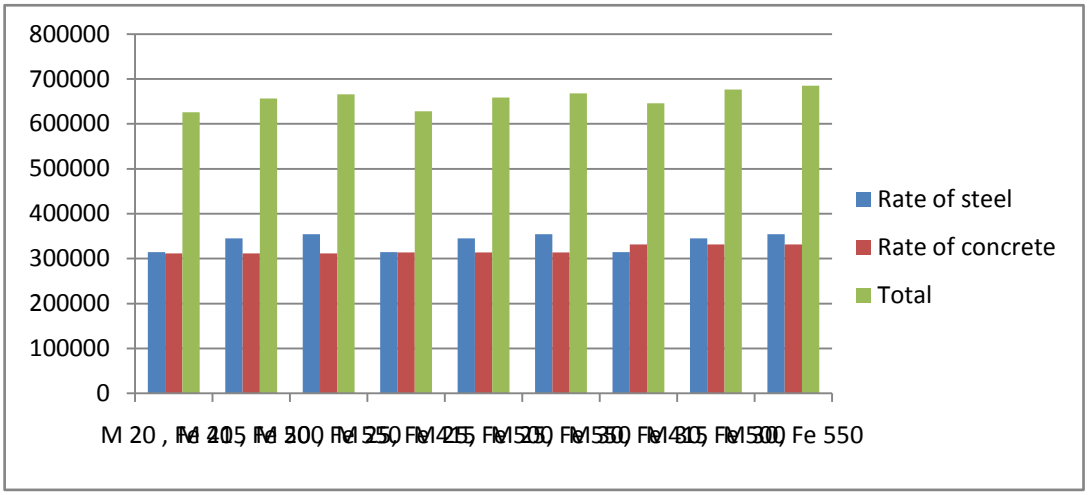

Fig 3: Graph of Cost of Various Design Combinations:

VI. Result

From the above graph can arrive the cost of various combination of structural element .By this way we can choose the optimum design combination.

- Above procedure is useful to selection of optimization design combination based on the cost.
- To recommending the optimized design for construction.
- The optimum design combination is M 20,Fe 415.

VII. Conclusion

The optimization technique is used to select the desired design combination based on the cost for construction.The expected result of this research will give the economical design combination.Cost effective construction techniques andmaterials during the execution of project plays important role in saving time as well as cost of construction. Thus, cost reduction techniques assure best cost and value over life cycle of the building or structure.

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