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COST OPTIMIZATION OF CONSTRUCTION PROJECTS USING ADVANCE CONSTRUCTION TECHNIQUES

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Abstract:

Construction industry could be considered as a very important sector for development all over the World and the construction cost is the most important element in it. The construction project can vary from extremely profitable to barely worth it and sometimes end up costing the contractor more than what he or she is getting paid to complete it. In construction industry the aim of project control is to ensure the projects finish on time, within budget and achieving other project activities. Time and cost are two main concerns which increase importance of cost reduction techniques. 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. This study was carried out to identify the factors affecting construction cost. The factors were identified based on case studies and market surveys. In this paper, we have studied different techniques for optimization. To minimize the construction cost and duration at each phase is important. It is a need to meet the present day requirements and to complete the project within the estimated time, cost, and available resources. Mainly affecting the factor on cost of project is delay in project and material. Several methods have been developed and applied to analyze the time-cost problems, but they can optimize only one parameter. Various low cost material also suggested for optimizing the cost of project along with maintaining the quality and strength of the project. Also various mathematical method and software based models studied for optimization. This study centers on assessing the cost of construction project and compare the construction cost with the optimized cost of the same building by using advance construction techniques and materials. Outcomes of cost study suggest that the construction cost of residential building project is reduced by 20-30%, 10-20% in infrastructural projects and 25-35% in industrial projects than the construction cost.

Keywords: Value Engineering, Cost Optimization Techniques, Advance methods, Material Management, etc.

I. INTRODUCTION

Construction industry is an important industry worldwide. The construction industry generally defined as a sector of the economy. The Industry is playing an important role in economic growth of the country, but it faces many challenges currently that lead to affect project goal and steady growth of the economy. Construction is a high hazard industry which comprises a wide range of activities involving plans, design, constructs, alteration, maintains repairs and eventually demolishes of buildings, civil engineering works, mechanical and electrical engineering and other similar works. Construction is always complex that make industry susceptible to disputes, delays and cost exceeding. The construction industry has characteristics that separately are share by other industries but in combination appear in construction alone.

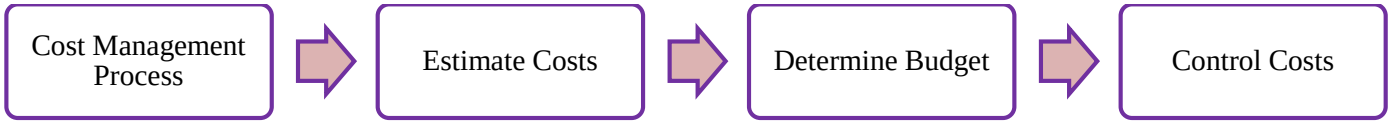
1.1 Importance of Cost Control in Project Management

When it comes to cost control in project management, it can be challenging to forecast and manage project costs effectively. In fact, there is news every day about construction projects going over budget and time, yet this is avoidable with strong cost management. Project cost management sets the baseline for project costs. Effective cost management ensures that a project's budget is on track and will be completed according to its planned scope. Without cost control, a company can easily lose money and costs can go above project profit.

Cost control is the process of monitoring, tracking and controlling the actual cost of any construction project. This includes:

a) Monitoring cost performance
b) Ensuring all changes are correctly submitted
c) Announcing any changes and impact to costs to project stakeholders

The process of managing project cost can be carried out in three steps. The first is estimating and planning cost, followed by developing a project budget, and finally, controlling spending and tracking costs in real time to make sure there are no unexpected changes. There are two types of costs in construction projects: direct and indirect costs. The direct cost is the amount of money spent directly to finish the project (e.g. necessary material, equipment, labor). The indirect cost is the amount of money spent to support indirect completion of the project (e.g. office costs, salaries, general administration). Another way to observe costs is how they appear in different stages with ongoing processes. Planned and estimated costs are the sum of direct and indirect costs over a given period of time. The actual cost is the sum of committed direct and indirect costs on an activity of the project's duration. Project overrun can dramatically cut margins and profit substantially. In order to minimize and prevent such risks, it is important to pay attention to initial planning. This task can be extremely difficult, as it necessitates a full awareness of everything involved in the field of construction projects. Another way to reduce project costs is to find work phases that can be done with less money or with cheaper resources. Moreover, as we all know, time is money, so a project period can be shortened, this will obviously help to reduce project costs.



1.2 Construction Process

Some construction projects are small renovations or repair jobs, where the owner may act as designer, paymaster and laborer for the entire project. However, more complex or ambitious projects usually require additional multi-disciplinary expertise and manpower, so the owner may commission one or more specialist businesses to undertake detailed planning, design, construction and handover of the work. Often the owner will appoint one business to oversee the project (this may be a designer, a contractor, a construction manager, or other advisor); such specialists are normally appointed for their expertise in project delivery, and will help the owner define the project brief, agree a budget and schedule, liaise with relevant public authorities, and procure the services of other specialists (the supply chain, comprising subcontractors). Contracts are agreed for the delivery of services by all businesses, alongside other detailed plans aimed at ensuring legal, timely, on-budget and safe delivery of the specified works.

Design, finance, and legal aspects overlap and interrelate. The design must be not only structurally sound and appropriate for the use and location, but must also be financially possible to build, and legal to use. The financial structure must be adequate to build the design provided, and must pay amounts that are legally owed. Legal structures integrate design with other activities, and enforce financial and other construction processes.

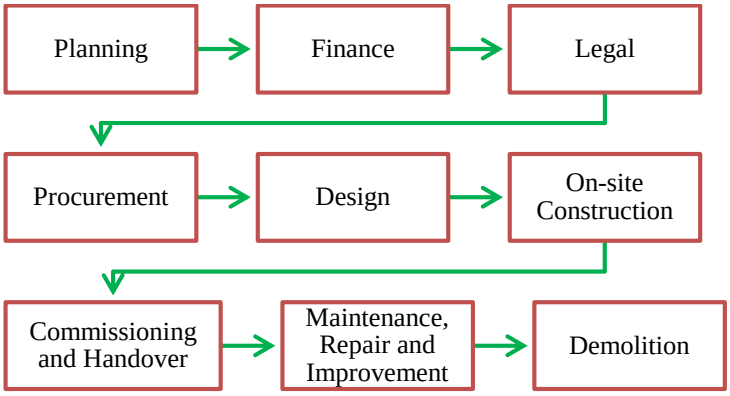


Figure 1: Construction Process

These processes also affect procurement strategies. Clients may, for example, appoint a business to design the project after which a competitive process is undertaken to appoint a lead contractor to construct the asset (design–bid–build); they may appoint a business to lead both design and construction (design-build); or they may directly appoint a designer, contractor and specialist subcontractors (construction management). Some forms of procurement emphasise collaborative relationships (partnering, alliancing) between the client, the contractor, and other stakeholders within a construction project, seeking to ameliorate often highly competitive and adversarial industry practices.

1.3 Problem Statement

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 result 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 principal aim of this study is to optimize cost of construction projects.

1.4 Aim of the Study

India is a country where every family dreams of staying in the house they own. But with the current increase in land costs, construction material prices and labour charges, it is becoming difficult for middle class families to fulfill their dream of living in their own homes. So I thought of putting forward some conclusion that can be helpful for such families to build the house of their dreams. 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.

1.5 Objectives of the Study

1. To study different construction projects with respect to cost and material, this includes residential project, infrastructure project and industrial project.
2. To minimize total cost of construction projects with respect to different factors. (Direct cost and Indirect cost).
3. To study cost reduction methods and advance materials for construction projects.
4. To compare cost of projects before and after using advance methods and materials.

1.6 Methodology of the Work

The different phases of this project of work are shown in the following diagram. The figure simply describes the experimental strategy of this study step by step.

a) Review the existing literature for cost optimization of construction projects,

b) Select different construction projects for conducting study with respect to cost and material,

c) Study the different factors which are responsible for increasing cost of construction projects,

d) Study of direct and indirect cost for reducing total cost of construction,

e) Study of different cost reduction techniques and advance materials,

f) Comparative analysis of different projects with respect to cost,

g) Interpretation of results and conclusion.

II. METHODOLOGY

2.1 DIFFERENT PROJECTS FOR CASE STUDY

Table -1: Overview of the Investigated Projects

Sr. No.	Project	Description	Location
1	Residential Project	Prangan Residential Flat Project (G + 20 Residential Building)	Nashik
2	Infrastructural Project	Chatrapati Shivaji Maharaj Uddanpul	Nashik
3	Industrial Project	Industrial Shed, Sinnar MIDC	Sinnar

2.2 COST REDUCTION TECHNIQUES

There are various cost effective techniques of construction. Many 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

2.3 DATA COLLECTION AND ANALYSIS

A. Project 1 : Residential Project

"Prangan" is an ongoing premium 2BHK and 3BHK residential flats project. This residential project "Prangan" consists of two wings namely 'Wing A' and 'Wing B'. Both wings are same, so for our study, we take 'Wing A'. "Prangan" residential flat project consists of G + 20 floors over 36 lifestyle amenities.

Table -2: Technical Data of Residential Project

Name of Project	Residential Project
Description	"Prangan" Residential Flat Project ("A" Wing)
Location	"Prangan", 4th Ave, Serene Meadows, Gangapur Road, Nashik – 422 013
No. of Floors	G + 20 Floors
Odd Floors	1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21
Even Floors	2, 4, 6, 8, 10, 12, 14, 16, 18, 20
Carpet Area	Odd Floor : 1026 sq. ft. (95.36 sq. m) Even Floor : 1023 sq. ft. (95.04 sq. m)
Usable Area	Odd Floor : 313 sq. ft. (29.05 sq. m) Even Floor : 289 sq. ft. (26.83 sq. m)
Built-up Area	Odd Floor : 2365 sq. ft. (219.79 sq. m)

	Even Floor : 2158 sq. ft. (200.55 sq. m)

Table -3: Construction Cost of "Prangan" (Wing A) Residential Project

Total Carpet Area	21516 sq. ft. (1996.63 sq. m)
Total Usable Area	6333 sq. ft. (588.57 sq. m)
Total Built-up Area	47595 sq. ft. (4423.33 sq. m)
Construction Cost	1500/- per sq. ft.
Total Cost	1500 x 47595 = 7,13,92,500 INR Seven Crore Thirteen Lacs Ninety Two Thousand and Five Hundred

Construction costs form part of the overall costs incurred during the development of a built asset such as a building. Very broadly, construction costs will be those costs incurred by the actual construction works themselves, and on some projects may be determined by the value of the contract with the main contractor.

Figure 2: 3D View of Prangan Residential Flat Project

However, the construction contract may include costs that might not in themselves be considered literal construction costs (hard costs), such as fees, profits, overheads, and so on. Many projects will also include costs that it is not possible to determine when the construction contract is awarded (such as prime cost sums and provisional sums), and there may be construction works that are awarded by the client outside of the main contract. There are some other charges like scrutiny fees, construction development charges, ancillary charges, process charges, drainage charges, tree plantation charges, land development charges etc. are not considered in construction cost. It is because; our objectives are to minimize Cost Construction Projects by using Advance Construction Techniques and Materials.

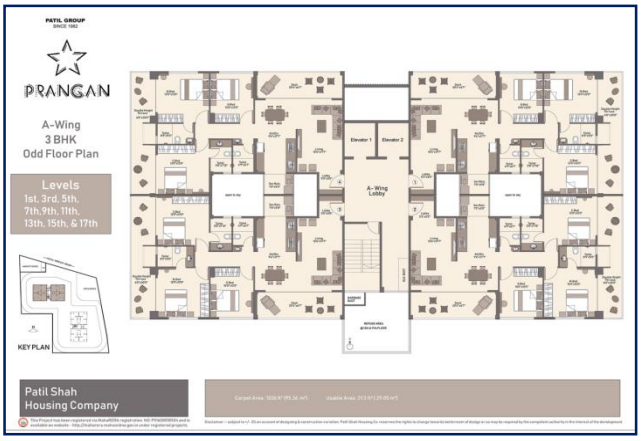


Figure 3: Floor Plan of "Prangan" Residential Flat Project (Odd Floor)

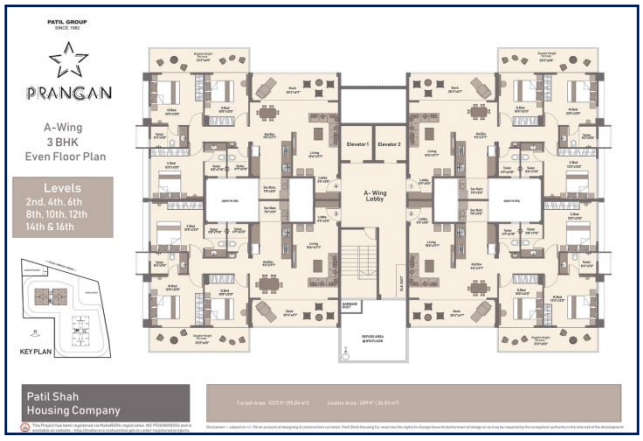


Figure 4: Floor Plan of "Prangan" Residential Flat Project (Even Floor)

B. Project 2 : Infrastructural Project

Chatrapati Shivaji Maharaj Uddanpul is in Nashik city, Dwarka area and located on National Highway 3 (India). It starts from Pandavleni caves and ends near Panchavati Stadium, it is India's first externally strutted segmental box girder bridge used over 2100 and having capacity of 100 Ton each and India's Second Longest road bridge. It was approved by Atal Bihari Vajpayee in 2002.

Table -4: Technical Data of Infrastructural Project

Name of Project	Infrastructural Project
Official Name	Chatrapati Shivaji Maharaj Uddanpul
Location	Nashik
Carries	4 lanes not allowed for pedestrians, bicycles, Motor-Cycles, and Auto Rickshaws.
Characteristics	
Maintained by	Ashoka Buildcon, Larsen & Toubro, National Highways Authority of India
Material	Steel
Total length	14 Km.
Width	120 ft.
Height	70 ft.
Clearance above	20 ft.
Clearance below	20 ft.
Constructed by	Ashoka Buildcon and Larsen & Toubro
Statistics	
Daily traffic	50,000 vehicles

Toll	Free both ways in City.

Figure 5: Chatrapati Shivaji Maharaj Uddanpul, Nashik

Table-5: Construction Cost of Chatrapati Shivaji Maharaj Uddanpul, Nashik

Total Length	16 km
Cost of Construction per km	25,00,00,000/-
Total Cost	4,00,00,00,000 INR (Four Hundred Crore Rupees)

c. Project 3: Industrial Project

Table -6: Technical Data of Industrial Project

Name of Project	Industrial Project
Official Name	Amruta Industries, Sinnar Industrial Shed, Sinner MIDC
Location	B-24, Sinnar Taluka Industrial Co. Opp Etate Ltd, Sinnar, Maharashtra
Length	40 m (131.23 ft)
Width	15 m (49.21 ft)
Plan Area	40 m X 15 m = 600 sq. m (131.23 ft X 49.21 ft = 6457.83 sq. ft)

Figure 6: Amruta Industries, Sinnar

Table -7: Construction Cost of Amruta Industries, Sinnar

Plan Area	40 m X 15 m = 600 sq. m (131.23 ft X 49.21 ft = 6457.83 sq. ft)
Cost of construction per sq. ft	240/- Rs.
Total Cost	6457.83 X 240 = 15,49,879 INR (Fifteen Lacs Forty Nine Thousand Eight Hundred and Seventy Nine Rupees)

D. Cost Reduction Programme

Cost reduction aims at improvement of human efforts. In a business organisation several persons are engaged in diverse activities. It may be a short-term or long-term under special problems such as reduction in profit, specific inefficiencies in certain spots (or fall in production). A special cost reduction programme is geared into action to meet the situation and improve the position. Long-term cost reduction plans improve major reductions in costs and may involve capital expenditure.

Briefly, a programme of cost reduction consists of the following:

a) Numerous centres or points where costs are incurred are located and grouped according to departmental responsibility.
b) Each such point or group or points is then submitted a value analysis scheme to determine whether optimum efficiency has been achieved in its performance or whether there is a norm for cost reductions.
c) Suitable techniques are, therefore, applied to reduce costs. No cost reduction programme can be effective unless a joint effort is made by all the departments concerned and the plan is linked with responsible management. Allocation of responsibility of the various cost reduction levels of management is an important requirement for control of cost reduction of the operation and spheres under his control.
d) The programme for cost reduction should be clearly defined and responsibilities delegated. Thus, each executive should be aware of his role in the over-all scheme of cost reduction and of the function he has to perform.

Effective Ways to Reduce Material Cost	Advance Construction Materials	Advance Construction Techniques
a) Substitute Lower Cost Materials Where Possible	a) Durable Concrete	a) Precast Flat Panel System
b) Reduce Waste	b) High Performance Concrete	b) 3D Volumetric Modules
c) Eliminate Unnecessary Product Features	c) Self–compacting Concrete (SCC)	c) Flat Slab Construction
d) Negotiate, Negotiate, Negotiate	d) The Use of Mineral Admixtures	d) Precast Cladding Panels
e) Leverage Suppliers	e) Fly Ash	e) Concrete Wall and Floors
f) Buy Need, Not Potential	f) High Volume Fly Ash Concrete (HVFA)	f) Twin Wall Technology
g) Trade Time for Discounts	g) Ground Granulated Blast Furnace Slag (GGBFS)	g) Precast Concrete Foundation
h) Buy Bargains	h) Condensed Silica Fume (CSF)	h) Concrete Formwork Insulation
i) Transform Buyers into Suppliers	i) Ternary Blends	
j) Barter Finished Goods for Raw Materials	j) Cement Silos	
k) Provide Warehouse and Distribution Services	k) Durability Enhancing Products	
l) Offer Quick Payment for Lower Prices	l) Hydrophobic Concrete Waterproofing System	
m) Enter Into Cooperative Purchase Agreements to Gain Buying Muscle	m) Reinforcement	
n) Negotiate Long-Term Supply Agreements		

F. Cost Optimization by Using Advance Construction Techniques and Materials

The problem of cost optimization is actually the lack of knowledge and inadequate planning for the implementation coupled with the poor management of construction resources. General methods that are used by Builders for cost optimization methods are as follows:

a) Comparison with a cost standard.
b) Subdivision by detail.
c) Integration with other functions.

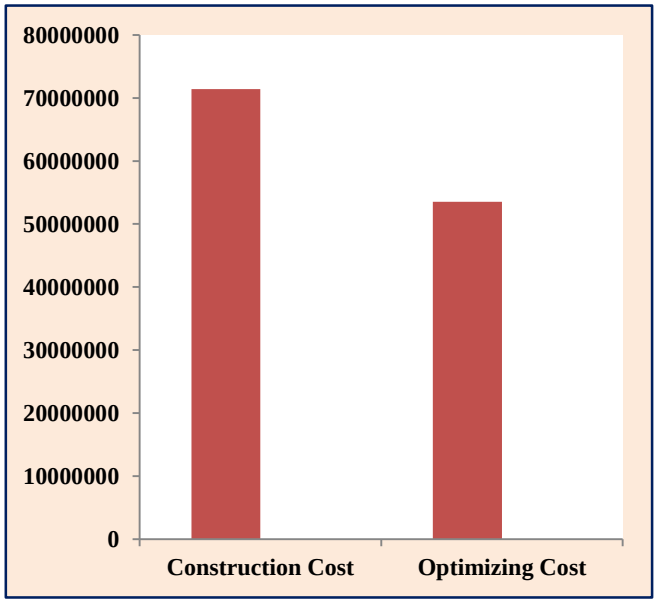
The availability of qualified experts is the main problem faced by Builder in optimizing the costs of construction projects. Project managers/ civil engineers don't have cost Reconcile approach they do not prepare Cost control documents for their Projects that's why they don't have expertise in Cost optimization.

1. As per study, 20-30% cost can be optimized in residential projects by using advance construction techniques and materials.

2. 10-20% cost can be optimized in infrastructural projects by using construction and demolition waste materials.
3. In industrial projects, 25-35% cost can be optimized by using Pre-Engineered Buildings.

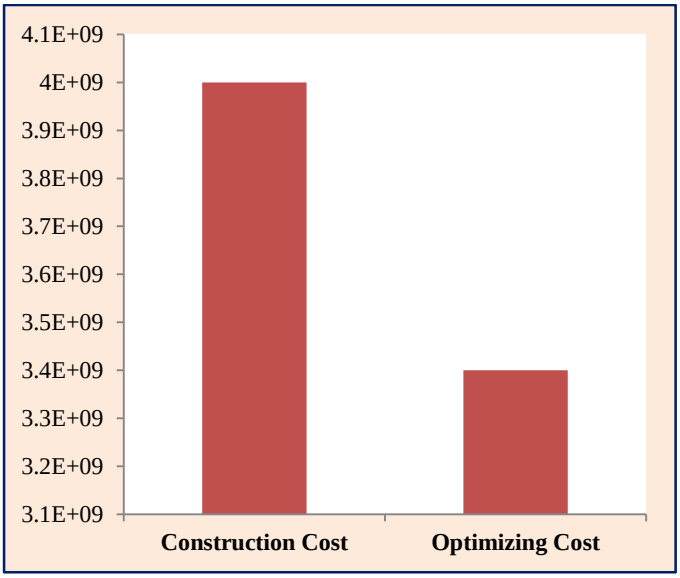
Table -8: Cost Optimization of Different Projects

Sr. No.	Description	Construction Cost	Optimizing Cost
Project 1	Prangan Residential Flat Project (G + 20 Residential Building)	7,13,92,500 INR	5,35,44,375 INR
Project 2	Chatrapati Shivaji Maharaj Uddanpul	4,00,00,00,000 INR	3,40,00,00,000 INR
Project 3	Industrial Shed, Sinnar MIDC	15,49,879 INR	10,84,915 INR

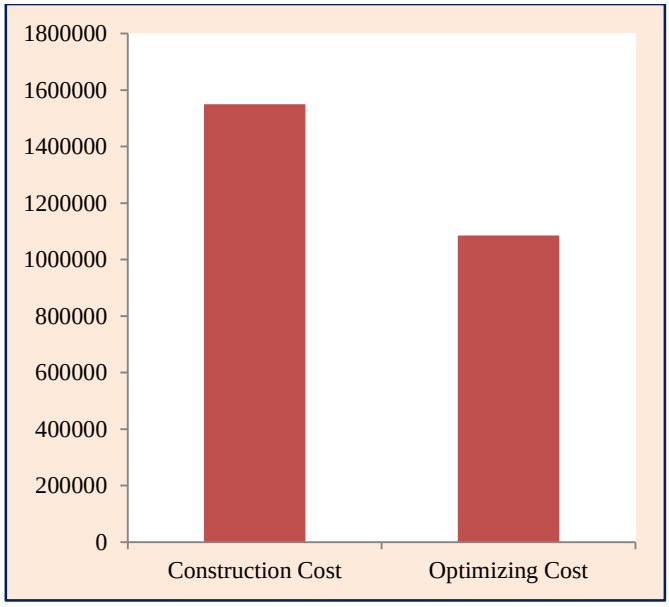


Graph -1: Cost Optimization of Residential Project (Project 1)

Contour Crafting technology can also be used for cost optimization of construction projects. Contour crafting is a building printing technology being researched by Behrokh Khoshnevis of the University of Southern California's Information Sciences Institute (in the Viterbi School of Engineering) that uses a computer-controlled crane or gantry to build edifices rapidly and efficiently with substantially less manual labor. It was originally conceived as a method to construct molds for industrial parts. Khoshnevis decided to adapt the technology for rapid home construction as a way to rebuild after natural disasters, like the devastating earthquakes that have plagued his native Iran.



Graph 2: Cost Optimization of Infrastructural Project (Project 2)



Graph 3: Cost Optimization of Commercial Project (Project 3)

III. CONCLUSION

In this paper, we have studied different techniques for optimization. To minimize the construction cost and duration at each phase is important. It is a need to meet the present day requirements and to complete the project within the estimated time, cost, and available resources. Mainly affecting the factor on cost of project is delay in project and material. Several methods have been developed and applied to analyze the time-cost problems, but they can optimize only one parameter. Various low cost materials also suggested for optimizing the cost of project along with maintaining the quality and strength of the project. Also various mathematical method and software based models studied for optimization. This study centers on assessing the cost of construction project and compare the construction cost with the optimized cost of the same building by using advance construction techniques and materials. Outcomes of cost study suggest that the construction cost of residential building project is reduced by 20-30%, 10-20% in infrastructural projects and 25-35% in industrial projects than the construction cost. The current research has multiple limitations. First, the study was conducted based on a single building construction project, thus it is difficult to generalize the findings of the study for other projects. Small sample size also compromised the statistical validation of the study. Second, the remedies of cost reduction were based on previous studies, as the study team was unable to interview people involved in the project. Third, in this study, only construction cost was compared. If the total life cycle costs are compared then there might be an offset for the projects. Finally, the study excluded the schedule information of the project because of data unavailability. Future research should address all these issues to analyze the cost and time of the building construction projects.

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