

Impact of Prefabrication Technology on Profitability in Construction Industry

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Abstract

Precast construction system is a well-known technology though it was developed many years ago but its implementation is not up to the mark in India. Precast elements are prepared in controlled environment which results in proper curing and monitored closely resulting in faster construction. This study focuses on the comparison of conventional and precast construction technology. The construction cost estimation of an eighteen storey building was done by both conventional and precast construction system. Microsoft Project software was used for scheduling and tracking the activities of construction projects. Comparative analysis of equipment's used in both conventional and precast has been carried out, from the data obtained breakeven analysis and has been done for each of the equipment, for obtaining the production rate. Regression analysis was used for comparative analysis to make effective decision making in selecting the technology. Breakeven analysis results yielded that the replacement of equipment within it's the useful life. Cost analysis results shows that precast construction cost is 22.81% higher than conventional. Regression analysis results shows that complete precast construction is not a better option instead combination of conventional and precast construction results in economic construction.

Key Words: Construction Cost Comparison, Feasibility Analysis, Breakeven Analysis, Regression Analysis.

1. INTRODUCTION

The construction industry in India is developing at a fast rate of growth. It provides wide opportunity in India for a new entrant in prefab sector. At present precast concrete buildings are the advanced construction techniques available over worldwide. Being its wide applicability, the total precast concrete buildings systems are becoming a popular choice for many construction.

The forms used in a precast plant may be reused hundreds to thousands of times before they have to be replaced, which allow cost of formwork per unit to be lower than for site-cast production.

According to study the total cost and time of the double storey residential building has been determined for both conventional and precast construction methods. The comparison between these two methods gave there is huge cost difference in between the two methods, in which the precast construction method is high when compared to conventional construction method.

The study on conventional and precast construction method for a school building which includes G+7 floors of area 2670sq.m. Overall cost for the construction of building using precast method is reduced by 20 percent when compared with conventional construction. Economics are generated through reduced requirement for formwork, access scaffolding. When compared to conventional construction the following saving is expected Formwork 75 % less, Scaffolding 75 to 90%. Factory production will ensure increased accuracy and good quality finish.

Study was made on different estimates and data collection was done for various construction projects. Analyzed the collected data and compared the estimated cost and time to understand the causes and implementation of less use in construction of precast method. Examined the cost and time required for both conventional and precast construction by estimating time and cost by applying payback period and breakeven

analysis method to both construction methods. Listed out all the shortcomings and identified the reasons how precast method is more essential for construction.

Forty five factors affecting labour productivity building projects in pune. Prioritization is done from a contractors view point. Prioritization is done using relative importance index. Main factors are lack of labour surveillance, labour experience, inspection delay and many more [1].

The comparison was made based on the initial and life cycle cost, of a housing unit and the construction time effects and man hour input [2]. The comparison cost of the housing unit constructed by the lightweight construction method was calculated in 3 different methods, due to change in the data of cost-related whose share in the Israeli market had been less in the past [1].

The construction industry in Malaysia has been changed from conventional construction system to a more systematically, mechanized an industrialized forms and adopted the modernized and latest technology. The results of the case study they concluded that industrialized construction system is better when compared to conventional construction system in cost saving of construction.

2. SCOPE OF THE STUDY

2.1 Objective

To know the processes involved in precast construction, to carry out estimation (cost) and time taken by conventional and precast construction methods. Carrying out breakeven analysis and regression analysis analysis of precast and conventional construction methods and to provide sufficient data and comparative analysis for effective decision making.

2.2 Scope of Present Investigation

- i. Site visit yielded a data collection of equipment's and process involved in precast construction method.

- ii. Preparation of detailed report of cost estimation for the construction of 18 storey building by both conventional and precast construction method.
- iii. Estimating the total duration (time) required for the completion of project by using MS Project.
- iv. Calculation of Breakeven analysis of the equipment used in both the construction method by using annual worth method for knowing the revenue generated breakeven with the expenditure
- v. From the results of breakeven analysis, regression analysis has been carried out to give comparative relation between the conventional and precast construction system.

3. METHODOLOGY

3.1 Cost estimation of Conventional construction method

The floor plans of 18 storey apartment residential building the estimation of building quantities for conventional construction system was considered. Quantity surveying shows that total cost of the project is Rs 83,83,20,866 and it is calculated using SCHEDULE OF RATES 2015-2016, KARNATAKA. Total cost is tabulated in Table 1 and Table 2.

Table 1. Total cost of conventional construction

Activity	Cost (Rs.)
Earth work	54,16,382
PCC	51,89,080
RCC	11,18,95,915
Steel Reinforcement	18,58,50,000
Shuttering	1,36,86,001
Masonry	11,67,18,785
Plastering	7,10,77,200
Flooring	13,84,28,717
Painting	15,16,63,523
Carpentry	4,79,97,190
Fabrication	42,27,880
Total cost(Rs)	83,83,20,866

Table 2. Total Cost of precast construction system

Activity	Cost(Rs)
Earth work	54,16,382
PCC	51,89,080
RCC	5,54,15,625
Concrete (batching plant)	7,78,92,812.03
Steel reinforcement	34,75,71,000
Shuttering	6,80,490
Pallet	2,16,96,974
Formwork	67,44,600
Reinforcement cutting	1,65,51,000
EOT cranes	2,89,29,300
Curing	2,16,96,975
Transportation	43,39,395
Erection	5,06,267.5
Grouting	28,92,930
Flooring	13,84,28,717
Painting	15,16,63,523
Carpentry	4,79,97,190
Fabrication	42,27,880
Total(Rs.)	1,08,61,18,651

3.2 Cost estimation of precast construction method

For the same floor plans of 18 storey apartment residential building the estimation of building quantities for precast construction system like earthwork, PCC, RCC, Crane operation reinforcement cutting, Reinforcement, for substructure and super structure etc. were carried out using center line method of estimation. Here the total length is multiplied by breadth and depth of respective item to get the total quantity at a time.

After calculating all the quantities the total cost of the project is Rs. 1,08,61,18,651 and it is calculated using SCHEDULE OF RATES 2015-2016, KARNATAKA.

3.3 Total Days required for project completion of conventional construction

3.3.1 Microsoft Project

Microsoft Project 2010 is a product of Microsoft Corporation. It is designed to assist project managers in developing plans, assign resources to tasks, tracking progress, managing budgets and analyzing workload. Microsoft Project based on work assignments, resource prices and budget. Since the allocation of resources assigned to a task and work time estimates, the cost of each program is equal to the calculated speed, which will be compiled into a working time of the task, and many summary task, and finally to the project level.

Microsoft Project was used for knowing the total number of days required for project completion, schedules and assign cost to each task.

3.3.2 Identification of Activities

Before starting scheduling in MS Project a list of a major activities involved in the conventional construction system is listed out. The activities involve starting from planning and purchase of land to the completion of project, inspection.

3.3.3 Scheduling in Microsoft Project

Scheduling in Microsoft Project in tabulated in Table 3.

Table 3. Microsoft project scheduling conventional construction

Task Mode	Task Name	Duration	Start	Finish	Predecessors	Resource Names	Cost
	<New Summary Task: 1688 days?		Fri 5/5/17	Tue 10/24/2:			₹ 782,627,260.00
	Initial activities	42 days					₹ 0.00
	meeting by authorities	2 days	Fri 5/5/17	Mon 5/8/17		director, Manager,Project	₹ 15,400.00
	Planning and purchase of land	10 days	Tue 5/9/17	Mon 5/22/17	3	director, Manager,Plannii	₹ 2,052,000.00
	Registration	3 days	Tue 5/23/17	Thu 5/25/17	4	director,Manage	₹ 21,600.00
	Consulting Engineer/	2 days	Tue 5/23/17	Wed 5/24/17	4	director, Project	₹ 13,000.00
	Soil testing	3 days	Thu 5/25/17	Mon 5/29/17	6	Site Engineer,sk	₹ 40,200.00
	Design Drawings and approval	20 days	Tue 5/30/17	Mon 6/26/17	7	Architect, Planning	₹ 134,000.00
	Contractor selectiv	2 days	Tue 6/27/17	Wed 6/28/17	8	director,Project	₹ 13,000.00
	Civil Works						₹ 0.00
	substructure	67 days	Wed 5/10/17	Thu 8/10/17			₹ 0.00
	Excavation(drawin	20 days	Wed 5/10/17	Tue 6/6/17		Back hoe,Dumpe	₹ 338,000.00
	Soil protection	4 days	Wed 6/7/17	Mon 6/12/17	13	Shuttering[1],Siti	₹ 307,200.00
	Antitermite	2 days	Wed 6/7/17	Thu 6/8/17	13	mason,	₹ 53,800.00

3.4 Total Days required for project completion of precast construction system

Scheduling for precast construction is tabulated in Table 4.

Table 4. MS project scheduling conventional construction

Sl. No.	Activity	Duration (days)	Start Date	End Date	Resources	Cost (Rs.)
10	precast activities	64 days	Mon 5/15/17	Thu 8/10/17		₹ 0.00
11	erection of batching plant	10 days	Wed 8/2/17	Wed 8/16/17	Engineers, Helper, Mobile	₹ 69,500.00
12	erection of precast plant	15 days	Thu 8/3/17	Wed 8/23/17	Dumpers, Engineers, Helpe	₹ 267,000.00
13	erection of precast shed	5 days	Wed 8/2/17	Wed 8/9/17	Engineers, Safety engineer,	₹ 16,000.00
14	laboratory	4 days	Wed 8/9/17	Tue 8/15/17	Engineers, Mobil	₹ 400,000.00
15	storage yard	3 days	Wed 8/9/17	Mon 8/14/17	Engineers, Site E	₹ 4,200.00
16	site office	2 days	Wed 8/9/17	Fri 8/11/17	Engineers, RMC t	₹ 12,000.00
17	installitition of equipment	15 days	Fri 8/11/17	Fri 9/1/17	Engineers, EOT crane, Mobi	₹ 19,500.00
18	curing chamber	5 days	Wed 8/9/17	Wed 8/16/17	Engineers, Helpe	₹ 1,500.00

3.5 Data collection of conventional construction equipment's

The equipment's used during the construction of conventional construction method data has been tabulated in Table 5.

Table 5. Equipment's list for Conventional Construction

Equipment name	Cost (Rs.)	Useful life(Years)
Excavators(backhoe)	25,00,000	10
Bull dozer	75,00,000	15
Batching plant	1,50,00,000	20
Compacting machine	60,000	4
Concrete mixer	90,000	6
Mobile crane	15,00,000	10
Tower crane	50,00,000	18
Concrete pumping machine	18,50,000	12
Dump trucks	1,00,000	10
Loader	13,00,000	12
Builder hoist	8,000	5

3.6 Data collection of precast construction equipment's

The equipment's used during the construction of conventional construction method data has been tabulated in Table 6.

3.7 Breakeven analysis of equipment's used in conventional construction system

Taking the example of the back hoe equipment

1) Backhoe

P= Rs. 25, 00,000 (P= initial cost); SV=Rs.10, 00,000 (Salvage value); Life =10years; Operating and maintenance cost= Rs.40, 000 / year; i=10 % (Interest rate)

Assuming one operator is required to operate the backhoe at cost of Rs. 40 per hour.

It can excavate 50m³ of earth in 1 hour. The results of breakeven analysis are tabulated in Table 7 and Table 8.

Table 6. Equipment's list for Precast Construction

Equipment name	Cost(Rs)	Useful life(Years)
EOT crane	12,00,000	25
Circulating pallets	40,000	13
Concrete spreader	18,00,000	15
Rack Operator	4,00,000	20
Stirrup bending machine	45,00,000	10
Welding machine	60,000	8
Reinforcement cutting machine	1,25,000	10
Fork lift	8,00,000	10
Trailers	6,00,000	15
Threading machine	1,15,000	12
Mobile crane	15,00,000	10
Tower crane	50,00,000	18
RMC plant	1,50,00,000	20
Transit mixer	25,00,000	12
Loader	13,00,000	12

Table 7. Break even analysis of Backhoe

Value	Awe(Rs.)	AWr(Rs.)
0	4,47,232.7	62,000
500	4,47,632.7	1,62,000
1000	4,48,032.7	2,62,000
1500	4,48,432.7	3,62,000
2000	4,48,832.70	4,62,000

Table 8. Break even analysis of Equipment's used in Conventional Construction

Equipment	Working	Unit
Bull dozer	516.91	Hrs
Mobile crane	277.13	Ton
Concrete mixer	228.27	M ³
Loader	211.46	Hrs
Transit mixer	572.79	M ³
Tower crane	426.18	Ton

3.8 Regression Analysis

The comparison of equipment costs of both the construction method is carried out and results are tabulated in Table 9.

Table 9. Total cost of equipment for each activity

Activity	Conventional (Rs.)	Precast(Rs.)
Excavation	1,01,00,000	1,01,00,000
Footings	1,94,10,000	2,40,35,000
Columns	1,94,10,000	2,40,35,000
Beams	1,94,10,000	2,40,95,000
Slabs	1,95,00,000	3,06,35,000
Block work/wall panel	65,00,000	2,80,75,000
Reinforcement Handling	25,00,000	58,25,000

4. RESULTS AND DISCUSSIONS

The results of total cost, duration of project completion by both the methods. Breakeven analysis of equipment's in both construction methods and regression analysis for construction activity.

Figure 1 and 2 show cost and time of conventional and precast construction system. The total cost of conventional construction system is Rs.83,83,20,866 and total cost of precast construction system is Rs.1,08,61,18,651. The total duration for conventional construction system is 1688 days and precast construction system is 1454 days. There is a huge cost difference in both the construction system as the activities involved in precast construction system is more when compared to conventional construction system.

Figure 3 shows the graph of regression analysis excluding the block work/wall panel and the result obtained is $R^2 = 0.8974$ which is a good result.

Regression analysis yielded that for all the activities it is not a good result and for excluding the block work/ wall panel activities it shows a good result.

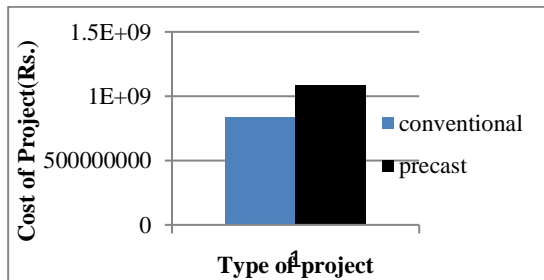


Fig. 1 Cost comparison of conventional and precast construction system

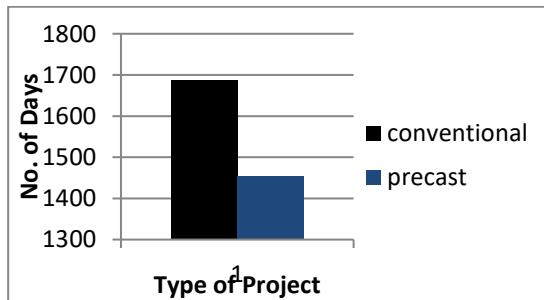


Fig. 2 Time comparison of conventional and precast construction system

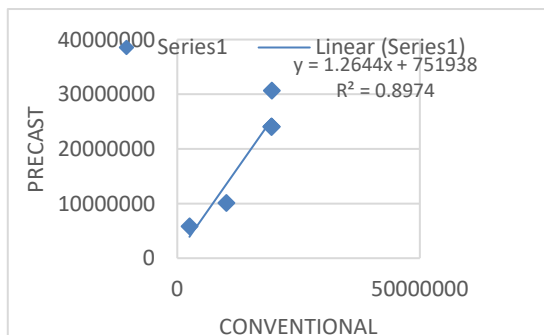


Fig. 3 Regression analysis excluding block work/wall panel

5. CONCLUSIONS

- Cost analysis results shows that precast construction cost is 22.81% higher than conventional construction cost
- The total duration for precast construction is 1454 days which is less when compared to conventional construction method.
- Breakeven analysis of each equipment is done for criterion selection based on the most economical solution.
- Regression analysis relationship between both construction method equipment showed a good result's excluding the wall panel equipment's.

REFERENCES

- [1] Navon R. (1995) Economic benefits of lightweight versus conventional constructional methods, *Journal of Construction Engineering and Management*, 121(1), pp. 22-25,
- [2] Chen J. H., Yang L.-R., Tai H.-W. (2016) Process reengineering and improvement for building precast production, *Automation in Construction*, 68, pp. 249-258.