A Study of Cost Comparison of Precast Concrete Vs Cast-In-Place Concrete

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Abstract:The growth of Indian construction is going to become a fast to fulfill (meet) the need of future generation, time effective and achieving advance technique. The paper based on time comparison of precast concrete vs. cast-in-place (i.e. traditional) concrete. How total time of construction by precast concrete system is less than the time by use of cast-in-place concrete. Time of any construction is directly varied with cost of construction. The time required for steel binding, shuttering, concreting then time required for curing will be minimize (7 days).The Precast is manufactured in factory (i.e. in controlled environment) with required quality, easily mix, and curetill achieved good quantity with desired strength. Precast concrete is manufactured in factory and transport to site. The strength of precast concrete is achieved in greater extent by using high technology, controlled system. For precast construction less manpower is required, labors are required only to joint precast members. That means time required for excavation, PCC, steel binding, shuttering and deshuttering is eliminated. Precast members are cured in factory till gate desired strength so no need to cure on site result into save in time of currying. There for the time (in days) is saving in construction site. Precast construction technique enhanced the quality of work, save time, reduced the cost of construction required for maintenance of work. The time for shuttering and deshuttering is eliminated by using precast will result into saving total time of construction. The time of rework due to improper work, faulty construction method, unskilled labor, material quality, onsite environmental problem can be eliminated by using precast members.

Keywords:Time Comparison, Time Effective, Strength of Precast Concrete, Advance Technique, Transport to Site, Time for Shuttering, Time of Currying, Need of Future

I. INTRODUCTION

The concept of precast (also known as “prefabricated”) construction includes those buildings where the majority of structural components are standardized and produced in plants in a location away from the building, and then transported to the site for assembly. These components are manufactured by industrial methods based on mass production in order to build a large number of buildings in a short time at low cost [1-3].

This type of construction requires a restructuring of the entire conventional construction process to enable interaction between the design phase and production planning in order to improve and speed up the construction. One of the key premises for achieving that objective is to design buildings with a regular configuration in plan and elevation.

In general, precast building systems are more economical when compared to conventional multifamily residential construction (apartment buildings) in many countries [4-8].

- Analyze the cost of switching from cast in place to precast concrete. This will include:
    - Immediate actual cost of both systems
    - Long term cost of both systems
    - Construction cost of each system
    - Equipment used

- Material used
- Machinery needed
- Storage Area cost
- Labor cost
- Transportation Cost of both systems
- Analyze Structural Load.
- Analyze Mechanical Load.
- Compare Duration impacts of both systems on the project schedule. The Factors included:
    1. Labor differences
    2. Placing time (installation)
    3. Efficiency of workers
- Analyze other factors such as safety concerns, logistics and sequencing of both systems.

Resources

1. Relative Project Documents
2. Commitment Construction Project Team Members
3. Industry Professionals And Faculty Members

Objective of the Study

- Construction of similar building elements wherein there could be a huge repetition of moulds resulting in increased productivity and economy in cost by using precast concrete.
- To explore problems of implementation of precast Building technology
- To study different stages & process involved in Precast Concrete Construction of commercial, industrial and residential sectors
- To compaire the cost & time of precast concrete vs cast-in-place concrete.
- To explore future opportunities in Precast Concrete Construction
- To determine which method will help to reduce on-site labour.
- To outline effective planning means to reduce construction cost.

To identify which method will help to reduce on-site waste.

II. LITERATURE REVIEW

The precast industry is booming. Due to its many advantages, such as reduction of building time, product selection, enhanced quality with certified performance levels, cost optimization and so on, it currently represents 20% of concrete production worldwide. In the precast industry, the use of SCC is increasing and it is expected to replace vibrated concrete in many applications because of its various advantages, including the reduction of harmful effects of noise in urban environments, the possibility of pouring in congested reinforced areas or Complex geometry, and a reduction in industrial process costs [4].

The use of cast-in-place columns in bridge construction requires long on-site construction times and large labor requirements in the field. Cast-in-place construction is particularly disruptive in situation in which it exacerbates traffic congestion. Using precast bridge elements is one solution for reducing on-site construction time, field labor requirements, and traffic delays. This strategy is widely applied for bridge girders. Although full bridges can be constructed off site, precasting is usually limited to the columns to make fabrication and transportation easier. However, achieving good connections between precast column and footing, particularly column-to-drilled shaft connections, is challenging in seismically hazardous areas.This paper describes the concept, and seismic performance of the connection between a precast column and drilled shaft, and provides recommendations to ensure desirable performance [6, 8-13].

Recent advancements in bridge construction include innovative methodologies that bring about ease of construction and acceleration of the overall project delivery time. Prefabrication of bridge elements contributes to this construction method and facilitates the whole construction process, the bridge is new or a replacement. Connections between precast concrete bridges elements in the substructure are some of the most critical components in bridges constructed using accelerated bridge construction. Researchers are in the process of investigating the suitability of various connection configurations in moderate-tohigh seismic regions [7]. Load capacity, ductility level, and reparability are three significant acceptance criteria for any connection considered in [8]. The application of precast concrete structural systems has been attaining vast progress worldwide, particularly in Indonesia in the last few decades. This is due to the fact that the precast structural systems possess several advantages compared to monolithic systems, such as quality control, speedy construction, and suitable application to regularly modular systems. In the middle of 2006, the Indonesia Government launched massive and speedy construction of 1000 low-cost apartment towers nationwide.To cope with the enormous need, Indonesian prominent research workers have been developing several precast concrete structural systems. The paper deals with the research and the application of precast concrete structural systems in Indonesia.The paper also describes the vast development already achieved to date in the applications of the precast concrete structural systems in the constructions of low-cost apartments in Indonesia. The research and applications of precast concrete structural systems are intended to support accelerated construction of one thousand low-cost apartment tower throughout large cities in Indonesia.

III. RESEARCH METHOD

The study required detailed information of both precast and cast-in-situ concrete.The study has been broadly undertaken as follows:

- Identify the project which has undergoes the cost and time comparision of precast and cast-in-citu concrete.
- Studied all available estimates and collected data about the project.
- Analyzed the data obtained and compaired the estimated cost and time to understand the causes and implication of less use in contruction of precast concrete.
- Examined the cost and time required for both precast and cast-in-situ by estimating time and cost and by applying the "*Berackeven Analysis*" and "*Pay back period*" method to both the typ of construction system.
- Listed out all the shortcommings.
- Identify the resons how precast concrete is more essential for construction.

A) Breakeven Analysis

Break-even point analysis is a measurement system that calculates the margin of safety by comparing the amount of revenues or units that must be sold to cover fixed and variable costs associated with making the sales. In other words, it's a way to calculate when a project will be profitable by equating its total revenues with its total expenses.

$\sum TC\ Cost = \sum DC \times Qi + \sum IC \times Ti$

Whereas the following symbols represent the stated variables:

TC_Cost (in Rs): Total concrete cost in Rs. for either CIP or PC.

DC (in Rs/Cu Meter):	Direct costs of proportional erected concrete (i.e. dependent on the quantity of erected CIP or PC concrete).
Qi (in Cu Meter):	Quantity of concrete in cubic meter for either CIP or PC.
IC (in Rs/day):	Indirect costs for concrete works that is proportional to the of concrete erection.
Ti (in Days):	Duration of Concrete Erection (including Manufacturing for PC Concrete)

B) Pay Back Period Method

The payback period is calculated by counting the number of years it will take to recover the *cash* invested in a project.Payback period in capital budgeting refers to the period of time required to recoup the funds expended in an investment, or to reach the break-even point.

The formula to calculate payback period of a project depends on whether the cash flow per period from the project is even or uneven.

In case they are even, the formula to calculate payback period is:

$$\text{Payback Period} = \frac{\text{Initial Investment}}{\text{Cash Inflow per Period}}$$

When cash inflows are uneven, we need to calculate the cumulative net cash flow for each period and then use the following formula for payback period:

$$\text{Payback Period} = A + \frac{B}{C}$$

In the above formula,

A = Last period with a negative cumulative cash flow

B = Absolute value of cumulative cash flow at the end of the period A

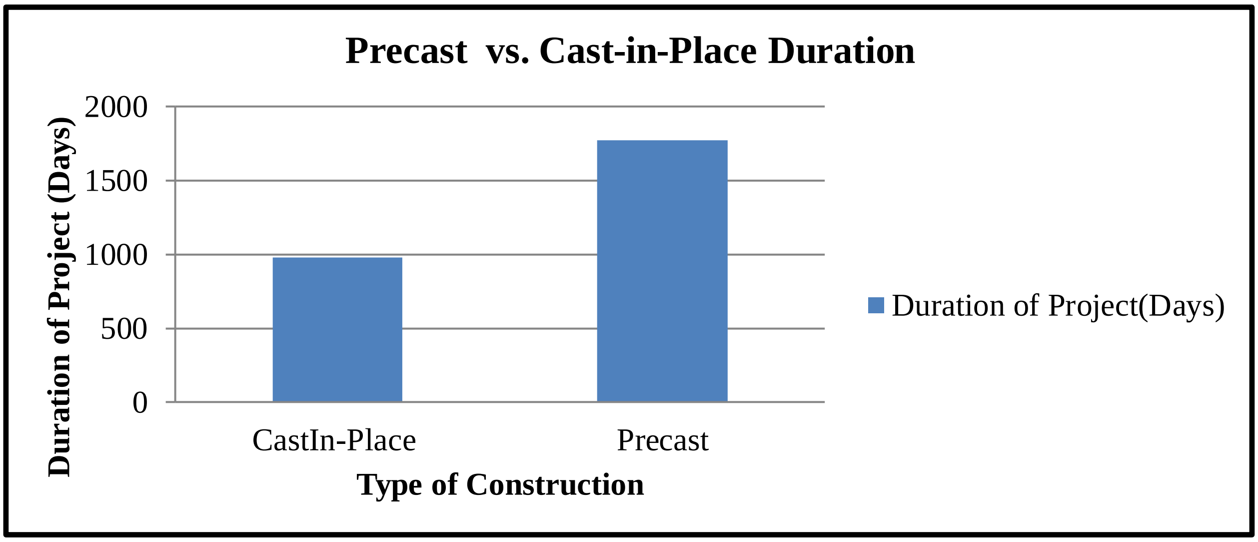
C = Total cash flow during the period after A

Following Company (Project) are selected as a Case Study;B.G.ShirkePvt.Ltd.

To examine the formula for selecting either of the two structural systems of CIP or PC, relevant input data is collected. The construction activity duration of project by PC system is 980 days and by CIP it is 1772 days required to complete theproject.Table 6 Presents unit prices and quantities of concrete for major structural members for CIP and PC systems

Table 3: Duration of Concrete Precast vs. Cast-in-Place

Type of Construction	*Cast-In-Place*	*Precast*
Duration of Project(Days)	980	1772



Figue 1: Duration of Concrete Precast vs. Cast-in-Place

Table 4: Quantities of Concrete Works by Structural Members

	Project A			*Project A*		
Type of Structure	By Cast In Place Concrete			By Precast Concrete		
Structural Member	Qty. of Concrete (In m³)	Unit Cost (In Rs/ m³)	Total Cost ForIndividual Structural Element (In Rs)	Qty. of Concrete (In m³)	Unit Cost (In Rs/ m³)	Total Cost ForIndividual Structural Element (In Rs)
Foundations	7478	11244	88,535,256	7478*	11244	88,535,256
Columns	6609	12120	80,105,806.8	3869**	20408	78,960,100
Beams	13489	12120	163490073.6	7274	24008	174,637,102
Slabs	3157	12120	38259931.2	2120	13056	27,678,720
Stairs	1223	15795	19323129.15	1223	39487	48,293,213
	Cumulative Costs		409,037,326	*Cumulative Costs*		406,340,525

Notation:

* CIP Concrete is used for foundations and slab on earth for PC structure.

** Volume of the PC column is much smaller than the CIP column since it is a hollow column with 0.2 meter.

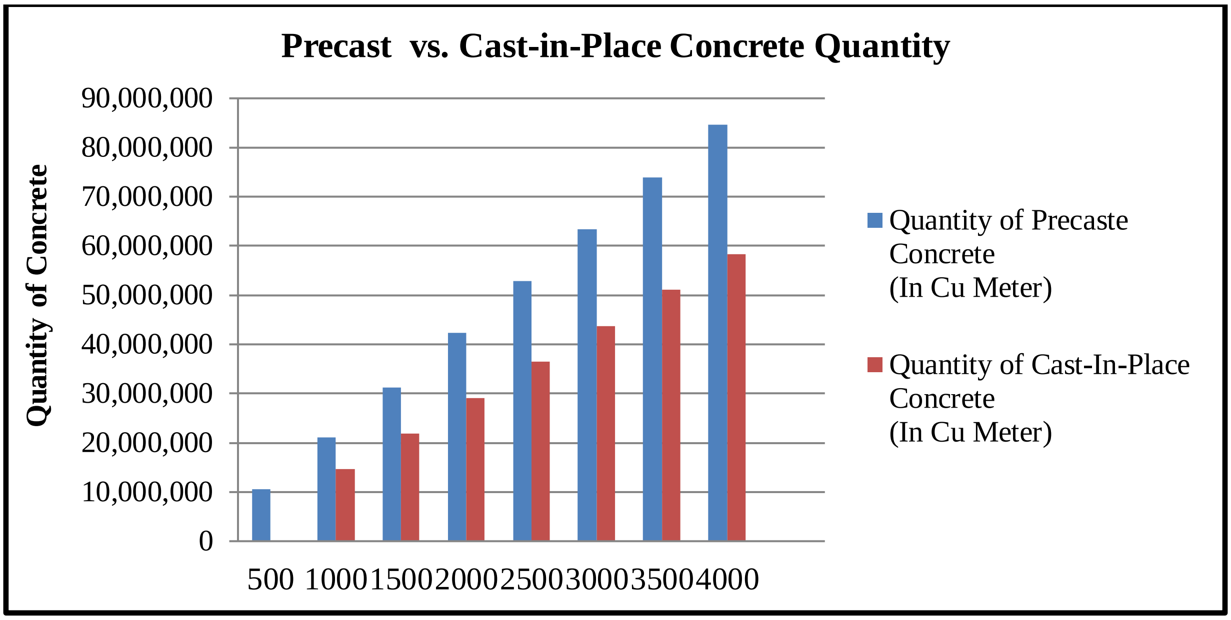


Figure 2: Precast vs. Cast-in-Place Concrete Quantity

i) Cast-In-Place Concrete (CIP) Structure Costs

From Table 6, total Quantity of CIP concrete is 23,255 m³ is to be erected in 1772 days (fromproject schedule) at average price of 12120Rs/m³ for all structural members excluding foundation and stairs (which are common for both alternatives);

Total cost = 23255 * 12120 =281,850,600 Rs.

Assuming an inverse linear relationship between concrete cost and duration of its erection and that all concrete works fall on the critical path, then

Cost of 10000 m³ CIP concrete = 121,200,000 RsEq 2

And if the Time for erecting 23,255 m³ of concrete is 1772 days; then Time to finish 10,000 m³ of concrete is 761 days.

Assuming indirect cost & profit margin is 25% (of 121.2 millions) of total costs which is 70,462,650 Rs; and then Eq. 3

The indirect cost & profit margin / day = 70,462,650 /761 = 92,592.18 Rs /Day Eq. 4

Thus, the direct cost for 10,000 m³ of CIP concrete is

Direct cost = Total cost – Total Indirect cost

= 281,850,600 - 70,462,650 (Eq 2 - Eq. 4)

= 211,387,950Rs

i.e. Direct Cost = 21,138 Rs/ m³ Eq. 5

For simplification, the findings of equations 2-4 are presented by the following variables:

DC1: Direct cost = 21,138Rs/ m³

T1: Time for finish 10,000 m³ = 761 days

IC1: Indirect cost & profit margin = 92,592 Rs/Day

Substituting the above variables in Eq.1, then it can be written as follows:

Total Costs (in Rs) of CIP concrete = DC1*Qi + IC1*Ti

= 21,138 * Qi + 92,592 *761

= 70,462,650 + 21,138 * Qi

ii) Precast Concrete (PC) Structure Costs

From Table 6,Total Quantity of PC concrete is 13263 m³ is to be erected in 240 days (from project schedule) at average price of 16157 Rs/ m³ for all structural members excluding the foundations and stairs; therefore,

Total cost of PC concrete = 13263* 16157 = 214,290,291 Rs.

And by extrapolation between concrete cost and duration of its erection given all concrete works fall on the critical path, then

Cost of 10,000 m³ PC concrete = 161,570,000 RsEq 6.

And if the Time for erecting 13263 m³ of concrete is 980days; then Time to finish 10,000 m³ of concrete is 739 days.

For the sake of simplicity, assume that the indirect cost & profit margin for the PC contractor is similar to contractor of the CIP, then

IC2 = IC1 = 92,592 Rs/Day Eq. 7

Total Indirect Cost for PC concrete = 92,592 Rs /Day * 739 Days

= 68,425,488 Rs

Thus, the direct cost for 10000 m³ of PC concrete = 214,290,291 Rs– 68,425,488 Rs

= 145,864,803 Rs, or

= 14,586 Rs/ m³ Eq. 8

For simplification, the findings of equations 21-31 and 41are represented by the following variables:

DC2: Direct cost = 14,586 Rs/ m³

T2: Time for erecting 10,000 m³ of PC concrete = 739 days

IC2: indirect cost & profit margin = 92,592 Rs/Day

Substituting the above variables in Eq.1, then it can be written as follows:

Total Costs (in SR) of CIP concrete = DC2*Qi + IC2*Ti

= 14,586 * Qi + 92,592 *739

= 68,425,488 + 14,586 * Qi

iii) Finding the Breakeven Point

Having developed Eq. 5 and Eq.51 for the relationship between both CIP and PC quantity of concrete versus total costs of erection, then a breakeven point whereby both linear equations are equal in total costs and equal in quantity of concrete can be found by equating Eq. 5 and Eq.51 as follows:

TC1 = TC2, i.e., 70,462,650 + 21,138 * Qi

= 68,425,488 + 14,586 * Qi, and thus

Qi = (70,462,650 - 68,425,488)/ (14,586 – 21,138)

= -310.9 m³ of concrete.

Table 6: Concrete Quantities vs. CIP/PC Costs

S.N.	*Quantity ofConcrete(m^3)*	*Cost of CIP Concrete(Rs/ m^3)*	*Cost of PCConcrete(Rs/ m^3)*
1	500	10,569,397	7,29,240
2	1000	21,138,795	14,586,480
3	1500	31,308,192	21,879,720
4	2000	42,277,590	29,172,960
5	2500	52,846,987	36,466,200
6	3000	63,416,385	43,759,440
7	3500	73,985,782	51,052,681
8	4000	84,555,180	58,345,921

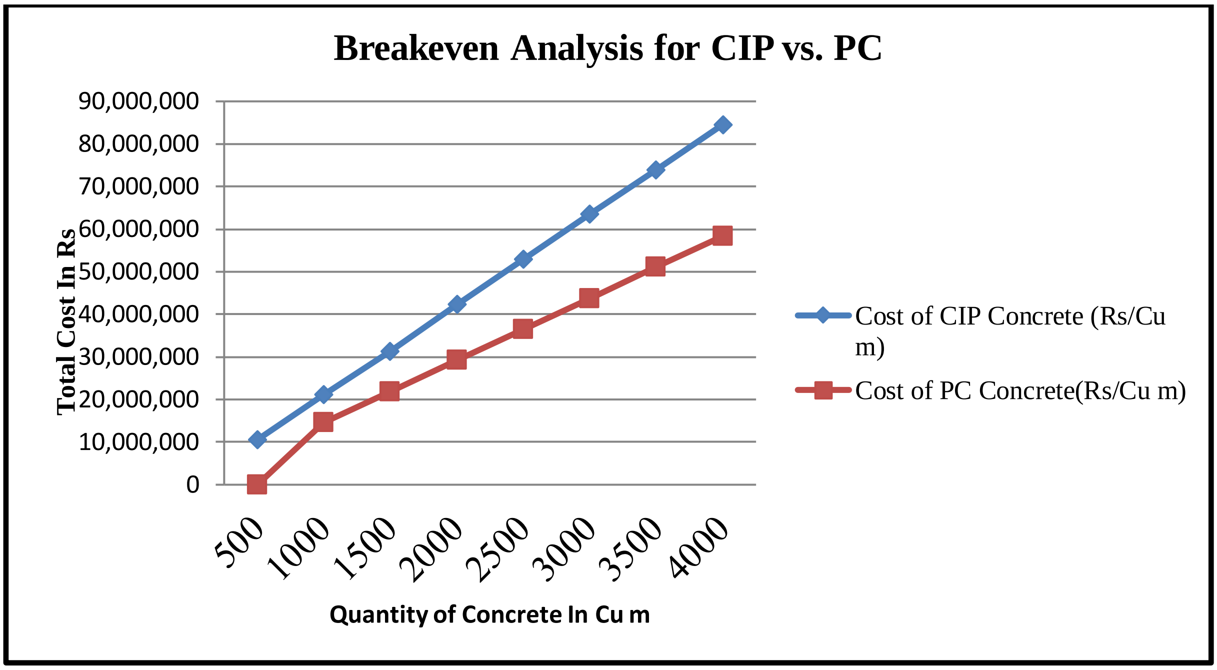


Figure 3: Breakeven Point of CIP vs. PC

A) PAY BACK PERIOD METHOD

Cast-In-Place

Total Investment into Project =225Cr

Total Duration for Completion of Project =1772 Day's

=4.8 Year's

Net Profit =326Cr

Table 8: Pay-Back Period for Cast-In-Place Concrete System

Year	*Profit*	*Cumulative Profit*
1	32.6	32.6
2	48.9	81.5
3	48.9	130.4
4	48.9	**179.3**
5	65.2	**244.5**
6	81.5	326

Calculation of Pay Back Period for Cast-In-Place Concrete System

In 365 Days Return from Project is 81.5 Cr.

365 Day's = 81.5Cr.

X = (244.5-179.3)

X = (365*65.2)/81.5

= 292 Day's

Pay Back Period is = 292 + 4 Year

= 292 + 1460

= 1452 Day's

Pay Back Period = 4.8 Year's

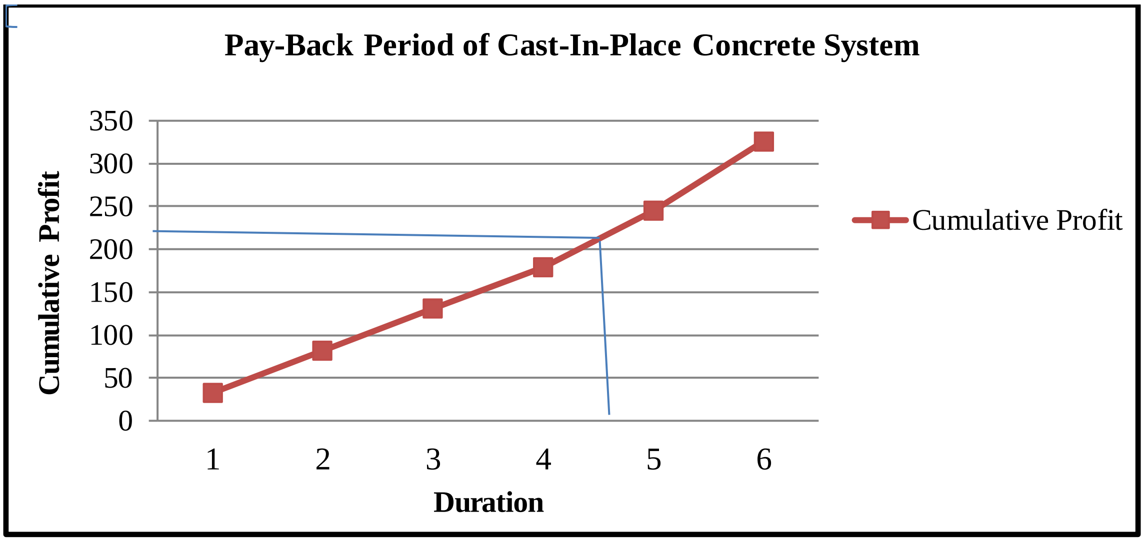


Figure 4: Pay-Back Period of Cast-In-Place Concrete System

B) PRECAST CONCRETE SYSTEM

Total Investment into Project =225Cr

Total Duration for Completion of Project =980 Day's

=2.68 Year's

Net Profit =326Cr

Table9: Pay-Back Period for Precast Concrete System

Year	*Profit*	*Cumulative Profit*
1	81.5	81.5
2	114.1	195.6
3	97.8	293.4
4	32.6	326

Calculation of Pay Back Period for Precast Concrete System

In 365 Days Return from Project is 195.6 Cr.

365 Day's = 195.6 Cr.

X = (293.4-195.6)

X = (365*97.8)/195.6

= 183 Day's

Pay Back Period is = 183 + 2 Year

= 183 + 730

= 912.5 Day's

Pay Back Period = 2.5 Year's

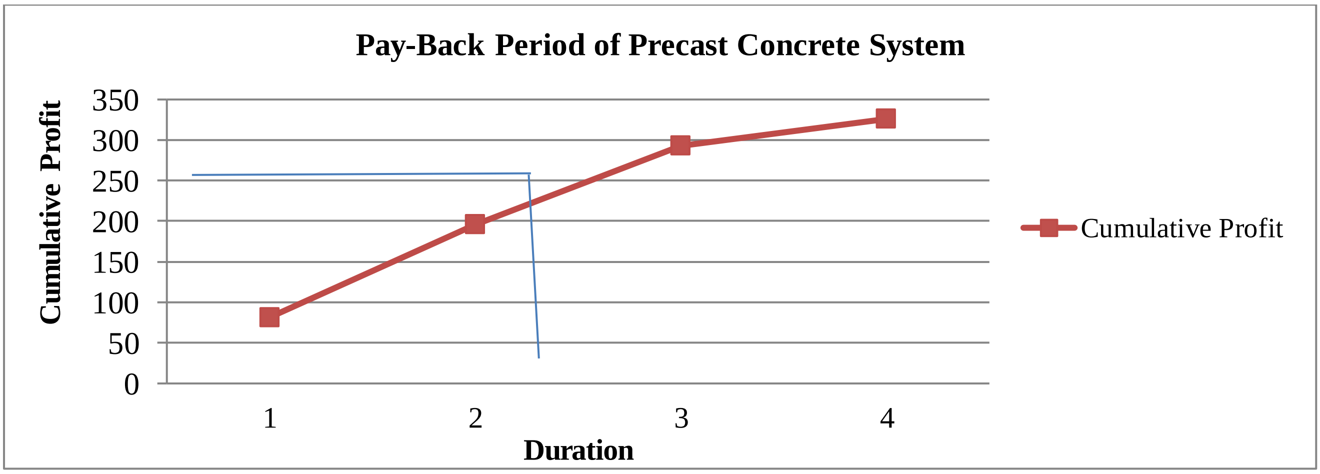


Figure 5: Pay-Back Period of Precast Concrete System

IV. CONCLUSION

Breakeven formula is derived to preliminarily evaluating and selecting best alternative between two competing construction methods offered by two different contractors for the structural members, those of Cast-in-Place concrete vs. precast concrete. The criterion for selection is based on the most economical solution. The quantities of works, i.e., concrete, are treated as independent variable. . The outcome of this research is, transportation & shifting cost of precast members considerably affective on total cost of construction which help to assist decision makers and engineers to compare both concrete construction methods early in the construction planning phase of a project.

By using Pay Back Period method we conclude that the Cast-In-Place Concrete system takes more time for Pay back the Invested Cash as compare to Precast Concrete System (i.e. Cast-In-place required 3.8 Years and Precast Concrete required 2.5 Years to Pay Back The Invested Amount in to the Project.)

Conflict of Interest: The authors declare that they have no conflict of interest.

Ethical Statement: The authors declare that they have followed ethical responsibilities.

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