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Design, Cost & Time analysis of Precast & RCC building

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Abstract - *Precast concrete is well known technology in which some standardized units which are manufactured in factories are used for fast construction. Though the technology is developed many years ago but the implementation is not up the mark in our country. In this study we have carried out detailed study of various concepts of precast, go through number of literature & found the facts associated with it. We have taken one building as a case & Design the same building as a precast building & Traditional Cast in-situ building. Here we have made cost analysis as well as feasibility check on basis of costing & Duration. For more practical study we have visited the two ongoing construction sites of Precast & cast in-situ & gathered required information, From this analysis It is remarkably seen that the cost of precast building is significantly reduces & duration of construction is also much lesser than traditional method. From all this study we can be conclude that the precast concrete system is economical than conventional cast in place method but still there are some conditions which we have to take care of while using precast, those are quantity of construction, Distance of site from manufacturing unit, Type of building etc.*

Key Words: Precast concrete, Cost of Precast, Cost & Time analysis etc.

1. INTRODUCTION:

Earlier Roman builders use concrete for construction of culverts, tunnels etc. Now a day's pre-cast technology include a variety of architectural and structural applications which can be used in various element of building. The process was invented by city engineer John Alexander Brodie, Actually idea was not taken up broadly in Britain Yet, it was adopted all over the world, The Precast Concrete industry focuses on utility, underground, and other non-pre-stressed products, and is represented primarily by the National Precast Concrete Association.
In this study we have gone through precast structural concepts, structure suitability, feasibility, & cost & time analysis of precast structure. We have also made comparison of both precast & Traditional cast in situ construction method on the basis of selected case. The detailed design of precast & RCC building is prepared & costing of both is compared.

2. METHODOLOGY

Literature review:
To study the construction techniques of precast and traditional method we have gone through various research papers, books,
Case study & Visits
In the reference of our work we have visited two constructions sites & Study the similar cases. One is of precast construction & Second was for RCC Structure the actual implementation of precast work is been observed & site difficulties were discussed with engineers & Project manager.
Analysis:
In this work we have made cost comparison as well as feasibility check for precast construction on large scale. Also few advantages & Drawbacks are identified by us.
Design:
In this study we have made Precast Design of a 12 storied building, sincere attempt is made here to follow the standards. Also for comparison we have made the typical RCC design of the same building & compare it with precast one.
Cost comparison:
After design calculations we have find out the cost of both the structures (i.e RCC & Precast) & made comparison of both. For calculation the market rates are considered.

From above Process we have come to the conclusion about the precast construction & related facts about execution & economic aspects. & detail conclusions have been drawn in the report.

3. DESIGN CONCEPT FOR PRECAST SYSTEM

Structural Concept:
Taking consideration of cost economy, build ability and the structural concept developed consists of
• Conventional foundations comprising footings, raft slab or piles and pile caps.
• Precast concrete non-load bearing walls.
• Precast concrete floor system, either:
- Precast concrete beams and precast slabs with a composite in-situ topping or precast concrete walls with precast concrete slab system

Design of Precast Building:

Here we have considered a 12-storey office building for design of precast building. The structural system of the selected office block is based on skeletal frame consisting of a framework of beams and slabs, columns. The structural frames are the most common system due to the advantage of greater flexibility in the building & functionality. These are also widely used as precast members because of their behaviors against forces & movements of structural elements however it is important to understand the physical effects of these forces and how they are transferred through the complete structure.

We have designed precast columns, beams, staircases, walls and their connections have been selected to illustrate as many as possible of the types of design in a building project for which calculations may have to be prepared. The drawings and calculations provided by us are preliminary one. They can be act as illustrative examples for others and more detail analysis is required, while implementation of project.

Description of Building

The building is a 12 stories commercial & office block including car parks, shopping malls and service apartments. A typical floor of the building measures around 72 m x 24 m & having 8 m building grids in both directions is shown in Figure. The design floor-to-floor height is 3.6 m. Staircases, lift cores and other building services such as toilets etc. are included & the cast in-situ construction is provided wherever necessary.

Structural System:

The building is consideed partialy as cast insitu cosstruction for tasking advantage of regularness in building grids. Beside acting as load bearing walls. staircase wells and lift cores also function as stabilising cores for the superstructure. The precast components consist of hollow core slabs, beams. columns and staircase flights.

a. Hollow core slabs

The design of hollow core slabs is based on class 2 prestressed concrete structures with least 2 hours fire retention. The hollow core slabs are 215mm thick & cast with concrete. Each unit is designed as simply supported with minimal 100 mm seating at the support.

b. Precast beams:

Precast beams are used in the office area are 540mm deep. The beams, which are un-propped during construction, are seated directly on column corbels and they are designed as simply supported structures. For Limiting the cracking of the topping concrete at the supports, site placed reinforcement is provided.

c. Precast columns:

Here for this structure, columns are of size 500 mm x 700 mm and with base plate connection at every alternate floor. That is designed as pin-ended at the ultimate limit state. The base plate connections are designed so that they are enabling to withstand moment capacity of column to behave as a two story cantilever. The advantage of base plate connection is to eliminate heavy column props and result in a safe & Easy execution. A sufficient tolerance is necessary for in-situ reinforcement at the time of execution so 50mm gap is designed for column to column at the beam support regions.

Every column is to be casted in the direction of precast beam with Reinforced concrete corbels with T25 dowel bars which are prevents topping beams when we laid the precast slabs while execution. All columns are to be considered braced in both directions.

d. Diaphragm action of Floor & structural reliability

Here all precast elements are bound by a 65 mm thick concrete topping. These elements are reinforced with a layer of steel fabric mesh. Which can serves as structural ties in order to satisfy the reliability ties requirement of strength the whole floor structure will perform as a stiff diaphragm which distributes horizontal loads to the stabilizing cores at each end of the floor.

Design information

a. Codes of Practice

BS 6399 :Design Loading for Building

CP 65 : The Structural Use of Concrete

CP3, Chapter V :Wind Load

b. Materials

Concrete : M30 for topping, walls and all other in-situ works

: M40 for precast beam

: M40 for precast columns and hollow core slabs

Steel : fy = 250 N/mm2 mild steel reinforcement

: fy = 460 N/mm2 high yield steel reinforcement

: fy = 485 N/mm2 for steel fabric reinforcement

c. Dead loads

Concrete density = 24 kN/m3

Partitions, finishes and services = 1.75 kN/m2

Brick walls = 3.0 k/Nm2 in elevation

RCC Design for same building:

We Have Also made RCC Design for the same structure.

The Details of RCC Design are as follows.

The following image shows typical slab portion for the selected case of building.

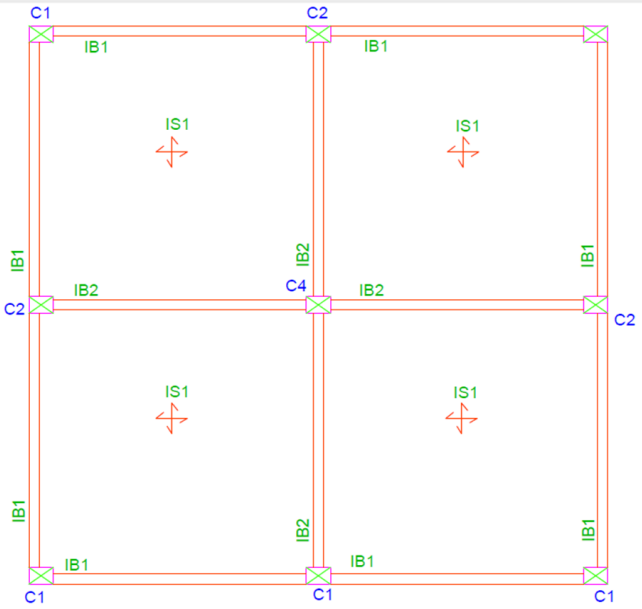

Figure 01 Showing Slab units considered for Design

RCC Design Summary:

Table No 01: Showing RCC Design Summaries

Name	No's	Size	Reinforcement	Reinforcement	Remark
IS1	20X12=240	d= 9"	12#@ 5.5"cc	12#@ 5.5"cc	TWO WAY SLAB
IB1	26x12=312	20" X 27"	BOTTOM:- 2 # 32- FULL 2 # 32- CURTAIL	TOP:- 2 # 20 DE:- 1# 32 CE:- 3 # 32	
IB2	26x12=312	20" X 30"	BOTTOM:- 3 # 32- FULL 2 # 32- CURTAIL	TOP:- 2 # 20 DE:- 1# 32 CE:- 4 # 32	
Column	33	750 X 500	12 # 40	TIES:- 10 # @ 8"C/C	
FOOTING	33	7550 X 7550 X 1300	32 # 100mm c/c	32 # 100mm c/c	A + B= 1300 A = 650,B= 650

4. COST COMPARISON & TIME EFFECTIVENESS

General comparison

Table 02: Comparison of precast & Cast in situ

Particular	Precast	RCC
Construction speed	Very rapid speed of erection. Rapid construction on site.	Comparatively slow construction On site casting, so reinforcement laying & fixing, formwork, setting of concrete required time.
Quality control	Good quality control.	Quality may affect due to site conditions, due to bad supervision, unskilled labor.
Environmental conditions	Weather is eliminated as a factor-you can cast in any weather and get the same results, which allows you to perfect mixes and methods	Environmental conditions like temperature, humidity can affect on performance of concrete.
Labor Requirement	Less labor is required and that labor can be less skilled	More Labors required on site in case of RCC.
Manufacturing conditions	High quality can be achieved because of the controlled conditions in the factory.	RCC is to casted on site & the site conditions are not regularized, so it may affect on strength.
Quantity discount	Since a Precasters can buy materials for multiple projects, quantity discounts can lower costs	The owner can only buy small required quantity so quantity discount is not that much.
Durability	With the ability to so tightly control the process, from materials to consolidation to curing, you can get extremely durable concrete	RCC is sufficiently durable but it required proper quality control.
Size & Shape	Repeatability-it's easy to make many copies of the same precast product; by maximizing repetition, you can get plenty of value from a mold and a set-up This cannot be modified on site There is no	In-situ concreting is suitable where the building is in uneven shape & there are no repetitive shapes, Can be possible to modify shape on site More flexibility in execution.

	flexibility in changing size shape on site.	
Connections	Connections are simpler	Connections may be difficult
Design Flexibility	building design flexibility is more	Somewhat limited building design flexibility
Size Limitation	No limitation for size.	Because panel size is limited, precast concrete cannot be used for two-way structural systems.
Cost	It is comparatively economical when the building having no regular shapes.	Economics of scale demand regularly shaped buildings.
Shape	Here we Need Regular shapes in building to achieve economy, Need for repetition of forms will affect building design..	It can be casted in any shape on site.

Cost & Duration Comparison:

As the population continuously growing rapidly, so the need of rapid or fast construction is requirement of future generation. Precast concrete construction methods are become feasible and alternatives method or solution in such applications Ides buildings and bridges. The primary benefit of precast construction is reduction in time of construction. Waste management and cost efficient construction.

Precast concrete is the ideal solution for residential because the structure of residential buildings are somewhat standard so the construction of same type of elements are easy and result in to cost saving on if its production is in bulk. Precast concrete provides stability, Flexibility, sound durable and adaptability with cost efficiency. Precast concrete construction required less construction process which saws money on financing costs. Cost minimization on labor policies, skills, development of employ, providing training to them is main factors. Repairs cost also reduces in precast concrete construction. The following table shows the comparison of precast & cast in situ on basis of duration.

Table 03 Shows Comparison of precast & Cast In-situ on basis of Duration.

Operation	Precast	Cast-in-place
	Number of Day	Number of Day
Excavation, Filling, etc.	Same	Same
Pouring & Curing concrete Strip Base	1	2
Pour. Cure. Strip Wall	NA	2
Pour. Cure. Strip Top	NA	2
Damp proof course	NA	1
• Install on site	1	Included
• Total Duration in Days	2	7

Recent works on the concept of precast construction includes those buildings where the majority of structural components are standardized i.e. having same & repetitive size shape and produced in factory in a location away from the construction site. Normally these members are manufactured on bulk production in industries to provide easy construction with less cost & time. When we wisely use precast elements in building systems are seems to be economical when it compared with Conventional type construction of buildings.

8.3 Cost Comparison of Selected Building:

After design & Analysis we have made cost analysis of same structure. And comapare cost of RCC structure with precast structure rates are adopted from DSR & market inquiry.

This is overall estimating which attempts to find out nearby cost of structure & accordingly we can determine the economic aspects in this study. The comparison of both the structure is provided below.

Table 04 Showing cost comparison of RCC & Precast building.

Perticular	Precast Costing	Perticular	Cast Insitu cost
Excavation for foundation in soft murrum	582912	Excavation for foundation in soft murrum	582912
Excavation for foundation in Hard murrum	1689600	Excavation for foundation in Hard murrum	1689600
Providing & Laying Plain cement concrete for Footting as a PCC bed	1607232	Providing & Laying Plain cement concrete for Footting as a PCC bed	1607232
Providing & laying M-40 RCC for fotting & foundation	8728693.1	Providing & laying M-40 RCC for fotting & foundation	8728693.07
RCC PRECAST Column : Providing and laying RCC precast column of required size with 1:1.5:3 nominal mix using 20mm and down size crushed stone aggregates including shuttering, mixing, compacting, pond curing for 14 days etc. transporting from the place of casting. (Size 700 X 500)	2245320	Providing and casting in situ cement concrete M-40 of trap / granite /quartzite/ gneiss metal for R.C.C. columns as per detailed designs and drawing or as directed including centering, formwork, cover blocks compacting and roughening the surface if special finish is to be provided and curing complete. (Excluding reinforcement).With fully automatic micro processor based PLC with SCADA enabled reversible drum type concrete mixer With Crushed sand (Size 750 X 500)	2405700
RCC PRECAST BEAM :(For Even area) Providing and laying RCC precast Beams of required size with 1:1.5:3 nominal mix using 20mm and down size crushed stone aggregates including shuttering, mixing, compacting, pond curing for 14 days etc. transporting from the place of casting.(size 535 x 800)	5015604	Providing & casting in situ cement concrete M-20 of trap / granite /quartzite/ gneiss metal for R.C.C. beams and lintels as per detailed designs & drawings or as directed including centering, formwork, cover blocks compaction & roughening the surface if special finish is to be provided & curing complete. (Excluding reinforcement). With fully automatic micro processor based PLC with SCADA enabled reversible drum type concrete mixer With natural sand. (For uneven area)	9238986
RCC PRECAST SLAB :(For even area) Providing and laying RCC precast slabs of required size with 1:1.5:3 nominal mix using 20mm and down size crushed stone aggregates including shuttering, mixing, compacting, pond curing for 14 days etc. as per IS 456, transporting from the place of casting. Reinforcent steel shall be paid separately .	15493968	Providing and casting in situ cement concrete M-20 of trap/ granite / quartzite/ gneiss metal for R.C.C. slabs and landings canopy, waist slab with steps as per detailed designs and drawings including centering, formwork, cover blocks compacting and roughening the surface if special finish is to be provided and curing complete. (Excluding reinforcement).With fully automatic micro processor based PLC with SCADA enabled reversible drum type concrete mixer With natural sand. Spec. No.: Bd.F.8 Page No. 302 and B.7, Page No.38	25054617.6
Providing & fixing precast reinforced cement concrete chajja (0.750mm around the building)(100mm thick)	622080	Providing & casting in situ cement concrete M-20 of trap/ granite/ quartzite/ gneiss metal for R.C.C. chajja as per detailed design & drawings including centering, formwork, cover blocks compacting & roughening the surface if special finish is to be provided & curing complete. (Excluding reinforcement). With fully automatic micro processor based PLC with SCADA enabled reversible drum type concrete mixer With natural sand.(0.750mm around the building)(100mm thick)	1449619.2
Providing second class Burnt Brick masonry + Precast Wall costruction in even areas	186331296	Providing second class Burnt Brick masonry with conventional/ I.S. type bricks in cement mortar 1:6 in superstructure including striking joints, racking out joints, watering and scaffolding Complete..	15386717
Providing and fixing Ghana teak wood double or single leaf second class fully paneled door shutter with 35mm thick style and rail with 25 mm thick panels with openable fan light as per detailed drawings. excluding the door frame 60mm x 100mm stainless steel fixtures and fastening and finishing the wood work with oil painting 3 coats. Spec. No.: Bd-T-7 & 8 Page No. 481-82	3077550	Providing and fixing Ghana teak wood double or single leaf second class fully paneled door shutter with 35mm thick style and rail with 25 mm thick panels with openable fan light as per detailed drawings. excluding the door frame 60mm x 100mm stainless steel fixtures and fastening and finishing the wood work with oil painting 3 coats. Spec. No.: Bd-T-7 & 8 Page No. 481-82	3077550

Providing and fixing frame with / without ventilator of size as specified with non teak wood for doors including chamfering, rounding, rebating, iron holdfast of size 300mm x 40mm x 5mm with oil painting, etc. complete. Spec. No.: As directed by Engineer in charge.	6096480	Providing and fixing frame with / without ventilator of size as specified with non teak wood for doors including chamfering, rounding, rebating, iron holdfast of size 300mm x 40mm x 5mm with oil painting, etc. complete. Spec. No.: As directed by Engineer in charge.	6096480
Providing and fixing Ghana teak wood double or single leaf second class fully paneled door shutter with 35mm thick style and rail with 25 mm thick panels with openable fan light as per detailed drawings. excluding the door frame 60mm x 100mm stainless steel fixtures and fastening and finishing the wood work with oil painting 3 coats. Spec. No.: Bd-T-7 & 8 Page No. 481-82.	3105000	Providing and fixing Ghana teak wood double or single leaf second class fully paneled door shutter with 35mm thick style and rail with 25 mm thick panels with openable fan light as per detailed drawings. excluding the door frame 60mm x 100mm stainless steel fixtures and fastening and finishing the wood work with oil painting 3 coats. Spec. No.: Bd-T-7 & 8 Page No. 481-82.	3105000
Providing and fixing window frame with / without ventilator of size as specified with non teak wood for doors including chamfering, rounding, rebating, iron holdfast of size 300mm x 40mm x 5mm with oil painting, etc. complete. Spec. No.: As directed by Engineer in charge(1.8 X2.3 M Opening asumed)	590400	Providing and fixing window frame with / without ventilator of size as specified with non teak wood for doors including chamfering, rounding, rebating, iron holdfast of size 300mm x 40mm x 5mm with oil painting, etc. complete. Spec. No.: As directed by Engineer in charge(1.8 X2.3 M Opening asumed)	590400
Providing and laying Polished Tandur Stone flooring 25mm to 30mm thick required width in plain/ diamond pattern on a bed of 1:6 C.M. including cement float, filling joints with neat cement slurry, curing, polishing and cleaning complete. Spec. No.: Bd.M.3 Page No. 380	14552525	Providing and laying Polished Tandur Stone flooring 25mm to 30mm thick required width in plain/ diamond pattern on a bed of 1:6 C.M. including cement float, filling joints with neat cement slurry, curing, polishing and cleaning complete. Spec. No.: Bd.M.3 Page No. 380	14552524.8
Providing & Laying Precast RCC Stair For structure. 1.5m landing	120268.8	Providing & Laying Precast RCC Stair For structure. 1.5m landing	236930
External Plastering (Not Necessary for precast)	Nil	Providing rough cast cement plaster externally in two coats to concrete, brick or stone masonry surfaces in all positions with base coat of 12 to 15 mm thick in C.M. 1:4 and rough cast treatment 12mm thick in proportion 1:1 1/2:3 including scaffolding and fourteen days curing complete.	2903040
	82158929		104580330
Add 5 % for Plumbing, Electrification & water charges	4107946		4980015
	86266875		**104580330.34**

We have work out the cost of both the buildings (RCC &Precast), From this analysis & calculations it can be said that the precast concrete system is economical than conventional cast in place method, the cost difference is found to be around 1.83 cr. but still there are some conditions which we have to take care of while using precast, those are quantity of construction, Distance of site from manufacturing unit. Type of building etc. we have identified that for standard & Repetitive work precast is the best option to choose. The main limitation of precast is transportation from place of manufacturing to place of site where it is to be fixed.

5. CONCLUSION

As we have seen various methods of precast, Design, case studies of precast & it is found that, the design comes out as economical if proper care while designing is taken. We have design the same building by traditional & precast method & Notice the Cost & completion duration It is remarkably seen that the cost of precast building is significantly reduces & duration of construction is also much lesser than traditional method. From all this study we can be conclude that the precast concrete system is economical than conventional cast in place method but still there are some conditions which we have to take care of while using precast, those are quantity of construction, Distance of site from manufacturing unit. Type of building etc. we have identified that for standard & Repetitive work precast is the best option to choose. In observation the most important thing is to be observed project is in precast construction technique is the time effective it require less time to construct. It requires skilled worker and qualified contractor, Lower initial cost especially for large project. We can achieve better concrete quality control and lighter concrete unite. The main limitation of precast is transportation from place of manufacturing to place of site where it is to be fixed.

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Anexure-I