

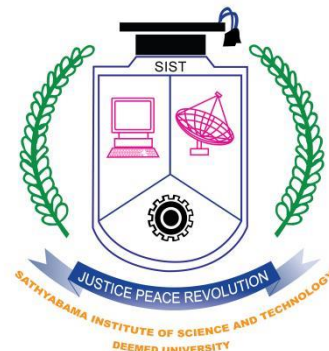
FEASIBILITY STUDY OF PRECAST CONCRETE CONSTRUCTION IN HIGH RISE MASS HOUSING IN INDIA

A Thesis

Submitted in partial fulfillment of the requirements for the award of
Master of Architecture degree in Building Management

by

RAJARAJAN.B (39840016)



**DEPARTMENT OF ARCHITECTURE
SCHOOL OF BUILDING AND ENVIRONMENT**

SATHYABAMA

**INSTITUTE OF SCIENCE AND TECHNOLOGY
(DEEMED TO BE UNIVERSITY)**

Accredited with Grade "A" by NAAC

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OCTOBER 2021



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BONAFIDE CERTIFICATE

This is to certify that this Report is the bonafide work of **RAJARAJAN.B (39840016)** who carried out the Thesis entitled “**FEASIBILITY STUDY OF PRECAST CONCRETE CONSTRUCTION IN HIGH RISE MASS HOUSING IN INDIA**” under our supervision from June 2019 to October 2019.

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ABSTRACT

Conventional construction method is the process consisting of cast in situ constructions whereas the **Precast concrete construction** only involves assembly of already casted products in the site. By producing precast concrete in a controlled environment (typically referred to as a precast plant), the precast concrete is afforded the opportunity to properly cure and be closely monitored by plant employees. Utilizing a Precast Concrete system offers many potential advantages over site casting of concrete. Precast constructions has been a common construction method in United States of America and many European countries. Over the past 15 years, India has experienced the huge increase in housing demand in a very short period of time, requiring a massive production of residential buildings with the changing face of realty market. To meet high demand, some builders tried to innovate and bring about transition from the conventional cast-in-situ (CIS) construction and move to precast construction by making building components off-site, and then install them on site. Precast technology, the so-called unconventional method in Indian arena can facilitate both speed and quality and exploit the advantages that projects offer in terms of repetitions and volume. Today, the world agrees that precast/prefab construction makes significant impact on both time and budget. This was done by analyzing the scheduled activities and budget of the project and implementing it in real case studies.

Keywords: Mass housing, Construction management, Scheduling, Feasibility.

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LIST OF SYMBOLS AND ABBREVIATIONS

EWS	-	Economically weaker section
LIG	-	Low Income Group
BMTPC	-	Building Materials and Technology Promotion Council

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Precast construction system is generally a large panel system, modular system or a combination of both. Precast Large Construction Panel (PLCP) system consists of various precast elements such as walls, beams, slabs, columns, staircase, landing and some customized elements that are standardized and designed for stability, durability and structural integrity of the building. Precast residential building construction involves design, strategic yard planning, lifting, handling and transportation of precast elements. This technology is suitable for construction of high-rise buildings resisting seismic and wind induced lateral loads along with gravity loads. The building framing is planned in such a way that maximum number of repetitions of moulds is obtained. These elements are cast in a controlled factory condition. The factory is developed at or near the site which provides an economical solution in terms of storage and transportation. Two main types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements are used as per the details given below: *Precast concrete elements* – Concrete components of a building prefabricated in precast yard or site and shall be installed in the building during construction. Precast pre-stressed concrete elements. These shall consist of pre-stressing tendons within the elements to provide a predetermined force needed to resist external loadings and cracks such as hollow core slabs, beams and planks.

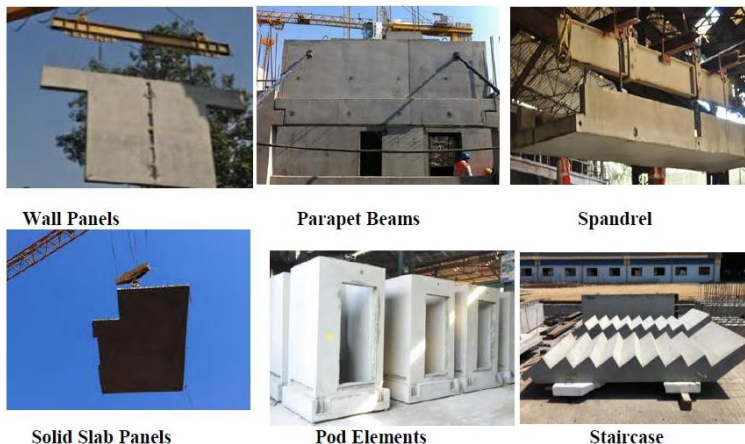


Fig 1.1 Precast Elements

1.2 AIM

The study aims to evaluate the effective use of Precast Concrete Construction in building systems in order to achieve affordable mass housing and also to minimize the intensive use of building materials.

1.3 OBJECTIVE AND SCOPE FOR THE STUDY

- To analyse and to study of Precast Concrete in construction management aspect in terms of cost and time.
- To analyse the cost of structure due to savings in materials.
- To familiarize with the Precast Concrete construction methodology with due focus on the difference from the conventional construction.
- To Identify and understand, pros and cons of Precast Concrete in residential construction (mass housing).

1.4 LIMITATION FOR THE STUDY

The study will focus only in construction phase cost, time and quality of precast concrete construction vs conventional construction.

1.5 METHODOLOGY

The research methodology is divided in two parts; theoretical aspect discusses the building design using Precast construction technology according to design manual, installation manual, and system requirements. Practical aspect concerning cost of operation process, In addition to that, data was gathered from different projects using Precast construction system concerning construction cost & installation procedures on site and is compared against the conventional building. The cost, time, quality and quantity analysis is done for Precast construction and the comparison of conventional building is done to know the feasibility of the Precast construction technology and the conventional system.

RESEARCH METHODOLOGY

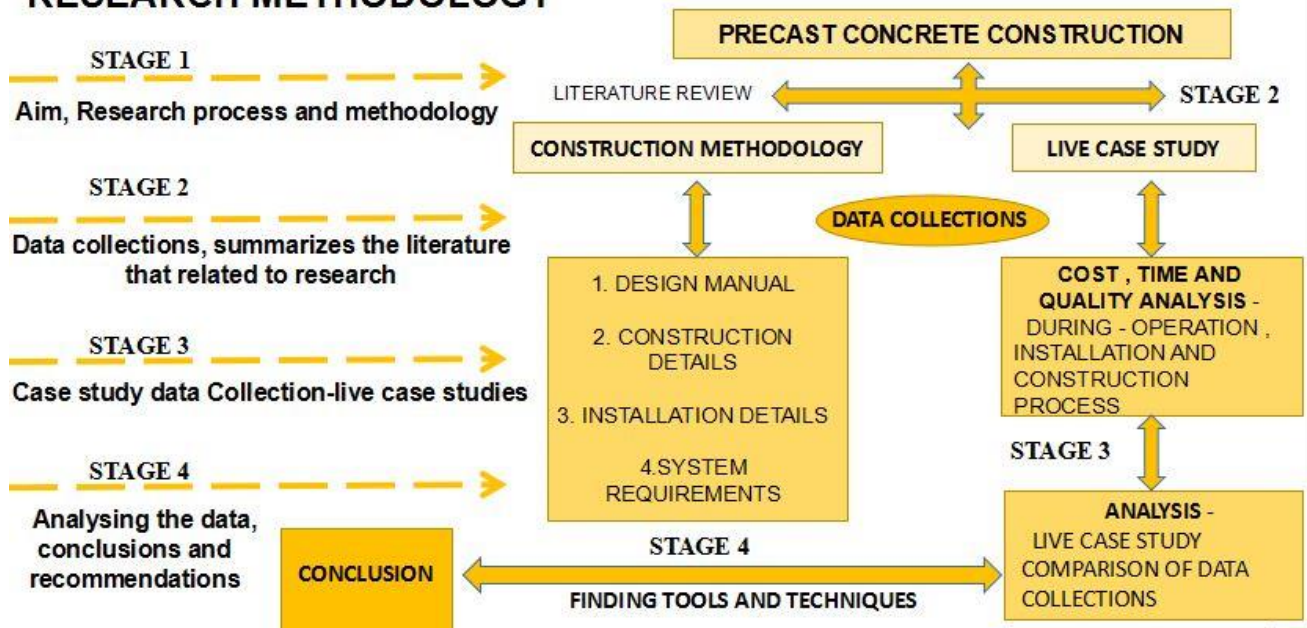


Fig 1.2 Research Methodology

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

In this new era of construction, several different building systems orientated for housing appeared in India. Most of these systems were introduced from first world countries and many were not able to fit into the Indian construction standards. On the other hand, many of these systems were functional in countries lacking earthquake trouble and the majority of them employed foreign supplies. In this case of India, structural systems were supposed to be designed according with earthquake standard E-030 of the National Building Code. On the other hand, Indian researchers in the last 20 years developed different solutions for building systems using locally available materials and most of them were tested and had the approval and registration of BMTPC. The present work introduced five construction systems that are approved by BMTPC. The economic issues are also the main reason for these different building systems. So we have to select the most viable and low cost construction for avoid the financial problems.

2.2 CONVENTIONAL BUILDING WORK

The major bulk of building construction work is small renovation, such as addition of a room, or renovation of a restroom. Often, the owner of the property work as the introspect, paymaster, and design team for the entire project. Although, all building construction projects consist of some elements in general – design, financial, estimation and legal considerations. Many projects of different sizes reach unwanted consequences, such as structural failure, cost overruns, and/or lawsuits. Due to such reasons, those with expertise in the field make comprehensive plans and keep cautious supervision throughout the project to ensure a positive result.

Commercial building construction is procured privately or publicly utilizing various delivery methodologies, including cost estimating, hard bid, negotiated cost, conventional,

organization contracting, construction management-at-risk, design & build and design-build bridging.

Residential construction practices, technologies, and resources should match to the regulations of local building authority and codes of practice. Materials readily accessible in the region usually dictate the building materials used (e.g. brick vs stone vs concrete). Cost of building construction can vary considerably based on site conditions, local policy, economy of scale (custom designed residences are often more costly to build) and the availability of trained workers and labours. As residential building construction (as well as all other types of construction) can produce a lot of waste, so careful planning again is required here.

2.3 PRECAST LARGE CONCRETE PANEL SYSTEM IN BRIEF

Precast concrete construction system has its own characteristics which influence the layout, span length, construction depth, and stability system to a great extent. In precast concrete construction, majority of structural members are manufactured in manufacturing plants away from the construction site. After that, they are delivered to the project site to be erected. Various connections have been developed to connect different types of structural elements like beam to column connection and panel to panel connection. In this manner, the imposed loads are transferred from superstructure to the foundation. Designers should consider the possibilities, restrictions, detailing, manufacturer, transport, erection and serviceability stages before finalizing the design of precast concrete structure.

Large panel systems are useful for the construction of apartments and hotels. It consists of large walls and floor concrete panels connected in the vertical and horizontal directions. Both horizontal and vertical panels withstand gravity loads. There are three arrangements of large panel system based on wall layouts which include cross-wall system, longitudinal-wall system, two-way system.

2.3.1 Specifications for the System

1. Ordinary Portland Cement: Shall be of 43 grade as per IS 8112:1989.

2. (i) Fine aggregate (M Sand): Shall be as per IS 383:1970 & IS 1542:1992 and 4.7 mm.
3. Coarse Aggregates: Shall be as per IS 383:1970 and of 20 mm, 40 mm size
4. Steel reinforcement: Shall be as per IS 1786:2008
5. Concrete: The grade of concrete shall be M 30 and slump for walls, floors and roofs shall be as per IS 456:2000.
6. Brick masonry: Shall be as per IS 1905:1987
7. Solid Block work: Shall be as per IS 2185 (Part 1):1979
8. Aluminium: Shall be as per IS 733:1983
9. Glass: Shall be as per IS 2835:1987
10. Non shrunk non-metallic grout: Cement based flowable grout shall have compressive strength of 65 N/mm², flexural strength of 9 N/mm² at 28 days and E-modulus of 37000 N/mm². (ASTM C 109 & ASTM C 293-79)
11. Water proofing membrane: Fibre reinforced repair mortar shall have compressive strength of 45 N/mm² at 28 days and density 2250 kg/m³ (ASTM C 109).
12. Baker Rod: Closed cell polymer based product shall have compressive strength of 0.45 kg/cm² min. at 25% deflection, density 22 kg/m³ min. and water absorption 0.14 gm/cm³ max.
13. Corrugated sleeve: Hot dipped galvanized prime steel sheet shall be as per IS 277:2003.

2.3.2 Types of precast elements

Two main types of precast concrete elements, namely precast reinforced concrete elements and precast pre-stressed concrete elements are used as per the details given below:
Precast concrete elements – Concrete components of a building prefabricated in precast yard or site and shall be installed in the building during construction.

i. Precast reinforced concrete elements

- These shall consist of reinforcement bars and welded wire meshes within the elements to provide the tensile strength and resistance against cracks such as façade walls, beams, columns, slabs, refuse chutes, staircases and parapet walls.

ii. Precast pre-stressed concrete elements

- These shall consist of pre-stressing tendons within the elements to provide a predetermined force needed to resist external loadings and cracks such as hollow core slabs, beams and planks

2.4 CONSTRUCTION TECHNIQUES FOR PRECAST BUILDING PANELS

Proper planning and preparatory works shall be required before the actual installation of precast concrete elements in order to ensure quality installation. The following items shall be planned in advance:

i. Method of sequence of assembly and installation: Precast elements should be identified based on their location number and the tagged.

ii. Method of providing temporary support: Elements should be supported temporarily before these get stabilized. Generally structural members with adjustable ends shall be used for

securing the panels. Shims should be used to adjust the panels to ensure dimensional correctness.

iii. Installation tolerances: Installation tolerances should be based on codal provisions and design considerations should be clearly indicated.

iv. Handling and rigging requirements: Elements should be checked for handling stresses before lifting and the cranes should have sufficient capacity to handle the precast panels.

At least 10% impact should be considered while calculating the lifting capacity of the crane.

At site locations, panels shall be first unloaded and stacked or directly lifted by the crane. The element shall then be installed on the site and supported by temporary jacks. The cranes shall be released for next lifting once the temporary supports are in place. Shims shall be used to carefully align the element before grouting. The panels shall be grouted after the final adjustments are done.

2.4.1 Waterproofing

External joints shall be sealed with baker rods and sealants after filling the joints with grout to avoid the leakage. Additional waterproofing treatment shall be provided at external joints and wet areas to ensure water tightness.

2.4.2 Mechanical, Electrical & Plumbing Fittings

Mechanical, electrical & plumbing fittings shall be kept open or concealed as per the requirements. For concealed fittings, provision for grooves, blockouts shall be made in casting moulds. The conduits and electrical boxes shall be embedded and fixed in moulds before casting. For open fittings, these shall be fixed after erection at site. For firefighting systems, provision of National Building Code (NBC) and local body law shall be adhered to.

Precast concrete shall be designed for fire rating of 1 to 2 hours based on codal requirements. Minimum precast concrete wall thickness of 120 mm shall be provided for 1 hour fire rating as per IS 456:2000. Variety of shapes, colours, textures and finishes may be obtained with precast concrete. The surface treatments shall be done by rebating, grooving, surface coatings, cement based renders, oxide coloring etc. Precast concrete facades of various shapes, colours and textures may be moulded and installed.

2.4.3 Design Considerations and Requirements

Structural Design Approach : The overall behavior of a precast structure is dependent on the behavior of the connections which must provide: Resistance to all design forces, Ductility in case of excessive deformation, Resistance to volume changes and related forces, Adequate durability, Required fire resistance, Feasible production considerations and Feasible construction considerations.

Floor panels: For reinforced concrete floors, concrete of minimum grade M 30 shall be used. Pre-stressed concrete floor units shall satisfy the strength requirements followed in usual design practice, namely, a minimum of M 35 for post-tensioned and pre-tensioned works. The thickness of the floor panel shall be such that the serviceability requirements are satisfied. The minimum thickness of concrete layer for cored slab is 50 mm. Panels shall be designed in accordance with the recommendations given in IS 456:2000 governing reinforcement and detailing.

Walls: Structural load bearing walls shall be designed as per codal provisions of IS 456:2000 and IS 13920:1993 as applicable. Internal non load bearing walls should be designed as plain concrete walls with nominal reinforcement for handling and erection stresses. Such walls may also be built using alternate partition wall systems. For concrete walls, minimum concrete grade should be M10.

Connections: The PLCP System is designed using the emulative detailing concept such that once the structure is completed it will behave similar to an equivalent RCC System and will provide necessary strength and ductility. Typically, wet connections are used to achieve the emulative behavior in the PLCP System.

Structural system: The structural system of superstructure consists of precast construction of RCC wall, columns, slabs and beams. Floor slab shall be considered to act as a rigid diaphragm to transfer the lateral forces to walls/column. Ground floors are mostly constructed by conventional method i.e. cast-in-situ construction. It shall be designed to take the cantilever load of the above floors. First floor to higher floors shall be constructed by precast technology i.e. precast wall and solid floor slab system.

Fire rating: Period of fire resistance of RCC buildings is based on NBC requirements. To meet the fire rating requirement, provision specified in IS 456:2000 shall be followed.

Design loads: 1. Dead loads – the dead load shall comprise of self-weight of all the frames and shell elements modelled in the structure as well as self-weight of slabs.

2. Imposed loads – The imposed loads that are envisaged to act permanently (whichever applicable) are as follows: i. Waterproofing: Shall depend on the thickness, slope and

kind of material to be used for waterproofing. ii. False ceiling/Internal partitions: False ceiling load shall be calculated based on type of material and thickness using unit weights specified in IS 875(Part 1):1987. Partition loads shall be as per actuals.

iii. All structural elements: Layout and size of elements shall be followed as per structural requirements.

Wind load: The wind pressure shall be calculated on the basis of data specified in clause 5.3 of IS 875 (Part 3):1987.

Earthquake loads: For seismic purpose, the PLCP System design shall be in compliance with the provisions of IS 1893:2002.

Design Methodology: All structural elements shall be designed according to the Limit state method as specified in IS 456:2000. For design of ties, key elements and joints etc. reference may be made to IS 15916:2010.

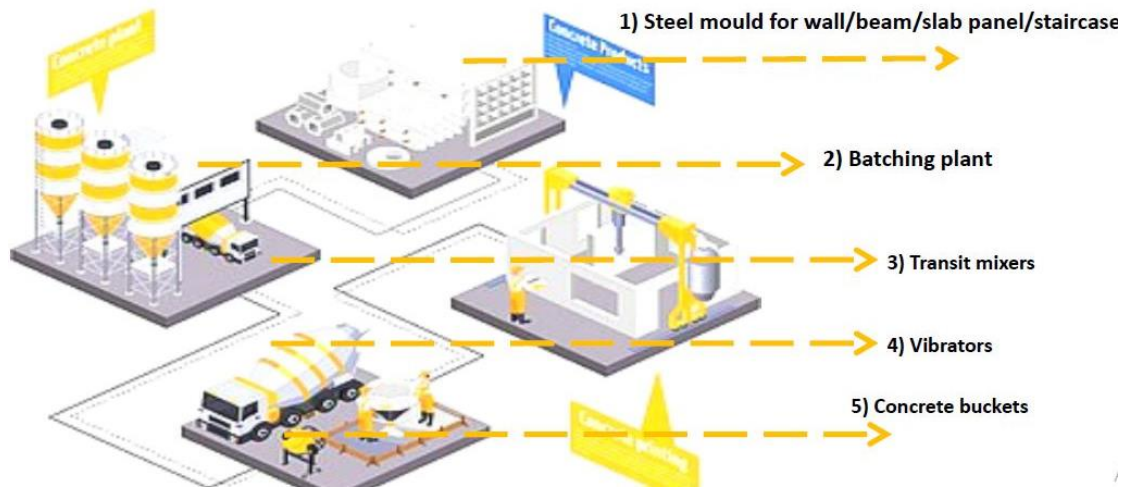
2.4.4 Production, Installation and Transportation Machinery

Production Machinery: 1) Steel mould for wall/beam/slab panel/staircase, 2) Batching plant, 3) Transit mixers, 4) Vibrators, 5) Concrete buckets.

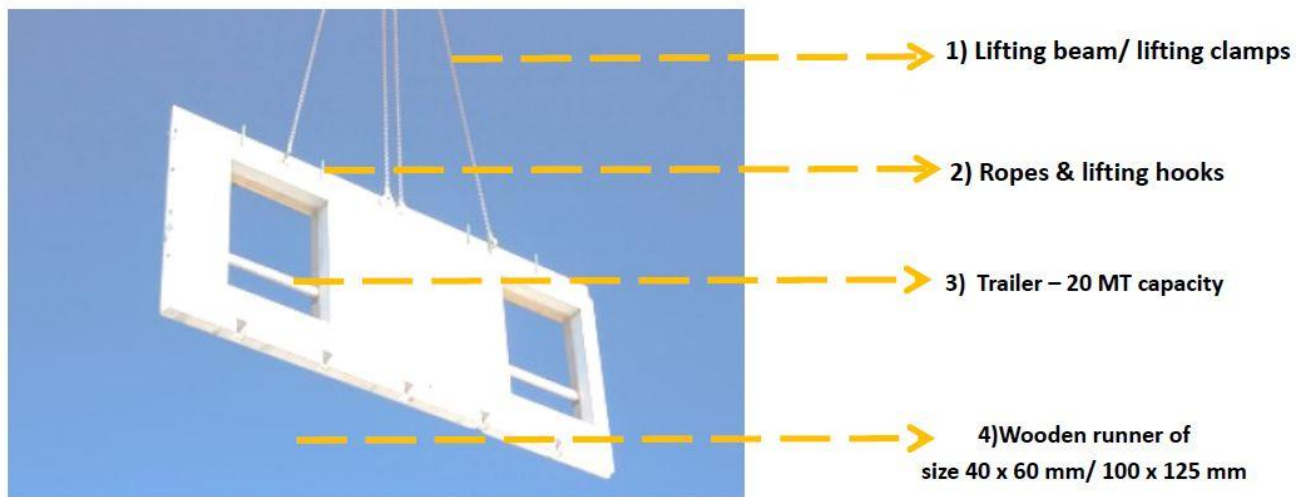
Transportation Machinery: 1) Lifting beam/ lifting clamps, 2) Ropes & lifting hooks, 3) Trailer – 20 MT capacity, 4) Wooden runner of size 40 x 60 mm/ 100 x 125 mm.

Cranes and Loaders: 1) Tower crane of 5.7 MT, 6.9 & 7.2 MT load carrying capacity and operating radius of 40 to 45 m, 2) Gantry cranes of 10 MT, 20 MT & 30 MT capacity and span of 20 to 25 m, 3) Wheel loader of 1.9 cum capacity, 4) Skid steer loader, 5) Truck mounted knuckle boom crane of 7 MT capacity.

1. PRODUCTION MACHINERY



2. TRANSPORTATION MACHINERY



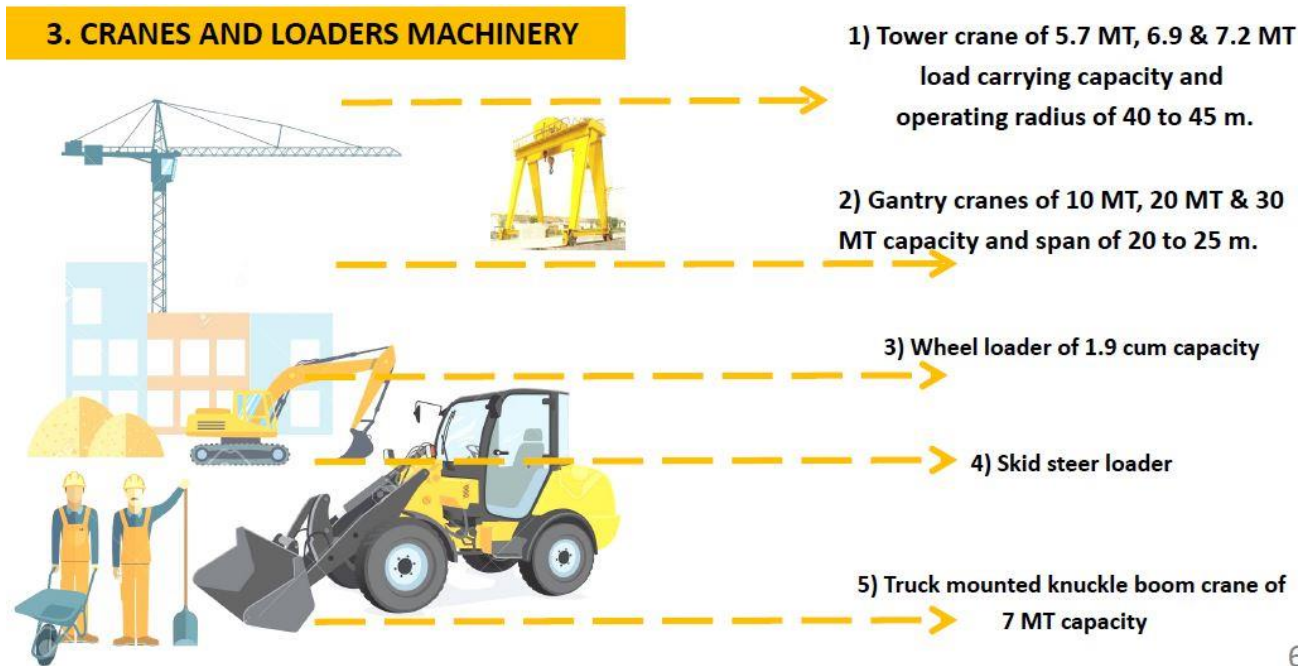


Fig 2.1 Production, Installation and Transportation Machinery

2.4.5 Stacking of elements

The surface of stacking area should be horizontal. The wooden runner shall be placed perpendicular to lifting points and the elements placed over runner. Number of the elements per lot should not exceed man height. In case of vertical stacking, the gap between the elements should be 150 mm to 200 mm. Stacking shall be done in such a way that slabs of longer span should be placed below that of shorter span.

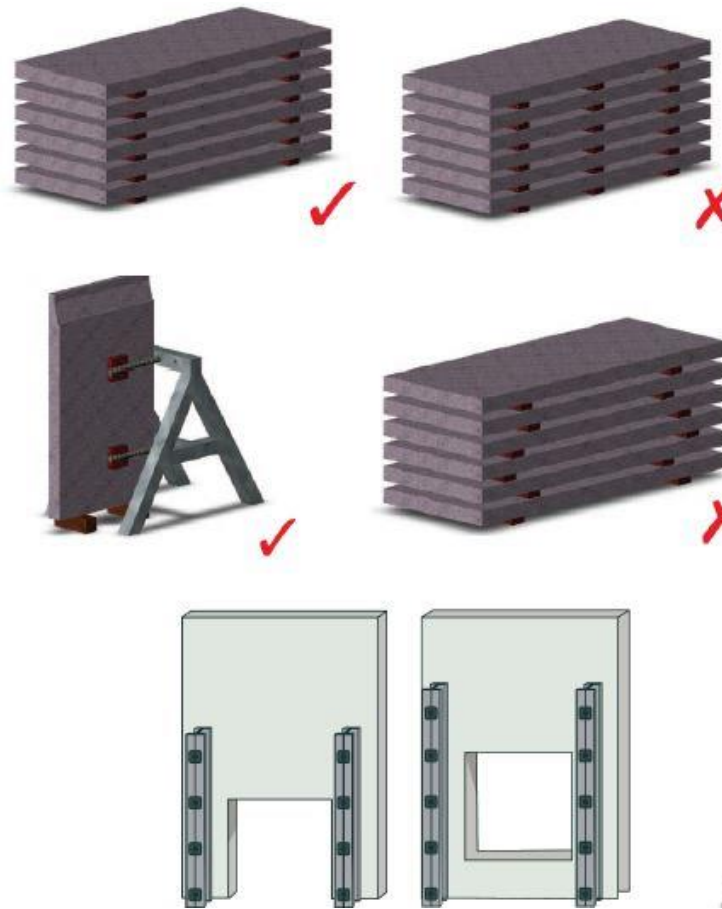


Fig 2.2 Stacking of elements

2.4.6 Lifting of elements from mould

It must be ensured that all the elements should have identification mark. It must be ensured that all side shutters are loosened so that the elements may be lifted without any damages. Before demoulding, it must be ensured that compressive strength of the cubes should meet the specified requirements. The lifting clamps/clutches shall be fixed to lifting beam at proper positions. Then the elements shall be lifted carefully to the stocking area.

2.4.7 Transportation of Elements

The process of transportation of precast elements from yard to site shall be as follows: Loading of slab over trailer It must be ensured that the identification mark on the slab should be the same as per dispatch list. Any damage occurred during loading should be informed to the concerned authority. The lifting clamps/clutches shall be fixed to the lifting beam at proper position. The lifting beam shall be placed over the precast elements and

ensured that the clutches are locked properly before lifting. Instruction regarding loading height, positioning of precast elements over the trailer should be followed as per capacity of trailer. The wooden rubber shall be placed in between the slabs at 500 mm from each end. Some of precast elements should be placed vertically and transported through “A” frame fixed vehicle. The slab shall not be overhanging from trailer. The slab shall be tied firmly to the trailer by means of belt/rope as moving the load without proper tie will cause damage. While transporting elements vertically, the vehicle should be loaded equally on both sides.

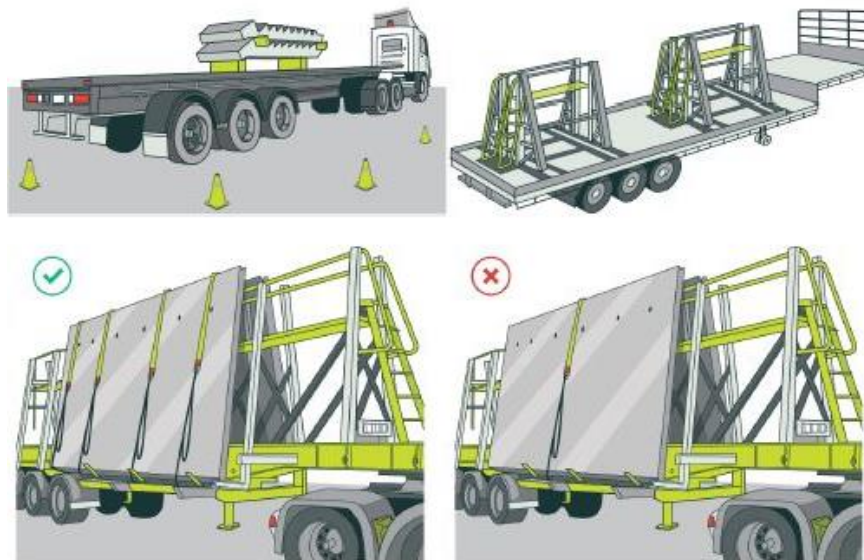


Fig 2.3 Transportation of Elements

2.4.8 Handling of Precast Elements

Every slab shall be inspected for dimensions/identification mark and damages etc. prior to unloading at site. The stacking area should be levelled and hard enough for stacking the elements. There should be proper access for trailer movement. Basically, the wall panels when handled must be balanced and in line with their center of gravity. The lifting points located to limit the bending moments within the beam element. For wall panels it is to be lift the panel in vertical position for installation so that turning is not required. Multiple lifting points can be designed to minimize undue stresses within the slab elements. Columns handled in horizontal position slings are attached to facilitate rotation. Columns lifted Panels

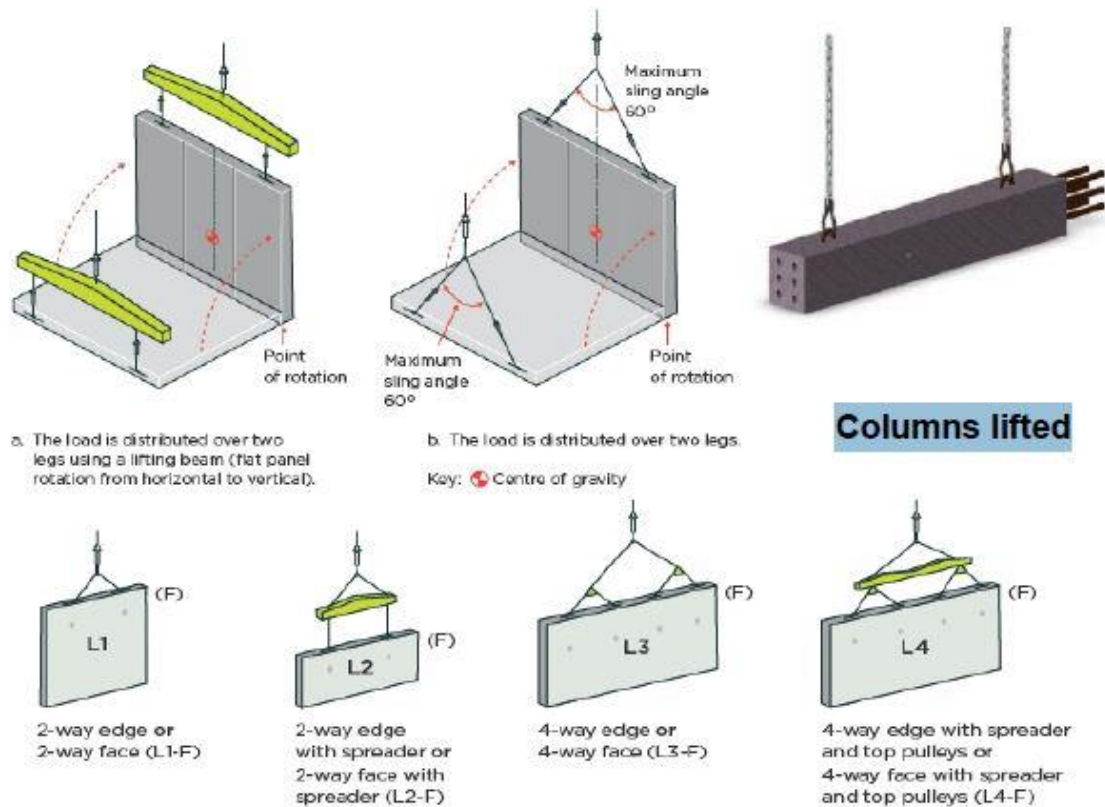


Fig 2.4 Handling of Precast Elements

2.4.9 Erection

The process of erection and installation of panels during the construction cycle by using tower cranes shall be as follows:

1. Before starting erection a survey of the area to receive precast elements shall be done to monitor any difference in dimensions or levels exceeding the tolerances. In case of unacceptable tolerances, necessary action shall be taken for rectification.
2. Installation shall be done by tower crane with sufficient capacity. Panels shall be shifted from the stack rack/truck from yard to the nearest point of construction site and shall be kept above the truck during the construction or inside the storage racks as per the site situation.
3. The necessary access for the truck to reach the nearest point of the tower shall be prepared before starting erection of the panels.

4. Once the truck reaches the tower, chain and lifting clutch with required capacity and guide rope shall be attached to the precast panels to allow the workers to control the load to its final place.
5. As the elements are lifted to its final position above the cast-insitu slab/precast panel, vertical and horizontal alignment of the panel shall be adjusted. The gap between the element and adjusted elements shall be maintained as per the drawings within the allowable tolerances. Shims and spacers shall be used for levelling and adjustment.
6. Temporary propping jacks shall be provided for restraining the walls laterally until grouting.
7. After completion of fixing, alignment of the panels shall be checked again.
8. Minor damages, if any to the precast panels shall be repaired by approved materials.
9. After completion of installation and alignment, elements shall be handed over for inspection.
10. The joints between the precast wall panels shall be filled with joint filler material.
11. Precast slab shall be erected above the wall panels without any scaffolding system. The electrical conduit/fitting shall be done. After electrical works are completed, screed concrete shall be laid over the precast slab.
12. Installation of the next floor shall start only after completion of screed concrete of the previous floor.

2.4.10 Inspections & Testing

Inspections & testing shall be done at appropriate stages of manufacturing process of all the components. The inspected frames and panels shall be stored & packed to ensure that no damage occurs during transportation. As part of quality assurance, regular in process inspections shall be carried out by the trained personnel of the PAC holder.

2.5 PRECAST CONSTRUCTION SYSTEMS

Precast construction system is generally: 1) A large panel system, modular system or a combination of both. 2) Precast residential building construction involves design, strategic yard planning, lifting, handling and transportation of precast elements. 3) This technology is suitable for construction of high-rise buildings resisting seismic and wind induced lateral loads along with gravity loads. 4) The building framing is planned in such a way that maximum number of repetitions of moulds is obtained.

Sr. No	Precast Components	Typical Sizes
1	Wall Panels	5m X 2.85 m
2	Slabs	3m X 5m
3	PODS	1.52mX1.36mX2.83
4	Beam	0.20 X 0.40 X L
5	Staircase	-
6	Columns	0.90m X 0.35m X2.85m

Fig 2.5 Precast Components - Typical Sizes

2.5.1 Mould types - Precast Components

Battery moulds for precast concrete elements offer maximum productivity in minimum space. The battery moulds have been designed for vertical concreting of individual concrete panels and floor elements in various sizes and thicknesses. Beam moulds are flexible, where you can adjust the height easily by raising the base of the mould. Tilting moulds is used to cast the wall panels in the horizontal position and then tilting the entire mould upto 90 degrees. Done using the hydraulic jacks. In this mould we will get mould finish only one side of the wall and the other side manual troweled finish. Hollow core slabs are prestressed slabs where the tendons are used. These slabs are produced using the extruders which have the side forms and the pipe for creating the hollowness in the slab. Prestressing the tendons arrangement has to be made using proper mono or multi stressing hydraulic jacks.

2.5.2 Mould types - Precast Wall

Structural load bearing walls shall be designed as per codal provisions of IS 456:2000 and IS 13920:1993 as applicable. Internal non load bearing walls should be designed as plain concrete walls with nominal reinforcement for handling and erection stresses. Such walls may also be built using alternate partition wall systems. For concrete walls, minimum concrete grade should be M10.

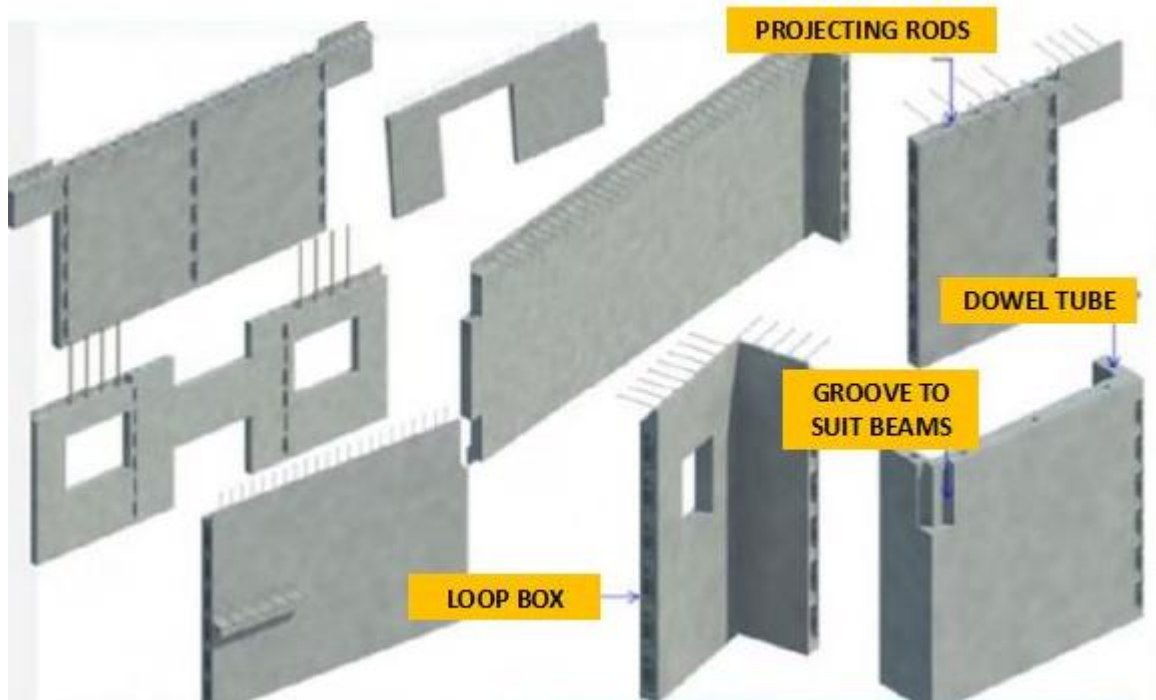


Fig 2.6 Mould types - Precast Wall

2.5.3 Mould types - Precast Pods

Pod technology is a type of offsite modular construction that has been there in the market since 1950s and has consistently gained popularity over time. Offsite construction of pods completed in a factory capitalizes on the ability to move product in a controlled manufacturing condition, on tight inventory control and project schedules. It is inherently waste conscious and can have minimum site impact if delivered carefully and strategically with respect to site constraints. These offsite solutions negate the need for snagging the finished bathroom areas – reducing the time and cost associated with what is widely known to be one of the most challenging components of a building to deliver. These self-supporting structures are factory made and assembled. This includes all mechanical, electrical and plumbing fixtures with termination of services at pre-agreed points.

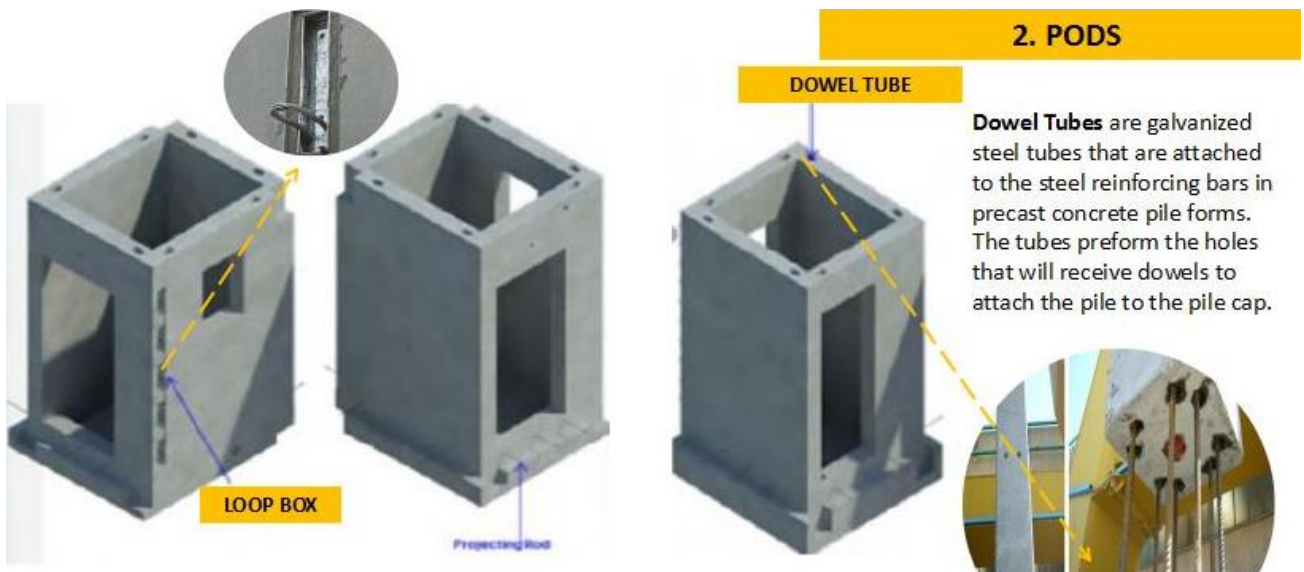


Fig 2.7 Mould types - Precast Pods

2.5.4 Mould types - Precast Spandrels Beam

Spandrels are horizontal precast pieces that may be structural with pockets, corbels or ledges to support double tees and hollow core plank, or non-structural elements in total precast buildings and parking garages.

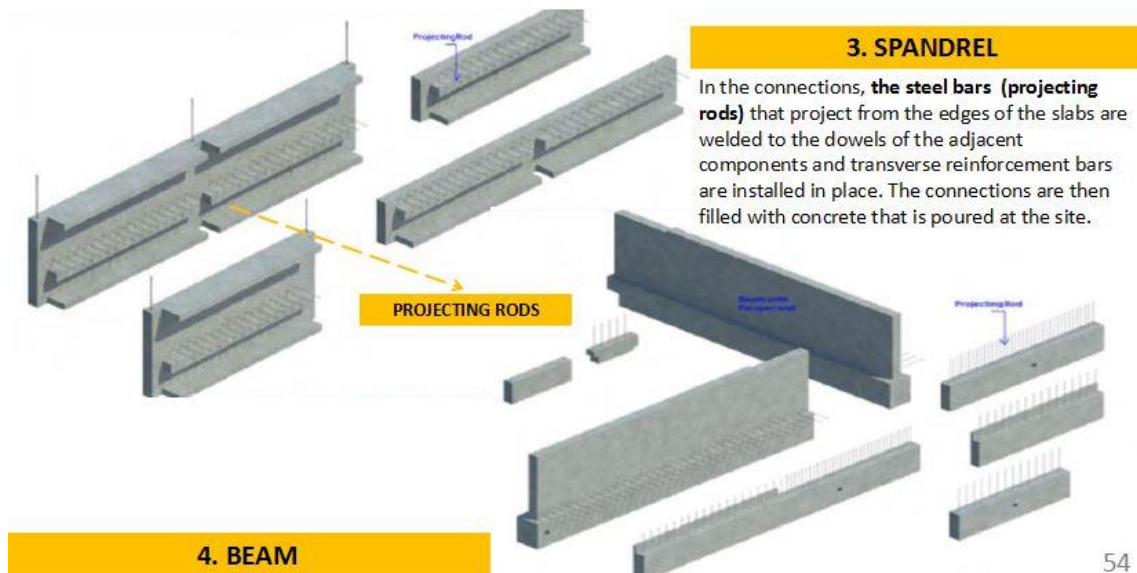
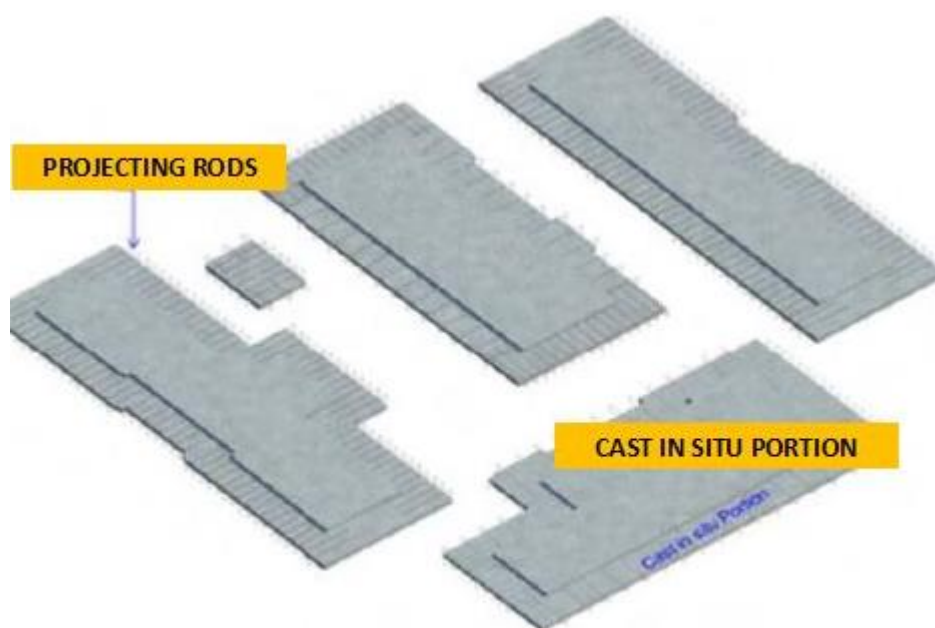


Fig 2.8 Mould types - Precast Spandrels Beam

2.5.5 Mould types - Precast Slab and Floor Panels

The minimum thickness of concrete layer for cored slab is 50 mm. Panels shall be designed in accordance with the recommendations given in IS 456:2000 governing reinforcement and detailing. For reinforced concrete floors, concrete of minimum grade M 30 shall be used. Pre-stressed concrete floor units shall satisfy the strength requirements followed in usual design practice, namely, a minimum of M 35 for post-tensioned and pre-tensioned works. The thickness of the floor panel shall be such that the serviceability requirements are satisfied.



cast-in-situ concrete is a standard concrete which is poured into the specific formwork on the site and cured to get the strength of RCC elements.

Fig 2.9 Mould types - Precast Slab and Floor Panels

2.5.6 Mould types - Precast Column, Staircase and Landing

The structural system of superstructure consists of precast construction of RCC wall, columns, slabs and beams. Floor slab shall be considered to act as a rigid diaphragm to transfer the lateral forces to walls/column. Ground floors are mostly constructed by conventional method i.e. cast-in-situ construction. It shall be designed to take the cantilever load of the above floors. First floor to higher floors shall be constructed by precast technology i.e. precast wall and solid floor slab system.



Fig 2.10 Mould types - Precast Column, Staircase and Landing

2.5.7 Precast Construction Yard

All activities related to the construction of reinforced concrete precast segments will be carried out in the precast yard, covering approximately 40,000 square metres of area, including: 1. Rebar storage & rebar jigs area (rebar cage fabrication area). 2. Segment casting area (moulds), 3. Stores & workshop area, 4. Segment storage area, 5. Site offices & basic facilities for staffs.

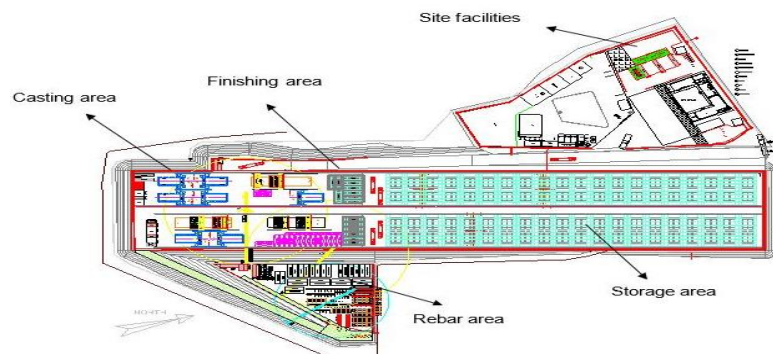
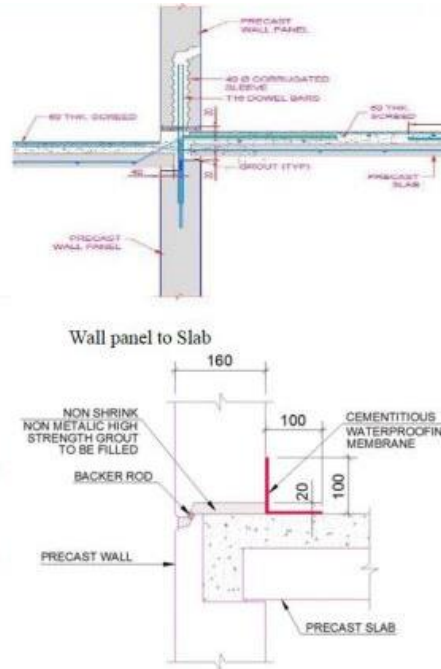
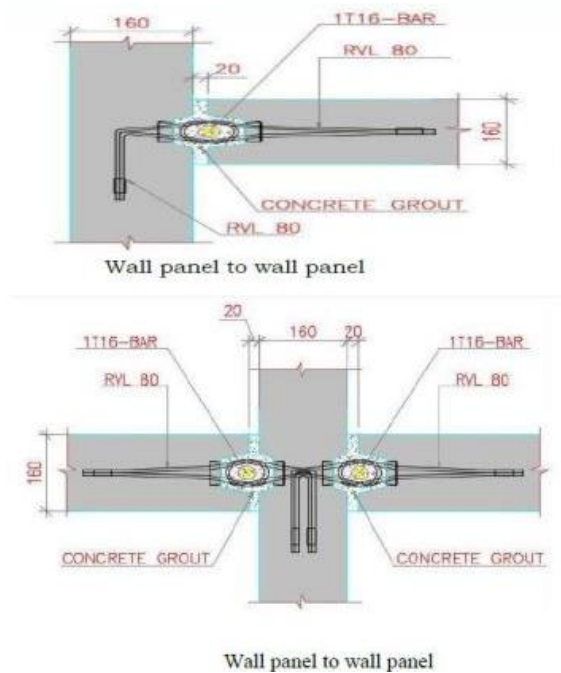


Fig 2.11 Precast Construction Yard

2.5.8 Precast Installation - At Site Connection Details

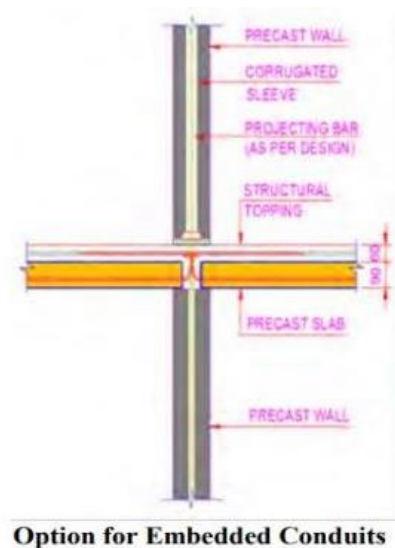
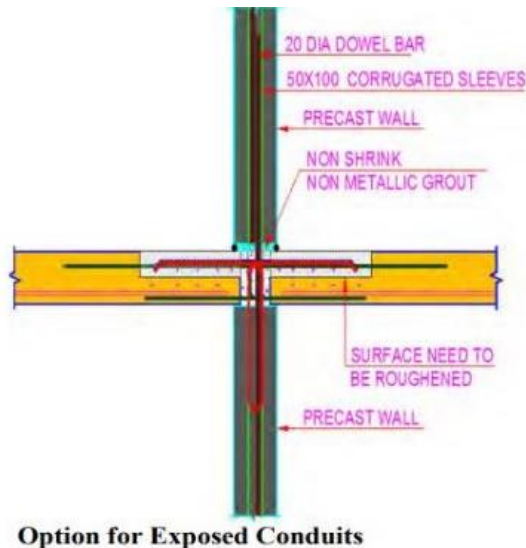
At site locations, panels shall be first unloaded and stacked or directly lifted by the crane. The element shall then be installed on the site and supported by temporary jacks. The cranes shall be released for next lifting once the temporary supports are in place. Shims shall be used to carefully align the element before grouting. The panels shall be grouted after the final adjustments are done.



Waterproofing
External joints shall be sealed **with baker rods and sealants** after filling the joints with grout to avoid the leakage.

Additional waterproofing treatment shall be provided at external joints and wet areas to ensure water tightness.

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Typical Horizontal Joint Detail Wall to Wall

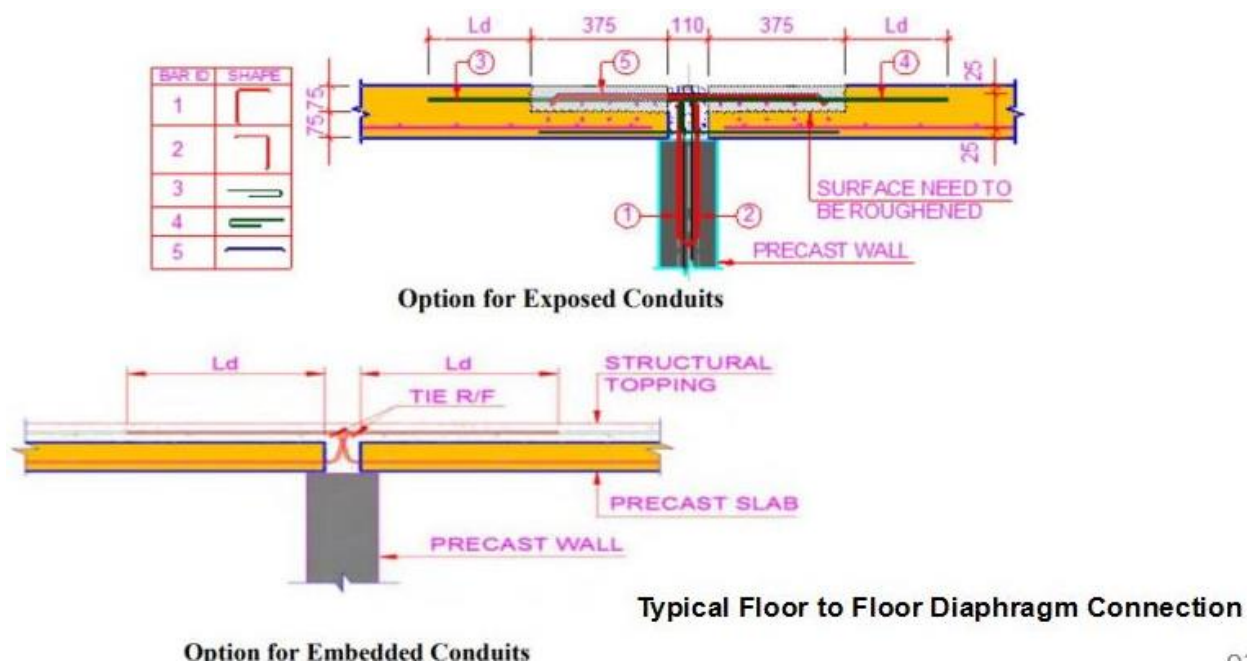


Fig 2.12 Precast Installation - At Site Connection Details

2.5.9 Schedule of Rates - Precast Items

Sl. No.	Description of Item	Unit	Rate
Note: Excess/less cement over the specified cement content used as per design mix is payable/recoverable separately)			
5.1	Concrete Grade-M-40 (cement content 400 kg)		
5.1.1	100 mm thick hollow core slab	metre	878.65
5.1.2	120 mm thick hollow core slab	metre	1032.55
5.1.3	150 mm thick hollow core slab	metre	1263.45
5.1.4	200 mm thick hollow core slab	metre	1546.55
5.1.5	250 mm thick hollow core slab	metre	1905.95
5.1.6	300 mm thick hollow core slab	metre	2265.30
5.1.7	350 mm thick hollow core slab	metre	2624.70
5.1.8	400 mm thick hollow core slab	metre	2984.10
5.2	Extra for using M-50 (Cement content 425 kg) instead of M-40		
5.2.1	100mm thick hollow core slab	metre	17.10
5.2.2	120mm thick hollow core slab	metre	20.55
5.2.3	150mm thick hollow core slab	metre	25.70
5.2.4	200mm thick hollow core slab	metre	31.95
5.2.5	250mm thick hollow core slab	metre	39.95
5.2.6	300mm thick hollow core slab	metre	47.95
5.2.7	350mm thick hollow core slab	metre	55.95
5.2.8	400mm thick hollow core slab	metre	63.95
5.3	Extra for using M-60 (Cement content 440 kg) instead of M-40		
5.3.1	100mm thick hollow core slab	metre	27.40
5.3.2	120mm thick hollow core slab	metre	32.90
5.3.3	150mm thick hollow core slab	metre	41.10
5.3.4	200mm thick hollow core slab	metre	51.15
5.3.5	250mm thick hollow core slab	metre	63.95
5.3.6	300mm thick hollow core slab	metre	76.70
5.3.7	350mm thick hollow core slab	metre	89.50
5.3.8	400mm thick hollow core slab	metre	102.30

Fabrication & Manufacturing of Prestressed Hollow Core slab (Hollow area 25 to 30%) of different thickness & modular width 1200 mm in Controlled Factory Environment. Cutting, making necessary cutout/holes of required sizes for services in slab element after achieving required strength, yard handling & stacking all complete as per approved shop drawings & design mix as per the direction of the Engineer-in-charge. (Cost of strands should be paid separately).

	Note: Excess/less cement over the specified cement content used as per design mix is payable/recoverable separately)		
6.1	Concrete grade M-35 (Cement content 370 kgs)	cum	13765.10
6.2	Extra for using M-40 (Cement content 400 kg) instead of M-35	cum	228.30
6.3	Extra for using M-50 (Cement content 425 kg) instead of M-35	cum	418.55
6.4	Extra for using M-60 (Cement content 440 kg) instead of M-35	cum	532.75
7	Providing & laying in position Prestressing steel strands (low relaxation) on hollow core bed by using mechanical pulling arrangement like Rabbit/ Bed master including all accessories for Stressing & destressing operations as per approved make conforming to IS1343 & grade FY-1860 etc, complete as per drawings and direction of Engineer -in-charge.	kg	130.75
8	Transportation of Precast Elements by flat bed Trailer (Double / Triple axle 40ft Length with proper accessories like A frame etc) from factory, including the cost of loading , unloading & stacking at site with the help of required capacity cranes.		
8.1	Lead within 15km	MT	389.85
8.2	Add/Deduct over item 5.1 for every additional lead of 5 km	MT	73.00

Fabrication and manufacturing of solid precast concrete element with provisions of shear keys, connecting loops, dowel tubes and proper lifting accessories for walls, beams, slabs, stairs, column etc, of various thickness, shape and size of different concrete grades manufactured in controlled factory environment with approved methodology including moulds.

Providing & laying in position Prestressing steel strands (low relaxation) on hollow core bed.

Transportation of Precast Elements by flat bed Trailer.

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Sl. No.	Description of Item	Unit	Rate
9	Erection & Installation of Precast/Prestressed Concrete elements in correct & final position with proper line level and plumb at site making all arrangements (i.e cranes, push-pull jacks & all another T & P for lifting Placing & Alignment of elements, within erection tolerance as per IS 15916 as per approved shop drawings and all complete as per the direction of Engineer-in-Charge but excluding the cost of sim pads, non shrink grout and steel works i.e hangers. All work up to fifth floor.		
9.1	Prestressed hollow core Slab up to 200 mm thickness	sqm	217.45
9.2	Prestressed hollow core slab above 200 mm up to 400 mm thickness	sqm	367.15
9.3	Solid concrete wall elements	cum	2642.60
10	Providing & Applying weather proof sealant on outer joints of approved make confirming to IS & directed by Engineer-in-charge.		
10.1	Sealant 25mmx10mm at joints	metre	460.45

Erection & Installation of Precast/Prestressed Concrete elements.

Providing & Applying weather proof sealant on outer joints.

11	Providing & Laying of levelling sim pads required sizes (5x5cm to 10x10cm) of PVC / Rubber to adjust level of bearing surface of supporting members as per the direction of Engineer in charge.		
11.1	2mm thick	each	17.55
11.2	5 mm thick	each	23.40
11.3	10 mm thick	each	35.00
12	Providing & Grouting of dowel tubes / Shear keys / Joints of precast members with M-60 grade cementitious grout (Non Shrink) of approved make by suitable means (Free flowing /pump),curing etc. Complete as per directions of Engineer-in-charge. (The payment shall be made on the basis of actual weight of approved grout injected.)		
12.1	Stirrer mixed cementitious grout (non shrink) of approved make in dowel tubes / Shear keys / Joints of precast members.	kg	65.00

Providing & Laying of levelling sim pads required sizes (5x5cm to 10x10cm) of PVC / Rubber.

Providing & Grouting of dowel tubes / Shear keys / Joints of precast members with M-60 grade cementitious grout.

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Fig 2.13 Schedule of Rates - Precast Items

2.6 RESEARCH PAPERS

The Initial literature study started with carrying out a study on Journals, Books and Net case study. The basic study started with doing reviews on research papers. The Research Papers Identified was :

1. A COMPARATIVE STUDY ON PRECAST CONSTRUCTION AND CONVENTIONAL CONSTRUCTION. 2. QUANTITATIVE ANALYSIS OF PRECAST AND CAST IN-SITU RESIDENTIAL HIGH RISE BUILDING. And 3. CASE STUDY ON USE OF PRECAST TECHNOLOGY FOR CONSTRUCTION OF HIGH-RISE BUILDINGS.

2.6.1 A Comparative Study on Precast Construction and Conventional Construction. International Research Journal of Engineering and Technology (IRJET) by P.Karthigai Priya¹,M.Neamitha² (Aug 2018).

The main objective of this project is to find out an optimal construction technique which has a minimal cost and gives a minimum duration of time by doing a comparative study between precast and conventional construction.

1. To compare the cost and time of precast construction vs conventional construction.
2. To determine the type of construction that would reduce the construction cost.
3. To determine the method of construction that would help to finish the construction project in shorter duration.

CASE STUDY: For the purpose of comparison and analysis of conventional technique and precast technique a case study is chosen. It is a real time project that is located near Ambattur Dunlop. The building is residential building comprising of stilt plus nineteen floors and each floor has eight flats. Cost estimation and scheduling is done for the same building for both precast construction and conventional construction.

COST ANALYSIS: The cost of the entire project including labour charges, cost of material in conventional construction is found to be Rs. 24,79,83,764. Whereas in precast construction the total cost for this project is Rs. 25,17,01,966 which includes the cost of casting, transporting and fixing the elements.

SCHEDULE ANALYSIS: The total duration required for the construction using conventional method of construction is 705 days whereas the total duration in precast construction is only 598 days.

CHECK LIST: Checks are to be done mainly while erecting, transporting and manufacturing. So data has been collected regarding various checks need to be done in precast construction and a check list is prepared.

RISK ANALYSIS: A questionnaire is done to know about the various risks and their level of impact on and off the people on the site. It is prepared based on the factors or conditions that cause injury such as due to heavy lifting, structural collapse, improper barricades and braces, working with heavy equipment etc. The questionnaire was surveyed from various people working in the field of precast.

INFERENCE: After comparison it is found that the cost of precast construction is 1.4% higher than that of the conventional construction. The precast construction can be completed at a rate of 15.17% earlier than the conventional construction. A questionnaire is prepared and analysed for the various risks on precast construction. Charts are drawn to know the impact of injury on various factors in precast construction and they are analysed and the results are provided. Earlier a questionnaire is done to know the importance of precast, so a comparative survey study on conventional and precast is done based on several factors

2.6.2 Quantitative Analysis of Precast and Cast In-situ Residential High Rise Building **International Research Journal of Engineering and Technology (IRJET) by Akshay Jagannath Rajagopal (Jun 2020)**

The main objective of this paper is to find out which construction technique is suitable for high rise buildings. This is done by finding out the cost and time for completion of the project. To find out the appropriate method for building of high rise structures, we “Compare the cost and time for both precast and cast in-situ building”.

METHODOLOGY - A plan of dimension 1380 sqft is drawn using Auto Cad, the carpet area is 1198 sqft. Also, a 3D view of both precast and conventional building are drawn to show

the difference between precast and conventional construction and to show the G+7 view of the building which consists of 48 houses (8 houses per floor).

	Precast Construction	Cast in-situ	Difference in cost	%
Total Cost	18,31,28,275	17,03,49,135	1,27,79,140	7.5
Cost Per House	38,15,173	35,48,940	2,66,233	7.5
Cost Per SqFt	2,765	2,572	193	7.5

Fig 2.14 Comparative Cost Analysis

Scheduling is done for both precast and conventional construction using Primavera P6. The time for completion of project when it is done using precast method is 244 days while for conventional is 544 days. The estimation of quantities is done except for foundation. The slab cycle for precast building is 11 days. The time for completing one floor using conventional method is 30 days.

The quantity estimation is done based on the following - (i) The grade of concrete is M20 and the mix design for both precast and conventional is 1:1.5:3, (ii) The cement mortar is in the ratio 1:6, (iii) For precast construction, the quantity is estimated based on the volume of the panels, (iv) The quantity of materials required for foundation is not calculated, instead a sum of ₹10,00,000 is allotted in the rate analysis, (v) The floor to floor height is 3 m, (vi) This dimension of brick is taken as 190mm x 90mm x 90mm and, (vii) The cost of water for precast and cast in-situ are ₹50,00,000 and ₹1,00,00,000, this is due to the large quantity of water needed for cast in-situ. The volume of one house is 31.5 m³. For 48 houses, the total volume is 1512 m³. As per the above regulations, the quantities of major components are as follows- (I) For Precast- Cement- 12096 Bags, Sand- 14742 cft, Steel- 12 tons, Aggregates- 31095 cft and GP2 Grout- 8064 bags. (II) For Conventional- Cement- 9072 Bags, Sand- 62855 cft, Steel- 30 tons, Aggregates- 10000 cft and Brick-

9,82,800 nos. The quantity of paint is found out as 1,230 liters which is split into 2 (for outer and inner). Tractor Emulsion is used and for inner Semi-Gloss is used.

The **rate analysis** is done based on the market rate in Bengaluru, India. The cost of materials which are give above are as follows- Aggregates- ₹3,900 per cubic foot, Cement- ₹280 per bag, Gp2 grout- ₹450 per bag, Sand-₹960 per cubic foot, Steel-₹42,000 per ton, Brick-₹8 per number, Tractor Emlsion-₹350 per liter and Semi-Gloss-₹635 per liter. The labour charge is estimated as ₹600 per person per day. The cost for setting up the precast plant is estimated as ₹50,00,000. The cost estimated for equipment for both precast and cast in-situ are ₹35,00,000 and ₹10,00,000 respectively. A sum of ₹5,00,000 is added as miscellaneous amount. The cost of foundation, water, plumbing and sanitation, electrical, glass and window panes, tiles, doors and windows for precast is estimated to be ₹1,96,00,000 and for cast in-situ is ₹2,46,00,000. The rate of constructing precast building is ₹18,31,28,275 and for conventional is ₹17,03,49135. Time required for completing pre-cast is 244 days and for conventional is 544 days.

INFERENCE: Although, the cost for completion of Conventional Building is Less than 7.5% less than Pre-Cast Building, the days to complete exceeds by 300 days. The major outcome of this study is, although the initial amount of precast construction is high, it has advantage over cast in-situ as time consumed is less, which is a huge beneficiary.

2.6.3 Case Study on use of Precast Technology for Construction of High-Rise Buildings International Journal of Scientific & Engineering Research (Sep 2016).

This paper highlights the case study for adoption of Precast Technology to achieve fast-track, sustainable, and cost-effective construction of high-rise buildings in Indian Scenario.

A REAL-TIME CASE STUDY- Dream Valley project is located in Greater Noida (West), Delhi NCR, India. It's a residential township with total 47 high-rise residential towers, 379 villas, commercial & institutional building, and other developments. The total built-up area of project is more than 10 million Sqft. The high-rise residential towers are divided in to six

series from A to F with further classification as A1 to A7, B1 to B6, C1 to C12, D1 to D2, E1 to E8, and F1 to F12. After a lot of brainstorming and feasibility study, Series A, D, E & F were planned to be constructed by using precast construction technology. To make the case easy to understand, this study will discuss the construction of series A having total seven towers. As of today, all the seven towers are nearing completion. There are 12 apartments per floor with carpet area of about 430 Sqft. for 1BHK. All apartments at of series A are identical that made precast technology a viable option.

CHALLENGES EXPERIENCED: Following are some of the key learning challenges which were encountered on the way.

1. As the project was located in seismic zone IV, the suitable design was adopted.
2. Lack of skilled manpower with the knowledge of precast industry, operation of various machineries & erection, which was overcome by providing detailed training.
3. It was difficult to counter the typical mind-set of people to adapt to change in construction technology, patience & willingness to experiment with a new technology.
4. Although, European and other standards were available for ready reference but unavailability of IS codes was deemed important. The designers from India had only few Indian Standard to refer.

The knowledge and understanding acquired during this case was carried forward to the projects underway. Many improvisations were based on the experiences of this projects.

RESULTS ACHIEVED: Some astonishing results along with learning experiences achieved through this landmark project are noted as follows:

1. 7 buildings of 2B+G+18 floors were completed in 18 months of timeline was made possible through precast technology.
2. Achieved a slab cycle of 10-12 days for a slab area of 7000 Sqft.
3. Superior quality & finish of construction.
4. Cost & time optimization with the use of hollow-core slabs.
5. Reduction in concrete & steel factor per Sqft of built-up area.
6. Elimination of brick work and plaster by the use of precast wall panels & cladding.
7. Automation & mechanization of construction project improved overall productivity.

8. Improved site safety & considerable reduction in wastage, dust & noise on site, thus reduced ecological footprint of project.

INFERENCE: The precast concrete technology has already arrived in India, due to large size projects, need for quality construction with speed & reduced labour force. All these advantages can be exploited to the maximum by careful planning & designing. This case study was aimed to share the hands-on-experience, and to aware the people about the potential the precast offers. From the above case study, it can be concluded that precast construction, if designed and executed with thorough planning, has a great potential to respond to new market demands. Precast is smart way to achieve the sustainability objectives of Green Building.

Dream Valley – Series A (Tower A1-A7), High Rise Residential Buildings	
Overall built-up Area (Precast+CIS)	10 Million Sqft
Built-up area planned in Precast	3.79 million Sqft
Built-up area of A series (A1-A7)	8.82 lacs Sqft
Structural frames	2B+G+18 Floors
Total apartments	1500 apartments; 12 apartments per floor
Structural system (Sub-structure)	Raft foundation (CIS)
Structural system (Super-structure)	Hybrid Precast Construction (Shear walls & Core in CIS)
Basement, Ground & terrace work	Cast In Situ
1 st to 18 th floor	Precast beams, wall panels, balconies, claddings, staircase, & hollow core slabs
Total precast concrete volume (m3)	~16000
Total Nos. of Precast elements (Tilts + HCS)	25000



Figure 6.1: Dream Valley: Overall Layout Plan



Figure 6.2: Typical apartment floor plan

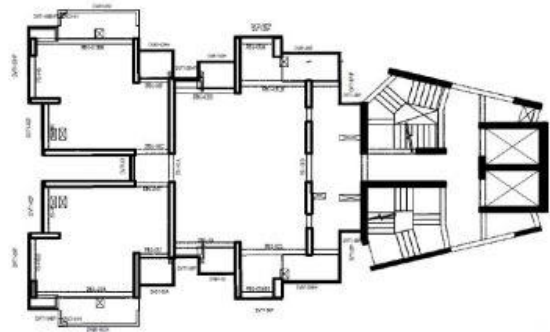


Figure 6.3: Typical Precast Elements layout for A1 Tower wing (4 flats)

Fig 2.15 Dream Valley project in Delhi NCR, India.

CHAPTER 3

CASE STUDIES

3.1 NET CASE STUDY - 1

Pragati towers project in Mumbai, India consists of eleven residential high-rise, total precast buildings using precast concrete system. All towers rise about 70 m above ground. Each tower consists of over 300 apartments with a total construction area of around 2.6 million square feet. G+23 Story 'Total Precast System' in Seismic Zone-3, Mumbai. Designed in conformance to all 'I.S. codal requirements'. Structural connections designed to comply with design codes. Innovative combination of 'Modular units' and 'Large Panel system' to suit the construction needs of the project. Mumbai is also a coastal city with design wind speed of 44m/s (~ 98.5 mph) which was considered for this project

Pragati Towers - Phase 1 – Six High-rise Buildings	
Overall Built Up Area	1.2 million square feet
Structural Frame	G + 23 Levels
Total Apartments	2024 Apartments; 14-16 Apartments per Level
Structural System – Super-structure	Large Panel Precast Shear Walls
Structural System - Sub-structure	Pile Foundation or Raft Foundation
Ground and Terrace Work	Cast In Situ
1st to 23rd Floor Work	Precast Members
Total Precast Member Count	~ 40,000

Table 2- Pragati Towers – Phase 1 Project Details



Fig. 1 Pragati Towers Phase 1 Project Photo



Fig. 2 Pragati Towers - Overall Phase 1 Layout

Fig 3.1 Pragati towers project in Mumbai

3.1.1 Design Implementation

Foundation system of the project consists of piles with pile caps connected with tie beams. Ground floors were constructed by conventional method i.e In-situ construction. Superstructure (i.e 1st to 23rd floor) consists of precast construction of RC walls & solid floor slabs, columns, and beams. Floor slab is considered to act as a rigid diaphragm to transfer the lateral forces to walls/columns. Precast concrete RC/shear walled structures, also called large panel systems, are load bearing members and are capable of carrying the vertical and lateral loads. The wall panels can be connected to each other and to the floor diaphragm to form an emulative monolithic structure.

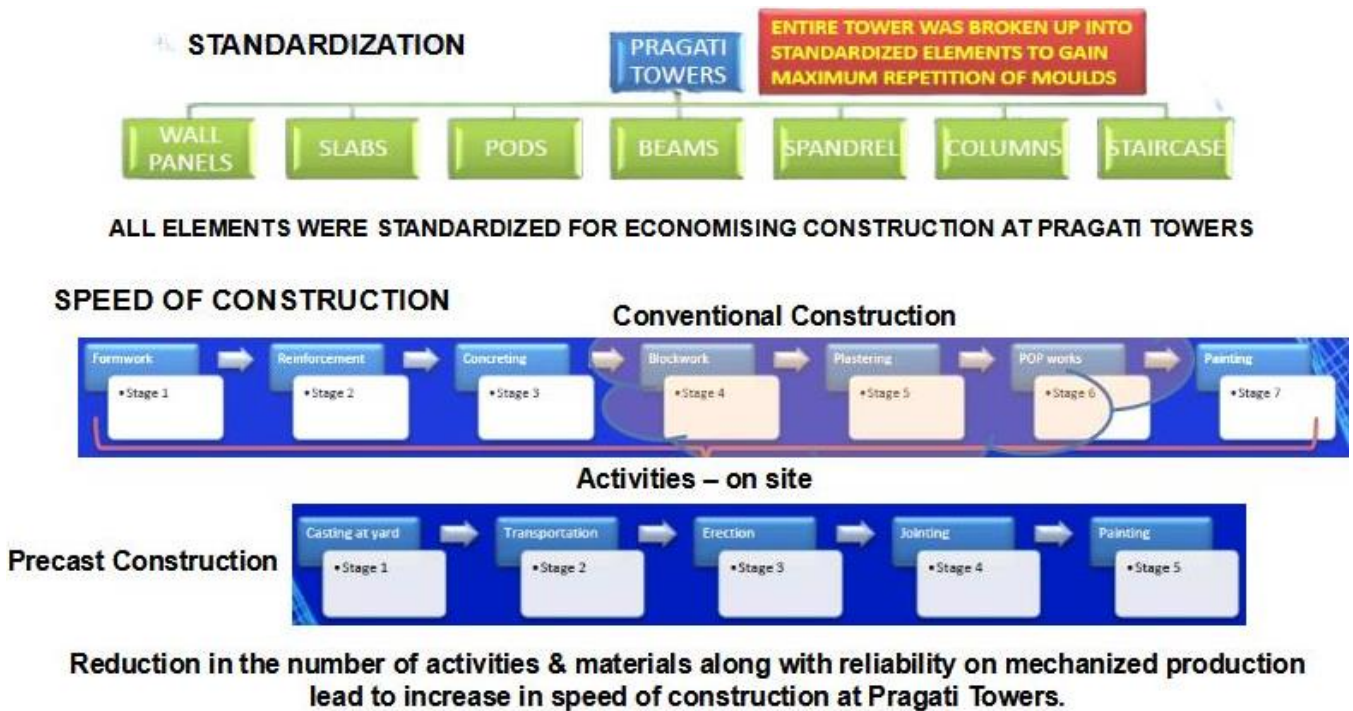


Fig 3.2 Design Implementation

3.1.2 Design Codes

Mumbai region is categorized as Seismic Zone 3 (Moderate Seismic Zone – typical Seismic Zones are defined from Zone 2 (Least Active) to Zone 5 (Highest)). Mumbai is also a coastal city with design wind speed of 44m/s (~ 98.5 mph) which was considered for this project. Seismic forces governed the design. The Bureau of Indian Standards (BIS) specifies building codes in India. IS 456 – 2006 is regarded as the primary building code for reinforced concrete structures. IS 1893 – 2002 provides guidelines for earthquake resistant

design and IS 13920– 1993 provides detailing requirements for ductility in concrete structures subjected to seismic forces. IS 11447 – 1985 provides design guidelines for large panel prefabricated construction. IS 15916-2010 is the most recent addition that provides guidelines for Design and Erection of Prefabricated Concrete.

3.1.3 Design Philosophy

As precast technology was adopted for a high-rise residential structure in India, the emulative design philosophy was selected based on mutual agreement between the Client, Consultant and Contractor. Onsite, wet grouted joints for horizontal and vertical connections between walls and in-situ concrete joints for slab-to-wall and slab-to-slab joints, termed as “stitched” joints were selected. ETABS software was used to build the structural model for analysis. Various modeling approaches were considered and compared to come up with the design forces at all joints in the structure.

3.1.4 Emulative System

Emulative detailing is defined as designing connection system in a precast concrete structure so that its structural performance is equivalent to that of a conventionally designed cast in place, monolithic concrete structure. Emulative design creates construction that either is monolithic at the critical joint locations or provides connections that act as if they are monolithic at those locations. In general, emulative connections involve connecting reinforcing bars across a joint by lap splicing, welding or couplers. Concrete is made continuous by filling the joint with high quality non-shrink non-metallic high strength grout in horizontal & vertical joints or cast in place concrete in vertical joints. Precast concrete members may be used only if they can provide same level of ductility as that of a monolithic reinforced concrete construction during or after earthquake.

3.1.5 Modeling Strategies

The entire superstructure was modeled primarily using shell elements. The walls were of shell elements and the slabs of membrane elements. A floor was considered as a rigid diaphragm at the respective level, to transfer the lateral forces to walls. The horizontal joints of the wall panels were idealized to simulate an equivalent monolithic behavior, in presence of the continuous vertical dowel bars. Therefore, the shell elements representing the panels were made continuous at the floor levels. A few beams and columns present in the structure were modeled using frame elements. Appropriate loads and its combinations, as

per relevant clauses in IS codes, for most unfavorable effects were chosen for design. In absence of a model for shear transfer the vertical joints between the panels were modeled as the following two extreme conditions.

3.1.6 Connections Details

Connections are needed not only to transfer loads but also to provide continuity and overall monolithic behavior of the entire structure. A complete system of precast units can be integrated to form a structure that behaves monolithically with sufficient strength, stiffness & durability to resist seismic & other dynamic loadings. To have a good interaction of wall elements, the elements have to be connected to the foundation, to each other and to the adjacent floor diaphragms. The connections act as bridging links between the components. The wall panel connections can be classified into horizontal joints & vertical joints.

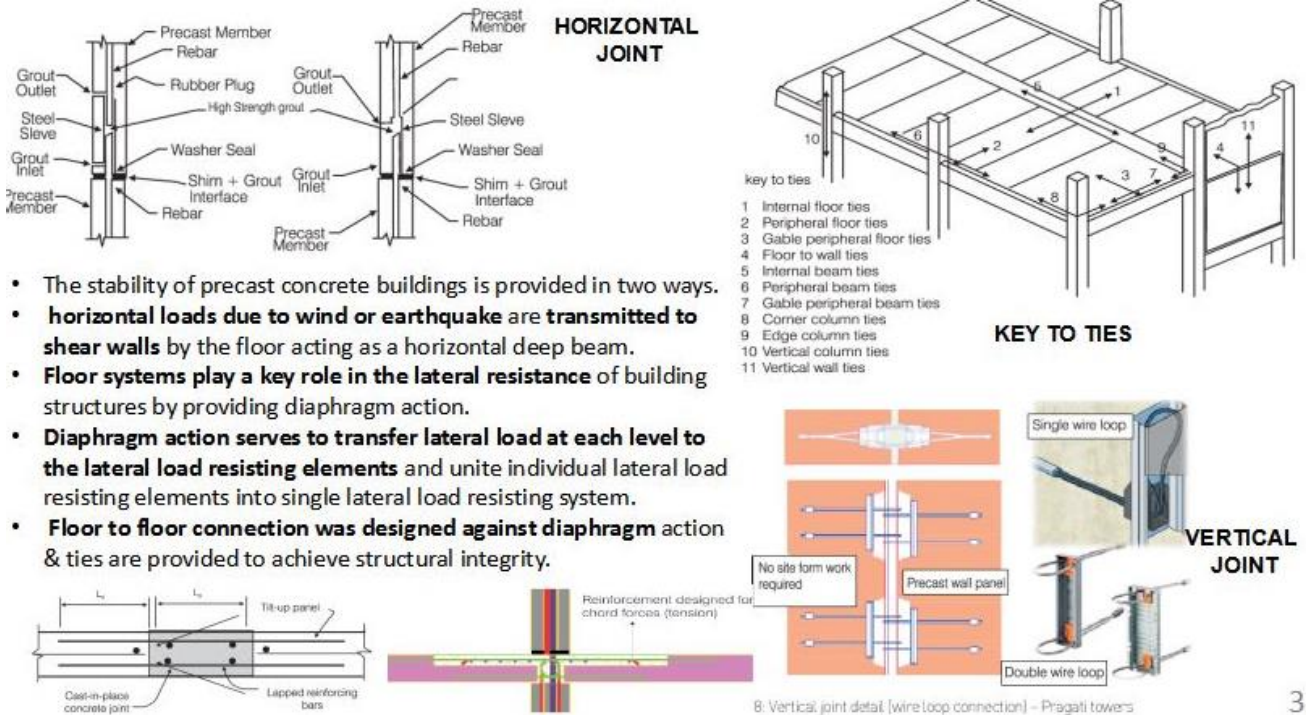


Fig 3.3 Connections Details

3.1.7 Water Tightness

The joint design was looked at, taking into consideration the local tropical climate with heavy monsoons. The grouted joints helped achieve water tightness. Backer rods were placed at the exterior face of exposed to weather joints to prevent water entry. In addition, waterproofing sealant was applied at these joints as an additional line of defense. The gable

end faces of the buildings were looked at in great detail due to the direct exposure to heavy rains. The horizontal joints on these elevations were detailed with an additional overlapping nib covering the joint across the length to avoid direct exposure of rain water. The nibs also provided a horizontal band as an architectural feature on the elevation.



Fig 3.4 Water Tightness

3.1.8 Progressive Collapse

To avoid progressive collapse, the structure should be sufficiently robust and redundant. Identification and proper design of the key elements in the structure is necessary to avoid progressive collapse. Recommendations in the codes were adopted to find the design load and the required amount of tie reinforcements. Here, tie reinforcements were provided horizontally, both internally and peripherally. The reinforcement at the shear key locations provide the horizontal tying and that at the joint regions gives the necessary vertical tying effect. The horizontal ties provide a cantilever action to hold the damaged parts. The vertical ties help to suspend the lower damaged elements to the intact upper portions. The horizontal and peripheral tie systems provide a catenary action to bridge the damaged portion. The wall-to-slab ties help to suspend the debris, and prevent the damaged floor from falling down on to the intact lower portions.

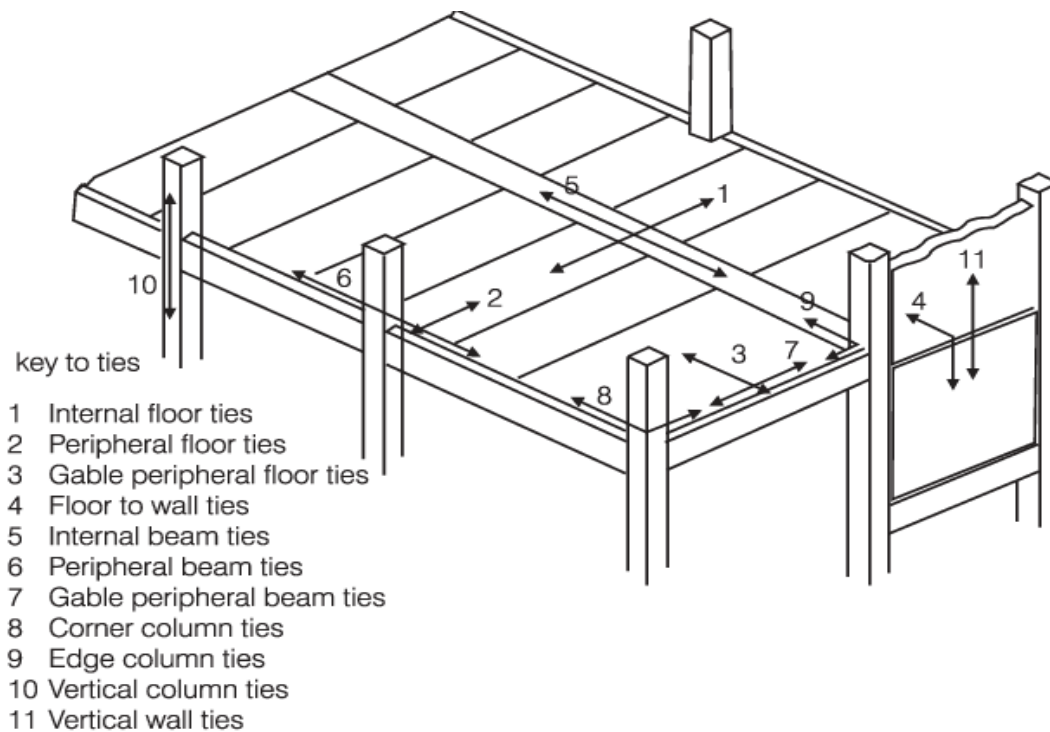


Fig 3.5 Progressive Collapse

3.1.9 Conclusion

1. To meet the demands of large volumes of construction in affordable housing sector in shorter duration there is a need for a fast-track technology in mass housing.
2. The emulative monolithic wall system seems to be adequate in moderate seismic zones. The provisions of tie reinforcements, reinforced shear keys and dowel bars provide the required structural integrity for the precast system. The modelling of vertical joints without considering the shear transfer through the shear keys, reinforced with shear links, lead to a conservative design.
3. Vertical joints are designed based on shear friction concept as a global practice & dowel bars are provided in the form of projected rebar's, overlapping hoops & drop in hoops etc filled with cast in place concrete at joint locations.
4. For this project vertical joints are provided with specially formed shear keys to increase shear stiffness and the shear capacity. The shear key works as mechanical locks preventing any significant slip along joint. Transverse reinforcement provided in the form of

wire loops (proprietary products) for ease of erection where there is no site formwork required.

5. As there is insufficient literature & testing available regarding cyclic actions on shear keys, on the conservative front for this project specified two models are generated i.e with & without influence of vertical joints& worst of the same results are adopted in the design.

3.2 NET CASE STUDY - 2

The eye-catching 30-storey residential building in Boston's Theatre District is bringing much needed residential housing to the downtown area, drawing young professionals into the city. The innovative AVA Theater District Apartments, located at 45 Stuart Street and next to Boston's cultural, educational and medical facilities, offer 398 residential units (representing 384,000 square feet) varying from studios and one and two-bedroom units. The first five floors include a 198 spot-parking garage, covered by a glass curtain wall facing Stuart Street. The parking garage is 90,000 square feet and features a pedestrian walkway connecting Stuart and LaGrange Streets. The 45 Stuart Street building is projected to be LEED Silver Certified.

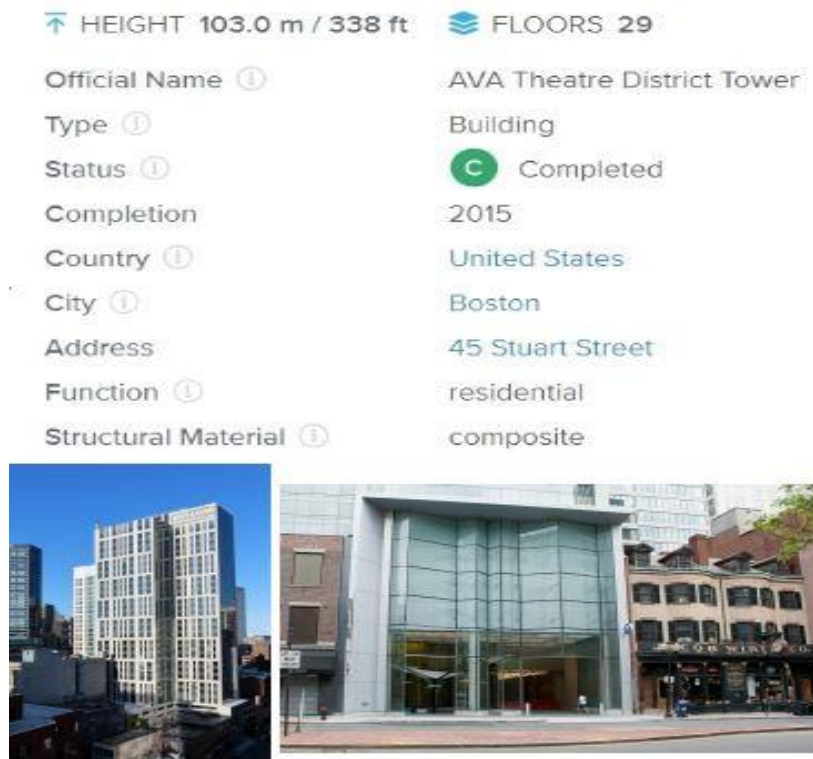


Fig 3.6 AVA Theater District Apartments

3.2.1 AVA Theater District Apartments: Precast Components

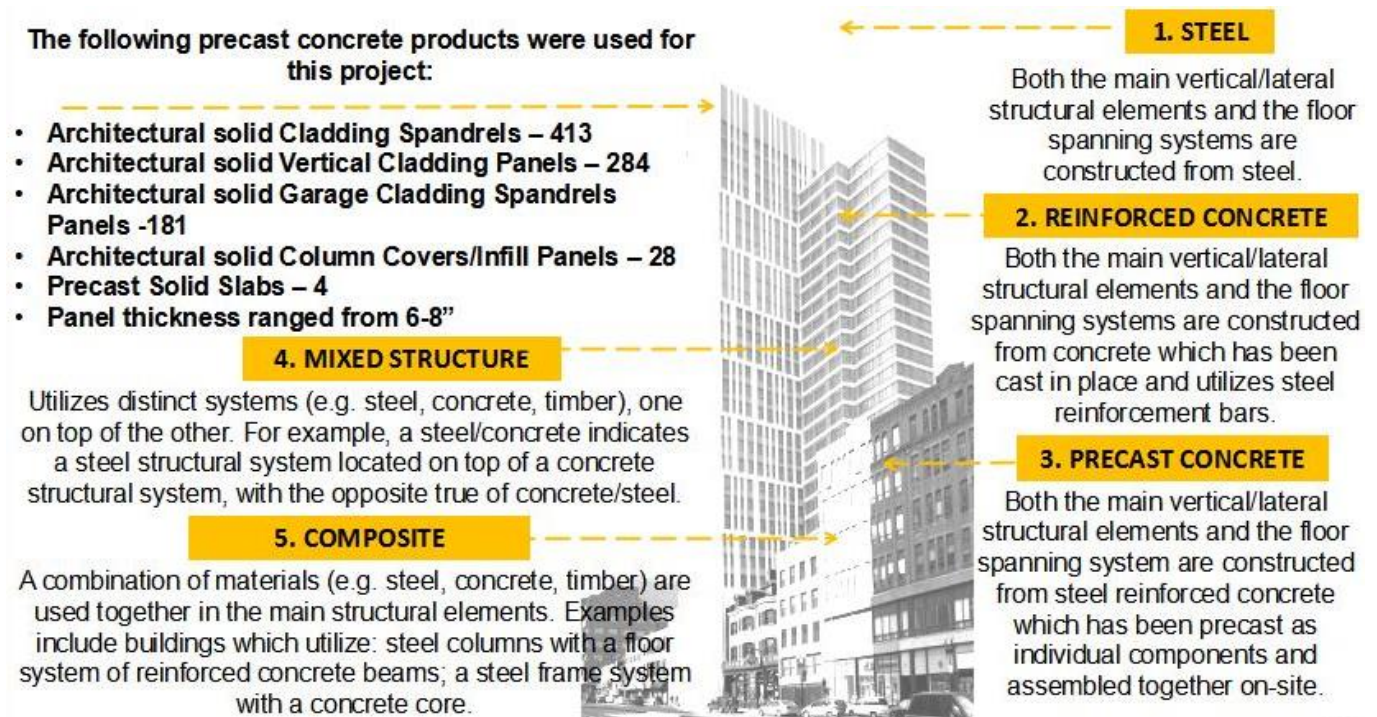


Fig 3.7 Precast Components

3.2.2 Design Considerations

Due to extremely restricted access to this project location, Strescon and AvalonBay Communities, Inc. coordinated efforts to perform night-time erection. This was to ensure they did not impact trades working on site during the day and to disturb the local community during busy hours. Erection of the precast concrete panels was scheduled in two phases. The initial Phase began in April 2014, followed by the second phase, which completed the end of summer 2015. Strescon Limited supplied roughly 100,000 square foot or 910 individual panels for this project, which were used in combination with metal panels and glass curtain walls to create the building's striking envelope. Architectural precast concrete is not only compatible with all structural systems, it can be designed to harmonize with, and complement, all other materials.

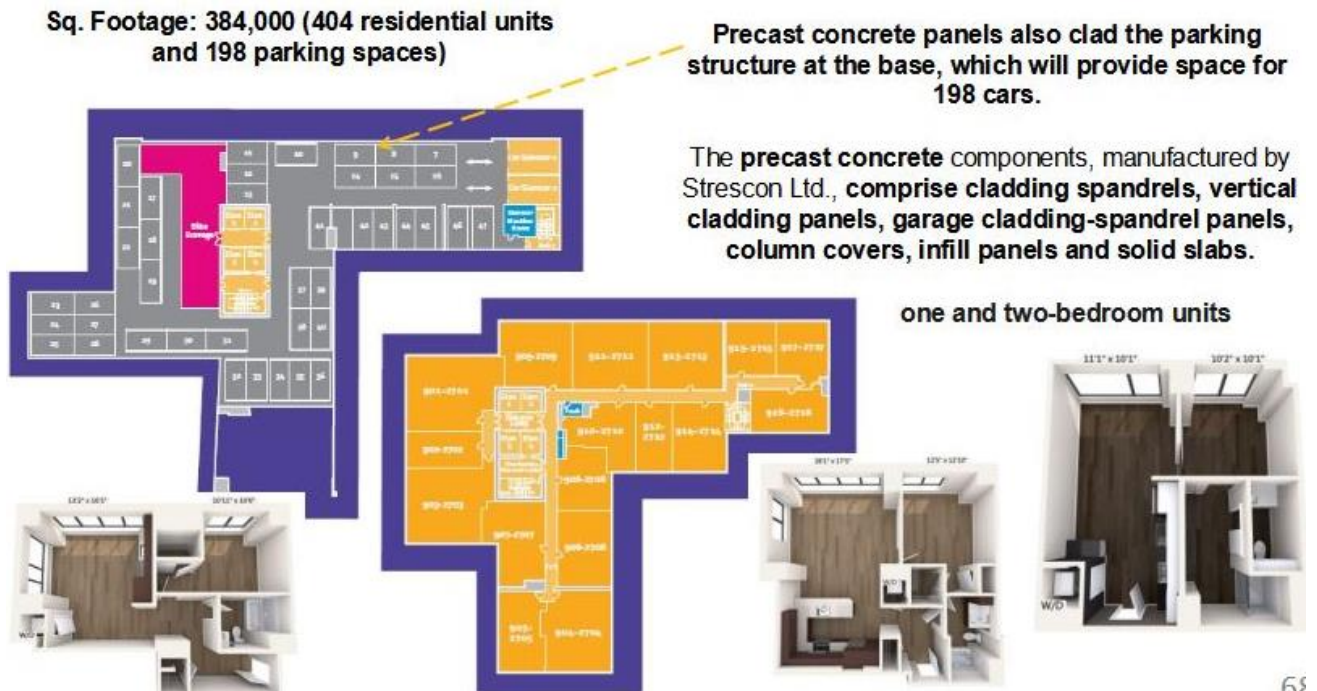


Fig 3.8 Design Considerations

3.2.3 Features

Each visible precast concrete element consists of the same architectural, light sandblast finish, to maintain consistency between the upper and lower sections of the structure. Improvements in fabricating processes allow architectural precast concrete to be produced in almost any color, form, or texture, making it an eminently practical and aesthetically pleasing building material.

3.2.4 Conclusion

The major factor in Strescon producing this project was their ability to design the unique, three-storey vertical column covers that CBT Architects had envisioned for this project. Precast concrete's moldability and versatility offers the freedom to sculpt the structure's facade in imaginative ways.

CHAPTER 4

ANALYSIS AND RESULTS

4.1 INTRODUCTION

The well-known real estate developer Sobha has brought an amazing and affordable residential project named Dream Acres at a really feasible location in Bangalore. The vast project will be spread over an area of 81 acres making it a highly spacious project in the area. The project will consist of 2 BHK and 2 BHK (Large) Mid - Segment Houses.

The Sobha Dream Acres Apartments at Bangalore is located in the closest proximity to the IT and ITES companies, colleges, malls and schools. The project is known to be the best in the area for its 80% open space availability, precast technology and other high- end construction techniques used in the construction.

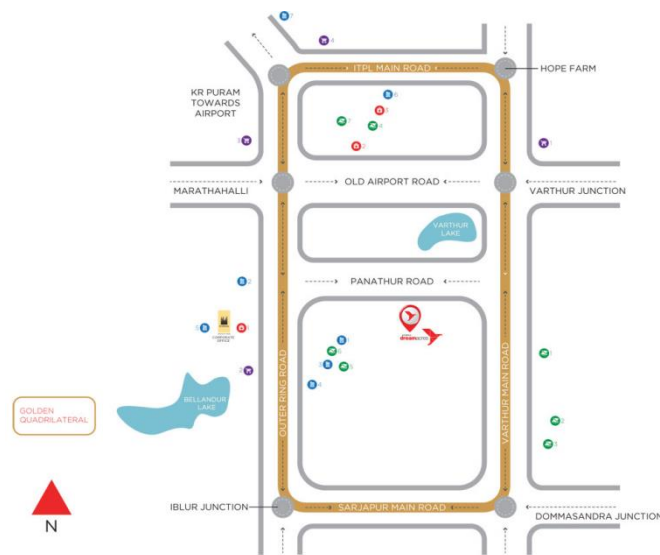


Fig 4.1 The Dream Acres Apartments at Bangalore

4.1.1 Precast Type - The Dream Acres, Bangalore

Type: Township

Area: 81 acres

No. of units: 6500 : 1 BHK - 59.96 Sq. mts to 61.43 Sq. Mts, 2 BHK Regular - 69.28 Sq. mts to 94.02 Sq. Mts and 2 BHK Large (phase -2) - 87.00 Sq. mts to 112.43 Sq. Mts.

Table 4.1 The Dream Acres Project

Type Of Apartment	Mid Segment Houses
Project Stage	Ongoing / Under Construction
Land Area	81 Acres
Type Of Flats	1 BHK, 2 BHK, 2 BHK (Large)
No of Units	6500+ units
Open Space	80%
SBA	650 Sq Ft – 1210 Sq Ft
Project Location	Panathur Main Road, Off ORR, Balagere, Bangalore - 560087
Project Zone	East Bangalore
Total Towers	10 Blocks (Phase 1)
Total Floors	G+13 & 14 Floors
Approvals	BDA/BBMP
Rate Per Sq Ft	Rs. 5150/-
Possession	2018
Budget	Rs. 40 Lakhs Onwards

4.1.2 Project Management

Monitoring: Assigning site engineers to check each activity on site.

Recording: Compiling the monitored data's ie based on DPR(Daily Progress report)

Tracking: Ensuring the work is done based on Master construction plan.

Reporting: Report all the data's to client on weekly basis.

Quality check: Ensuring the quality with quality checklist for each activity.

Quality surveying: Checking the material procurement bill produced by HNS contractor. Done based on material indent generated by vendor / contractor. Running account bill submitted by contractor will be checked and passed within 30 days from the date of submission.

Meetings: Organizing and coordinating a common meeting with client and contractors of many disciplines on weekly /monthly basis. Project manager creates Agenda before meeting and MOM(Minutes of meeting) after meeting.

Scope of services: Client Total Representation, Program Planning, Design Team Management, Time Scheduling, Project Documents Review, On-site Contractors Co-

ordination, Quality Control, Health & Safety Provisions Co-ordination and Ensuring all necessary Compliance.

Cost Management: Quantity Survey, Budgeting, Tendering Process, Contract Administration, Value Engineering, Cash-flow Management, Bill Certification and Cost Control.

4.1.3 The Sobha Dream Acres - Master Plan



Fig 4.2 The Dream Acres - Master Plan

4.1.4 The Dream Acres - Building Data

1. Column size (Base to 3rd) 300 mm × 675 mm Column size (4th to 9th) 230 mm × 675 mm Column size (10th to 13th) 230 mm × 600 mm Column size (14th to 18th) 230 mm × 525 mm

2. Beam size = 230 mm × 450 mm, 3. Thickness of slab = 115 mm, 4. Hollow core slabs - 150, 200, and 265 mm, 5. Stair case slab thickness = 150, 6. Parapet wall 1 m Height = 230 mm, 7. Live load = 2 kN/m², 8. Floor Finish = 1 kN/m², 9. Yield strength of steel = 415 MPa, 10. Density of concrete = 25 kN/m³ and 11. 5% Damping.

Overall built-up Area (Precast+CIS) : 10 Million Sq. ft.

Built-up area planned in Precast : 3.79 million Sq. ft.

Built-up area of A series (A1-A7) : 8.82 lacks Sq. ft.

Total apartments : 1500 apartments; 12 apartments per floor

Structural system (Sub-structure) : Raft foundation (CIS)

Structural system (Super-structure) : Hybrid Precast Construction (Shear walls)

Basement, Ground & terrace work : Cast In Situ 1st to 18th floor

Precast beams, wall panels, balconies, claddings, staircase, & hollow core slabs

Total precast concrete volume (m3) = 16000

Total Nos. of Precast elements (Tilts + HCS) = 25000

1 BHK - 59.96 Sq. mts to 61.43 Sq. mts



B1 Carpet Area: 61.22 Sq.mts
SBA: 87.00 Sq.mts
Wing number: 16

1 BHK TYPE - FLOOR PLANS



E1 Carpet Area: 41.37 Sq.mts
SBA: 61.43 Sq.mts
Wing numbers: 11

1 BHK - 59.96 Sq. mts to 61.43 Sq. mts



E2 Carpet Area: 41.37 Sq.mts
SBA: 61.02 Sq.mts
Wing numbers: 11

1 BHK TYPE - FLOOR PLANS



E3 Carpet Area: 41.24 Sq.mts
SBA: 59.96 Sq.mts
Wing numbers: 11

At
Gc

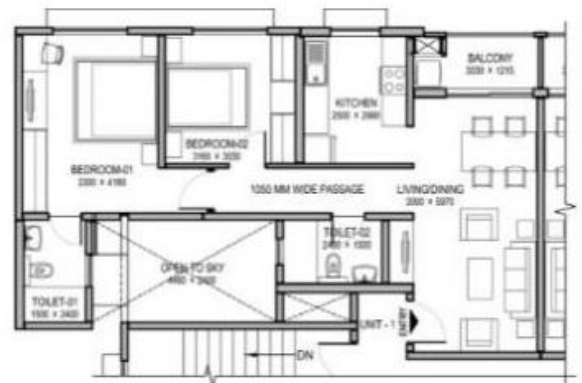
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2 BHK Regular - 69.28 Sq. mts to 94.02 Sq. mts



A2 CARPET AREA: 66.42 Sq.mts
SBA: 94.02 Sq.mts
Wing numbers: 1, 2, 3, 4, 5, 6, 49, 52, 53

2 BHK REGULAR TYPE - FLOOR PLANS



A2 CARPET AREA: 66.42 Sq.mts
SBA: 94.02 Sq.mts
Wing numbers: 5, 6, 49

No. of units: 6500

- 1 BHK - 59.96 Sq. mts to 61.43 Sq. mts
- 2 BHK Regular - 69.28 Sq. mts to 94.02 Sq. mts
- 2 BHK Large (phase -2) - 87.00 Sq. mts to 112.43 Sq. mts

2 BHK Regular - 69.28 Sq. mts to 94.02 Sq. mts



A3 CARPET AREA: 66.42 Sq.mts
 SBA: 93.59 Sq.mts
 Wing numbers: 1, 2, 3, 4, 5, 6, 49, 52, 53

2 BHK REGULAR TYPE - FLOOR PLANS



A4 CARPET AREA: 66.42 Sq.mts
 SBA: 94.77 Sq.mts
 Wing numbers: 47, 48

2 BHK Large (phase -2) - 87.00 Sq. mts to 112.43 Sq. mts



B2 CARPET AREA: 80.06 Sq.mts
 SBA: 112.43 Sq.mts
 Wing numbers: 16, 17, 41, 42, 43, 45, 46

2 BHK LARGE TYPE - FLOOR PLANS



B2 CARPET AREA: 80.06 Sq.mts
 SBA: 112.43 Sq.mts
 Wing numbers: 46

Fig 4.3 The Dream Acres - Building Data

4.1.5 The Dream Acres - Site Works

STAGES OF CONSTRUCTION - SITE WORKS - PRELIMINARY

WINGS 7, 8, 12, 13 WORKS



MARKING WITHIN THE SITE



EXCAVATE FOR FOUNDATION



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STAGES OF CONSTRUCTION - SITE WORKS - PRELIMINARY

WINGS 7, 8, 12, 13 WORKS



MARKING WITHIN THE SITE



Cranes and Loaders

- 1) Tower crane of 5.7 MT, 6.9 & 7.2 MT load carrying capacity and operating radius of 40 to 45 m.
- 2) Gantry cranes of 10 MT, 20 MT & 30 MT capacity and span of 20 to 25 m.

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Fig 4.4 The Dream Acres -Site Works

The sequence of erection shall be as follows:

1. Installation of precast wall panels above cast-in-situ slab.
2. Provide temporary props/jacks for restraining of the walls laterally.

3. Grout the connection between the wall panels & ground floor slab and the joint between each wall panel.
4. Installation of precast slab panels above the erected precast wall panels.
5. Screed concrete above the slab after placing of electrical conduits/ittings.
6. Installation of the wall panels over the floor slab.
7. Installation of the roof panels such as parapets etc.

4.1.6 The Sobha Dream Acres - Stages Involved in Construction

STAGES OF CONSTRUCTION - STAGE ONE

WINGS 7, 8, 12, 13 WORKS



COLUMN WORKS



PLINTH BEAM- REINFORCEMENT



PLINTH BEAM

Care should be taken on embedded items while concreting.



STAGES OF CONSTRUCTION - STAGE TWO

WINGS 7, 8, 12, 13 WORKS

PLINTH BEAM TO ACCOMMODATE THE STARTER BARS



plinth area with protruding starter bars which are meant to strengthen the interlocking with the cells of the panel.

Installation of precast wall panels above cast-in-situ slab.

Provide temporary props/jacks for restraining of the walls laterally.



Grout the connection between the wall panels & ground floor slab and the joint between each wall panel.

STAGES OF CONSTRUCTION - STAGE THREE

WINGS 7, 8, 12, 13 WORKS



The Precast elements shall be tied firmly to the trailer by means of belt/rope as moving the load without proper tie will cause damage. While transporting elements vertically, the vehicle should be loaded equally on both sides.



Instruction regarding loading height, positioning of precast elements over the trailer should be followed as per capacity of trailer



Fig 4.5 The Dream Acres - Stages Involved in Construction

4.1.7 The Sobha Dream Acres - Erection Works



Erection

WINGS 7, 8, 12, 13 WORKS

Installation shall be done by tower crane with sufficient capacity. Panels shall be shifted from the stack rack/truck from yard to the nearest point of construction site and shall be kept above the truck during the construction or inside the storage racks as per the site situation.



Fig 4.6 The Dream Acres - Erection Works

4.1.8 The Dream Acres - Lifting Works



As the elements are lifted to its final position above the cast-in-situ slab/precast panel, vertical and horizontal **alignment of the panel shall be adjusted**. The gap between the element and adjusted elements shall be **maintained as per the drawings within the allowable tolerances**. **Shims and spacers** shall be used for levelling and adjustment.

WINGS 7, 8, 12, 13 WORKS



The joints between the precast wall panels shall be filled with **joint filler material**.
Precast slab shall be erected above the wall panels **without any scaffolding system**. The electrical conduit/fitting shall be done. After electrical works are completed, screed concrete shall be laid over the precast slab.



Providing a controlled, off-site fabrication environment. Precast reduces the amount of wet trade work on site, making them cleaner, tidier and safer.

ENHANCES SAFETY



Fig 4.7 The Dream Acres - Lifting Works

4.1.9 The Sobha Dream Acres - Design and Implementation

Hybrid concrete construction is a method of construction which integrates precast concrete and cast in-situ concrete to make best advantage of their different inherent qualities. The accuracy, speed and high-quality finish of precast components can be combined with the economy and flexibility of cast in-situ concrete. In this hybrid construction foundation,

substructure, terrace work & all the shear walls for all floors were completed using conventional CIS method. Superstructure consisted of precast construction of beams, balcony, staircase, wall panels & hollow core slabs.

The ambitious real estate program features 13 towers of 18 floors built in a record time by precast construction methods supported by a purpose-built factory powered by Vollert equipment. After casting on the production line, the panel is brought to its final location for straightening and bracing installation. Locally sourced non-shrink grout is inserted into the cavity by injection. After injection, the bracing around the precast panel may then be removed after only 3 days.

4.1.10 The Dream Acres - Connections Details

The vertical members (shear walls) were constructed in CIS considering the economy and design aspects along with erection plan of other members. This hybrid design facilitated the overall faster erection and allowed for timely production & delivery of other precast members. The connection were simple and special dowel bars, corbels and provisions for connection were planned in advance for the members as per the design. The joints were made monolithic by grouting them with non-shrink grout. Onsite, wet grouted joints for horizontal connections between wall to wall, slabs to wall, termed as stitched joints were selected.

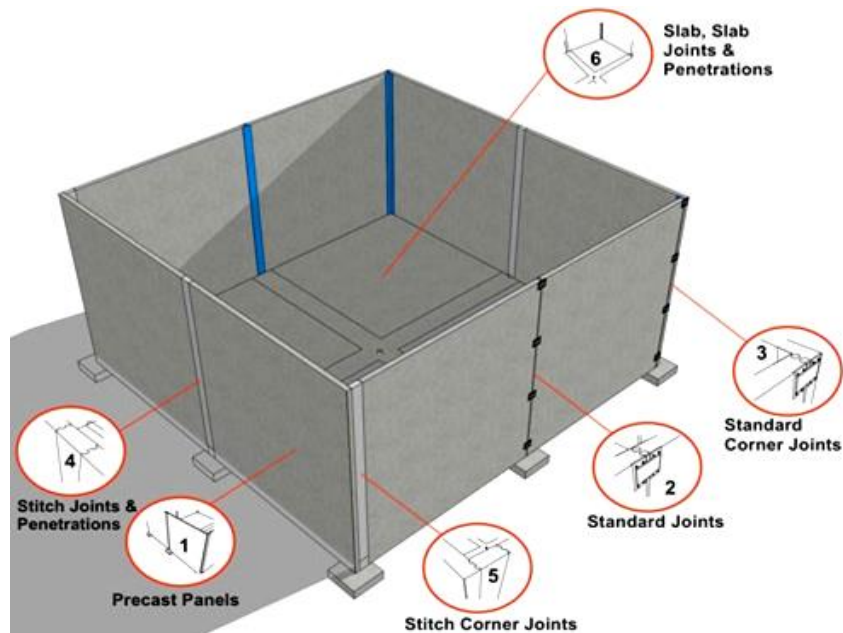


Fig 4.8 The Dream Acres - Connection Details

4.1.11 The Dream Acres - Challenges Experienced

As the project was located in seismic zone IV, the suitable design was adopted. Lack of skilled manpower with the knowledge of precast industry, operation of various machineries & erection, which was overcome by providing detailed training. Although, European and other standards were available for ready reference but unavailability of IS codes was deemed important. The designers from India had only few Indian Standard to refer.

4.1.12 The Dream Acres - Result Achieved

6 buildings of two buildings G+18 floors were completed in 14 months of timeline with superior quality was made possible through precast technology. Achieved a slab cycle of 10-12 days for a slab area of 7000 Sq. ft. Cost & time optimisation with the use of hollow-core slabs. Reduction in concrete & steel factor per Sq. ft. of built-up area. Automation & mechanisation of construction project improved overall productivity. Improved site safety & considerable reduction in wastage, dust & noise on site, thus reduced ecological footprint of project.

4.1.13 The Dream Acres - Conclusion

Hybrid precast instead of usually considered 'all precast or no precast' approach offers more benefits in terms of time, cost, and quality. Repetition of precast components is essential in order to meet quantity for cost effectiveness. Improved quality control, reduction of construction time, construction waste, dust & noise on site, and labour requirement on site. it results in higher useful gross floor area which contributed to significant cost benefits. A considerable reduction in steel factor can be achieved even for seismic zones IV & V. Precast technology allowed for flexible design and longer clear spans in the non-tower areas like parking. Precast is smart way to achieve the sustainability objectives of Green Building.

4.1.14 The Sobha Dream Acres - Vollert equipment

The ambitious real estate program features 13 towers of 18 floors built in a record time by precast construction methods supported by a purpose-built factory powered by Vollert equipment.



Special screeding lines with blade-equipped finishing heads ensure top architectural-concrete quality
Figure: Vollert



To assure that the entire production process runs at high cycle speed, special components with stationary formwork system are produced by Nuspl, the formwork specialists
Figure: Vollert

Fig 4.9 The Dream Acres - Vollert equipment

4.1.15 The Dream Acres - Checklists

Considering the transportation	
Traffic regulations limit the maximum length and weight	As per rule
load capacity of Lorries	As per rule
Height: 4 – 4½ m. (Rule)	3m
Length: 22m.	12m
delivered with proper supports ,frames ,cushioning and tie downs	support through stillage
Adequate packing or protection to the edges	not done

Considering the handling & storage		
Factors	yes	no
Check materials are stored as per MOS procedure for materials storage at site and/or suppliers recommendations		
All materials stored at site shall have proper identification		
Visual inspection is carried out		
All elements and components shall be clearly labelled for identification and traceability		
Inspection shall be done upon arrival in site to check if the materials have been damage during delivery		
Materials should be protected from water, contamination and weather		
Ground surface on which stacking to be done should be properly levelled		
Storage support position for panels should be within 300 mm from the lifting points		

Considering the Site preparation			Considering the Erection and Hoisting		
Items to be checked	yes	no	Items to be checked	yes	no
Site personnel should identify surveyors datum line			Ensure the correct panel before hoisting		
Tolerance information should be relevant to the design and installation of works			Ensure the crane lifting capacity before hoisting the panels		
Structural steel works shall be erected in accordance with tolerances given in project specification			Ensure the desired crane's working radius		
Refer to surveyors offset lines marked on the area			Ensure the anchorage for the propping does not damage panels		
Check the plumb & line of the wall			Ensure the desired verticality/position is achieved		
Ensure on a daily basis that jaws are in good working order prior to start of day's lifting			Ensure the lifting points located to limit the bending moments		
Drill holes in concrete at predetermined centres to accommodate starter bars, if starter bars are not already provided			Rotational transport, no horizontal movement		
Ensure all unwanted dowels, rubbish, epoxy is removed from work zone			Ensure horizontal and limited vertical movement		
			Ensure vertical and limited horizontal movement		
			Ensure the use of jack		

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Fig 4.10 The Dream Acres - Checklists

4.1.16 Conventional Type - Shobha Winchester, Chennai

2.SHOBHA WINCHESTER PALLAVARAM CHENNAI

4.29 ACRES – LAND AREA
 STRUCTURE 38+G + 19 FLOORS
NO. OF BLOCKS: 4 Blocks
 NO OF UNITS 344 UNITS
 TYPE OF UNITS 1,2,3,4 BED ROOMS

3 BASEMENTS +GROUND +19 storeyed RCC framed structure with concrete block masonry walls

Column Size = 350 mm x350 mm
 Beam size = 230 mm x 450 mm
 ❖ Parapet wall 1 m Height = 230 mm
 ❖ Live load = 2 kN/m²
 ❖ Floor Finish = 1 kN/m²



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Fig 4.11 Conventional Type - Shobha Winchester, Chennai

4.2 MERITS AND DEMERITS OF PRECAST AND CONVENTIONAL METHODS

The following tables explain about the : Complete details about the Precast technology and the conventional systems. Detailed estimation / quantity for Precast Technology and Conventional system is done. Cost and time comparison is done to know the feasibility.

4.2.1 Comparison of Precast system and conventional systems

Table 4.2 Comparison of Precast and conventional systems

PARTICULARS	DREAM ACRES (PRECAST)	SHOBHA WINCHESTER (CONVENTIONAL)
Construction speed	Very rapid speed of erection. Rapid construction on site - 462 DAYS.	Comparatively slow construction On site casting, so reinforcement laying & fixing, formwork. - 605 DAYS.
Quality control	Good quality control. Quality is checked under factory conditions periodically. Errors are avoided as they are computerized high durability is achieved. Curing also done in factory conditions.	Quality may affect due to site conditions, due to bad supervision, unskilled labour and procurement of materials. QC is checked regularly for achieving good quality.
Environmental conditions	Weather is eliminated as a factor-you can cast in any weather and get the same results.	Environmental conditions like temperature, humidity can affect on performance of concrete.
Labour Requirement	Fully automated in production stage with help of unskilled labours, but for erection technically skilled labours is needed.	More Labours required on site. Mix of skilled and unskilled labours are present according to the works.
Manufacturing conditions	High quality is achieved because of the controlled conditions in the factory. And they are of higher quality.	RCC is to casted on site & the site conditions are not regularized, so it may affect on strength.
PARTICULARS	DREAM ACRES (PRECAST)	SHOBHA WINCHESTER (CONVENTIONAL)
Cost	Rs. 1600/sq. ft	Rs. 2000/sq. ft
Connections	Connections are quite difficult 50 mm gap is maintained.	Connections are not needed.
Size & Shape	Repeated precast elements, so few moulds are prepared priorly with all the dimension check.	In-situ concreting is suitable where the building is in uneven shape & there are no repetitive shapes because of human errors.
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
Finishing	The finishing are perfect as it s all computer aided deigns	Manual error occurs always so finishing is not that much perfect.

PARTICULARS	DREAM ACRES (PRECAST)	SHOBHA WINCHESTER (CONVENTIONAL)
Dismantling	Dismantling can be so much easier as they can be removed by disconnecting all the joints.	Dismantling is not easy ,machinery or much labour s needed.
Carbon emission	5% less carbon emission.	Its more comparing to precast.
Services	Electrical conduits are fixed in wall panels and hollow core slabs in factory itself Plumbing pipelines are inlayed and then highly qualified water sealants are used thus making the building waterproof.	Electrical conduits are laid at the time of roof slab construction. Plumbing pipelines are designed and waterproof of the building depends on workmanship.

4.2.2 Detailed estimation / quantity for Precast System- Live case study

Table 4.3 Detailed estimation / quantity for Precast System

PRECAST METHOD : COLUMN (PER FLOOR)	
Precast column	M25 Grade
Column Size	0.35x0.35x2.820 M
Total volume	0.35 m3
Steel required	46 kg
R.M.C rate for 1m3 concrete for 0.35 m3 concrete cost.	Rs.5531 = (5531X0.35) = Rs.1936
Labor cost	Rs.1500
Erection cost	Rs.2500
Total cost required for 1 column Concrete	1936
Steel cost	= 46X53.9(Rate/KG) = 2479
Labour cost for precast production	Rs.1500
Total column cost	Rs.9915
Total no of column required for 1 floor 36 No's. Total cost = 9915X36 = Rs.356940 1m3 Rate for column = Rs.28329.	

PRECAST METHOD : BEAM (PER FLOOR)	
Precast Beam	M25 Grade
Total volume of Beam	14.202 m3
Steel required	2011.18 kg
R.M.C rate for 1m3 concrete	Rs.5531
For 14.202 m3 concrete cost	Rs.78551
Labor cost for 57 beam	500x57 = Rs.28500
Erection cost for 1 beam	RS.2500
Total 57 no's of Beam	2500x 57= Rs.142500
Total cost required for 57 no's of beam	
Concrete	Rs.78551
Steel cost	Rs.108403
Labour cost	Rs.28500
Erection cost	Rs.142500
Total beam cost = Rs.357954 1m3 Rate for Beam = Rs.25205	

PRECAST METHOD : LINTEL (PER FLOOR)	
Total volume of lintels	0.94 m ³
Steel required	72.16 kg
R.M.C rate for 1m ³ concrete	Rs.5531
For 0.94 m ³ concrete cost	Rs.5199
Labour cost	Rs.25
Erection cost for 1 lintel	Rs.40
Total cost required for 48 no's of lintel	
Concrete	Rs.5199
Steel cost	Rs.3889
Labour cost	Rs.1500
Erection cost @ site	Rs.4000
Production cost	Rs.5000
Total lintels cost = Rs.19588 1m³ Rate for lintels = Rs.434	

PRECAST METHOD : SLAB (PER FLOOR)	
Total cost Required for 92 panels	Rs.200640
Site Erection cost-Total 92 no's of panels	= 100x92nos = Rs.92000
Total cost required for 92 no's of panels	
Total slab panel cost	Rs.292640
Total volume Screeding of 40 mm.	8.32 m ³
Production & post-production cost	75000
For 1 m ³ m 25 grade rate of concrete	Rs.5531
Steel required	750 kg - 750x53.9 = Rs.40425
Total Screeding cost	
Concrete cost	8.32x5531 = Rs.46018
Steel cost	175x53.9 = Rs.9434
Total cost for screeding = Rs.55452 Total cost for slab = Rs.497474	

PRECAST METHOD : LINTEL WITH CHAJJA (PER FLOOR)	
volume of 1 lintels with chajja	0.78 m3
Steel required	188.19 kg
R.M.C rate for 1m3 concrete	Rs.5531
For 0.78 m3 concrete cost	Rs.4314
Labour cost	Rs.125
Erection cost for 1 lintel with chajja	Rs.150
Total 28 no's of lintels with chajja	Rs.4200
Production cost	Rs.20000
Concrete	$0.78 \times 5531 = \text{Rs.}4314 \times 28 = 120792$
Steel cost	$188.19 \times 53.9 = 10143$
Labour cost (@site)	Rs.2000
Erection cost (@site)	Rs.4500
Total lintel with chajja cost = Rs.161635 1m3 Rate for lintel with chajja = Rs.7525	

PRECAST METHOD : STAIRCASE (PER FLOOR)	
Total volume of staircase	0.48 m3
Steel required	36 kg
R.M.C rate for 1m3 concrete	Rs.5531
Labour cost	Rs.125
Erection cost for 1 staircase	Rs.1000
Total 4 no's of staircase	$4 \times 1000 = \text{Rs.}4000$
Total cost required for staircase	
Concrete	$0.48 \times 5531 = \text{Rs.}2655 \times 4 = 10620$
Steel cost	$36 \times 53.9 = \text{Rs.}1940 \times 4 = 7760$
Labour cost	Rs.5000
Production cost	Rs.12000
Total no of Staircase required for 1 floor 4 No's Total staircase cost = Rs.40380 Total cost per staircase = Rs.10095	

4.2.3 Detailed estimation / quantity for Conventional System - Live case study

Table 4.4 Detailed estimation / quantity for Conventional System

CONVENTIONAL METHOD : COLUMN (PER FLOOR)	
Column Size	0.35x0.35x2.820 M
Total volume	0.35 m ³
Steel required	46 kg
Conventional rate for 1m ³ concrete for 0.35 m ³ concrete cost	= RS.8188 = 8188X0.35 = RS.2866
Labor cost	Rs.5000
Total cost required for 1 column Concrete	RS.2866
Steel cost	= 46x53.9 = RS.2479
Shuttering Rs.25/sqft	= Rs.1000x36=36000
Total column cost	= RS.6345
Total no of column required for 1 floor 36 No's. Total cost = 6345x36 = Rs. 269420 1m³ Rate for column = Rs.21383	

CONVENTIONAL METHOD : BEAM (PER FLOOR)	
Total volume of Beam	14.202 m ³
Steel required	2011.18 kg
Conventional rate for 1m ³ concrete	Rs.8237
For 14.202 m ³ concrete cost	Rs.116982
Total cost required for 57 no's of Beam	
Shuttering Rs.25/sqft	= Rs.1000x57=57000
Labor cost	= Rs.5000
Concrete	= 14.202x8237 = Rs. 116982
Steel cost	= 2011.18x53.9 = Rs.108403
Total Beam cost = Rs.287385 1m³ Rate for Beam = Rs.20236	

CONVENTIONAL METHOD : LINTEL (PER FLOOR)	
Total volume of lintels	0.94 m ³
Steel required	72.16 kg
Conventional rate for 1m ³ concrete	Rs.8237
For 0.94 m ³ concrete cost	Rs.7743
Shuttering Rs.25/sqft	= Rs.1000
Labour cost	= Rs. 1000
Concrete	Rs.7743
Steel cost	Rs.3889
Total lintels cost = Rs.13632 1m³ Rate for lintels = Rs.302	

CONVENTIONAL METHOD : SLAB (PER FLOOR)	
Total volume of Slab	23.44 m ³
Steel required	2760 kg
Conventional rate for 1m ³ concrete(RMC) For 23.44 m ³ .	Rs.8843 x23.44m ³ = 207280
Shuttering Rs.25/sqft	= Rs.10000
Labour cost	= Rs.8000
Total cost required for Slab Concrete	Rs.207280
Steel cost = 2760x53.9= Rs.148764	
Total Slab cost = Rs.374044	

CONVENTIONAL METHOD : LINTEL WITH CHAJJA (PER FLOOR)	
volume of 1 lintels with chajja	0.78 m ³
Steel required	188.19 kg
Conventional rate for 1m ³ concrete	Rs. 5531
For 0.78 m ³ concrete cost	Rs.4314
Total cost required for 28 no's of lintel with chajja	
Concrete	28x4314=RS.120792
Steel cost	188.19x53.9=RS.10143
Labour Cost	1500
Shuttering Cost	1500
Total lintels cost = Rs.133935	
1m³ Rate for lintels = RS. 6235	

CONVENTIONAL METHOD : STAIRCASE (PER FLOOR)	
Total volume of staircase	0.48 m ³
Steel required	36 kg
Conventional rate for 1m ³ concrete	Rs.5531
☐ Total cost required for stair case	
Concrete	$0.48 \times 5531 = \text{Rs.}2655 \times 4 = 10620$
Steel cost	$36 \times 53.9 = \text{Rs.}1940 \times 4 = 7760$
Labour cost	$1000 \times 4 = 4000$
Shuttering Cost	$2000 \times 4 = 8000$
Total staircase cost	30380
Total no of Staircase required for 1 floor 4 No's Total cost per staircase = 30380 / 4 = RS.7595	

4.2.4 Cost comparison between Precast and Conventional system

Table 4.5 Cost comparison between Precast and Conventional system

SI.NO	COMPONENTS OF THE BUILDINGS	PRECAST CONSTRUCTION	CONVENTIONAL CONSTRUCTION	COST DIFFERENCES
1.	Column	Rs.356940	Rs.269420	Rs.87520
2.	Beam	Rs.357954	Rs.287385	Rs.70569
3.	Lintel	Rs.19588	Rs.13632	Rs.5956
4.	Slab	Rs.497474	Rs.374044	Rs.123430
5.	Lintel with chajja	Rs.161635	Rs.133935	Rs.27700
6.	Staircase	Rs.40380	Rs.30380	Rs.10000
	Total cost	Rs.1453332	Rs.1108796	Rs.325175

4.2.5 Time comparison between Precast and Conventional system

Table 4.6 Time comparison between Precast and Conventional system

SI.NO	DESCRIPTIONS - DREAM ACRES, BANGLORE	DURATIONS
1.	SUB STRUCTURE - (Site cleaning, Earthwork, Foundation, Basement, Soil filling & Consolidation)	88 days
2.	SUPER STRUCTURE – (Wall panels framing and Roofing slabs)	190 days
3.	FINISHING WORKS – (Electrical, Plumbing Painting, Tiling, and Windows, Extra items)	184 days
	TOTAL DURATIONS	462 days

**PRECAST BUILDING
CONSTRUCTION**

**CONVENTIONAL BUILDING
CONSTRUCTION**

SI.NO	DESCRIPTIONS - SHOBHA WINCHESTER	DURATIONS
1.	SUB STRUCTURE - (Site cleaning, Earthwork, Foundation, Basement, Soil filling & Consolidation)	88 days
2.	SUPER STRUCTURE – (Wall and Roofing slabs)	333 days
3.	FINISHING WORKS – (Electrical, Plumbing Painting, Tiling, and Windows, Extra items)	184 days
	TOTAL DURATIONS	605 days

	WBS	Task Name	Duration	Start	Finish
1	1	DREAM ACRES SHOBA RESIDENTIAL APARTMENTS BANGALORE	462 days	Tue 9/21/21	Mon 3/13/23
2	1.A	BLOCK - A - PRECAST CONSTRUCTION TECHNOLOGY	462 days	Tue 9/21/21	Mon 3/13/23
3	1.A.a	Site Activities	13 days	Tue 9/21/21	Tue 10/5/21
4	1.A.a.1	Mobilization	13 days	Tue 9/21/21	Tue 10/5/21
5	1.A.b	Substructure	343 days	Tue 9/21/21	Tue 10/25/22
6	1.A.b.1	Foundation	343 days	Tue 9/21/21	Tue 10/25/22
7	1.A.b.1.13	Earth work	20 days	Wed 10/6/21	Thu 10/28/21
8	1.A.b.1.14	Footing & Column marking	40 days	Tue 10/12/21	Fri 11/26/21
9	1.A.b.1.15	PCC	30 days	Wed 10/13/21	Tue 11/16/21
10	1.A.b.1.16	Pile Dismantling	30 days	Fri 10/15/21	Thu 11/18/21
11	1.A.b.1.17	Pile cap Concrete & Plinth Beam Concrete	42 days	Tue 10/26/21	Tue 10/25/22
12	1.A.b.1.18	Foundation Back filling	30 days	Thu 10/28/21	Wed 12/1/21
13	1.A.b.1.19	Column Concrete	30 days	Fri 10/29/21	Thu 12/2/21
14	1.A.b.1.20	Brick work upto FFL	30 days	Tue 11/2/21	Mon 12/6/21
15	1.A.b.1.21	Filling / Leveling	30 days	Fri 11/5/21	Thu 12/9/21
16	1.A.b.1.23	Anti termite treatment Flooring	25 days	Tue 9/21/21	Tue 10/19/21
17	1.A.b.1.24	Flooring PCC Concrete	25 days	Tue 9/21/21	Tue 10/19/21
18	1.A.c	Superstructure	275 days	Tue 9/21/21	Sat 8/6/22
19	1.A.c.1	Roof Slab Beam and Slab	48 days	Tue 9/21/21	Mon 11/15/21
20	1.A.c.1.7	Ground floor roof slab	24 days	Wed 9/29/21	Tue 10/26/21
21	1.A.c.1.7.8	Erection of Column and Beam	18 days	Wed 9/29/21	Tue 10/19/21

25	A.c.1.7.12	Electrical conduits fixing / Plumbing sleeves fixing	1 day	Fri 10/22/21	Fri 10/22/21
26	A.c.1.7.13	Reinforcement Laying and Formwork Erection	2 days	Sat 10/23/21	Mon 10/25/21
27	A.c.1.7.14	Concreting	1 day	Tue 10/26/21	Tue 10/26/21
28	1.A.c.1.8	1st floor roof slab	48 days	Tue 9/21/21	Mon 11/15/21
29	A.c.1.8.12	Erection of Column and Beam	5 days	Thu 10/28/21	Tue 11/2/21
30	A.c.1.8.13	Grouting of Column and Beam	9 days	Fri 10/29/21	Mon 11/8/21
31	A.c.1.8.14	Placing of Precast Slab Panels	9 days	Sat 10/30/21	Tue 11/9/21
32	A.c.1.8.15	Grouting of Slab joint	9 days	Mon 11/1/21	Wed 11/10/21
33	A.c.1.8.16	Electrical conduits fixing / Plumbing sleeves fixing	10 days	Wed 11/3/21	Sat 11/13/21
34	A.c.1.8.17	Reinforcement Laying and Formwork Erection	10 days	Thu 11/4/21	Mon 11/15/21
35	A.c.1.8.22	Concreting	1 day	Tue 9/21/21	Tue 9/21/21
36	1.A.c.1.9	2nd floor roof slab	16 days	Thu 9/23/21	Mon 10/11/21
37	A.c.1.9.12	Erection of Column and Beam	5 days	Thu 9/23/21	Tue 9/28/21
38	A.c.1.9.13	Grouting of Column and Beam	9 days	Fri 9/24/21	Mon 10/4/21
39	A.c.1.9.14	Placing of Precast Slab Panels	9 days	Sat 9/25/21	Tue 10/5/21
40	A.c.1.9.15	Grouting of Slab joint	9 days	Mon 9/27/21	Wed 10/6/21
41	A.c.1.9.16	Electrical conduits fixing / Plumbing sleeves fixing	10 days	Wed 9/29/21	Sat 10/9/21
42	A.c.1.9.17	Reinforcement Laying and Formwork Erection	10 days	Thu 9/30/21	Mon 10/11/21
43	A.c.1.9.18	Concreting	9 days	Fri 10/1/21	Mon 10/11/21
44	1.A.c.1.10	3rd floor roof slab	17 days	Tue 9/21/21	Sat 10/9/21
45	.c.1.10.12	Erection of Column and Beam	5 days	Tue 9/21/21	Sat 9/25/21
46	.c.1.10.13	Grouting of Column and Beam	9 days	Wed 9/22/21	Fri 10/1/21
47	.c.1.10.14	Placing of Precast Slab Panels	9 days	Thu 9/23/21	Sat 10/2/21

	WBS	Task Name	Duration	Start	Finish	September		
						9/6	10/18	11
GANTT CHART	46	c.1.10.13	Grouting of Column and Beam	9 days	Wed 9/22/21	Fri 10/1/21		
	47	c.1.10.14	Placing of Precast Slab Panels	9 days	Thu 9/23/21	Sat 10/2/21		
	48	c.1.10.15	Grouting of Slab joint	9 days	Fri 9/24/21	Mon 10/4/21		
	49	c.1.10.16	Electrical conduits fixing / Plumbing sleeves fixing	10 days	Mon 9/27/21	Thu 10/7/21		
	50	c.1.10.17	Reinforcement Laying and Formwork Erection	10 days	Wed 9/29/21	Sat 10/9/21		
	51	c.1.10.18	Concreting	9 days	Thu 9/30/21	Sat 10/9/21		
	52	1.A.c.1.11	4 4th floor roof slab	16 days	Tue 9/21/21	Fri 10/8/21		
	53	c.1.11.12	Erection of Column and Beam	5 days	Tue 9/21/21	Sat 9/25/21		
	54	c.1.11.13	Grouting of Column and Beam	9 days	Wed 9/22/21	Fri 10/1/21		
	55	c.1.11.14	Placing of Precast Slab Panels	9 days	Thu 9/23/21	Sat 10/2/21		
	56	c.1.11.15	Grouting of Slab joint	9 days	Fri 9/24/21	Mon 10/4/21		
	57	c.1.11.16	Electrical conduits fixing / Plumbing sleeves fixing	10 days	Mon 9/27/21	Thu 10/7/21		
	58	c.1.11.17	Reinforcement Laying and Formwork Erection	10 days	Tue 9/28/21	Fri 10/8/21		
	59	c.1.11.18	Concreting	9 days	Wed 9/29/21	Fri 10/8/21		
	60	1.A.c.1.11.24	4 5th floor roof slab	16 days	Tue 9/21/21	Fri 10/8/21		
	67	A.c.1.11.24.1	Concreting	9 days	Tue 9/21/21	Thu 9/30/21		
	66	A.c.1.11.24.2	Reinforcement Laying and Formwork Erection	10 days	Tue 9/21/21	Fri 10/1/21		
	65	A.c.1.11.24.3	Electrical conduits fixing / Plumbing sleeves fixing	10 days	Tue 9/21/21	Fri 10/1/21		
	64	A.c.1.11.24.4	Grouting of Slab joint	9 days	Tue 9/21/21	Thu 9/30/21		
	63	A.c.1.11.24.5	Placing of Precast Slab Panels	9 days	Tue 9/21/21	Thu 9/30/21		
	62	A.c.1.11.24.6	Grouting of Column and Beam	9 days	Tue 9/21/21	Thu 9/30/21		
	61	A.c.1.11.24.7	Erection of Column and Beam	5 days	Tue 9/21/21	Sat 9/25/21		
	68	1.A.c.1.12	4 Stair Head room roof slab & OHT	12 days	Tue 9/21/21	Mon 10/4/21		
	69	c.1.12.18	Marking & Starters	5 days	Tue 9/21/21	Sat 9/25/21		

	WBS	Task Name	Duration	Start	Finish	September		
						9/6	10/18	11
GANTT CHART	70	c.1.12.19	Erection of Columns and Slab	5 days	Wed 9/22/21	Mon 9/27/21		
	71	c.1.12.21	Slab Reinforcement laying	7 days	Tue 9/21/21	Tue 9/28/21		
	72	c.1.12.22	Electrical conduits fixing	2 days	Wed 9/22/21	Thu 9/23/21		
	73	c.1.12.23	Concreting	2 days	Thu 9/23/21	Fri 9/24/21		
	74	c.1.12.26	Base Slab Reinforcement	5 days	Tue 9/21/21	Sat 9/25/21		
	75	c.1.12.27	Base Slab Concrete	2 days	Mon 9/27/21	Tue 9/28/21		
	76	c.1.12.28	Walls panels placing	5 days	Wed 9/29/21	Mon 10/4/21		
	77	c.1.12.30	Walls concreting	2 days	Tue 9/21/21	Wed 9/22/21		
	78	c.1.12.32	Cover slab reinforcement	4 days	Tue 9/21/21	Fri 9/24/21		
	79	c.1.12.33	Cover slab concrete	2 days	Sat 9/25/21	Mon 9/27/21		
	80	c.1.12.34	4 Lift machine room	11 days	Tue 9/21/21	Sat 10/2/21		
	81	.1.12.34.7	Marking & Starters	2 days	Sat 9/25/21	Mon 9/27/21		
	82	.1.12.34.8	Placing Columns	4 days	Mon 9/27/21	Thu 9/30/21		
	83	.1.12.34.10	Slab Reinforcement laying	7 days	Tue 9/21/21	Tue 9/28/21		
	84	.1.12.34.11	Electrical conduits fixing	2 days	Wed 9/29/21	Thu 9/30/21		
	85	.1.12.34.12	Concreting	2 days	Fri 10/1/21	Sat 10/2/21		
	86	1.A.c.2	4 Construction of Precast Floor	71 days	Tue 9/21/21	Sat 12/11/21		
	87	1.A.c.2.7	4 Ground floor Slab	20 days	Fri 11/19/21	Sat 12/11/21		
	88	A.c.2.7.5	Placing of precast slab panels	15 days	Fri 11/19/21	Mon 12/6/21		
	89	A.c.2.7.6	Grouting Slab joints	10 days	Thu 11/25/21	Mon 12/6/21		
	90	A.c.2.7.7	Reinforcement laying and formwork	10 days	Sat 11/27/21	Wed 12/8/21		
	91	A.c.2.7.8	Concreting	12 days	Mon 11/29/21	Sat 12/11/21		
	92	1.A.c.2.8	4 First floor Slab	40 days	Fri 10/15/21	Tue 11/30/21		
	93	A.c.2.8.5	Placing of precast slab panels	30 days	Fri 10/15/21	Thu 11/18/21		

	WBS	Task Name	Duration	Start	Finish	September		
						9/6	10/18	11/
94	A.c.2.8.6	Grouting Slab joints	25 days	Sat 10/23/21	Sat 11/20/21			
95	A.c.2.8.7	Reinforcement laying and formwork	25 days	Mon 10/25/21	Mon 11/22/21			
96	A.c.2.8.8	Concreting	30 days	Wed 10/27/21	Tue 11/30/21			
97	1.A.c.2.9	▀ Second floor Slab	40 days	Tue 9/21/21	Fri 11/5/21			
98	A.c.2.9.5	Placing of precast slab panels	30 days	Tue 9/21/21	Mon 10/25/21			
99	A.c.2.9.6	Grouting Slab joints	25 days	Wed 9/29/21	Wed 10/27/21			
100	A.c.2.9.7	Reinforcement laying and formwork	25 days	Thu 9/30/21	Thu 10/28/21			
101	A.c.2.9.8	Concreting	30 days	Sat 10/2/21	Fri 11/5/21			
102	1.A.c.2.10	▀ Third floor Slab	40 days	Tue 9/21/21	Fri 11/5/21			
103	A.c.2.10.5	Placing of precast slab panels	30 days	Tue 9/21/21	Mon 10/25/21			
104	A.c.2.10.6	Grouting Slab joints	25 days	Wed 9/29/21	Wed 10/27/21			
105	A.c.2.10.7	Reinforcement laying and formwork	25 days	Thu 9/30/21	Thu 10/28/21			
106	A.c.2.10.8	Concreting	30 days	Sat 10/2/21	Fri 11/5/21			
107	1.A.c.2.11	▀ Fourth floor Slab	40 days	Tue 9/21/21	Fri 11/5/21			
108	A.c.2.11.5	Placing of precast slab panels	30 days	Tue 9/21/21	Mon 10/25/21			
109	A.c.2.11.6	Grouting Slab joints	25 days	Wed 9/29/21	Wed 10/27/21			
110	A.c.2.11.7	Reinforcement laying and formwork	25 days	Thu 9/30/21	Thu 10/28/21			
111	A.c.2.11.8	Concreting	30 days	Sat 10/2/21	Fri 11/5/21			
112	1.A.c.2.12	▀ Fifth floor Slab	24 days	Sat 10/23/21	Fri 11/19/21			
113	A.c.2.12.6	Placing of precast slab panels	12 days	Sat 10/23/21	Fri 11/5/21			
114	A.c.2.12.7	Grouting Slab joints	10 days	Tue 11/2/21	Fri 11/12/21			
115	A.c.2.12.8	Reinforcement laying and formwork	10 days	Fri 11/5/21	Tue 11/16/21			
116	A.c.2.12.9	Concreting	12 days	Sat 11/6/21	Fri 11/19/21			
117	1.A.c.3	▀ Electrical conduiting & box fixing	79 days	Sat 10/9/21	Sat 1/8/22			

	WBS	Task Name	Duration	Start	Finish	September		
						9/6		
118	1.A.c.3.7	▀ Ground floor	30 days	Mon 12/6/21	Sat 1/8/22			
119	A.c.3.7.5	Plaster button marking	25 days	Mon 12/6/21	Mon 1/3/22			
120	A.c.3.7.6	Chasing, fixing conduits & electrical boxes in walls	20 days	Wed 12/8/21	Thu 12/30/21			
121	A.c.3.7.7	Fixing DB	20 days	Fri 12/10/21	Sat 1/1/22			
122	A.c.3.7.8	Mortar filling	25 days	Sat 12/11/21	Sat 1/8/22			
123	1.A.c.3.8	▀ First floor	35 days	Thu 11/4/21	Tue 12/14/21			
124	A.c.3.8.6	Plaster button marking	30 days	Thu 11/4/21	Wed 12/8/21			
125	A.c.3.8.7	Chasing & fixing conduits in walls	25 days	Sat 11/6/21	Sat 12/4/21			
126	A.c.3.8.8	Fixing electrical boxes	25 days	Tue 11/9/21	Tue 12/7/21			
127	A.c.3.8.9	Fixing DB	30 days	Wed 11/10/21	Tue 12/14/21			
128	A.c.3.8.10	Mortar filling	25 days	Wed 11/10/21	Wed 12/8/21			
129	1.A.c.3.9	▀ Second floor	35 days	Mon 10/11/21	Fri 11/19/21			
130	A.c.3.9.6	Plaster button marking	30 days	Mon 10/11/21	Sat 11/13/21			
131	A.c.3.9.7	Chasing & fixing conduits in walls	25 days	Wed 10/13/21	Wed 11/10/21			
132	A.c.3.9.8	Fixing electrical boxes	25 days	Fri 10/15/21	Fri 11/12/21			
133	A.c.3.9.9	Fixing DB	25 days	Sat 10/16/21	Sat 11/13/21			
134	A.c.3.9.10	Mortar filling	30 days	Sat 10/16/21	Fri 11/19/21			
135	1.A.c.3.10	▀ Third floor	35 days	Mon 10/11/21	Fri 11/19/21			
136	A.c.3.10.6	Plaster button marking	30 days	Mon 10/11/21	Sat 11/13/21			
137	A.c.3.10.7	Chasing & fixing conduits in walls	25 days	Wed 10/13/21	Wed 11/10/21			
138	A.c.3.10.8	Fixing electrical boxes	25 days	Fri 10/15/21	Fri 11/12/21			
139	A.c.3.10.9	Fixing DB	25 days	Sat 10/16/21	Sat 11/13/21			
140	A.c.3.10.10	Mortar filling	30 days	Sat 10/16/21	Fri 11/19/21			
141	1.A.c.3.11	▀ Fourth floor	35 days	Sat 10/9/21	Thu 11/18/21			

						September	
						9/6	10
	WBS	Task Name	Duration	Start	Finish		
GANTT CHART	142	A.c.3.11.6	Plaster button marking	30 days	Sat 10/9/21	Fri 11/12/21	
	143	A.c.3.11.7	Chasing & fixing conduits in walls	25 days	Tue 10/12/21	Tue 11/9/21	
	144	A.c.3.11.8	Fixing electrical boxes	25 days	Thu 10/14/21	Thu 11/11/21	
	145	A.c.3.11.9	Fixing DB	25 days	Fri 10/15/21	Fri 11/12/21	
	146	.c.3.11.10	Mortar filling	30 days	Fri 10/15/21	Thu 11/18/21	
	147	1.A.c.3.12	▸ LMR & SHR	16 days	Sat 11/13/21	Wed 12/1/21	
	148	A.c.3.12.4	Plaster button marking	12 days	Sat 11/13/21	Fri 11/26/21	
	149	A.c.3.12.5	Chasing, fixing conduits & electrical boxes in walls	10 days	Tue 11/16/21	Fri 11/26/21	
	150	A.c.3.12.6	Mortar filling	12 days	Thu 11/18/21	Wed 12/1/21	
	151	1.A.c.4	▸ Plastering/Gyproc Putty	79 days	Sat 10/16/21	Sat 1/15/22	
	152	1.A.c.4.8	▸ Ground floor	30 days	Mon 12/13/21	Sat 1/15/22	
	153	A.c.4.8.3	Ceiling plastering	20 days	Mon 12/13/21	Tue 1/4/22	
	154	A.c.4.8.4	Wall plastering	27 days	Thu 12/16/21	Sat 1/15/22	
	155	1.A.c.4.9	▸ First floor	40 days	Mon 11/15/21	Thu 12/30/21	
	156	A.c.4.9.3	Ceiling plastering	30 days	Mon 11/15/21	Sat 12/18/21	
	157	A.c.4.9.4	Wall plastering	37 days	Thu 11/18/21	Thu 12/30/21	
	158	1.A.c.4.10	▸ Second floor	40 days	Thu 10/21/21	Mon 12/6/21	
	159	A.c.4.10.3	Ceiling plastering	30 days	Thu 10/21/21	Wed 11/24/21	
	160	A.c.4.10.4	Wall plastering	37 days	Mon 10/25/21	Mon 12/6/21	
	161	1.A.c.4.11	▸ Third floor	40 days	Thu 10/21/21	Mon 12/6/21	
GANTT CHART	162	A.c.4.11.3	Ceiling plastering	30 days	Thu 10/21/21	Wed 11/24/21	
	163	A.c.4.11.4	Wall plastering	37 days	Mon 10/25/21	Mon 12/6/21	
	164	1.A.c.4.12	▸ Fourth floor	40 days	Wed 10/20/21	Sat 12/4/21	
	165	A.c.4.12.3	Ceiling plastering	30 days	Wed 10/20/21	Tue 11/23/21	
	166	A.c.4.12.4	Wall plastering	37 days	Sat 10/23/21	Sat 12/4/21	
	167	1.A.c.4.13	▸ Staircase head room & Lift machine room	31 days	Sat 11/20/21	Sat 12/25/21	
	168	A.c.4.13.5	Ceiling plastering	15 days	Sat 11/20/21	Tue 12/7/21	
	169	A.c.4.13.6	Wall plastering	20 days	Wed 11/24/21	Thu 12/16/21	
	170	A.c.4.13.7	outer plastering	15 days	Sat 11/27/21	Tue 12/14/21	
	171	A.c.4.13.8	Parapet inner wall plastering	25 days	Sat 11/27/21	Sat 12/25/21	
	172	1.A.c.4.14	▸ External Plastering	50 days	Sat 10/16/21	Mon 12/13/21	
	173	A.c.4.14.5	East side outer plastering	30 days	Sat 10/16/21	Fri 11/19/21	
	174	A.c.4.14.6	South side outer plastering	30 days	Mon 10/25/21	Sat 11/27/21	
	175	A.c.4.14.7	West side outer wall plastering	30 days	Tue 11/2/21	Mon 12/6/21	
	176	A.c.4.14.8	North side outer plastering	30 days	Tue 11/9/21	Mon 12/13/21	
	177	1.A.c.5	▸ Terrace water proofing	15 days	Mon 12/6/21	Wed 12/22/21	
	178	1.A.c.5.3	▸ OHT water proofing	15 days	Mon 12/6/21	Wed 12/22/21	
	179	A.c.5.3.5	1st coat water proofing	9 days	Mon 12/6/21	Wed 12/15/21	
	180	A.c.5.3.6	2nd coat water proofing	9 days	Wed 12/8/21	Fri 12/17/21	
	181	A.c.5.3.7	water proofing cement plastering	12 days	Thu 12/9/21	Wed 12/22/21	
	182	A.c.5.3.8	Water ponding test	8 days	Sat 12/11/21	Mon 12/20/21	
GANTT CHART	183	1.A.c.7	▸ Tile laying	95 days	Wed 11/3/21	Mon 2/21/22	
	184	1.A.c.7.7	▸ 1st floor	40 days	Wed 11/3/21	Sat 12/18/21	
	185	A.c.7.7.5	Wall Tiles	38 days	Wed 11/3/21	Thu 12/16/21	
	186	A.c.7.7.6	Laying floor tiles	35 days	Thu 11/4/21	Tue 12/14/21	
	187	A.c.7.7.7	laying Skirting tiles	35 days	Fri 11/5/21	Wed 12/15/21	
	188	A.c.7.7.8	Pop laying	37 days	Sat 11/6/21	Sat 12/18/21	
	189	1.A.c.7.8	▸ 2nd floor	35 days	Mon 11/15/21	Fri 12/24/21	

GANIT CHART	190	A.c.7.8.5	wall Tiles	35 days	Mon 11/15/21	Fri 12/24/21
	191	A.c.7.8.6	Laying floor tiles	30 days	Tue 11/16/21	Mon 12/20/21
	192	A.c.7.8.7	laying Skirting tiles	25 days	Thu 11/18/21	Thu 12/16/21
	193	A.c.7.8.8	Pop laying	30 days	Fri 11/19/21	Thu 12/23/21
	194	1.A.c.7.9	▸ 3rd floor	35 days	Sat 11/27/21	Thu 1/6/22
	195	A.c.7.9.5	Wall Tiles	35 days	Sat 11/27/21	Thu 1/6/22
	196	A.c.7.9.6	Laying floor tiles	30 days	Mon 11/29/21	Sat 1/1/22
	197	A.c.7.9.7	laying Skirting tiles	25 days	Wed 12/1/21	Wed 12/29/21
	198	A.c.7.9.8	Pop laying	30 days	Thu 12/2/21	Wed 1/5/22
	199	1.A.c.7.10	▸ 4th floor	40 days	Thu 1/6/22	Mon 2/21/22
	200	A.c.7.10.5	Wall Tiles	35 days	Thu 1/6/22	Tue 2/15/22
	201	A.c.7.10.6	Laying floor tiles	30 days	Sat 1/8/22	Fri 2/11/22
	202	A.c.7.10.7	laying Skirting tiles	25 days	Tue 1/11/22	Tue 2/8/22
	203	A.c.7.10.8	Pop laying	35 days	Wed 1/12/22	Mon 2/21/22
	204	1.A.c.7.11	▸ Lobby area & Staircase area Granite laying	41 days	Sat 12/25/21	Thu 2/10/22
	205	A.c.7.11.6	Ground floor	10 days	Mon 1/31/22	Thu 2/10/22
	206	A.c.7.11.7	1st floor	15 days	Sat 12/25/21	Tue 1/11/22
	207	A.c.7.11.8	2nd floor	15 days	Mon 1/3/22	Wed 1/19/22
	208	A.c.7.11.9	3rd floor	10 days	Tue 1/11/22	Fri 1/21/22
	209	A.c.7.11.10	4th floor	10 days	Wed 1/19/22	Sat 1/29/22
GANIT CHART	210	1.A.c.8	▸ Electrical wire Pulling	90 days	Thu 11/18/21	Wed 3/2/22
	211	1.A.c.8.7	Ground floor	25 days	Thu 1/20/22	Thu 2/17/22
	212	1.A.c.8.8	1st floor	25 days	Thu 11/18/21	Thu 12/16/21
	213	1.A.c.8.9	2nd floor	25 days	Wed 12/1/21	Wed 12/29/21
	214	1.A.c.8.10	3rd floor	25 days	Tue 12/14/21	Tue 1/11/22
	215	1.A.c.8.11	4th floor	30 days	Thu 1/27/22	Wed 3/2/22
	216	1.A.c.8.12	Terrace floor	15 days	Fri 1/14/22	Mon 1/31/22
	217	1.A.c.9	▸ Electrical switch plate, fixtures fixing	91 days	Wed 11/24/21	Wed 3/9/22
	218	1.A.c.9.7	Ground floor	30 days	Sat 1/29/22	Fri 3/4/22
	219	1.A.c.9.8	1st floor	30 days	Wed 11/24/21	Tue 12/28/21
	220	1.A.c.9.9	2nd floor	30 days	Tue 12/7/21	Mon 1/10/22
	221	1.A.c.9.10	3rd floor	30 days	Mon 12/20/21	Sat 1/22/22
	222	1.A.c.9.11	4th floor	30 days	Thu 2/3/22	Wed 3/9/22
	223	1.A.c.9.12	Terrace floor	25 days	Thu 1/20/22	Thu 2/17/22
	224	1.A.c.11	▸ External works	123 days	Thu 3/17/22	Sat 8/6/22
	225	1.A.c.11.2	▸ Electrical	123 days	Thu 3/17/22	Sat 8/6/22
	226	A.c.11.2.9	Cabling in Shafts	75 days	Thu 3/17/22	Sat 6/11/22
	227	A.c.11.2.10	Panels & Meter Boards erection	75 days	Sat 3/19/22	Tue 6/14/22
	228	A.c.11.2.11	External lighting cabling	75 days	Tue 3/22/22	Thu 6/16/22
	229	A.c.11.2.12	Common area Light fixtures fixing	60 days	Thu 3/24/22	Wed 6/1/22
	230	A.c.11.2.13	Testing & Earthing	90 days	Thu 3/24/22	Wed 7/6/22
	231	A.c.11.2.14	Stilt Floor Flooring	90 days	Wed 3/23/22	Tue 7/5/22
	232	A.c.11.2.15	Elevation Work	30 days	Wed 4/27/22	Tue 5/31/22
	233	A.c.11.2.16	Yard Work, compound wall and pavior	90 days	Mon 4/25/22	Sat 8/6/22

Fig 4.12 Time comparison between Precast and Conventional system

CHAPTER 5

CONCLUSION

5.1 CONCLUSION

- A sample analysis for a floor alone (small scale) is taken as a example in which precast structure is costlier than conventional, but Project labor and time are very much less than Conventional. Also, Precast is much economical than Conventional method when the project scale increases. Study says that In a large scale projects with high rise buildings, Precast is 20-25% economical than Conventional.
- From the analysis of the case studies conducted, it was found that the cost of construction of Precast structures was 14.5cr. whereas in case of Conventional building it was 17.1cr.
- Based on the above analysis, we can infer that a construction of Precast structure is quicker than a Conventional structure. Hence we can infer that **Precast Structures requires very less labor & Time saving building solution**
- As of now, **Precast method is the best solution for affordable mass housing in India.** To conclude that, Precast method of construction is an alternative and efficient solution for building construction techniques.
- **Therefore, this is the good solution for fast delivery of mass dwelling / housing and plays a vital role in reducing huge urban housing shortage in India.**

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