

Building Cost Comparison of Precast Concrete Construction with Conventional Construction

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ABSTRACT: In the present scenario construction industry replacing its method of implementing conventional methodology by various new innovations in the process of construction and selection of materials. This provides more systematic and mechanized system and this system is named as industrialised building system (IBS). This new method of construction can increase productivity and quality of work through the use of better construction machinery, equipment, materials, and extensive pre-project planning. This study is essential since there is no organised body, which can provide the necessary information on the building cost comparison between the conventional system and industrialised building system in construction industry when the site taken at Thanjavur, Tamilnadu. Purpose of the study is to compare the conventional method and precast concrete construction.

KEYWORDS: Precast concrete, mould cost, Erection cost, panelization, conventional method

I. INTRODUCTION

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. The forms used in a precast plant may be reused hundreds to thousands of times before they have to be replaced, which allow cost of formwork per unit to be lower than for site-cast production. There are many different types of precast concrete, forming systems for architectural applications, differing in size, function, and cost. Precast architectural panels are also used to clad all or part of building facade free-standing walls used for landscaping, soundproofing, and security walls, and some can be prestressed concrete structural elements. Storm water drainage, water and sewage pipes, and tunnels make use of precast concrete units. Issues related to precast concrete construction is classified into direct and indirect issues. Issues directly related to precast concrete are Elements, connections, systems, production, handling, assembling and demounting. Issues indirectly related to precast concrete materials, technology, structural analysis, building physics and equipment. A selective use of precast concrete within conventional building systems may have economic and managerial advantage even in the case of small and heterogeneous projects.

II. LITERATURE REVIEW

The paper "2000 Peurifoy Lecture: Construction Practices in Developing Countries" reviews some of the more significant differences in construction practices in developing countries and Five primary factors are discussed 1. Cost of labor 2. Cost of money. 3. Technology and methods 4. Infrastructure 5.Role of the design professional (**Randolph Thomas. H,2002**)

The article, "Documenting and Analysing Construction Failures", by **Yates K.J., et.al.**, provides description of the methods used for the research, results obtained from the industry survey, summary of the results of an

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investigation into case studies on construction failures, analysis of the results, discussion on construction failure investigative techniques, guidelines developed during the research project for investigating and documenting failures, recommended format for reporting the findings of failure investigations. Four stages are necessary to produce improvements and changes diagnosis/evaluation, changes implementation, control and standardization (**Javier Freire, et.al., 2002**).

III. DOCUMENTATION ON PRECAST CONCRETE CONSTRUCTION

Precast components are used in various applications and projects of all types. Key components include **Wall panels**, which can include an inner layer of insulation and be load- supporting if desired, **Spandrels**, which generally span between columns and are used with window systems in office buildings or in parking structures, **Double tees**, so named due to the two extending “stems” perpendicular to the flat horizontal deck. These tees are often used for parking structures and buildings where long open spans are desired, **Hollow-core slabs**, which are long panels in which voids run the length of the pieces, reducing weight while maintaining structural strength, **Columns and beams**, including columns and a variety of beam shapes, **Bridge components** for both substructure and superstructure designs, including girders in a variety of shapes, box beams, and deck panels and **Piers, piles, caps** and other sup- porting components for bridges.

Precast concrete components can begin to be erected shortly after foundations are ready and can be installed quickly, often cutting weeks or months from the schedule. This allows construction to get into the dry more quickly and enables interior trades to begin work earlier. The fast enclosure also decreases concerns for weather or material damage during erection, reducing the contractor’s risks and costs.



Figure 1: Panel-to-panel connections were designed to expedite construction of the University of Nebraska Duplex housing complex in Nebraska.

Architectural precast concrete panels can be sculpted to resemble a wide range of finish materials, including limestone and brick. This substitution ensures the building blends with nearby structures, whether contemporary or historic, or projects its own striking, cutting-edge appearance while meeting a tight budget. Precast concrete panels

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require caulking only every 15 to 20 years to maintain their reliability. This makes precast concrete easier to maintain than other façade materials. The panels' fewer locations for moisture possible with precast concrete can be included in the design. Efficiencies in component size, connections, delivery, and erection can be factored into the design, maximizing the benefits offered by precast concrete.

Outline of the study is to illustrate the process involved in the implication of precast concrete products in construction industry and to compare the same with conventional construction methods. It focuses the various issues related directly and indirectly. A building example has been taken and the activities are scheduled for constructing the building by both conventional and precast concrete construction. Various factors affecting the construction process is analyzed and addressed. The cost of the project is calculated and it is compared with conventional to locate the differences, advantages and disadvantages of precast concrete construction. Architectural precast concrete panels can be sculpted to resemble a wide range of finish materials, including limestone and brick. This substitution ensures the building blends with nearby structures, whether contemporary or historic, or projects its own striking, cutting-edge appearance while meeting a tight budget. Precast concrete panels require caulking only every 15 to 20 years to maintain their reliability. This makes precast concrete easier to maintain than other façade materials. The panels' fewer locations for moisture

IV. ANALYSIS OF PRECAST FRAMING COMPONENTS

After analyzing the various advantages and limitations of precast concrete construction the institutional building is taken and designed with precast concrete components. In order to compare the conventional construction methods with precast concrete construction the example taken is designed with both methodologies.

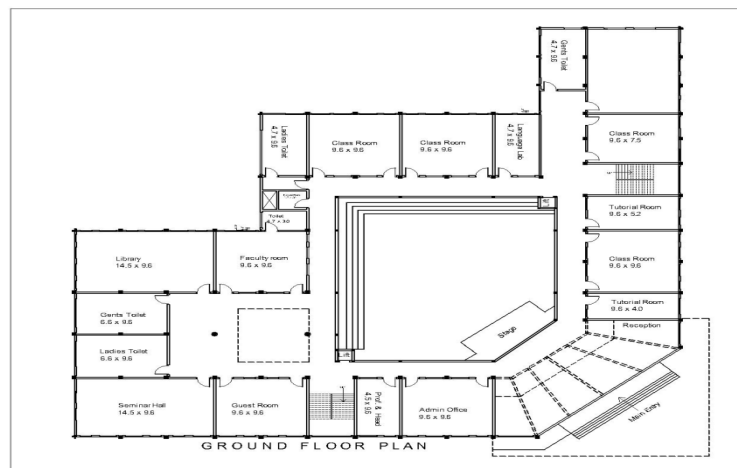
A building having seven storeys is taken and designed with precast concrete components.

Name of the project: School of Education,

Total built up area: 18800 sq.m

No. of Floors: G + 7

The multi – storey institutional building is situated in the campus of Periyar Maniammai University, which is designed to satisfy the function of School of Education. It planned with eight floors of area 2670 Sq.m. The buildings precast façade was chosen as a means of integrating this building with the surrounding neighbourhood. The ability to control colour and texture of the finish and the ability to break up the façade into smaller elements with rustication joints, allows the precast concrete to relate comfortably to both the 19th and 21st century buildings that surrounds it. The use of precast concrete provided the ability to create a prefabricated window anchor system throughout the building, which enabled the creation of multiple visual elements.



On lower floors, window boxes protrude from the façade, bringing the building to life for pedestrians. Elsewhere, the designers were able to achieve deep window recesses, especially on the lower portion of the building.

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This resulted in more – pronounced shadow lines, providing enhanced visual definition on the tower portion of the building. A strong pilaster expression, enhancing the vertical planes of the buildings, is also achieved through the use of precast concrete. Combined with the deeply recessed windows, the articulation of the pilaster forms provides a dimensional texture to the entire building.

It is often the case that, in the initial design stage, high degree of repetition appears possible. However, as the details are finalized, considerable discipline is required on the other part of the designer if the creation of a large number of non – repetitive units is to be avoided. Budgets costs used at the initial design stage should take into account the possibility that the number of different units are unavoidable, costs can be minimized if the units can be cast from a “master mold” with the simple modifications without the need for completely different molds. However, even relatively minor variations, such as dimensional change of a rail, block out location, connection hardware position, or a different number of block outs of any kind, are mold changes that increases costs. The precast concrete lends itself to the fluidity of the design. The precast concrete forms a delicate frame for the window walls and incorporate scale, dimension and shadow to the wall.

Elements such as the fabrication of molds, challenges to casting and finishing specific designs or shapes, relative material costs, handling methods at the plant and jobsite, approaches for connecting panels to a structure and establishing acceptable colour ranges are important to fully understand precast concrete and maximize its potential.

Reveals and rustications must be placed in a repetitive pattern in order to minimize modification throughout a mold’s life. Reveals, like all form features, must be designed with draft so the panel can be stripped from the mold without damaging the mold feature. Cost premiums are introduced to a project when panels cross –section becomes more complex or intricate surface features are added. Projecting cornices, bullnoses, form liners, bottom and/ or top returns and curves are the most typical features to be added. The exact sizes, shapes and locations are the designer’s options. Cost will be added if the location of these features within a mold will be changed frequently. On the other hand, these intricate features can be added at a minimal cost if they are used repetitively in the overall design. The point behind designing repetitive pieces is to amortize engineering and mold costs effectively. As many pieces as possible should be designed to be cast in the same mold and produced from a single shop drawing.

IV. RESULTS AND DISCUSSIONS

Mold cost depends on size, complexity and materials used. The mold material selected and number of molds depends on a project’s schedule. A project with a long precast concrete production period should permit fewer molds to be built. The architect can make significant contribution to economic production by designing precast concrete panels with knowledge of the master mold concept and by providing the precaster with sufficient production lead – time, making the duplication of molds to meet project schedule requirements unnecessary. When using the master mold, individual castings do not have to be the same color or texture. It is relatively easy to alter the panel size if the variations can be contained within the total master mold envelope. This strategy eliminates the need of the constructing a mold for every panel change. The use of bulkheads, blockouts or reveals placed on the top of the mold surface is less expensive than cutting into the mold surface for a projecting detail. When a large number of precast concrete units can be produced in each mold, the cost per square foot will be more economical. The master mold concept is illustrated in the table

S.NO.	NUMBER OF USES	PANEL SIZE (SQ.FT)	MOLD COST(Rs.)	MOLD COST PER SQ.FT.(Rs.)
1.	1	200	2,25000	1125
2.	10	200	2,25000	112.5
3.	20	200	2,25000	56.25
4.	30	200	2,25000	37.35

Table 1: Showing variation in the mold cost due to increase in number of uses.

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largest piece and then subdivided as needed to produce the other required sizes. Whenever possible, the largest pieces should be produced first to avoid casting on areas that have become worn and damaged by placing and fastening side form bulkheads. Although every project will have typical conditions, the most successful and cost effective projects maximise the repetition of elements. The more often a mold that careful planning is necessary to achieve good repetition without sacrificing design freedom.

PANEL SIZE AND PANELIZATION

Precast concrete pricing is determined primarily by the size of the pieces and repetition. Pricing is more dependent on large project. For example, a 100 – piece project of large panels can be less expensive per square foot (sq.m) than a 1000 – piece project using much smaller panels. The reason piece size is so important is because most labor functions performed by an architectural precaster and erector are required because of the existence of a piece. The more pieces the project has, the more labor hours it will take to engineer, cast, strip, finish, load, deliver and install the panels. Therefore, it is more economical to enclose a larger portion of the building’s exterior with fewer precast concrete panels.

For maximum economy, minimize the number of pieces b making them as large as possible within normal manufacturing and shipping limitations. Handling and erecting precast concrete components constitutes a significant portion of the total precast concrete expense. The cost difference in handling and erecting a large rather than a small unit is insignificant compared to the increased square footage of a large unit. To be economical, a project’s average piece size should be at least 100 to 150 Sq.Ft (9 to 14 sq.m) and ideally, larger than that.

S.NO	PANEL SIZE(Sq.Ft.)	ERECTION COST PER PIECE PER SQ.FT			
		500 (Rs.)	1000(Rs.)	1500(Rs.)	2000(Rs.)
1.	50	10.00	20.00	30.00	40.00
2.	100	5.00	10.00	15.00	20.00
3.	150	3.33	6.67	10.00	13.33
4.	200	2.50	5.00	7.50	10.00
5.	250	2.00	4.00	6.00	8.00
6.	300	1.67	3.33	5.00	6.67

Table 2: Showing the Erection cost with respect to Panel size.

There is no exact optimum panel size. Usually the optimum panel size is dictated by size and weight limitations imposed by transport, site access or crane capacity. The panel size is also a function of the design loads and support locations for connections. Close collaboration between the designer and a precaster is required during the early stages of a building’s design to determine the optimum panel size or panelization scheme. Piece sizes that require highway permits for over height, width, length or weight generally should be avoided. There is a balance between maximizing potential economy of the façade elements and maintaining the economy of the supporting structural system. The key is to recognize where localized loads will occur. Often the added cost of local reinforcing of the supporting structure that may be required to accommodate larger precast concrete panels will be more than offset by savings that result from erecting fewer panels.

In addition to providing cost savings during erection, larger panels secondary benefits by shortening a project’s schedule, reducing the joints to be sealed, and requiring fewer connections. Using fewer lineal feet of joint sealant translates directly into less probability of joint sealant failure, which could allow both air and moisture infiltration into the wall cavity. Thus, larger units are usually preferable unless they lack adequate repetition or incur significant cost premiums for transporting and erecting.

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TOTAL WALL ANALYSIS

The total cost of an architectural precast concrete wall may be lowered by taking full advantage of the precast concrete portion. In addition to acting as exterior walls, the precast concrete panels may perform other functions: may be loadbearing, wall – supporting, serve as formwork or shear walls or be used as grade beams; they may be insulated or may provide the interior finish; they may serve partly or fully as containers of mechanical/electrical services; or they may combine several of these functions to become a wall sub system. Precast concrete panels may also be cast compositely with other materials to provide an entirely different finished surface. Clay products and natural stones have all been used as veneer facing.

Solid wall panels use finish, shape, size and repetition as the major design and cost considerations. The high level of design flexibility possible with custom wall panels allows for a wide variety of architectural appearances. Window wall panels may be flat or heavily sculptured. They may contain a single opening or series of windows. They are either one storey height and made as wide as possible, or cast narrower to span vertically for two to three floors, except in high seismic areas where storey drift may control design. Window openings placed within the body of the panel provide closer tolerances for window installation than when the window is defined by edges of separate spandrels and mullions. The large panel size is disguised by the use of both horizontal and vertical reveals.

Spandrel panels are horizontal units that separate adjacent strips of glass. They may be cast flat, have returns at the top /bottom or be heavily sculpted. A designer will sometimes require that the structural frame of a building be expressed in the building’s façade. In such cases, the use of precast concrete spandrel elements made up either as a series of individual units or as one unit extending between columns with support located on the floor or on the columns with support located on the floor or on the column is an aesthetically appropriate solution. Emphasizing the linearity or horizontality of the design, white spandrel panels wrap the building at each floor interrupted at the middle by the four – storey entry. The graphs given illustrates the cost of material and labour used to construct the building taken as an example. From the graph comparison between conventional method and precast concrete method has been made.

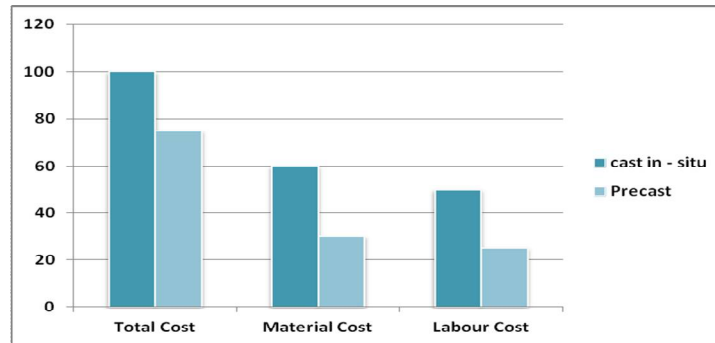


Figure 3: Labour and Material Cost Comparison

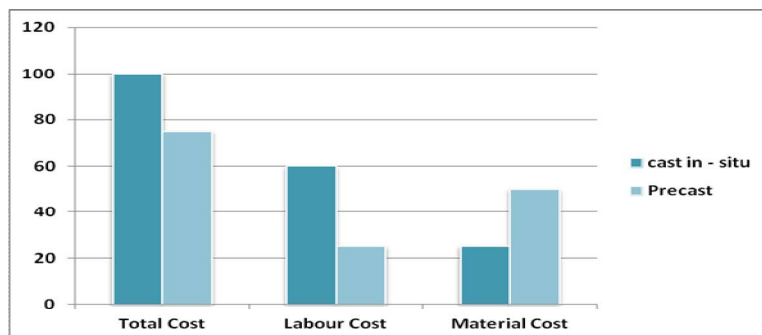


Figure 4: Cost Comparison of Internal Walls

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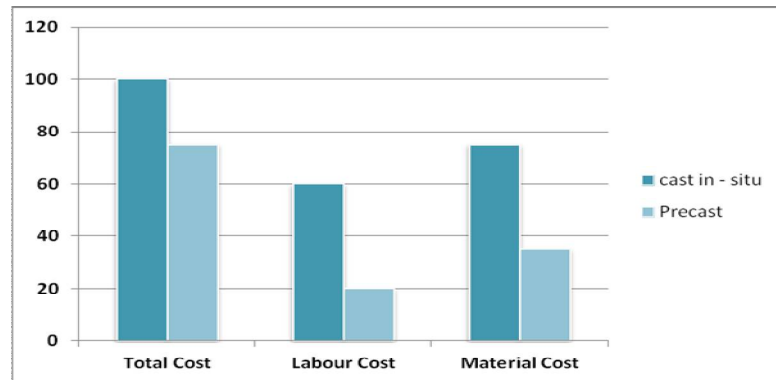


Figure 5: Cost Comparison of External Walls

In the above analysis clearly states that the direct cost required for precast construction is very less in case of cast – in – situ constructions. This can be achieved when the production unit is very near the site, repetitions of form of buildings indirectly demands to use the same mould again and again, which in turn reduces the cost of the building.

V. CONCLUSION

In case of cost overall cost required for constructing the building using precast concrete method is reduced by 20% when compared to conventional method. Economies are generated through reduced requirements for formwork, access scaffolding and less reliance on wet trades. Reduced on site - supervision by the main contractor is also a saving. Compared to cast in situ, the following savings can be expected 1. Formwork 75% less 2.Scaffolding 75% to 90% less 3. Wet concrete 90% less. Factory production ensures increased accuracy and quality of finish and decreases weather dependency. Compared with cast in situ structures, site labour is reduced by between 50% and 80% using precast. Work for following trades is reduced by between 30% and 50% depending upon finishes.

REFERENCES

- [1] Y.-S. Jeong a, C.M. Eastman a, R. Sacks b, I. Kaner b “Benchmark tests for BIM data exchanges of precast concrete”, *Journal of Automation in Construction* vol.18,pp.469–484, 2009.
- [2] VacharapoomBenjaoran a,NashwanDawood b, “Intelligence approach to production planning system for bespoke precast concrete products”, *Automation in Construction* vol.15,pp.737– 745,2006.
- [3] Rafael Sacks*, Charles M. Eastman, Ghang Lee, “Parametric 3D modeling in building construction with examples from precast concrete”, *Automation in Construction* vol.13,pp.291–312,2004.
- [4] Ian Holton a,b,*, Jacqui Glass b, Andrew D.F. Price b, “Managing for sustainability: findings from four company case studies in the UK precast concrete industry”, *Journal of Cleaner Production* vol.18, pp.152–160,2010.
- [5] N.N.Dawood , “Scheduling in the Precast Concrete Industry Using the Simulation Modelling Approach” , *Building and Environment*, Vol. 30, No. 2, pp. 197-207, 1995
- [6] NingGua,Kerry London b, “Understanding and facilitating BIM adoption in the AEC industry”, *Automation in Construction*,vol.19,pp. 988–999,2010.
- [7] Dr. Rafael Sacks Eng. Ronen Barak, “A Qualitative and Quantitative assessment of the Impact of 3D Modelling of Building Structures on Engineering Productivity”, *Submitted to Tekla Corporation Building and Construction Division Espoo, Finland December 2005*
- [8] Rafael Sacks, Charles M. Eastman, and Ghang Lee, “Information and process flow in models of precast concrete design and construction”, 3rd international conference on concurrent engineering in construction 1-2 July 2002 – University of California, Berkeley
- [9] Ghang Lee, Charles M. Eastman, and Rafael Sacks, “Eliciting Information for Product Modeling using Process Modeling”, under review.
- [10] Albert P. C. Chan; David Scott; and Ada P. L. Chan, “Factors Affecting the Success of a Construction Project”, *Journal of construction engineering and management*, ASCE , 2004
- [11] Martha VanGeem, P.E., “Achieving Sustainability with Precast Concrete”, *PCI Journal*.
- [12] Rafael Sacks, “Evaluation of Economic Impact of Three-Dimensional Modeling in Precast Concrete Engineering”, *Journal Of Computing In Civil Engineering* © Asce / October 2004.
- [13] The benefits of using precast concrete component for sustainable construction – Technical Note - LEED
- [14] David Ardit, M.ASCE; Ahmed Elhassan; and Y. CengizToklu, “Constructability Analysis in the Design Firm”, *Journal Of Construction Engineering And Management / March/April 2002*.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 5, May 2016

- [15] Sydney Freedman – Design factors influencing the aesthetics of architectural pre cast concrete – Technical Note
- [16] R. Soetanto, A.R.J. Dainty, J. Glass and A.D.F Structural frame selection processes: case studies of hybrid concrete construction projects Phillip s. Dunston, A.M.Asce, and Xiangyu Wang, “Mixed Reality-Based Visualization Interfaces for Architecture, Engineering, and Construction Industry”, Journal Of Construction Engineering And Management © ASCE / December 2005.
- [17] GulPolat, “Factors Affecting the Use of Precast Concrete Systems in the United States”, Journal Of Construction Engineering And Management © Asce / March 2008.
- [18] H. Randolph Thomas, M.ASCE, “2000 Peurifoy Lecture: Construction Practices in Developing Countries”, Journal Of Construction Engineering And Management / January/February 2002
- [19] Javier Freire and Luis F. Alarco’n, “Achieving Lean Design Process: Improvement Methodology”, Journal Of Construction Engineering And Management / May/June 2002.
- [20] Juan D. Manrique; Mohamed Al-Hussein; AviTelyas; and Geoff Funston “Constructing a Complex Precast Tilt-Up-Panel Structure Utilizing an Optimization Model, 3d cad, and animation”, journal of construction engineering and management © asce / March 2007.
- [21] LiyinShen, M.ASCE; Yuzhe Wu; and Xiaoling Zhang, Ph.D., “Key Assessment Indicators for the Sustainability of Infrastructure Projects”, Journal Of Construction Engineering And Management © Asce / June 2011
- [22] Leonhard E. Bernald, “Spatial Integration in Construction”, Journal Of Construction Engineering And Management / September/October 2002
- [23] Michael J. Mawdesley; Saad H. Al-jibouri; and Hongbo Yang, “Genetic Algorithms for Construction Site Layout in Project Planning”, Journal Of Construction Engineering And Management / September/October 2002
- [24] Robert F. Cox; Raja R. A. Issa, M.ASCE; and Dar Ahrens, “ Management’s Perception of Key Performance Indicators for Construction, Journal Of Construction Engineering And Management © Asce / March/April 2003
- [25] The Green Side of Precast Concrete By Andrew Zumwalt-Hathaway
- [26] PCI Journal – Technical Notes.