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An Introduction to Precast RCC Wall Panels

Pradeepa.S[1] Anitha J [1], Lalit Soni[2], Medha[3]
[1] *Assistant Professor, Dept. of Civil Engg, Sir M. Visvesvaraya Institute of Technology, Bangalore*
[2] *B.E., Dept. of Civil Engg, Sir M. Visvesvaraya Institute of Technology, Bangalore*
[3] *Under Graduate Students, Dept. of Civil Engg, Sir M. Visvesvaraya Institute of Technology, Bangalore*
Email: pradeepasai1980@gmail.com[1], lalitsoni1993@gmail.com[2]

Abstract- Sustainability is a global concern and hence the goal of human kind should be to create a sustainable world. In order to achieve sustainability, methods that are to be employed are effective utilization of currently available resources for a prolonged period of time, minimization of wastage of material, energy and controlling overuse, and ensuring that there are reserves kept for future generations without complete exhaustion. This paper projects a report on the results of an investigation of utilization of precast RCC Wall Panels in construction and how it is done. It must be assured that it is an easy, stable, economic, fast and a solution to environmental imbalance caused due to excessive use of materials and energy.
Thus, we aim to conclude that by using Precast RCC Wall Panel in construction rather than conventional construction methods, we can achieve an easy, fast and cheap method of construction.

Index Terms- Precast RCC; wall panels; reinforcement; compressive strength.

1. INTODUCTION

FACTORY WALL PANELS is shaped and structured to make full use of its profile to provide greater stability and to facilitate services and modifications like electrical, plumbing, etc. even after the panels are fixed, modification made can be repaired with cement-sand mortar. These are easy to erect and shift machineries can be used along with local labor force. With slight modifications, the panels can be used for permanent formwork for concreting. Sustainable type of construction as volume of material consumed is minimal. Cement, sand and aggregate are essential needs for any construction industry. Sand is a major material used for preparation of mortar and concrete and plays a most important role in mix design. In general consumption of natural sand is high, due to the large use of concrete and mortar. The developing country like India facing shortage of good quality natural sand and particularly in India, natural sand deposits are being used up and causing serious threat to environment as well as the society. The facts like in India is almost same in others countries also. Therefore, the need to find an alternative to river sand in construction works has assumed greater importance now-a days.
Contractors have long recognized that conventional in situ construction in large cities has resulted in excessive labor cost and delay due to time lost in transporting workers to and from the project site, transport materials, equipment, tools etc. through congested vehicular traffic. Due to extremely high development of the land area, there is very restricted space for storage of materials and maneuvering of equipment. Intense activity at the construction site results in untidiness, dust, noise, air pollution, traffic congestion, other inconveniences and constant nuisance to the people living nearby buildings.
In the case of precast concrete construction, prefabrication of structural and architectural concrete products is performed at more accessible sites away from the crowded centers. Wall panels, beams, columns, slabs, stairways, architectural facades and other components are fabricated under controlled conditions in areas with adequate operational and storage space. Precast components are formed with high strength, durable steel and high quality concrete in steel or fiber glass moulds, which provide for extensive repetitive and economic reuse.

2. INTRODUCTION TO PRECAST RCC WALL PANELS

Precast RCC factory wall panel is a ready to use product. The wall panels are designed such that they are economical for construction, easy for transportation and placing. These walls do not require laying of foundation for installation as they are already casted with required base for self-standing.
These walls are provided with required base with the respect to the SBC of the soil. Hence these walls are self- standing. These are completely non-load bearing walls which are designed to take only wind loads. These walls do not require plastering as they are casted with better finish. These walls are joined with a mesh band which is poured with mortar. These walls are eco-friendly as they are manufactured using artificial sand and the reduction of noise pollution. These walls can be casted for the required number of walls in the given amount of time.

The structural details of wall panel: Length - 2.44m, Thickness – 0.1m, Height – 2.92m, Base width – 0.4m.

Fig. 1. Precast RCC Wall Panels

3. LITERATURE REVIEW

A study had been carried on ICW-25 (Internal Cavity Wall) Precast Concrete-Non-load bearing partition wall construction by Mr. Kartik Janakram. ICW-25 is a sustainable technology of manufacturing precast concrete wall that combines greater stiffness matrix with a rib profile, enhancing the structural stability. A thickness of 25mm was achieved due to the configuration which prevents bending along the width. These are LIGHT in weight with a unique TWIN cavity wall panel fixed back to back with a 50mm air gap, facilitating services to be added after erecting of panels in one direction. ICW-25 panels improve the quality of work and reduce load on the structure. Its lower thickness results reduction in raw material. It is more durable and affordable.

An analytical Study on connection design of precast load bearing wall by A. Surekha, J.D. Chaitanya Kumar and E. Arunakanthi says lateral load on a multi-storey building is most critical one to consider for the design. In order to observe the seismic effect and wind effect on multi-story building, a study on precast load bearing wall of G+11 has been carried out. Four different seismic zones and all wind zones are considered for analysis using ETABS. The structural response due to lateral loads with load combination is extracted. Effect of lateral load on out-of-plane moments, axial forces, shear force, base shear, maximum storey drift and tensile forces on shear wall are plotted. Finally, the effect of seismic zone and wind zone is tabulated.

A paper on Low Cost Housing is been published by Rinku Taur and Vidya Devi (TCE Consulting Engineers Ltd, New Delhi). This paper aims to point out the various aspects of prefabricated building methodologies for low cost housing by highlighting the different prefabrication techniques, and the economic advantages achieved by its adoption. The major current methods of construction systems considered here are namely, structural block walls, mortar less block walls, prefabricated roofing components like precast RC planks, precast hollow concrete panels, precast concrete/Ferro cement panels are considered.

4. MATERIALS

Ordinary Portland cement of grade 53, meeting the requirements of IS 12269: 1987 (reaffirmed 1999) was used in this research. Aggregates, which account for 60 to 75 percent of the total volume of concrete, are divided into several distinct categories, and are either coarse or fine.

M-sand is used as fine aggregate in this research. The dust is selected from the nearest source as raw materials without any processing of the dust from the quarry. The quarry dust is the by product which is formed in the processing of the granite stones which broken downs into the coarse aggregates of different sizes.

Ordinary granite broken stone aggregates of size 16mm, 12mm and 8mm are used in panel. The aggregate serves as reinforcement to add strength to the overall composite material, concrete. Coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. Primary, or 'virgin', aggregates are either Land- or Marine-Won. Gravel is a coarse marine won aggregate; land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

MasterGlenium- 8233 is used as an admixture in manufacture of these wall panels. MasterGlenium 8233 is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. MasterGlenium 8233 is free of chloride & low alkali. It is compatible with all types of cements.

8mm and 6mm diameter steel are used as reinforcement, using regular binding wire. TMT 500D is a high strength ribbed TMT bar, used for the reinforcement of concrete. The superior strength of this rebar is 500 MPa and 'D' represents its high

ductility, thereby explaining the specific nomenclature. Consistency of strength is ensured across the entire length of the rebar as the level of impurities like Sulphur and Phosphorous are maintained below 0.075% in the composition. TATA Tiscon 500 D adheres to the most updated standards (last revision 2012) set by Bureau of Indian Standards (BIS)

5. BASIC MATERIAL TESTING

Basic tests on materials is performed and results are tabulated as below

5.1 *Test on cement*

Table-1 Properties of Cement

Properties	Cement
Specific Gravity (SSD)	3.10
Normal Consistency	31.00 %
Initial Setting Time	110 min

5.2 *Test on M-Sand and Coarse Aggregate*

Table- 2 properties of M-Sand and Coarse Aggregate

Properties	M- Sand	Coarse Aggregate
Specific Gravity (SSD)	2.6	2.65
Absorption (%)	2.67%	1.98%
Bulk density (loose)	1.3892	1.370
Bulk density (compacted)	1.7248	1.479

6. CONCRETE MIX DESIGN AND REINFORCEMENT DETAILS

In the present study, M53 grade with nominal mix as per IS 456-2000 was used. The concrete mix proportion (cement: fine aggregate: coarse aggregate) is 1: 1.8: 2.925 by volume and a water cement ratio of 0.42 is taken. Mass of admixture added is 1.90 Kg/m^3.

6.1. Mix Proportions for One cum of Concrete (SSD Condition) –

Mix proportions is designed for a Target Mean Strength of 38.25 N/mm^2 and characteristic strength of 30 N/mm^2 @ 28 days.

Table-3 Mix proportions for 1m^3 of concrete

Mass of Cement in kg/m3	400
Mass of Water in kg/m3	160
Mass of Fine Aggregate in kg/m3	720
Mass of Coarse Aggregate in kg/m3	1170
Mass of Admixture in kg/m3	1.90
Water Cement Ratio	0.42

6.2. *Reinforcement Details*

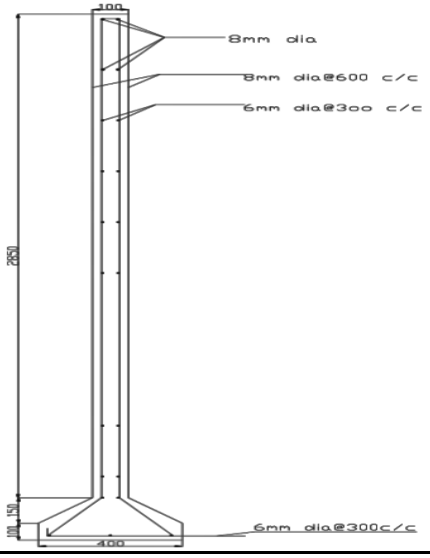

Fig. 2- Cross-section of Wall Panel

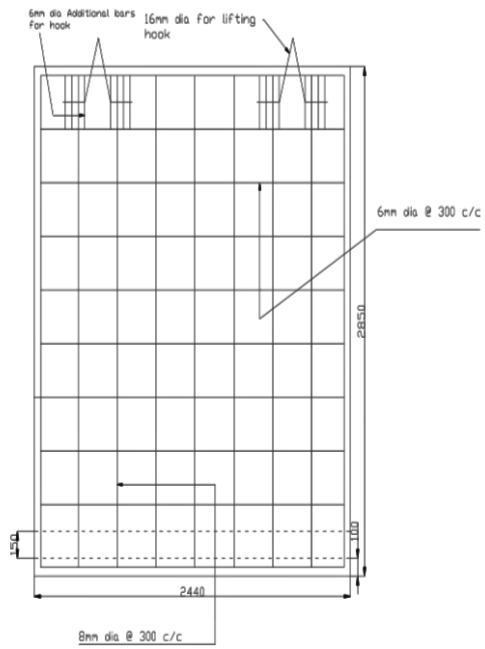

Fig. 3- Arrangement of Rebars in Wall Panel (Plan)

7. TEST ON CONCRETE

7.1. *Compressive Strength Test*

Testing of hardened concrete place on important role in controlling and confirming the quality of cement concrete work. One of the important properties of the hardened concrete is its strength which represent the ability of concrete to resist forces. If the nature of the forces is to produce compression, the strength is termed compressive strength. The compressive strength of the hardened concrete is generally considered to be the most important property and is

often taken as an index of overall quantity of the concrete which is defined as the load which causes a failure of specimen, per unit area of crass section in uneasily compression under given rate of loading. Testing cubes are prepared as per specifications and kept for curing for 3,7 and 14 days. Test is performed in compression testing machine as per specifications mentioned in IS code.

Table-4 Compressive strength of Concrete

Specimen No.	No. of days cured	Load on cubes (tons)	Strength (N/mm^2)
1	3	53	23.108
2	7	68	29.65
3	14	80	34.88

Where cube strength is calculated as-
Cube strength = avg. strength / Area of crass section

7.2. Slump Test

Unsupported concrete when it is fresh will flow to the sides and a sinking in height will takes place. This vertical settlement is known as slump. Slump is a measure indicating the consistency or workability of cement concrete it gives an idea of water content needed for concrete to be used for different works. A concrete is said to be workable if it can be easily mixed and easily placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation occurs when coarse aggregate tries to separate out from the finer material and contraction of coarse aggregate at one place occurs. This result in large voids, less durability and less strength. Bleeding occurs when the excess waters comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable. Slump increases with increase in W/ C ratio.

To perform the test the mix components are calculated. Mix the dry constituents thoroughly to get a uniform color and the add water. Test is performed as per IS specifications and results are tabulated.

Table-5 Slump value for concrete mix

Water-Cement Ratio	Slump (mm)
0.42	290

8. FABRICATION AND INSATLLATION

8.1. Fabrication

8.1.1 *Bar Bending*

The rebar's are bent to required shape and length. The rebar size, spacing and lap length are checked in accordance with the drawings. Rebar's, cast in-terms, corrugated sieve pipes, recesses, lifting hooks and inserts must be correctly positioned and properly secured. Use of fabrication rig can help to ensure the accuracy of rebar's fixing and spacing. Where needed, tack welding may be carried out to secure these items. Sufficient numbers of spaces with the correct sizes should be properly placed and secured to achieve the required concrete cover during casting. For precast pre-stressed concrete element, such as planks, the strand hauling should only be carried out when the form release agent has dried to a certain degree that will not contaminate the strands. Check and verify that all details completely with drawings

8.1.2 *Concrete Mixing*

Check the concrete grade used in according to design specification. Conduct slump test in compliance with IS standards to assess the workability of concrete mix before placing the concrete to the mould. Mechanical mixer is used for mixing of concrete. Mix ratio 2:5:7 is used. While mixing 300 ml of admixture (master glenium-8233) is used per 50 kg of cement.

8.1.3 *Molding*

Mould details and connections ISMB 200, ISMC 200, 60×6 mm flat, 5mm sheet (mesh sheet) are the materials used for the mould. Different sections of the mould are fixed by using bolt connections. It should be checked that the joints and edges of the mould, bolts are properly secured. Dimensions of the mould are within the specified tolerances. The mould used in the process should be clean and free from the debris and old mortars using remover or scaling bars. Engine oil or mould release agent should be applied evenly over the mould surfaces. The type of mould is decided as per the cost or finance available.

Molding process Rebar's cast in-items, lifting hooks must be correctly positioned and properly secured. Welding is carried out to secure items, wherever needed. Sufficient number of spacers with the correct sizes should be properly placed and secured to achieve the required concrete cover during casting. Prepared concrete mix is poured on the mould, the drop height of concrete mix should not exceed more than 1 meter. Proper vibration is done using vibrator of 3000rpm, 150hp, needle tip vibrator. The top surface excess concrete is troweled off. Finishing is done using roller.

8.1.4 *Demolding and* Curing

During demolding the concrete strength must be higher to overcome the suction and frictional forces during demolding. Crane is used for demolding, because of the weight. The mould is placed in such a way that the wall panel rests on the ground. Loosen and remove all bolts and end side mould forms. Mould is now lifted using crane, a small hammering will ensure release of mould from panel due to vacuum release.

Adequate curing time and desired environment is determined. Wall panels are covered with wet mats and cured for 3 days. After 3 days of curing, wall panel will be shifted to storage place.

8.2. Transportation

Wall panels are subjected to inspection before transporting. Required markings and numberings are made to avoid confusion at site. 6 wheeled truck will have a limit of 10 tones load on it, so four panels are mounted on it which will be 8.8 tones. The walls are placed in horizontal direction on truck with a suitable packing material between them for protection against jumps and jerks from truck. Loading of panels on truck will be made using crane.

8.3. Installation

Earth excavation of 1 feet deep and 600mm wide is made. A 100mm thick PCC bed is laid. Wall panel is unloaded from the transport vehicle using crane. Wall is placed on the PCC bed, with a gap of 2 inches or other suitable dimension between walls depending on the building plan. Panel alignment is checked, and fine adjustments can be made. The rebar left from the bottom of the wall is welded with 8mm rebar throughout length. Fill the foundation void using the remaining earth work. The gap between panels is filled with mortar and also can be covered with a mesh and then filled with mortar.

9. STABILITY CHECK

The stability of wall panel on different types of soil can be found by using self-weight of wall panel, base area and SBC of particular soil. The values given below for safe bearing capacity for different types of soils are according to National Building Code of India (SP 7)

10. COST ANALYSIS

Volume of 1 Wall – (2.44 X 2.82 X 0.1) + 2 (0.5 X 0.08 X 0.15) + (0.4 X 0.1X 2.44) = 0.815m^3
Considering the volume of material calculated above approximate cost of materials for 1 wall is Rs.5777.

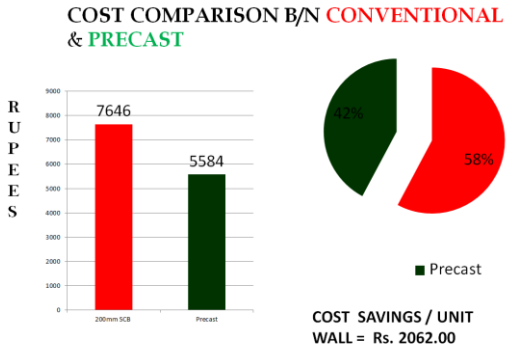

Fig. 4- Cost comparison between conventional & precast

For cost analysis purpose a case study is carried on. Estimated cost is calculated for a factory building constructions by conventional methods (using bricks and C.C. blocks) and compared with panel construction method as listed below in Table-5.

Table-6 Coat comparison for construction

Type of construction	Cost of construction (in INR)
Conventional construction using Bricks	1,583,150.00
Conventional construction using C.C Blocks	1,400,750.00
Panel Construction	1,000,130.00

11. TIME ANALYSIS

The average time required for various activities is noted and tabulated below for one wall fabrication.

Table-7 Time required for fabrication, shifting and placing of one wall

Work	Time Required
Bar Bending	2 hours
Molding	1 hours
Demolding	20 min
Curing	3 days
Loading at factory	20 min.
Transport to site	Depends on site location
Unloading	15 min.
Placing	10 min.

12. CONCLUSION

The study done on the construction done using RCC wall panels gave an excellent outcome on major construction worries like reduction of time in construction, paved an idea towards the reusable concrete structures, the replacement of natural sand by M sand, extensive reduction in labor which is a major concern these days. The following study notably established the following;

- The replacement of natural sand by M sand made the reduction in the sand cost by 70% which makes the wall panels more economical in the present scenario of sand shortage.
- The time analysis conducted showed that construction using wall panels is faster than conventional construction by 56% which is remarkable as the productivity becomes twice.
- The panels are more stable than the usual brick walls as the joint are reduced enormously.
- The joints between the walls are made by mortar strips so which can be removed and the wall panels can be reused. This shows that the concrete structures can be reused as steel structures.
- The cost analysis on a simple factory construction project showed that wall panel construction reduces the cost almost by 30 to 35%.

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(A.1)

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