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Study On Precast Concrete Wall Panels: Quality, Strength, Speed, & Sustainability

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ABSTRACT

Now a days the cost of construction, quality and speed of construction play vibrant role in installation of structure.The precast concrete members are the solution of construction of structure due to economic advantages in the speed of construction. The connections between panels are tremendously important since they affect both the speed of the assembly and the overall reliability of the structure.Precast concrete wall panels have many advantages over cast insitu members, including reliable quality, speed of erection, and high strength of concrete. In recent time, precast technique is adopted to remediate this problem such as speed, quality and cost. In this paper, the study is carried out on precast concrete wall panel which area sustainable building option, offering durability, reduced moisture and air infiltration, energy efficiency, recycled content, recyclability, light weight, and low maintenance. The connection between panels are very important since they provide the monolithical behaviour of the structure.

Keyword: Precast Concrete, Economic, Strength, Durability, Monolithical, Energy Efficient.

I.INTRODUCTION

What is precast concrete?

Precast concrete is a structural product which is formed by casting the concrete in a mould and can be preserved in controlled environment, placed to the construction site and raised& subjected into place.

Precast concrete section is alternative of cast in-place structure. The cast in-place concrete has commonly used, where its basic materials are simply available anywhere around the country. But for the total cost efficiency, construction speed, high quality of work, for light weight structure and environment friendly projects, the precast hollow concrete component are alternative solution for engineer. For infrastructural development the precast concrete industry is mainly conquered by Government initiated projects. However, these are also being broadly used for residential (low and high rise) and viable constructions because of their various favorable features. The efficiency, durability, ease, cost effectiveness, and ecological properties of these products have brought an innovative shift in the time consumed in construction of any structure.

Construction industry is a vast energy consuming industry, and precast concrete products are and will continue to be more energy efficient than its Counter-parts. The extensive range of designs, colors and structural options that these products provide is also making it a favorable choice for its consumers.

The conventional concrete is strong but high in self-weight. This factor affects the ease of Construction which will lengthen the construction period. More construction workers are needed to accelerate the progress of the construction work. Due to increase of workers, the cost will also Increase. The traditional labour-exhaustive practices which includes the three problems; namely, filthy, difficult and hazardous have always been associated with the construction industry. The construction industry agonises from low productivity, safety and quality control due to this condition. The Materials used for precast concrete structures are given as concrete, structural steel & bolts, steel reinforcement, and Non cementitious material (rubbers & mastics are used for soft bearings pads, Elastomeric bearings for Neoprene, backing strips etc.). Many different types of precast concrete forming systems are differing in size, purpose, and cost can be used for architectural purpose.

Figure 1: Precast wall panel and Installation of precast concrete wall panel

II. PRINCIPLES OF PRECAST CONCRETE WALL PANEL

The world is witnessing a revolution in construction put into practise along with a new stage of development powered by the rapid economic growth and the high rate of urbanization. The direct means for the development, expansion, improvement and maintenance of urban settlements are provided by Construction.

i) Cast in-situ walls

ii) Tilt-up panels

iii) Low cost insulated walls for residential construction

In all over the world, pre-fabricated structural elements in building construction is a growing trend in construction industry for the development and construction. The building industries using the precast concrete panel due to their economical advantages, superior thermal and structural efficiency. At the same time it will contribute to green building by producing a cleaner and well-ordered environment at project site, controlled quality, and a lower total construction time and cost (Salihuddin and Ramli M., 2008).

Figure 2 Precast wall casting. **Figure 3 precast wall transport at sit**

III.MATERIALS USED FOR PRECAST CONCRETE CONSTRUCTION

3.1 Concrete

Concrete is often the material chosen for outside walls on commercial buildings due to its high structural honour and low maintenance requirements. Unlike other building materials, concrete developments most of its strength in the first 30 days but continues to increase strength over the life of a building. Since structures have an affinity to vitiate over time, rather than improve, concrete is an interesting variance. The hydration process is the motive behind its non-traditional of advanced years. Hydration continues and complexes in cement get elongate; as the compounds lengthen, they interlink and create a stronger unit.

Precast concrete structure is of the utmost probable quality both in terms of strength and durability. Concrete is cast into clean steel moulds, for the production of standard elements such as columns and beams. The use of fastened vibrators tuned to the correct oscillation's for the size and weight of the filled mould make sure correct compaction to a density of around 2400kg/m3(excluding reinforcement). The resulting surface finish, results in minimum porosity for maximum durability.

Figure 4 Precast non-composite concrete wall panel.

3.2 Steel Reinforcement

Steel offers high tension and shear strength to make up for what concrete deficiencies. Steel and concrete behaves similarly in changing environments that is it will shrink and expand with concrete, helping avoid cracking. Rebar is the most common form of concrete reinforcement. It is typically made from steel, with ribbing to bond with concrete as it cures. Rebar is versatile enough to be bent or assembled to support the shape of any concrete structure.

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Carbon steel is the most common rebar material. However, stainless steel, galvanized steel and epoxy coating can be used to prevent corrosion. High tensile hot rolled ribbed bar (HT rebar) is used in 95% of cases, even in shear links where mild steel would be suitable.

3.3 Structural Steel and Bolts

These include rolled rectangular & square hollow sections (RHS, SHS), solid billets, channels & angles, plates and welded tees, etc.

In many highly stressed support situations where direct contact between concrete surfaces is to be avoided Rolled steel sections & bent or flat steel plates are welded to form steel connectors are used. Hot dipped galvanized steel is used for exposed connections, such as dovetail channels for brick ties. High strength friction grip bolts are used in special circumstances where the integrity & safety of connections made with ordinary bolts in clearance holes.

3.4 Non Cementations Material

Connections where a quick gain in strength is required, e.g. up to $40N/mm^2$ in 2-3 hours, epoxy based mortars are used to make either partially or completely. The thermal expansion of epoxy materials is 7 times that of concrete.

Elastomeric bearings for Neoprene, rubbers & mastics are used for soft bearings pads, backing strips, etc.

IV. SUSTAINABILITY

Sustainable architecture is the practice of designing and constructing buildings that have a positive impact on their environments. A durable building contributes to sustainability because its long life means it will not need to be replaced as soon as less durable buildings. To increases a building's thermal performance so that the resources needed for heating or cooling are reduced, minimize the air and moisture infiltration into a structure ,also to reduces dangerous mold,. When a Material uses reprocessed content in its manufacture, requires less virgin raw materials, requires less fuel for transportation, and can be repurposed once its initial use is complete, the material decreases its environmental impact through the building's lifecycle.

In this section, we'll look at how precast, non-composite concrete panels provide sustainability benefits in all of these aspects.

V.SPEED OF INSTALLATION: QUICK ASSEMBLY

Precast composite wall panels subsidise to speed of installation in several ways. Panels can be cast at the factory while site work is underway.

Precast concrete walls can be erected in a fraction of the time needed for masonry or cast-in-place walls once delivered to the job site. Up to 250 feet of wall panels can be erected in one day. Erecting the building structure more quickly allows interior jobs to begin work earlier and provides a strong work platform for construction on higher levels.

Quick delivery and erection not only saves time, but also adds to customers' financial success.

Figure 5 Installationof precast wall

Figure 6 erection of precast wall

VI.PREVIOUS RESEARCH ON CONCRETE WALL PANEL

Lian (1999), Study the decisive limit behaviour of reinforced concretesandwich panels under axial and eccentric loads, 4 specimens were cast, tested and approved out a test program. The panels were1.5m long, 0.75m wide and 40-50-40 mm construction, i.e. 40 mm thick concrete element with a 50mm thick insulating layer. The ultimate load carrying capacity for pure axial loaded panels was calculatedusing expressions for design of solid reinforced walls. It was reported that some of the expressionsapplicable to solid walls could not be directly applied to the precast wall panel. However, it may benoted that the slenderness ratio (H/t) is an important factor manipulating the load bearing capacity ofaxial loaded panels, and the number of the tested panels was also small, no generalized inferencescould be drawn.

Oberlender (1973) with slenderness ratios (H/t_w) varying from 8 to 28, aspect ratios (H/L) from 1 to 3.5 and thicknesses equal to 75 mm with hinged top and bottom ends under consistently distributed axial and eccentric loadings, tested on 54 wall panels. The eccentricity was applied at 1/6 of the wall thickness. The reinforcement was ready in double layers in proportion and separately placed within the wall thickness. Vertical reinforcement ratios (ρv) were more than the minimum requirements and varied between 0.0033 and 0.0047. Mpa The yield strength of steel varied from 512.8 to 604.2 MPa and the compressive strength of cylinder of concrete was between 28 and 42. The following conclusions were reached:

a) Panels with H/t_w values less than 20 failed by crushing while those with larger values of H/t_wfailed due to buckling, under axial and eccentric loading. The lateral deflections at the instant of failure did not increase intensely for H/t_w values less than 20, while a theatrical increase was observed for values more than 20.

b) The fall in strength due to an eccentricity of $t_w/6$ of the wall thickness varied from 18 percent to 50 percent for variation in slenderness ratios from 8 to 28 respectively.

Heng (1998), An experimental study was conducted , in which 6 precast concrete sandwich panel were subjected to different loadings to cause pure axial compression, pure flexure combined with axial compression.

Only one panel was however tested under pure axial load. The test indicated that the panel tended to split near the edges prior to the failure. This could be due to the lack of any stiffener near the edge of the panel. However, the limited data available from this study does not allow to draw any general conclusions.

The alternative method for secretarial for the percent composite action, presented by Benayoune et. al. (2008) and Salmon et. al. (1997) was established by taking the ratio of the experimental behaviour with respect to the fully composite behaviour. The experimental to compound ratio permits for the maximum applied moment to be increased and the panel designed for fully composite behaviour.

Benayoune et. al. (2008) tested a series of small scale, two wythe panels under one way and two ways bending reinforced with a wire truss shear transfer mechanism and polystyrene foam. The type of polystyrene foam was not specified. The moment of inertia was compared experimentally to the fully composite uncracked moment of inertia resulting in percent composite actions ranging from 70% to 90% by doubling the shear transfer reinforcement ratio.

Table 1 gives a summary of experimental tests carried out and an overview of the work undertaken by various researchers on wall. Also plotted the experimental results for various reinforced concrete walls (with an eccentricity of $t_w/6$) along with ACI318-99 and AS3600-01 wall equation predictions (Jeung-Hwan Doh, 2002).

Research	Number of test	Concrete Strength (MPa)	Slenderness ratio (H/t_w)	Aspect ratio (H/L)	Steel ratio (ρ_v)	Eccen-tricity (e)
Seddon (1956)	N/A	17.5 to 28	18 to 54	1.5	0.008 single 0.004 double	0 to $t_w/3$
Leabu (1959)	Theoretical analysis	-	-	-	-	-
Oberlender (1973)	54	28 to 42	8 to 28	1 to 3.5	0.0033 single 0.0047 double	$t_w/6$
Pillai and Parthasarathy (1977)	18	16 to 31.5	16 to 31.5	5 to 30	0.0015 or 0.003	$t_w/6$
Kripanarayanan (1977)	Theoretical analysis	28	0 to 32	0 to 0.66	-	$t_w/6$
Zielinski et al. (1977)	5	33 to 37.5	72	2.25	N/A	0, $t_w/6$
Saheb and Desayi (1982, 1983)	24	20.2 to 25.17	12 to 27	0.67 to 2.0	0.00173 to 0.00856	$t_w/6$
Sanjayan (1998)	4	58.5 to 60.5	40	1.33	0.0094 to 0.0122	$t_w/2$
Waddick and Swifte (1991)	3	41.1 to 43.2	80	2	0.00245	0
Fragomeni et. al (1995)	20	36 to 60.7	12 to 25	2 to 5	0.0025 to 0.0031	$t_w/6$
Butler (1998)	8	48.5 to 75.2	30	1	0.00266 to 0.002894	$t_w/6$

VII.APPLICATION OF PRECAST CONCRETE

- Lightweight blocks for high-rise buildings.
- Panels and partition walls of various dimensions either pre-cast or poured in place.
- All types of insulation works, including cavity walls.
- Roofing and ceiling panels.
- Soundproofing applications.
- Pre-cast industrial and domestic building panels, both internal and external.
- Precast/in-place exterior wall frontages for all sizes of buildings.
- Foundations for roads and sidewalks.
- Subsurface for sports arenas, e.g., tennis courts are made easily by precast panel.
- Void filling and infill sections between beams of suspended floors.
- Aircraft arresting beds.

- Crash barriers.
- Explosion-resistant structures.
- Highway sound barriers.
- Floating barges, jetties, walkways, fish cages and floating homes.
- Slope protection.

VIII. CONCLUDING REMARKS

In this project it is shown that the building and other structure can build economically and with speed by the uses of precast concrete components. The efficiency of labour can be achieved through the factory controlled mass production techniques and good quality of material.

The precast concrete hollow wall and slab panels can be jointed vertically and horizontally to form a building frame which behave as completely monolithic. The monolithic action makes it of good strength, stiffness and durable to resist seismic loading. Precast concrete component are successful in both high and low rise building.

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