Experimental Studies on Portal Frames made with Palm oil Shell Light Weight Fiber Reinforced Concrete

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Abstract. This present research mainly focused on the behaviour of monolithically and precast portal frames made with lightweight fiber reinforced concrete. The lightweight fiber reinforced concrete (LWFRC) is achieved with Palm oil shells (POS) and glass fibers (G.F). The POS is replaced with coarse aggregates and the G.F is added to the concrete to increase ductility parameters. To reduce the further density of the concrete, replaced cement with GGBS and Palm Oil Fuel Ash (POFA) individually. All these replacements are helping the reduction of solid waste and greenhouse gases from cement Industries. Portal frames are made with M30 Grade LWFRC through replacements. All the precast frames are connected with the Dowel bar connection through the grouting. All the LWFRC frames are compared with conventional concrete frames. The palm oil shells are replaced up to 50% in coarse aggregates to diminish the density of the concrete and also to decrease the greenhouse gases from the cement industry; cement is replacing with Ground Granulated Blast Furnace Slag (GGBS) and Palm Oil Fuel Ash (POFA).

Keywords: Portal Frames, Precast, Grouting, POS, GGBS, Dowel bar connection, and POFA, Light Weight Concrete, Fiber Reinforced Concrete, Glass Fibers.

1. Introduction

To satisfy up the gigantic need for the need for moderate lodging units, the structure business in India is quickly moving towards assembling techniques for development. By and large, lightweight development is viewed as positive because of the investment funds in development materials. Fewer material methods less 'encapsulated energy' in the structure. The 'operational energy' is lower and hence a generally bigger measure of exemplified energy is needed to redress or even to level out. The fact of the matter is fairly more nuanced than the hypothesis. In some cases, lightweight development is more energy-effective than heavyweight development. The energy effectiveness of a structure in the utilization stage relies upon numerous variables, atmosphere, general climate, area and direction, the capacity of the structure, and limit use to give some examples of boundaries. Also, the absolute operational energy of a structure comprises just 30% of the energy utilized for warming and cooling. Just this part is affected by the (warm) mass of the structure. Energy-saving because heavier structures can along these lines never sum to more than this 30%. The Design aspects of the precast connections should satisfy the Standardisation, simplicity, tensile capacity, and ductility.

In non-industrial nations where plentiful horticultural and mechanical squanders are released, these squanders can be utilized as likely material or substitution material in the development industry [¹]. This solid is made with OPS as coarse total OPS concrete. Is likewise lightweight cement. The blending plan for OPS concrete has brought about cement with adequate qualities as determined for underlying lightweight cement and has given adequate usefulness with superplasticizers [²]. The sodden relieved examples invigorate higher compressive than dry-restored tests of cement with certain
admixtures \cite{3}. Oil palm shell (OPS) is the hard endocarp that encompasses the palm bit. It is light and normally estimated that it is appropriate as total in lightweight cement. Operations concrete can be utilized as lightweight concrete \cite{4}. Like other biodegradable materials, OPS is probably going to rot under an overwhelming climate except if additive treatment is done on the OPS aggregate \cite{5}. The association detail created and recommended in this examination which has versatile joint and steel plate connector fulfilled the prerequisite endorsed in the ACI primary rule and accordingly was confirmed to give astounding seismic execution. So flexible joint with blasted get together with steel plate type association can be recommended for the plan of precast solid structures in the seismic area \cite{6}. The precast examples had lower stacking limits and energy dispersals. Along these lines, computing the flexural strength without considering the ideal impact of the pillar shell and the little breadth high-strength steel bars in the pressure zone appears reasonable \cite{7}.

The primary explanation is the commitment of the stirrups to the opposition of the association, which isn't adequately taken into account \cite{8}. To increment the flexibility of the disappointment system and guarantee the satisfactory control of the break opening at the intermittence segment. Also, the elective proposition of holding associations for precast solid structures will be the subject of ensuing studies \cite{9}. In light of the exploratory discoveries and further assessments, amending the important prerequisites in plan codes, for example, greatest dividing of pillar cross over the fortification, embracing extra vertical ties, and the unbonded length way to deal with opposing early clasp and crack of flexural rebars is proposed \cite{10}. The bar segment association utilized is imaginative contribution a reasonable speed in execution just as little expenses. The conduct of such association is explicit to semi-unbending connections \cite{11}, avoidances, it is reasoned that the sort of precast associations embraced in the investigation is more malleable when contrasted with solid associations, precast associations can be utilized as the substitution of solid connections \cite{12}. The precast particular floorboards made with OPS concrete have commonly performed greater at a later age than at an early age. They can be, hence, utilized for private lodging at palm oil ranches or even country regions where the transportation cost of customary coarse totals is high \cite{13}.

2. Material Properties and Mix Design

2.1. Conventional Concrete: Ordinary Portland cement confirming to IS:12269 (with specific gravity 3.15), fine aggregates (Specific Gravity -2.66, Zone -II), Coarse aggregates (Specific Gravity -2.63), and portable water were used for controlled Reinforced Portland cement concrete (RPCC) test specimens.

2.2. Light Weight Concrete: was obtained by mixing different combinations of cement, GGBS (Specific Gravity -2.98), POFA (Specific Gravity -2.2), Fine aggregates, Coarse aggregates, and palm oil shells (POS- 2.2 Specific Gravity). SNFC based Superplasticizer is used for all the mixes. Other than conventional materials are shown in fig:1.

2.3. Mix Proportions: For this M - 30-grade concrete is designed with aggregates replacement with POS and cement is substituted GGBS and POFA with up to 50%. All the mechanical properties of the above two mentioned concretes are calculated for 12- mix ids. The mix Ids with different percentages of replacements are presented in the table. 1.

| MIX ID | Percentage | Proportions (C: GGBS/POFA: C. A: POS: F.A) |
|--------|------------|------------------------------------------|
| N1     | Conventional Mix | 1.0:3.52:0:2.03                         |
| N2     | Conventional + G F | 1.0:3.52:0:2.03                         |
| G1     | 10% POS + 10% GGBs | 1.0:0.11:2.84:0.14:1:82                |
| G2     | 20% POS + 20% GGBs | 1.0:25:2.83:0.31:2:04                  |
| G3     | 30% POS + 30% GGBs | 1.0:43:2.83:0.53:2:33                  |
| G4     | 40% POS + 40% GGBs | 1.0:67:2.82:0.83:2:71                  |
| G5     | 50% POS + 50% GGBs | 1:1:2.82:1.24:3:25                     |
3. Experimental Investigation
To know the behavior of portal frames the following frames are considered. (i) Monolithic portal frames and (ii) Precast Portal frames. The two frames are cast for both conventional and Lightweight concrete. After preliminary investigations, the frames are cast only 20% replacements for lightweight concrete. To know the behavior of portal frames, both conventional concrete and Lightweight fiber reinforced concrete frames (monolithic and precast) are cast with a 1.0 m bay distance and the 150 mm x 150 mm cross-section. The portal frames are tested in the loading frame of the capacity of 200Tones. The frames are tested under two-point loading and the deflections are recorded for the equal interval of loading at the middle of the beam. The detailed dimensions of the portal frames are shown in Fig:2. The portal frames are cast for the Mix Id’s N2, P2, G2. The precast frames are cast individual elements and joined with dowel bar connections. The beam rested on column corbels. The corbels are 150 mm x 150 mm in dimension. The dowel bar of 16 mm diameter is introduced with the corbel hole is 25 mm is considered. PVC pipes are placed in the corbel and beam groves. These pipes are removed after the hardening stage of frames, the beam and column are connected with dowel joints by grouting [15-17].

10 mm diameter longitudinal reinforcement bars are introduced for both and beams, columns, and corbel. For the shear reinforcement, 8 mm diameter bars are used. The beam reinforcement is bent into the column to proper load distribution. The design of frames are done as per the Indian standards. 4 - hooks are provided at different places of the frame (2 are in columns and 2 are in beams) for lifting purpose [18, 19]. The frames are tested for fixed end conditions. The detailed reinforcement for the portal frames is shown in Fig:3. The frames are cast and tested for 28 days of membrane curing. After the curing period, the frames are lifted with help of cranes and placed on the loading frame. After placing the frames on LF with the help of the chain pulleys frames are aligned for testing. The testing of portal frames is shown in Fig:4.
Grouting:
Fosroc Lokfix S is used for grouting, it is High strength Polyester Resin Anchor grout for vertically down application. Fosroc Lokfix S is rapid strength gain grout. Rapid strength gain (RSG) grout is used to join the beam and columns through the dowel bar connection. Before doing grout, the surface of the beam-column joint makes rough with sandpaper. RSG contains liquid and powder, both liquid and powder (1:1) will mix properly to make homogenous mortar. The columns are placed on LF and end conditions are fixed properly, by the support of the chain pulley the beam is placed on two corbels for proper alignment. The chain pulley is used as temporary support up to hardening the grout mortar. After grout mortar is prepared, the dowel bar is placed in the beam-column groove. After hardening the grout, the chain pulleys are released and tested under two-point loading.

Fig: 2. Portal Frames

Fig: 2.a. Monolithic Frame
Fig: 2.b. Precast Frame

Fig: 3. Portal Frames Reinforcement Details

Fig: 3.a. Monolithic Frame Reinforcement Details
Fig: 3.b. Precast Frame Reinforcement Details
Fig: 4. Portal Frames

4. Results and Discussion

4.1. Dry Density of Concrete: The dry density of Conventional concrete, Fiber-reinforced concrete, and lightweight fiber reinforced concrete calculated from the mix quantities are ranging from 2479 kg/m$^3$ to 2078 kg/m$^3$. The entire 3 – concretes with three mix designs are represented in Fig: 5. From figure: 5 it is observed that Fiber-reinforced concrete having a high density i.e., 2479 kg/m$^3$ and the P5 mix is shown the least density of 2078 kg/m$^3$. The dry density is reducing with increasing replacing percentage of POS in both GGBS and POFA replaced concretes.

Fig: 5. Dry Densities of all Mixes
4.2. **Mechanical Properties:** The strength characteristics of all 12 mixes are calculated as per the Indian standards and those are presented fig:6. In this compressive, split, bending strengths and modulus of elasticity (E) are calculated. The E values are shown in Gpa and reaming all 3 strengths are presented in Mpa.

![Mechanical Studies](image)

4.3. **Durability Studies:** The compressive strengths are calculated for different chemical attacks (H$_2$SO$_4$, MgSO$_4$, and NaCl) for different curing periods under the Compressive Testing Machine (CTM). The effect of all chemical attacks is explained in Figure:7, the X-Axis is representing the Mix Id and the Y-axis is Represented the Compressive strength of all 12 Mixes.

![Durability Studies](image)

4.4. **The behavior of Precast:** The load Vs Deflections of monolithic and portal frames are examined and represented in Fig:8, 9 respectively. In figures, the deflections are denoted on the horizontal and load in denoted on the vertical axis.
The behavior of all 6 frames almost similar to conventional frames. From the figures it is observed that the precast frame made with Mix Id – G2 shown the maximum deflection, 7.62 mm, and the monolithic frame made with Mix Id – N2 shown minimum deflection, 1.5 mm.
Fig: 9 Precast Frames Load Vs Deflection Curves

It is observed from the load Vs deflection curves, the precast frames made with LWFRC are showing 67% of load-carrying capacity in monolithic frames load-carrying capacity. Till the maximum deflection, all the LWFRC frames are shown stable and monolithic. After reaching load carrying capacity, the monolithic frames are shown cracks at the beam-column portion, and in precast frames the cracks at the corbel portion.

5. Conclusion
From all investigations is reasoned that the palm oil can be supplanted with the coarse totals to deliver the lightweight cement, yet 30% is the solitary ideal substitution. The point-by-point ends is given underneath.

- The Demould thickness of all blends has accomplished the thickness of the LWC.
- The Compressive strength up to 30% in GGBS substitution invigorated more than the 30 Mpa and however, in POFA substitution surrendered 30 Mpa to 20% substitution.
- The compressive strength is more for 20% substitution of POS contrast with the 10% substitution.
- In Acid Attack the thickness is diminishing and Sulfide and magnesium assaults expanding the thickness with relieving age and level of POS. Practically in all the substance assaults, the compressive strength of cement is less with contrasting with the typical water restoring.
- The precast LWFRC outlines are conveying 67% of the heap conveying limit of solid casings.
- Deflections, it is reasoned that the kind of precast associations embraced in the investigation is more malleable when contrasted with solid associations. precast associations can be utilized as a substitution for solid associations.

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