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EXPERIMENTAL STUDY ON GLASS FIBER REINFORCED GYPSUM (GFRG) PANELS FILLED WITH ALTERNATE CONCRETE MIX USING FLY ASH

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***Abstract*— There is a substantial growing demand for housing in India as the population increase rate is skyrocketing. More and more people are shifting from rural to urban areas day by day, making urban areas denser. The Ministry of Rural Development assessed that India's rustic housing lack remains at 44 million dwelling units. India's metropolitan housing lack has risen 54 percent to 29 million out of 2018 from 18.78 million of every 2012, of which 96% relates to Economically Weaker Section (EWS) and Low-Income Group (LIG) type, according to the gauge of the Ministry of Housing and Urban Poverty Alleviation.**

To address these difficulties, India requires innovative, energy-effective structure materials for a reliable, quick, and tough housing strategy for development at a moderate expense. It is likewise significant that housing structures are catastrophes impervious to secure individuals' lives and properties. Every one of these worries is engaged with a maintainable and comprehensive turn of events. One such strategy to accomplish that is by utilizing Glass Fiber Reinforced Gypsum (GFRG) panels. They serve the purpose of fast construction and be cost-efficient, earthquake-resistant, best suitable for the financially Indian backward class of people and in the country's earthquake-prone regions like Gujarat.

The phosphogypsum's effective disposal is achieved through the Glass Fiber Reinforced Gypsum (GFRG) panel, also known as Rapid wall. These can be used as load-bearing as well as non-load-bearing structures. To use GFRG in load-bearing buildings, M20grade concrete is used as a filling material to overcome the hurdles provided by gravity and other factors. M20 grade concrete is used in these panels to satisfy the minimum requirements mentioned in IS 456:2000.

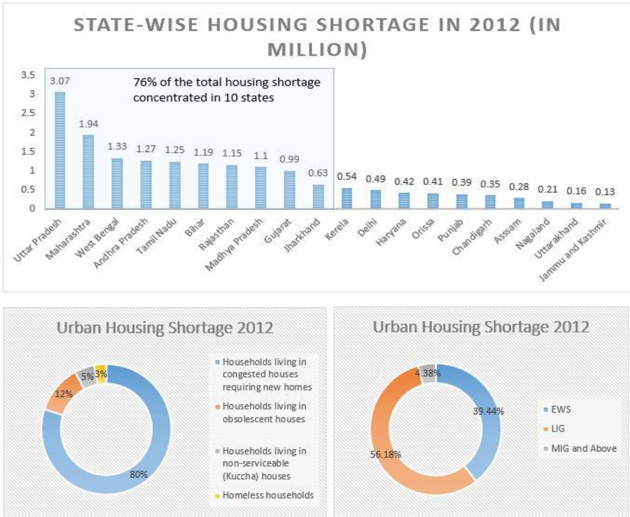

Fig 1. Housing Shortages in India

Keywords— **Glass Fibre Reinforced Gypsum (GFRG) panels, Concrete Mix, Fly ash aggregates (FAA), Fly ash Fine Aggregates (FAFA), Fly ash Coarse Aggregate (FACA), Fly ash Aggregate Concrete (FAAC), Compressive Strength, Split tensile strength, Flexural strength, Control concrete (CC)**

I. INTRODUCTION

Glass fiber reinforced gypsum (GFRG) panels or Rapid walls are among the most advanced building methods in today's era. It is developed by the GFRG Building System Australia for mass-scale development of houses in a limited capacity of time and money to meet the people's needs. GFRG panels are manufactured using calcined strengthened gypsum mortar, with glass strands that, when combined with fortified cement to an applicable extent, get sufficiently able to go about as a heap bearing

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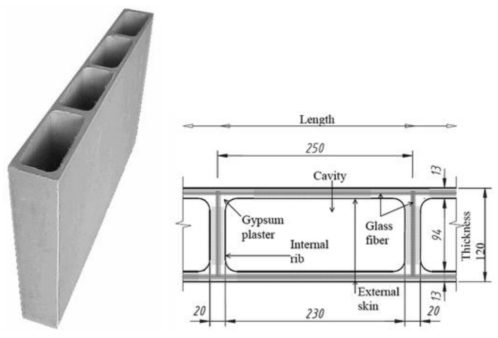
shear divider. GFRG boards can withstand the tremor up to 8 on the Richter scale. Rapid Wall Panel gives quicker development. The paper depicts the strategy for development utilizing Rapid wall panels dependent on the development manual arranged by IIT Madras to suit Indian circumstances. Certainty and RCF, two compost monsters under the open area, set up Rapid wall and mortar items fabricating plant at Ambalamugal utilizing Rapid wall advancements of Australia called FACT RCF Building items Ltd. (FRBL). More than 7 million ton of gypsum is available as produces as residue from factories. By setting up Rapid wall and Plaster items plant, they mean to create 1.4 million sqm or 15 million sq ft board each year and around 50000 tons of predominant quality wall mortar and wall clay, answering large numbers of the above issues and concern.

A concrete mix of ordinary Portland cement was used in the conventional method of preparing the filling material for the GFRG panels. Still, it is heavy in weight due to its high density ranging between 2200 to 2600 Kg/m3, which results in the increment of self-weight of the building. This creates a big problem. An alternate mix of concrete is to be prepared with desired low density by using fly ash to overcome this problem. This results in the reduction of the building's cost as the fly ash is a waste of the coal industry, and there is a need to reduce this waste as it will cause severe problems in the future. This leads to the development of lightweight concrete. Lightweight concrete is defined as a concrete that has been made lighter than the conventional concrete by changing the material composition or production methods. Lightweight aggregate concrete is the concrete produced by replacing the usual material aggregate with lightweight aggregates. Lightweight concrete cannot fulfill the demand of strength potential but serves to reduce and thus provide economic structures and enhanced seismic resistance, high sound absorption, and good fire resistance. Because of the above reasons, the study on fly ash aggregates concrete is conducted to increase the cost efficiency of a building using GFRG panels.



(a) GFRG panel **(b)** Cross-sectional details

Fig 2. GFRG Panels

II. Materials and Methods

To prepare the test specimens, the following materials were used.

i) 43 grade Ordinary Portland cement was used for the study as per IS:8112-19899.

ii) Fly ash wash collected Mettur Thermal power plant confirming IS: 3812-19811

iii) River sand belonging to IS Grading Zone II: 383-1970 was used in preparing the concrete as it is easily available nearby.

iv) "Fly ash Fine Aggregate (FAFA) obtained from cement fly ash ratios of 10:90, 12.5:87.5, 15:85, 17.5:82.5, 20:80 and 20:80 respectively." [2]

v) "Hard Broken Granite Stone (HBG) confirming the size of 20mm graded aggregate as per IS: 383-1970." [2]

vi) "Fly ash Coarse Aggregates (FACA) collected from cement fly ash of proportion 10:90,12.5:87.5,15:85,17.5:77.5,20:80 and 22.5:77.5." [2]

vii) Bore well water for mixing and curing specimens.

III. PROPERTIES OF AGGREGATES

Table 1. Physical properties of Conventional Fine Aggregate (CFA) and Fly ash fine aggregate (FAFA)

S. No	Properties	CFA	(FAFA)
1	Specific gravity	2.70	1.28
2	Bulk density (Kg/m^3)	1808	838
3	Size (mm)	Below 4.75	Below 4.75
4	Fineness modulus	2.68	2.70

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Table 2. Physical properties of Conventional Coarse Aggregate (CCA) and Fly ash Coarse Aggregate (FACA)

S. No	Properties	CCA	FACA
1	Shape	Angular	Spherical
2	Specific gravity	2.75	1.3
3	Bulk density (Kg/ m^3)	1685	913
4	Size (mm)	4.75mm to 20mm	4.75mm to 20mm
5	Crushing value (%)	24.94	25.6
6	Impact Value (%)	23.86	21.6

Table 3. Chemical Composition of Fly Ash (Class F)

Chemical Composition			
Constituent		World Std. %	Fly ash used in thesis work %
Silica	SiO_2	62.57	54.92
Alumina	$Al2O_3$	31.45	23.04
Ferric Oxide	$Fe2O_3$	1.87	-
Titanium Dioxide	TiO_2	1.45	-
Manganese Oxide	MnO	0.005	-
Calcium Oxide	CaO	0.40	3.84
Magnesium Oxide	MgO	0.38	2.82
Sodium Oxide	Na_2O	0.05	-
Potassium Oxide	K_2O	0.82	-
Iron	FE_2O	-	6.62
Phosphorus	P_2O_5	-	0.30
Alkalimetal's Oxide		-	2.70
Sulphur	SO_3	-	0.76
Magnesium	Mgo	-	2.82
Loss on Ignition	LOI	1.0	2.88

Table 4. Comparison of Workability of FAAC with Conventional Concrete

Type of Concrete	Workability Test			
	Slump (mm)	Workability	Compaction factor	Workability
Control concrete	40	Medium	0.91	High
Fly ash aggregate concrete	60	Medium	0.9	High

IV. EXPERIMENTAL PROCEDURE

A. The first stage of the experiment consists of formation of fly ash aggregate. The main constituents taken are cement, fly ash and water. Water acts as a binding agent.
B. Cement and fly ash are taken in the ratio 10:90, 12.5:87.5, 15:85, 17.5:82.5, 20:80 and 22.5:77.5
C. A mixture was prepared of cement and fly ash and mixed in a drum using the above ratios. Water was added with the water cement ratio of 0.3. This method of formation of fly ash aggregates is called palletization.

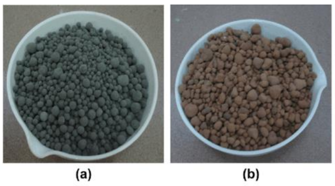

Fig 2. Fly ash Aggregates

D. Fly ash aggregates were removed from the mixer, dried for a day and then cured for 7 days in a water tank.
E. The aggregates were segregated after curing according to their size.

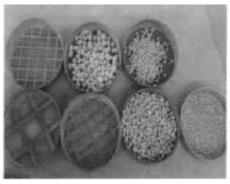

Fig 3. Segregation of fly ash aggregates

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F. A mix design for M20 grade concrete was prepared confirming suitable IS method taking the mix proportion of 1:1.53:2.68:0.5

G. For casting of test specimens, concrete cubes of different aggregates were tested including conventional fine aggregate (CFA) and conventional coarse aggregate (CCA) and using fly ash fine and fly ash coarse aggregates.

V. RESULTS AND DISCUSSION

A. Compression Test

"As per IS 516-1959, 15cm x 15cm x 15cm concrete cubes were tested. The test was performed on the compression measuring machine 120T. At a rate of approximately 140kg/cm2/min, the load was applied until the specimen failed. The maximum load applied to the specimen until failure was documented and shown in Table-5." [2]

Table 5. Compressive strength of fly ash aggregate concrete and control concrete with different ages of testing

Age of testing	Proportion Cement : Fly ash	Compressive Strength in N/mm^2
1 day	10 :90	2.62
	12.5:87.5	2.76
	15 :85	3.84
	17.5:82.5	2.57
	20 :80	2.21
	22.5:77.5	2.13
	Control concrete	3.33
3 days	10 :90	6.41
	12.5:87.5	6.55
	15 :85	9.43
	17.5:82.5	6.81
	20 :80	6.61
	22.5:77.5	6.28
	Control concrete	8.37
7 days	10 :90	11.62
	12.5:87.5	12.89
	15 :85	15.93
	17.5:82.5	13.10
	20 :80	12.90
	22.5:77.5	10.24
	Control concrete	14.34
14 days	10 :90	14.20
	12.5:87.5	15.60
	15 :85	20.24
	17.5:82.5	16.20
	20 :80	15.80
	22.5:77.5	12.60
	Control concrete	17.62
28 days	10 :90	16.30
	12.5:87.5	17.23
	15 :85	23.71
	17.5:82.5	17.90
	20 :80	17.20
	22.5:77.5	14.80
	Control concrete	20.80
56 days	10 :90	17.12
	12.5:87.5	18.26
	15 :85	25.35
	17.5:82.5	19.20
	20 :80	18.32
	22.5:77.5	16.19
	Control concrete	22.44
90 days	10 :90	19.10
	12.5:87.5	19.40
	15 :85	27.03

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	17.5:82.5	20.18
	20 :80	19.54
	22.5:77.5	18.64
	Control concrete	24.96

B. **Split Tension Test**

Dimensions of the concrete cylinders: Diameter: 15cm, Height: 30 cm
Concrete cylinders were tested confirming to IS 5816-1976.

Table 6. Split tensile strength of fly ash aggregate concrete and control concrete with different ages of testing

Age of testing	Proportion Cement : Fly ash	Splitting tensile Strength in N/mm^2
7 days	10:90	3.15
	12.5:87.5	3.45
	15:85	4.60
	17.5:82.5	3.20
	20:80	3.05
	22.5:77.5	2.95
	Control concrete	4.10
28 days	10:90	3.70
	12.5:87.5	4.10
	15:85	5.56
	17.5:82.5	3.90
	20:80	3.65
	22.5:77.5	3.20
	Control concrete	4.84

C. **Flexural Strength Test**
Dimensions of the concrete beams tested: 10cm x 10cm x 50cm

The concrete beams were tested confirming to IS 516-1959.

Table 7. Flexural strength of fly ash aggregate concrete and control concrete at different ages of testing

Age of testing	Proportion Cement : Fly ash	Flexural Strength in N/mm^2
7 days	10:90	4.10
	12.5:87.5	4.50
	15:85	5.49
	17.5:82.5	4.40
	20:80	4.20
	22.5:77.5	3.95
	Control concrete	4.95
28 days	10:90	4.40
	12.5:87.5	4.75
	15:85	6.22
	17.5:82.5	4.60
	20:80	4.35
	22.5:77.5	4.15
	Control concrete	5.36

Fig 4. Comparison of Compressive strength of fly ash aggregate concrete and control concrete vs Number of days of curing

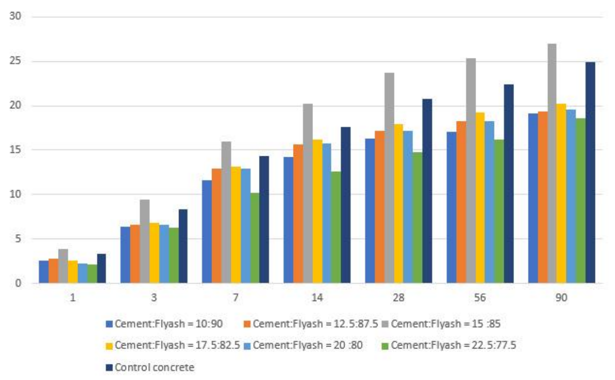
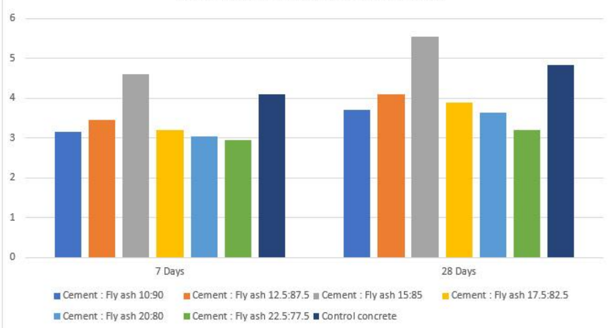


Fig 5. Comparison of Split Tensile Strength of fly ash aggregate concrete and control concrete vs Number of days of curing



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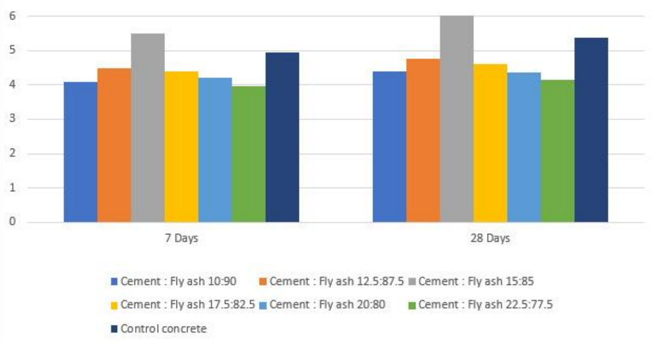

Fig 6. Comparison of Flexural strength of fly ash aggregate concrete and control concrete vs Number of days of curing

VI. CONCLUSION

i) Compared to control concrete cubes at all curing ages, the compressive strength for fly ash aggregate concrete cubes with a cement fly ash ratio of 15:85 was increased.

ii) Compared to the control concrete beams, the split tensile strength of fly ash aggregate concrete beams with fly ash aggregates of cement fly ash ratio 15:85 was improved at all ages of 7 days and 28 days compared to the control concrete beams

iii) Compared to the control concrete at the ages of 7 days and 28 days of curing, the increase in flexural strength of the sample was observed for the fly ash aggregate concrete containing fly ash aggregates made using cement fly ash ratio of 15:85.

iv) The use of fly ash as an aggregate in concrete mix for filling the GFRG panels increases the compressive strength, split tensile strength and flexural strength when mix the ratio of Cement : Fly ash was 15:85.

v) Using fly ash as an aggregate solves the problem of waste in coal industries.

vi) The weight of the concrete cubes compared to the conventional concrete is reduced to about 27.5% by weight.

vii) The increasing demand for housing can be fulfilled by GFRG panels with good and light weight aggregate concrete mix using fly ash to provide better strength and resistivity towards earthquakes.

viii) There is an increasing issue of natural resource depletion in the world. So, we have to come up with some ecofriendly methods to meet the demands the people and using fly ash in concrete mix is one such method.

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