



# EXPERIMENTAL STUDY ON COIR BLENDED CONCRETE STRENGTHENED WITH FLY-ASH AND GRANITE POWDER

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## ABSTRACT

This paper describes the experimental studies on the use of Coir as an enhancement of concrete, Fly-ash and Granite powder as a partial replacement of cement and fine aggregate. The addition of Coir significantly improved the engineering properties of concrete, the application of Fly-ash is to enhance the workable performance of the concrete and the application of Granite powder increases the mechanical strength of the concrete. The definitive goal of this research paper is to focus on the environmental sustainability and to find an alternative to normal control concrete. Concrete mix design of M40 was prepared based on Indian standard code (IS 10262). In the concrete mix, the cement was partially replaced with fly-ash (10%, 20%, 30%, 40% and 50%) by weight fraction along with partially replacement of fine aggregate with granite powder (25% and 50%) by weight fraction and incorporation of 1% coir fibre by volume fraction. Concrete cubes, cylinders and beams were casted and tested for attaining mechanical and physical properties for 7 and 28 days of curing. Non-destructive tests have proved the concrete to be a perfect alternate to control concrete. Mechanical test like compressive strength showed varying results but notable values were seen during the flexural and tensile strength test. Thus, it was accepted that fly-ash and granite powder can be proven perfect replacement for cement and sand along which coconut coir fibre increases the flexural and tensile strength while having varying effect on the compressive strength.

**Keywords:** fly-ash, granite powder, coir, fine aggregate, non-destructive tests, mechanical tests.

## INTRODUCTION

In construction sector, concrete is considered as the most vastly used material for building purpose globally. The concrete mixture is composed mainly of cement, coarse aggregate, fine aggregate and water. Cement being one of the expensive and energy-intensive concrete materials, is heavy on pocket. The primary cost of concrete can be diminished to upmost by replacing cement with materials which shares same properties and are cost efficient. Fly-ash bearing the similarities with cement can be used as its replacement. Fly-ash is one of the environment risk hazard. Disposing of fly-ash waste directly to environment causes severe environment problems. It reacts directly with water forming cementitious compounds, while being pozzolanic material can chemically react with calcium hydroxide to form compounds possessing cementing properties. The utilization of fly ash on economic grounds can be done by using it as a partial replacement of cement instead of disposing it as a waste material to the environment. On other hand, fly-ash can be beneficial for concrete because of its lower evolution of heat, lower water demand for identical workability and reduced bleeding.

Fine aggregate is a fundamental and basic component of concrete. The consumption of sand has increased due to the vast use in concrete which has elevated the demand for sand quite high in developed countries for the virtue of infrastructural growth. This causes shortage of sand supply all over the country. Granite powder being one of the outcome of granite stone crushing process, is a non-biodegradable waste that are responsible for most dust formation that can be easily

inhaled by human being and animals and is also harmful to the environment not being used for any other purposes rather than stuffing over low lying areas and is identified as a replacement material for sand in concrete with added benefit of sustaining the environment.

Coir fibers obtained from coconut husk, are agricultural waste products, and are available in large quantities in the tropical regions of the world. Coir fiber has been used to improve concrete and mortar, and has proven to enhance the toughness of the concrete. Hence this study focuses on the use of fly-ash as a partial replacement of cement and using granite powder as a partial replacement of fine aggregate along with adding natural fiber (coir) to enhance the strength of the concrete and also keeping it economic by processing an alternate to the conventional. The objective of our project is to study the influence of partial replacement of cement with fly ash in variation of 10%, 20%, 30%, 40% and 50% by weight fraction, the partial replacement of sand with granite powder in variation of 25% and 50% by weight fraction and adding 1% natural fiber (coir) by volume fraction, and to compare it with physical and mechanical properties of ordinary M40 concrete. We are also trying to find the percentage of fly ash and granite powder replaced in concrete that makes the optimum strength of the concrete maximum.

## REVIEW OF LITERATURE

T. Felixkala had obtained from the experimental results that granite powder of preferable quantity as partial replacement of sand has favourable effect on the mechanical properties such as compressive strength, split



tensile strength and modulus of elasticity. She also indicated that the results of shrinkages both plastic and drying, of concrete in the granite powder concrete specimens were nominal than those of ordinary concrete specimens. She examined the possibility of using granite powder as replacement of sand and partial replacement of cement with fly ash in concrete. The percentage of granite powder added was 0%, 25%, 50%, and 75% by weight as a replacement of sand used in concrete and cement was replaced with 10% fly ash. The water-cement ratios on mechanical properties was kept 0.45, plastic and drying shrinkage strain of the concrete were studied and compared with natural fine aggregate concrete[1].

Kanmalai Williams *C et al.* reported the results of an experimental study on the performance of concrete made with granite powder as fine aggregate. The percentage of granite powder replaced by sand was in a range of 0, 25, 50, 75 and 100% by weight used in concrete and cement was replaced with 7.5% Silica fume, 10% fly ash, 10% slag and 1% super plasticizer. The water-cement ratio was kept at 0.40 for 1, 7, 14, 28 and 56 days of curing. Compressive strength, Split tensile strength, modulus of elasticity, water penetration and drying shrinkage of concrete were studied. Their results indicated that the maximum compressive strength was achieved in samples containing 25% replaced granite powder concrete, which was 47.35 kPa. The overall test performance disclosed that granite powder can be utilized as a partial replacement of natural sand in concrete [2].

Raja and Ramalingam (2016) studied the influence of granite fines in concrete. The percentage of replacement of granite fines to fine aggregate were 0, 10, 20, 30, 40, 50 and 100 for M20 grade concrete and specimens are tested after 28 days of curing. The specimens with 40 % replacement of granite fines to fine aggregate gave promising increase in strength when compared to control conventional specimens [3].

Bahar Demirel investigated the influence of using waste granite dust as a fine material on the mechanical properties of the concrete. For this study, four varying series of concrete mixtures were prepared by replacing the fine sand with granite dust at proportions of 0, 25, 50 and 100% by weight. In order to determine the influence of the granite dust on the compressive strength with respect to the curing age, compressive strengths of the samples were observed at the curing days of 3, 7, 28 and 90 days. The compressive strength increases with increase in curing days and fineness of granite dust [4].

Jagadesh *et al.* investigated on fiber cement sheet enriched with fly ash which increases the strength with age of concrete and indicates better durability. They explained that utilization of fly ash prevents pollution, protects the environment and conserves natural resources. Further they concerned that Calcium enriched fly ash improves frost and carbonation resistance and usage of fly ash is economic of the as fly ash is cheaper than cement [5].

Minnick *et al.* have investigated the role of particle size distributions and the reactivity of fly ash. The

effect of various grain size distributions and the reactivity of fly-ash on the strength attribution of fly-ash cement concretes had been investigated. It was found that the particles below 45/11m are accountable for the pozzolanic effect. But the increase in compressive strength appears more in particle size below 10-20P [6].

Puri has stated that fineness is one of the main parameters to be appraised for fly ash to be added into the cement, as it enhances the rate of development of mechanical strength. However, they found out that there is an optimal fineness above which the increase in mechanical strength becomes less significant as specific surface of concrete increase in later [7].

Watt *et al.* have investigated on some concrete specimens enriched with variations of fly-ash for 7, 14, 28, 56, 91 and 160 days of curing. They have observed that the presence of  $\text{SiO}_2$  or  $(\text{SiO}_2\text{-Al}_2\text{O}_3)$  in a fly ash effects the pozzolanic activity which increases with increase in curing days and that higher strengths are obtained with silica or silica alumina content present in it. They also observed that if fly-ash be enriched with sulphates and lime; they play a principal role at early ages of hydration reaction during curing [8].

Vinod Goud *et al* studied of the effect of fly ash on the properties of concrete for nominal mix of M25 grade of concrete and observed that although slump loss of concrete increases with increase in w/c ratio of concrete, the 10% and 20% replacement of cement with fly ash shows good compressive strength for 28 days but the 30% replacement of cement with fly ash shows ultimate compressive strength of concrete slightly decreases. [9]

Baruah *et al.* investigated the properties of plain concrete and fiber reinforced concrete in volume fractions ranging from 0.5% to 2% with different fiber. Fibers used for their investigation were natural fibers (jute and coir fibers). As compared to those of plain concrete; the compressive strength, split tensile strength, modulus of rupture and shear strength of coir fiber reinforced concrete with 2% fibers by volume fraction were increased up to 13.7, 22.9, 28.0 and 32.7 %, respectively. It is also noted from their research that all these properties were also improved for Coir fiber reinforced concrete with all other tested volume fractions of fibers (0.5, 1 and 1.5 %)[10].

Reis investigated the mechanical properties (flexural strength, fracture energy and fracture toughness) of polymer concrete reinforced with natural fibers (coconut, sugarcane bagasse and banana fibers). Fracture toughness and fracture energy of coir fiber reinforced polymer concrete were increased than that of other fibers reinforced polymer concrete and along with flexural strength increased up to 25 % with just coir fiber only [11].

## MATERIALS AND THEIR PROPERTIES

### Design quantity values

Cement	= 400 kg/m <sup>3</sup>
Water	= 160liters



Fine aggregate = 660kg/m<sup>3</sup>  
 Coarse aggregate = 1168kg/m<sup>3</sup>  
 Water: cement: F.A.: C.A. = 0.4: 1: 1.65: 2.92  
 (Mix ratio)

### Overall mix proportion

The following Table-1 shows the overall nomenclature of the mixes proposed and their denotations on the basis of binder fine and aggregate replacements.

**Table-1.** Overall mix proportions.

Binders		Fine Aggregates		Reinforcement (Fibre)	
Cement	Fly ash (FA) %	River sand (RS) %	Granite powder (GP) %	Coir %	Denotations
100%	0%	100%	0%	1%	Conventional
90%	10%	75%	25%	1%	10%F+25%G
90%	10%	50%	50%	1%	10%F+50%G
80%	20%	75%	25%	1%	20%F+25%G
80%	20%	50%	50%	1%	20%F+50%G
70%	30%	75%	25%	1%	30%F+25%G
70%	30%	50%	50%	1%	30%F+50%G
60%	40%	75%	25%	1%	40%F+25%G
60%	40%	50%	50%	1%	40%F+50%G
50%	50%	75%	25%	1%	50%F+25%G
50%	50%	50%	50%	1%	50%F+50%G

### Fly-ash

Fly-ash is pozzolonic and reactive mineral admixture generated by combustion of coal in thermal power plants and comprises of very fine particles. Generally, two types of fly ash such as Class 'C' and Class 'F' are available in market. This study work involves the use of low calcium fly ash (class F) Fly-ash. The chemical and physical properties of fly-ash conform to IS 3812 – 2003 are tabulated in Table 2 and 3.



**Figure-1.** Fly ash powder sample.

**Table-2.** Chemical composition of fly ash.

Sample (%)	SiO <sub>2</sub>	CaO	MgO	Al <sub>2</sub> O <sub>3</sub>	Na <sub>2</sub> O	K <sub>2</sub> O	Fe <sub>2</sub> O <sub>3</sub>	SO <sub>3</sub>	P <sub>2</sub> O <sub>5</sub>	TiO <sub>2</sub>	LOI <sup>a</sup>
Fly-ash	49.45	3.47	1.3	29.61	0.31	0.54	10.72	0.27	0.53	1.76	1.45

a- Loss of Ignition

**Table-3.** Physical properties of Fly ash.

S. No.	Description	Result
1	Specific Gravity	2.45
2	Initial Setting Time	110
3	Final Setting Time	210
4	Fineness	235.1m <sup>2</sup> /kg
5	Class of Fly-ash	Class F
6	Bulk Density	1435.28Kg/m <sup>3</sup>

**Granite powder**

Granite powder obtained from the granite crushing units and the properties were found. Since the granite powder was fine, hydrometer analysis was carried out on the powder to determine the particle size

distribution. The chemical and physical properties of Granite powder are tabulated in table 4 and 5.

**Figure-2.** Granite powder sample.**Table-4.** Chemical composition of Granite powder.

Sample (%)	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	K <sub>2</sub> O	Na <sub>2</sub> O	CaO	FeO	Fe <sub>2</sub> O <sub>3</sub>	MgO	TiO <sub>2</sub>	P <sub>2</sub> O <sub>5</sub>	MnO
Granite powder	72.04	14.42	4.12	3.69	1.82	1.68	1.22	0.71	0.30	0.12	0.05

**Table-5.** Physical properties of Granite powder.

S. No.	Description	Result
1	Specific Gravity	2.77 - 2.82
2	Water absorption	1.6%
3	coefficient of curvature	1.95
4	coefficient of uniformity	7.82
5	Thermal Conductivity(K)	~2.2
6	Density	2.65 to 2.75 g/cm <sup>3</sup>

**Table-6.** Physical parameters of fine aggregate.

S. No.	Description	Result
1	Specific Gravity	2.60
2	Water absorption (%)	1.15
3	coefficient of curvature	1.3
4	Bulk Density (kg/m <sup>3</sup> )	1561
5	Density	1.58-1.77
6	Thermal Conductivity(K)	2.05
7	Zone	II

**Fine aggregate**

River Sand (of Zone II) passing through 4.75mm sieve was taken which cater all norms of Indian standards as per IS 383:2016. The physical parameters are shown in Table-6.

**Figure-3.** River sand sample.**Coarse aggregates**

Crushed granite stones of size 20mm and a specific gravity of 2.73 chosen as coarse aggregate. Aggregates passing through 20mm and retained over 12mm sieves were chosen as shown in Figure-4. Table-7 shows the properties of coarse aggregates.

**Figure-4.** Coarse aggregate sample 20mm passed and 12mm retained.



**Table-7.** Physical parameters of Coarse aggregate.

S. No.	Description	Result
1	Specific Gravity	2.72
2	Water absorption (%)	0.61
3	Surface Moisture	Nil
4	Fineness Modulus	2.1
5	% voids	39.02%
6	Crushing value	27.07%

**Coir**

Coir was bought from local coir dealer. The coir fibers were cut into lengths of 20mm with uniform diameter and soaked in mild warm water in a gunny bag for a period of 24 hours before mixing for achieving strength and ductility.

**Figure-5.**Coir fibre.**CASTING OF SPECIMENS****Mixing**

The required amount of coarse and fine aggregates were collected and placed in a laboratory mixer. With the addition of granite powder, cement and fly ash the materials were mixed initially dry in the laboratory mixer for about three to five rotations until all the coarse aggregate became well bonded with fine aggregate particles and the binder, as shown in Figure-5. Then while mixing the coir fibres cut into length was added into the mix. Water is then added gradually and then half the quantity of water is poured. When the mixture comes in operational condition, rest of the water is poured. The total mixing time was about 5 minutes for a mix fit for casting of abatch.



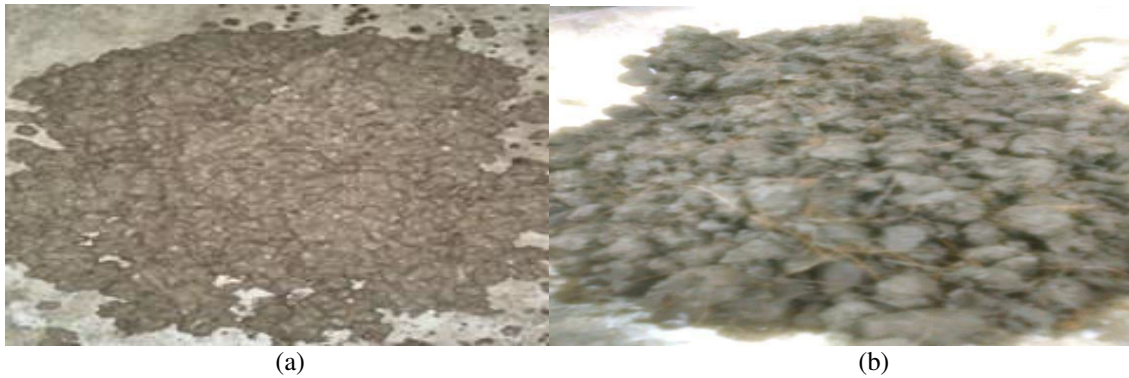
(a)

(b)

**Figure-6.** (a) Initial mix (b) Final mix.**Placing**

The fresh concrete mix after thorough mixing was then placed on a tray. The fresh mix was sufficiently handled for a period of at least 15 minutes without any sign of setting. In between this period the mix can be casted. The workability was checked by slump cone test as

was assumed that the workability of composite mix was more or less same to that of conventional mix due to the presence of coir fibre in the mix. The mixes were comparatively workable and stable for a period of 15 to 20 min. The concrete mix prior to placing over moulds is shown in Figure-7.



**Figure-7.**(a) Conventional mix (b) Replaced composite mix.

### Casting

Casting containing a total 11 mixes were scheduled and casted. In the initial mix of conventional concrete, specimens consists only of Ordinary Portland Cement as binder and only river sand as fine aggregate in this case. The final mix consists of replacement of cement with fly-ash in range of 10% to 50% in binder and

replacement of river sand with granite powder by 25% and 50% in fine aggregate along with the addition of coir. A total of 66 cubes (150x150x150mm), 66 cylinders (100x200mm) and 66 beams (500x100x100mm) were casted included for both 7 and 28 days of curing. The moulds after casting and finishing are shown in Figure-8.



(a) (b) (c)

**Figure-8.** (a) Finished cube moulds (b) Finished cylinder moulds (c) Finished beam moulds.

### Curing

The specimens after demoulding, were subjected to ambient curing for a while and are then shifted to a curing tank. The temperature in curing tank kept at room temperature ( $25 \pm 2^\circ\text{C}$ ) for rest of the curing period up to 7 and 28 day time period. The specimens kept under curing are shown in Figure-9.



**Figure-9.** Specimens kept in curing tank under room temperature ( $25 \pm 2^\circ\text{C}$ ).

## EXPERIMENTAL TESTING AND RESULTS

### General

The results of all the tests carried out on mix concrete and conventional concrete are presented and discussed in this chapter. The experiments were conducted with reference to Indian Standard codes. The results obtained for conventional concrete and concrete with replacements were compared so that the optimum concrete mix can be identified. The casted specimens went under various mechanical and physical property tests. After achieving the test results over the proposed time period of 7 and 28 day span, the results are depicted in detail with suitable graphical plots.

### Testing parameters

#### Non-destructive test

The Non-Destructive tests involved assessment of strength and quality by carrying out tests like Rebound hammer, Ultrasonic pulse velocity for the casted cubes, both at 7 and 28 days of curing.



### Rebound hammer test

The rebound hammer is principally a surface hardness tester. It works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. The rebound is then read off along a graduated scale on the rebound hammer to get the rebound number. There is little apparent theoretical relationship between the strength of concrete and the rebound number of the hammer. The testing elastic mass used is of steel having Brinell hardness of about 5000

N/mm<sup>2</sup>. Cube specimens (150x150mm) of 28 days curing were used for calibrating rebound hammers as was preferred by IS 13311(Part 2): 1992. The concrete cube specimens were held in a compression testing machine under a fixed load of 7 N/mm<sup>2</sup>. The measurement of the rebound number is then taken through the graduated scale and then relative compressive strength is then calculated through the rebound hammer graph. The rebound hammer test setup is shown in the Figure-10.

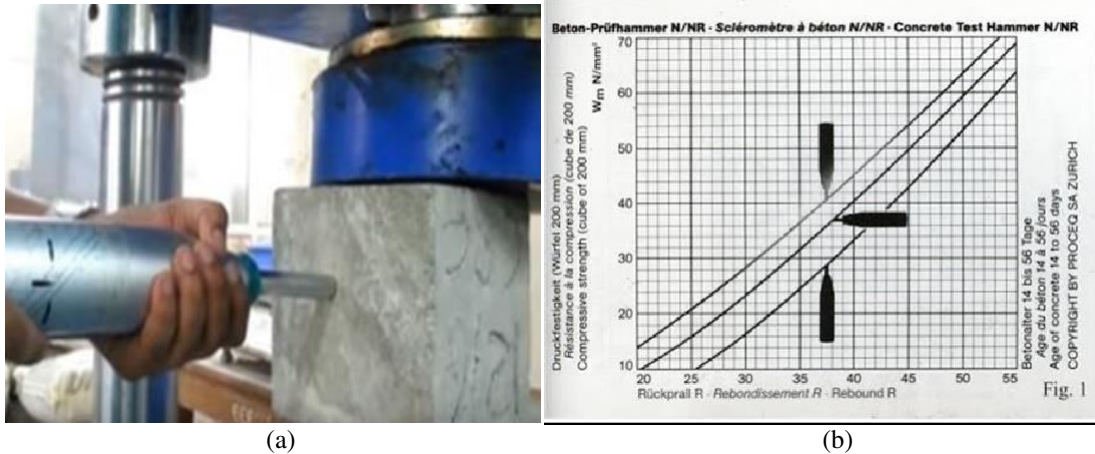


Figure-10.(a)Experimental setup for rebound hammer test (b) Rebound graph to derive the relative compressive strength.

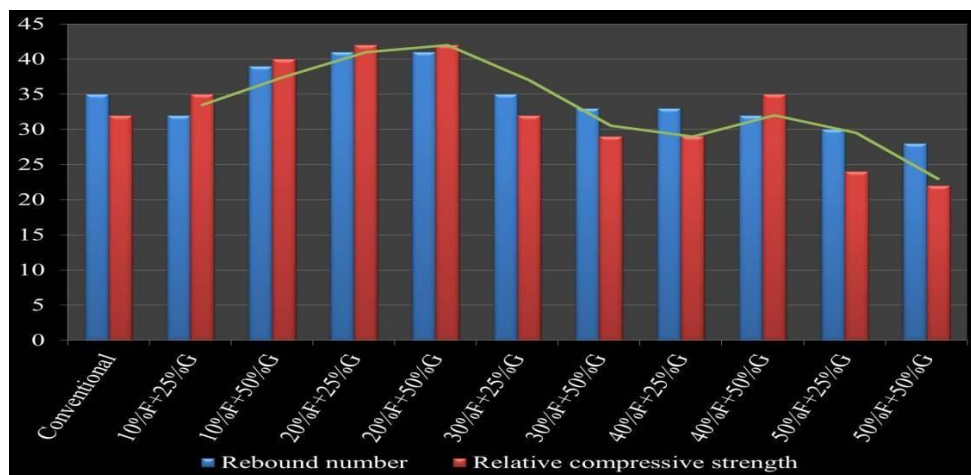


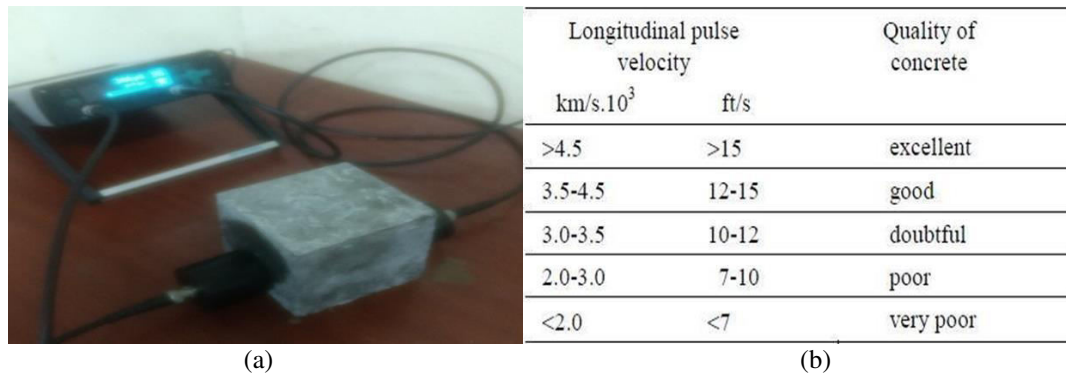
Figure-11. Rebound number with compressive strength comparison graph for 28 day curing.

### Ultrasonic Pulse Velocity Test (UPV)

Measurement of the velocity of ultrasonic pulses passing through concrete can be used for the Correlation of pulse velocity and strength as a measure of concrete quality. The principle behind the assessing of the quality of concrete is that comparatively higher velocities are acquired when the quality of concrete in terms of uniformity, density and correlativity is good. In case of poorer quality, lower velocities are obtained. The ultrasonic pulse generated by an electro acoustical transducer operating within the frequency range of 20 kHz

to 150 kHz is induced into the concrete, from there the pulses undergoes multiple reflections the within the concrete. A complicated system of stress waves is developed which involves longitudinal, transverse and surface waves. The receiver detects the onset of the fastest longitudinal waves which it displays as an ultrasonic pulse velocity value. Cube Specimens of both 7 and 28 days of curing were used for the test and the procedure was followed as per the norms of IS13311 (Part1):1992. The Ultrasonic pulse velocity test setup is shown in the Figure-12.





**Figure-12.** (a) Experimental setup for Ultrasonic pulse velocity test (b) Classification of the quality of concrete by UPV.

**Table-8.** Ultrasonic pulse velocity test values.

S. No.	Cementitious materials	7 day cured UPV(km/s)	28 day cured UPV (km/s)
1	100 % CEMENT+100% SAND	4.316	4.425
2	10% FLYASH+25% GRANITE+1% COIR	4.303	4.365
3	10% FLYASH+50% GRANITE+1% COIR	4.285	4.36
4	20% FLYASH+25% GRANITE+1% COIR	4.368	4.373
5	20% FLYASH+50% GRANITE+1% COIR	4.347	4.395
6	30% FLYASH+25% GRANITE+1% COIR	4.38	4.411
7	30% FLYASH+50% GRANITE+1% COIR	4.36	4.464
8	40% FLYASH+25% GRANITE+1% COIR	4.35	4.373
9	40% FLYASH+50% GRANITE+1% COIR	4.310	4.437
10	50% FLYASH+25% GRANITE+1% COIR	4.29	4.31
11	50% FLYASH+50% GRANITE+1% COIR	4.21	4.273

### Mechanical properties

The mechanical properties involved assessment of strength by carrying out tests like compression test, split tensile test and flexural test for the casted cubes, cylinders and beams for both 7 and 28 days of curing.

#### Compressive strength

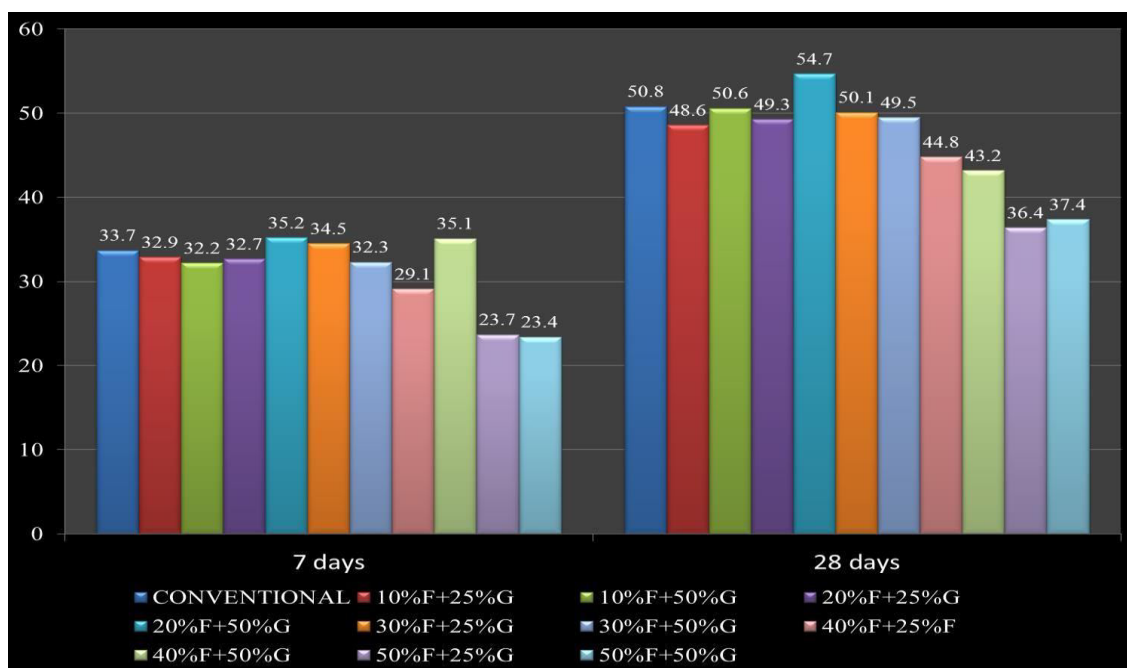
It is the capacity of a material or structure to withstand loads tending to reduce size against cracking. The cube specimens were tested under a constant load increasing stepwise until failure. The rate of loading was in the range of 1.0mm/min. The capacity of the Compressive testing machine (CTM) was 2000kN. The specimens used for this test were cubes of size

150x150x150 mm. The specimens were placed centrally along their axis over the loading plate of the compression testing machine and the test was carried out as per IS 516-1959. The partial replacement of cement and fine aggregate along with the addition of coir at 7 days cured testing showed reduced compressive strength of all mix proportions except for 20% Fly-ash replaced along with 50% Granite powder replaced concrete. This is probably due to non-contribution in compressive strength of the mix at early age. Also higher fibre content in the mix might have caused voids resulting in decreased compressive strength. At 28 days cured testing the strength improves due to continuous hydration process but is still less than that conventional concrete strength.





**Figure-13.** Experimental setup for compressive strength assessment.



**Figure-14.** Compressive strength graph for 7 and 28 days cured cubes for all mixes.

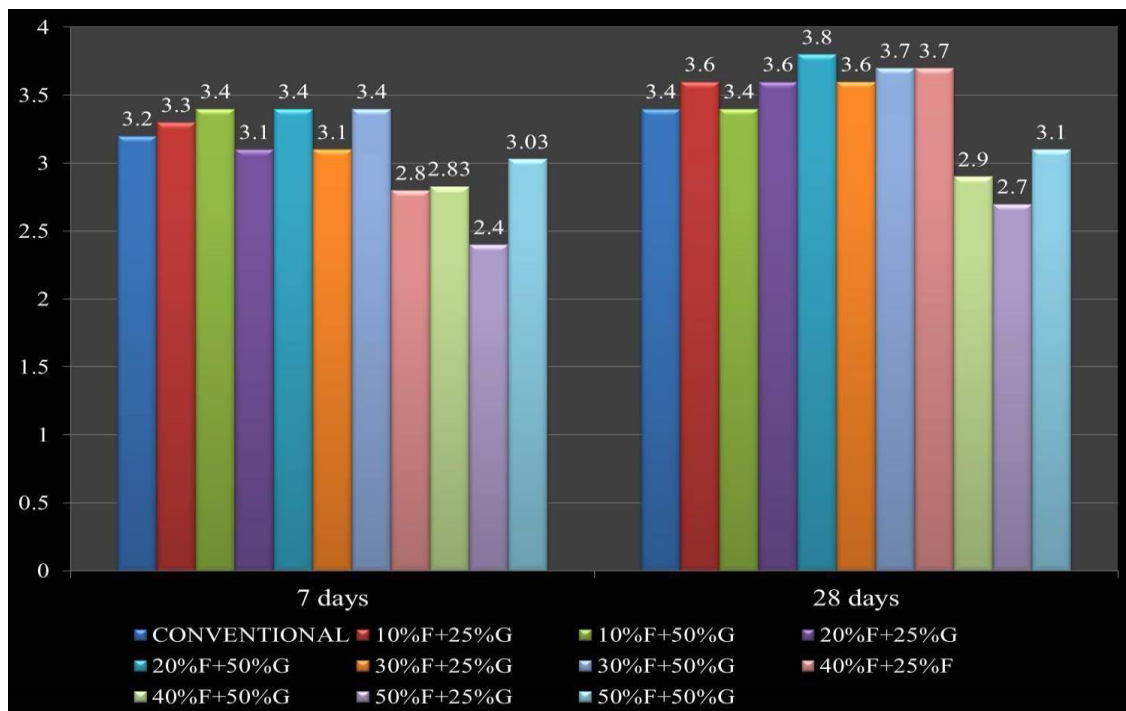
#### ▪ Split tensile strength

It is a method of determining the ability of a material to withstand a longitudinal stress. The specimens used are 100mm diameters and 200mm height cylinders. The cylindrical specimens were tested for splitting tensile strength check by applying progressive load across the longitudinal section of the cylindrical specimen. The specimens were tested over the compressive testing machine (CTM) of 2000kN capacity by placing suitable base plates above and below the specimen making uniform loading area longitudinally in order to make a uniform

splitting of the specimen across its edge. The specimen is tested as per IS 5816:1999 credentials. The Split tensile test results for both Conventional concrete and Replaced Composite concrete were observed. Split tensile strength test showed positive results both at 7 day and 28 day testing. Results showed that the mixes of the replaced composite concrete gives consistently higher strength than the mix of conventional concrete. From the test results, significant increase was observed in the concrete mixes with 20%fly-ash.



**Figure-15.** Experimental setup for split tensile strength assessment.



**Figure-16.** Split tensile strength graph for 7 and 28 days cured cylinders for all mixes.

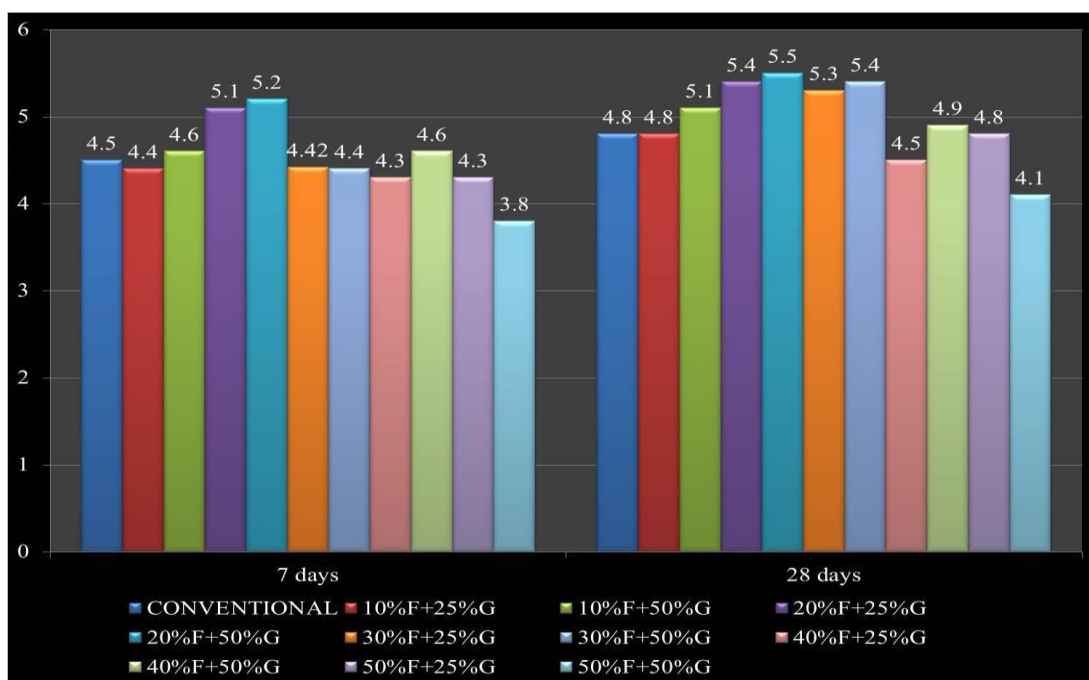
#### ▪ Flexural strength

The Flexural strength is a measure of an unreinforced concrete beam or slab to resist failure in bending. Specimens used are of size 500x100x100mm beams. The beam specimens were tested for flexure under a three point loading system by applying progressive load across the longitudinal section of the beam specimens. The specimens were tested over the universal testing machine (UTM) of 2000kN capacity. The specimens were marked with chalk to align them perfectly with the three point loadings so that the load could distribute evenly throughout the length of the beams. The specimens are

tested as per IS 516-1979 credentials. The Flexural strength test results for both Conventional concrete and Replaced Composite concrete were observed. Flexural strength test showed promising results both at 7 day and 28 day testing. Results showed that the mixes of the replaced composite concrete gives consistently higher strength than the mix of conventional concrete. From the test results, although many of the mixes showed increase in strength than that of conventional concrete but there was a significant increase observed in both of the concrete mixes with 20% fly-ash among which 20% fly-ash with 50% granite powder showed the highest flexural strength.



**Figure-17.** Experimental setup for flexural strength assessment.



**Figure-18.** Flexural strength graph for 7 and 28 days cured beams for all mixes.

## DISCUSSIONS

The Non-destructive test results showed a hope for the replaced composite mixes. The Rebound hammer test provided increased relative compressive strength results mostly by 2-3% for both of the 20% fly-ash replaced composites to that of conventional concrete and Ultrasonic pulse velocity test results of specimens with various proportions gave velocity within 4- 4.5 km/srated 'Good' quality concrete.

The increase in compressive strength for 20% Fly-ash replaced along with 50% Granite powder replaced concrete mix accounts for 4.45% and 7.68% than that of conventional mix for both days of curing. The split tensile strength for both 20% Fly-ash replaced concrete mixes accounts for increase in strength which ranges to 6.25% for 7 days of curing and increase in strength which ranges to 11.76% for 28 days of curing than that of conventional mix. The flexural strength for both 20% Fly-ash replaced concrete mixes accounts for increase in strength of 13.33% and 15.66% than that of conventional mix for 7 days of

curing and increase in strength of 12.5% and 14.58% for 28 days of curing.

## CONCLUSIONS

The incorporation Fly-ash (class F) in the mix ingredient enhances the performance of concrete by improving workability, flow-ability, finishing and compatibility in fresh state of concrete. The incorporation of fly ash and coir in the concrete makes it lighter so concrete can even be used as light weight concrete. Also, fly ash being cheaper than concrete makes it economical. Being a waste material such as fly ash can be used effectively in the civil engineering construction. Reinforcement of such composite materials with fibers further increases the strength and durability.

The Non-destructive tests provided an approval to the replaced composite mixes as a mix fit for construction purposes. The Rebound hammer test provided increased relative compressive strength results of the replaced composites to that of conventional concrete and Ultrasonic



pulse velocity test results of specimens with various proportions gave velocity within 4- 4.5 km/s rated 'Good' quality concrete which allows for an alternative to conventional concrete.

The specimens containing 50% granite powder showed more strength in all respects than those containing 25%. Hence we can conclude that 50% of granite powder is the optimum. The strength of the proportion containing 20% fly ash, 50% granite powder and 1% coir after 28 day testing showed promising values than that of the conventional mix and hence it can be used as a working substitute for conventional concrete.

The flexural strength of specimens was more than the conventional concrete showing that the use of natural fibers has helped in reinforcing the beams thus providing additional strength. Due to the uniform diameter property of the coconut fiber there will be uniform distribution of the reinforcement throughout concrete providing higher flexural strength.

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