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# Studies on strength behaviour of green self cured concrete with ecosand with impact of fly ash and ground granulated blast furnace slag

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**Abstract.** Construction firms now use artificial sand or else manufactured sand in concrete for a day instead of natural river sand, where the excavation prohibition applies to river sand along with the implementation law. Natural sand or River sand are one of the constituents of concrete taken from a river. The problems of deterioration of the ecosystem and costly and the condition of the natural sand of river is rising day by day. About the Global Natural sand consumption has increased because of excessive use of concrete to ensure a very strong demand for river sand, where Eco Sand is necessary to replace natural silica. Potable Water, meanwhile, is also the extremely ubiquitous feature for the concrete production and curing activity, and it is now insufficient for a limited period due to a superior growth in human population growth. Self-curing concrete helps to reduce the use of potable water, in contrast to the traditional curing system. In supplement to chemical admixture with the concrete mixture, this paper deals with the various studies of fresh and hardened concrete specimens with various replacement level of Eco sand and findings with the self-curing agent mixed with PEG 400 with Fly Ash and GGBFS proportioning. The results are correlated with the replacement of Eco sand with river sand with both ordinary self-curing concrete and blended self-curing concrete with M30 grade for the different combinations of blended proportions. Attempts have been made to research with Eco Sand to identify the properties of blended self-curing concrete.

## 1. Introduction

Portland cement is typically used to make concrete and other materials having cement characteristics such as fly ash and slag, where both cement acts as a binder of the aggregates. Consequently, In concrete, cement reacts with water and forms a hardened cement mass. In addition, the additives that are mineral admixtures such as fly ash, slag, are added to the production of cement for property enhancement. Curing, particularly in the early ages of concrete strength, is a very important component that remains important for the hydration process. However, by traditional curing methods, appropriate curing is not continuously probable, and it is suggested to make the entrenched water available for curing in order to solve this challenge on curing process.

Self-curing agents should be applied to reduce water evaporation from the concrete surface and improve the water retention potential of the concrete compared to conventional concrete. The self-curing agents apply to surface moisture in the atmospheric state. The hydrogen bond between molecules of polymerized fresh concrete water reduces surface water evaporation as time leads to



concrete reinforcement. Considerable autogenous deformation and early-age cracking can result due to hydration and other processes after drinking water, which is not frequently available.

Because of its chemical shrinkage striking during cement hydration, empty cavity formed within the cement paste, prominent to a reduction in its internal relative humidity and shrinkage influencing the early age cracking. Eco sand is a very fine grain, a bi-product of cement production, that can be used in concrete to boost performance. Its micro-filling effect decreases concrete pores and provides additional resistivity to moisture and thus durability. It has more consistent grading than several

extracted aggregates. Efficient and cost-effective use of waste material and thus performs as well as natural sand. The main extent of the paper is experimentally to examine the effect of polyethylene glycol (PEG 400) on strength characteristics of Self-curing concrete with replacements of Eco Sand. With use of eco sand instead of collected or extracted silt natural sand can help designers and engineers tackle environmental concerns. Finally, the compressive strength, tensile strength and bending of concrete are being evaluated in this analysis by utilizing eco sand, cement and super plasticizer in the given moulded specimens.

P. Magudeaswaran et al.[3] are investigating green high-performance concrete with the materials such as silica fume, eco sand, fly ash and coarse aggregates. The research to be carried out assess the physical and mechanical properties of replacement of cement with silica fumes between 7.5-15 % and about 15-40 % of fly ash. Shubham Gupta et al.[5] performed the analysis on Eco sand replacements for fine aggregates varies from 5 to 20 % and the mechanical analysis is analyzed. Compressive strength split tensile strength and flexural strength are included. Grade of the M40 is unique for the analysis and the rheological tests are also examined to evaluate the study on utilization of water.

The concrete is investigated with eco-sand and steel slag by Nandini Suri et al.[7] through replacing coarse aggregate with steel slag and 30 percent substitution of eco sand as fine aggregate, the goal is to improve the strength of the concrete. The blend consisted of 30% to 45 % of slag. It is observable that as compared to conventional blends, 50 % substitution and above tends to decrease the strength found. Nagraj T.S et.al [2] (1996) stated that rock dust consumes more cement compared to sand because of its higher surface area, which enhances workability and also studied the impact of rock dust and pebbles as aggregates in cement and concrete and discovered that crushed stone dust could be used to substitute concrete with natural sand.

The purpose of the experimental study was to understand the strength characteristics of internal cured blended concrete and to acquire the optimal percentage of PEG 400 and replacement level of Flyash and GGBFS which are self-curing. Attempts have thus been made to facilitate internal curing in concrete through the addition of self-curing admixtures, which may produce concretes that are equal or superior to traditional forms of curing. The aim of this research is to vary the mechanical characteristics of concrete such as compressive strength, split tensile strength and by varying the % PEG proportion by cement weight for both ordinary self-curing and blended self-curing concrete with partial replacement of Eco Sand in Fine Aggregate for grade concrete M30.

## 2. Materials

All the constituents of concrete making materials are properly tested under laboratory condition. The materials are listed as follows.

Polyethylene Glycol is an ethylene oxide group, general formula  $H(OCH_2CH_2)_nOH$ . Where n represents the average number molecular weight in ethylene oxide group ranges from 400 to 4000. In many medical applications, PEG is non-toxic, odourless, lubricating, neutral pH benefit & non-irritating, and even used. The effect of admixture (PEG 400) on compressive, split tensile strength and rupture modulus was analyzed by Jagannadha Kumar et al. The proportion of Polyethylene Glycol 400 by cement weight ranges from 0 % to 2 % for M20 and M40 blends.

It was found that 1% of PEG 400 by weight of cement was optimum for M20, while 0.5 % for M40 grade concrete for achieving maximum strength without compromising workability. Joseph et al., experimented on self-cured concrete with PEG400 for M20 grade of concrete also suggested 1% of PEG400 by weight of cement gives optimum strength for M20 grade of concrete and gets increased

the workability. Shikha Tyagi et al., (5) made M25 and M40 grade of concrete and found the optimum dosage of PEG-400 to be 1% for M25 and 0.5% for M40 grades of concrete.

As per previous investigations, it is founded that, Polyethylene Glycol (PEG) is widely used self-curing compound, which is taken to be chemical admixture in this experimental work having molecular weight as 400, pH value as 6.5 and specific gravity of PEG 400 as 1.12 respectively.

Ordinary Portland (OPC 53) cement and a particle density of 3.05 have been used to comply with both the IS 1489-1991 specification. Locally sourced aggregates of 4.75mm and 20.0mm sizes were used for sieve analysis, in conjunction with IS: 383-1970, these values of 2.74, 0.25 % and 3.05 respectively, the specific gravity, water content and fineness modulus are determined.

Eco sand is a very fine grain, a bi-product of cement manufacturing, that can be used in concrete to boost performance. Its micro-filling effect decreases concrete spaces and gives greater resistivity to moisture and thus resilience. It has more robust grading than many aggregates that have been extracted. Efficient use of waste products and thus cheap and cost-effective. It works just as well as fine aggregate. Eco sand contains numerous advantages, including such efficient energy, fire proof, dead load mitigation, environmentally sustainable, reliable, light weight, relatively inexpensive, and lower construction costs.

The Green Sand or Eco sand used in this experimental work should be conforming to the 4.75 mm sieve passage. The main properties were also been examined and it is having the specific gravity as 2.48, bulk density as 1500 kg/m<sup>3</sup> and fineness modulus as 4.33, whereas specific gravity as 2.62, bulk density as 1542 kg/m<sup>3</sup> and fineness modulus as 3.09 for naturally occurring sand, respectively.

Normally employed quality drinking water conforming to IS:456-2000. In this study, it was acquired from the National Thermal Power Plant, Dadri, where fly ash Class F was used. The characteristics of this fly ash are light grey and the specific gravity ranges from 1.90-2.55 if the uniformity is 3.1-10.7. Apart from diminished permeability, GGBFS blended concrete is considerably more resistant to the ingress of chloride ions through concrete.

GGBFS was procured in Jindal South West Steel Ltd, Karnataka mainly having SiO<sub>2</sub> as 35.20%, Al<sub>2</sub>O<sub>3</sub> as 19 % and CaO as 34.90 %. GGBFS is an aluminosilicate with major components such as SiO<sub>2</sub>, Al<sub>2</sub>O<sub>3</sub>, CaO, and MgO, and it has been discovered that the incorporation of GGBFS promotes flowability and extended compressive power.

The addition of Flyash and ground granulated blast furnace slag has also been found to provide coral aggregate-concrete with lower early strength capacity but superior early age strength due to late development of pozzolanic reaction. As a super plasticizer, a polycarboxylate-type, new-generation high-range water reducing admixture confirming ASTM C494 was used to enhance the flow or workability of blends with a decreased water-cement ratio.

**Table 1.** Chemical Composition of Class F Fly Ash

Chemical properties	SiO <sub>2</sub>	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	CaO	MgO	Na <sub>2</sub> O	K <sub>2</sub> O	SO <sub>3</sub>	Loss of Ignition	Cl
Compounds %	45.98	23.55	4.91	18.67	1.54	0.24	1.80	1.47	2.31	0.0053

### 3. Mix Proportioning of M30 Mix

The mix proportioning for M30 of binary and ternary mixed concretes developed with optimal mixtures of Fly ash (FA) and Ground Granulated Slag furnace mixtures was based on the Indian Code for Mix design approach in IS 10262: 2019. Numerous experimental mixes had to be done on mixed concrete mixes made of varying combinations of Fly Ash (FA) and Ground Granulated Blast furnace slag (GGBFS). Slump Cone experiments were performed out from the above literatures and studies for workability and dosage variations of 0.5 percent, 1 percent and 1.5 percent were taken for both natural sand and Eco sand as seen in Table 2.

**Table 1.** Proportions of Blended Self Cured Concrete with M30 grade mix

Material	Quantity (kg/m <sup>3</sup> )
Cement	350
Fine aggregate (River Sand)	744.25
Fine aggregate (Eco Sand)	744.25
Coarse aggregate	1314.18
Polyethylene Glycol (PEG 400)	2.28
Super Plasticizer	3.5
Water	175

As per IS 456-2000, clause 8.2.4.2, the maximum cement content is limited to 450 kilograms per cubic meter of concrete. Revised quantities in kg per cubic metre for grade (M30) mixed concrete mix are reached in subsequent trial mixes without compromising the necessary strength property. The estimated quantity of OPC is 350 kg and pozzolanic materials such as Flyash (FA) and Ground Granulated Blast Furnace Slag (GGBFS) have been segregated from the literature studies on different dosages formulated in Table 3. In the desired design mix, as per code provision IS:1199-1959, the percentage of PEG 400 kept constant as 1 % for the slump value also increases consequentially in different replacements of Flyash and Ground Granulated Blast Furnace Slag with the blended mixing parameters of River sand and Eco-Sand as shown in Table 2.

**Table 2.** Slump values for various PEG 400 percentages for Natural & M-Sand

Percentage of PEG	Slump in Natural Sand	Slump in Eco Sand
0.0%	74	62
0.5%	92	89
<b>1.0%</b>	<b>112</b>	<b>123</b>
1.5%	140	131

**Table 3.** Mix Proportion of M30 grade Blended mix for various percentages for Flyash & GGBFS

Mix (%)	Cement	Flyash	GGBFS	C.A	Sand %	River Sand	Eco sand	S.P	Water
M0 (100)	350	--	--		100	744.3	--		
M1 (100)	350	--	--		100	--	744.3		
M2 (60+25+15)		87.5	35.0		70+30	520.0	223.3		
M3 (60+15+25)		35.0	87.5		70+30	520.0	223.3		
M4 (60+25+15)		87.5	35.0		80+20	595.5	148.9		
M5 (60+15+25)		35.0	87.5		80+20	595.5	148.9		
M6 (65+20+15)		70.0	52.5		70+30	520.0	223.3		
M7 (65+15+20)		52.5	70.0		70+30	520.0	223.3		
M8 (65+20+15)	227.5	70.0	52.5		80+20	595.5	148.9		
M9 (65+15+20)		52.5	70.0		80+20	595.5	148.9		
M10 (65+10+25)		35.0	87.5	1314.18	70+30	520.0	223.3	3.5	140
M11 (65+25+10)		87.5	35.0		80+20	595.5	148.9		
M12 (65+10+25)		35.0	87.5		70+30	520.0	223.3		
M13 (60+20+20)		87.5	35.0		80+20	595.5	148.9		
M14 (60+20+20)		70.0	70.0		70+30	520.0	223.3		
M15 (70+10+20)	210.0	70.0	70.0		80+20	595.5	148.9		
M16 (70+20+10)		70.0	35.0		70+30	520.0	223.3		
M17 (70+10+20)		70.0	35.0		80+20	595.5	148.9		
M18 (70+20+10)	245.0	35.0	70.0		70+30	520.0	223.3		
M19 (70+20+10)		35.0	70.0		80+20	595.5	148.9		

\* All of the materials given in this table have a kg/m<sup>3</sup> unit.

\*\* Slump figures for different SCM mixtures of cement from M1 to M18 with 1 % addition of PEG 400.

#### 4. Mechanical Properties of Blended SCC mix with M-Sand replacements

Within that blended mixture of self-curing concrete together along with SCMs, the mixing among all materials was controlled for a period of about two minutes. The amounts of polycarboxylate-type superplasticizer was adjusted with each suitable mix with Natural sand and Eco Sand replacement quantities to meet the optimum workability without any kind of segregation resistance over fresh condition. Using these compressive cubic moulds including split-tensile cylindrical moulds preceding the mixture of concrete with the replacement percentages of eco sand of 20 percent and 30 percent with natural sand based on previous literature review, different specimens were produced with accurate blending of Flyash and Ground Granulated Blast Furnace Slag in various proportions.

After the castings were poured with a very well consolidated mixture of self-curing concrete, the fresh concrete surface was levelled and the specimens were placed in the moulds for 24 hours or one day under laboratory conditions, whilst the mould surface was covered by plastic wrap and then the demoulded specimens were left at room temperature during experimental investigation.

Self Curing Concrete mixtures with their strength parameters blended with Supplementary Cementitious components in various proportions of different percentages of Class F Flyash and Ground Granulated Blast Furnace Slag of various mixed percentages of M0 (Conventional mix), M1 (Ecosand Mix) and M2 to M18 has been tabularized in Table no.4.

In accordance with Table 3, the cube and cylinder specimens of replacements of Eco sand with natural sand with 20% and 30% with respect to previous studies, are casted for 7 days and 28 days, curing traditional full curing and self-curing concrete samples held at a temperature shadow of  $300c \pm 30c$ . The specific curing was carried out till the corresponding concrete specimens was examined after 7 & 28 days for compressive and split tensile strength. Cubes with dimensions of 100 mm x 100 mm x 100 mm were formed. The experiment is having adequate time will be provided for 24 hours of hardening of concrete and then it should be cured for 28 days also the specimen should be loaded to its failure load after 7 days and 28 days in the compressive testing machine. Split tensile strength test was carried out through cylindrical samples of sizes 150 mm diameter and 300 mm height at the 7 days and 28 days curing employing compression testing machine.

It is an indirect measure to assess the cylindrical samples' tensile strength.

**Table 3.** Strength parameters of M30 grade Blended SCC for various ratios for Flyash & GGBFS with various replacement levels of natural sand and Eco sand

Mix (%)	Cement	Flyash	GGBFS	Sand %	River Sand	Eco sand	Compressive Strength (MPa)		Split Tensile Strength (MPa)	
							7 Days	28 Days	7 Days	28 Days
M0 (100)	350	--	--	100	744.3	--	10.24	34.49	1.89	5.14
M1 (100)	350	--	--	100	--	744.3	11.12	35.6	2.14	4.98
M2 (60+25+15)	227.5	87.5	35.0	70+30	520.0	223.3	11.29	36.9	2.19	5.23
M3 (60+15+25)		35.0	87.5	70+30	520.0	223.3	10.49	35.88	2.23	4.98
M4 (60+25+15)		87.5	35.0	80+20	595.5	148.9	11.55	36.7	2.34	5.14
M5 (60+15+25)		35.0	87.5	80+20	595.5	148.9	11.24	35.88	2.19	5.11
M6 (65+20+15)		70.0	52.5	70+30	520.0	223.3	10.66	33.4	1.98	4.68
M7 (65+15+20)		52.5	70.0	70+30	520.0	223.3	10.74	34.58	1.91	4.71
M8 (65+20+15)		70.0	52.5	80+20	595.5	148.9	11.49	35.48	2.01	4.5
M9 (65+15+20)		52.5	70.0	80+20	595.5	148.9	11.89	36.8	2.16	4.69
M10 (65+10+25)		87.5	35.0	70+30	520.0	223.3	11.29	37.4	2.49	4.7
M11 (65+25+10)		87.5	35.0	80+20	595.5	148.9	12.3	38.7	2.7	4.98
M12 (65+10+25)		87.5	35.0	70+30	520.0	223.3	11.4	38.49	2.38	4.88

M13 (60+20+20)		35.0	87.5	80+20	595.5	148.9	12.4	38.8	2.5	5.34
M14 (60+20+20)	210.0	70.0	70.0	70+30	520.0	223.3	10.4	34.2	2.11	5.12
M15 (70+10+20)		70.0	70.0	80+20	595.5	148.9	11.14	34.8	2.14	5.21
M16 (70+20+10)	245.0	35.0	70.0	70+30	520.0	223.3	12.33	37.8	2.22	5.01
M17 (70+10+20)		70.0	35	80+20	595.5	148.9	12.48	38.48	2.49	5.3
M18 (70+20+10)		35.0	70.0	70+30	520.0	223.3	11.49	35.8	2.44	5.29
M19 (70+20+10)		70.0	35	80+20	595.5	148.9	11.98	36.21	2.31	5.35

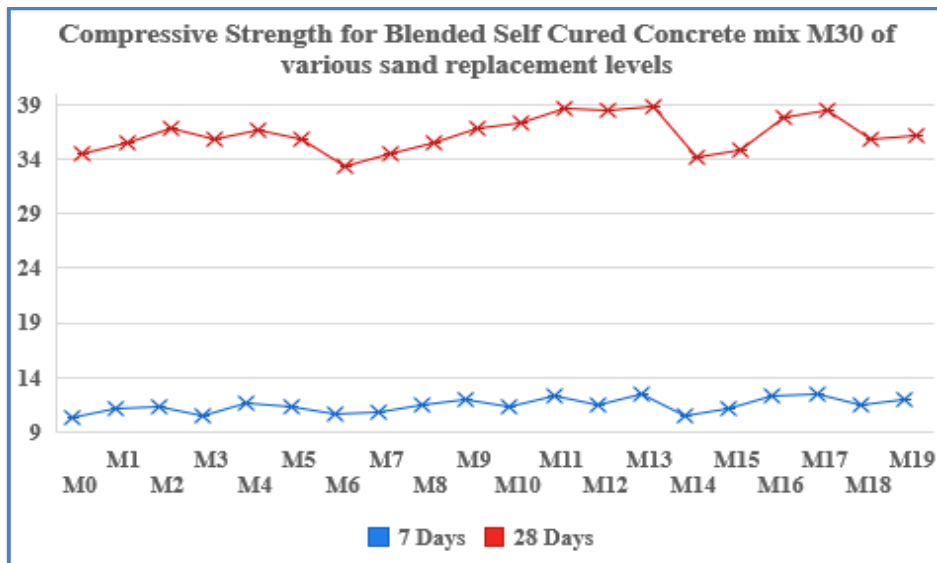


Fig 1. Compressive Strength of M30 grade Blended SCC for various ratios for Flyash & GGBFS with Eco sand replacement levels of 20% & 30 %

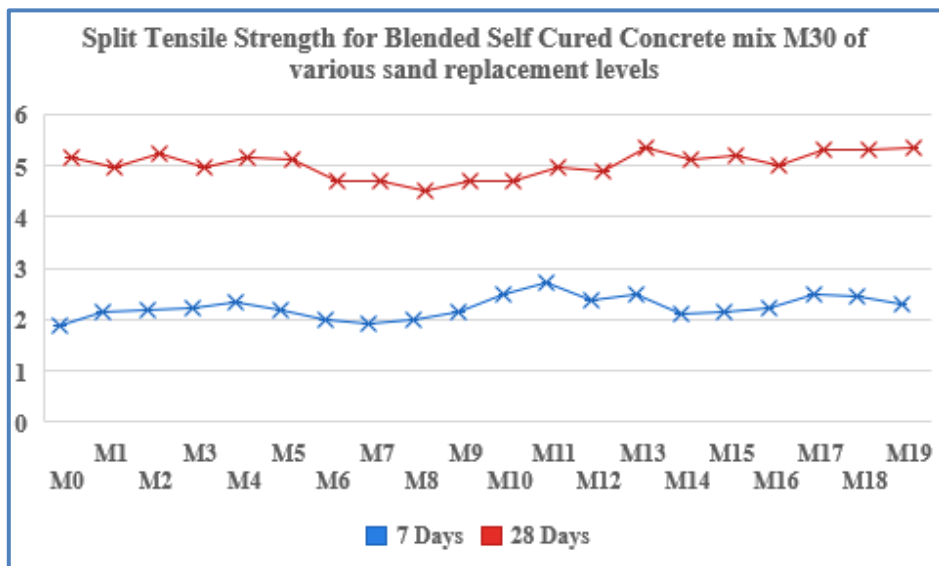


Fig 2. Split Tensile Strength of M30 grade Blended SCC for various ratios for Flyash & GGBFS with Eco sand replacement levels of 20% & 30 %

### 5. Results and Discussions

The mechanical properties like workability, compressive strength, split tensile strength and acid resistance which been improved with binary and ternary blended with the Flyash and GGBFS in the concrete mix of grade M30 with several mixes of River Sand with Eco Sand of 20% and 30 %

replacement. After this percentage of replacement, the mechanical properties having slight increase and decrease in the compressive strength parameters and very similar for eco sand to the naturally occurring river sand. Therefore, an optimum value of 1% of Polyethylene glycol based upon the workability is maintained throughout the blended mix and added to the mix.

In the slump test, a workable slump of 112 mm for natural sand and 123 mm for Polyethylene Glycol 400 for Eco sand was obtained for a water-cement ratio of 0.45, which is taken in mixed design in accordance with IS 10262:2009.

For all replacements of Flyash and GGBFS when eco sand from 20 % to 30 % have been incorporated such that there was an increase in mechanical properties in the strength parameter in mixes of M2 (60% OPC +25% FA+15% GGBFS with replacement of 70 % natural sand and 30 % eco sand having 36.9 MPa, M4 60% OPC +25% FA+15% GGBFS with replacement of 80 % natural sand and 20 % eco sand with 36.7 MPa, M8 65% OPC +15% FA+20% GGBFS with replacement of 80 % natural sand and 20 % eco sand with 35.48 MPa , M11 having the mix proportion of 65% OPC +15% FA+10% GGBFS with replacement of 80 % natural sand and 20 % eco sand with 38.7 MPa , , M12 with 65% OPC +10 % FA+25 % GGBFS with replacement of 70 % natural sand and 30 % eco sand with 38.49 MPa, M13 having blended mix of 60% OPC +20% FA+20% GGBFS with replacement of 70 % natural sand and 30 % eco sand having strength of 38.8 MPa and M17 with mix of 70% OPC +20% FA+10% with replacement of 80 % natural sand and 20 % eco sand having 38.48 MPa compressive strength respectively for their blended mix pattern as shown in fig 1.

The split tensile strength of mix around 15 to 20 % Flyash and GGBFS with eco sand was found to increase to a maximum of 10 % when compared to the control mix. While for the mixes M2 (60% OPC +25% FA+15% GGBFS with replacement of 70 % natural sand and 30 % eco sand, M4 60% OPC +25% FA+15% GGBFS with replacement of 80 % natural sand and 20 % eco sand, M8 65% OPC +15% FA+20% GGBFS with replacement of 80 % natural sand and 20 % eco sand with 35.48 MPa , M13 having the mix proportion of 60 % OPC +20 % FA+20 % GGBFS with replacement of 80 % natural sand and 20 % eco sand, , M15 with 70 % OPC +10 % FA+20 % GGBFS with replacement of 70 % natural sand and 30 % eco sand, M17 with mix of 70% OPC +20% FA+10% with replacement of 80 % natural sand and 20 % eco sand and at last with M19 with mix of 70% OPC +15 % FA+15 % GGBFS with replacement of 80 % natural sand and 20 % eco sand, shown in fig 2, incorporating with Eco sand increase in tensile strength by varying GGBFS percentages from 15% to 25 % and decrease in split tensile strength at the age of 28 days have been noticed down from mixes ranging from M6 to M10.

## 6. Conclusions

Based on the results obtained from this experimental work for blended self cured concrete with M30 mix incorporated with Eco Sand with replacements with Natural sand, the following conclusions have been drawn:

It is found that there is a reduction in workability characteristics as the percentage substitute of natural sand by 20 % and 30 % of Eco sand, which have been is enhanced with a PEG 400 as 1 %. The shape and surface texture of eco sand, that imparts more internal friction having slight reduction the flow characteristics of concrete, are the factors for reducing workability.

The use of eco sand rather than natural river sand doesn't always affect the compressive strength of concrete throughout this experimental analysis. The replacement of cement with high volume fly ash approximately 10 to 25 percent raises the compressive strength marginally, while the rise in fly ash volume steadily reduces the compressive strength and breaks the tensile strength. Whereas the blending of GGBFS provides the initial early strength and increased workability of M30 grade self cured mix with PEG 400 as 1% ranging percentage varies from 10 % to 20 % of blended mix.

In this experimental analysis, it is noted that the use of Eco sand rather than River sand doesn't really affect the compressive strength of the composite substitution concrete with high volume



fly ash approximately 10 percent, marginally increasing the compressive strength, and the rise in fly ash volume will decrease gradually the compressive strength.

GGBFS provides greater improvement in the compressive strength while increasing the variation from 15 % to 25 %. Moreover, with the blended mix of 20 % of Ground Granulated Blast Furnace Slag provides greater strength in all the mixes of Self Cured Concrete, which did not affect the other parameters of concrete strength.

The blended concrete mixture of 12% to 20 % of Class F Flyash with eco sand have achieved an appropriate increase in compressive strength when compared to control concrete mix at the age of 28 days, when compared to river sand, there is no significant difference in dry shrinkage in concrete made with eco sand.

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- [23] BS: 5075- 3:1985," Concrete admixtures. Specification for super plasticizing admixtures"
- [24] IS 516:1959 Reaffirmed in 2004,"Methods of tests for strength of concrete" (New Delhi, India: Bureau of Indian standards).