Published by :
http://www.ijert.org

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

Green Concrete: Recycled Aggregate and Partial Replacement of Cement with Fly Ash

Vipin Mahadeven[1], Abhishek Kumar Verma[2]
[1]Assistant Professor,
[2]Student, Civil Engg. Dept. Rajkiya Engineering College
Azamgarh, Uttar Pradesh, India

Deepak Patel[1], Raj Singh[2], Peeyush Gond[3]
[1]Student, Civil Engg.
Dept. Rajkiya Engineering College
Azamgarh, Uttar Pradesh, India

***Abstract*— The current scenario deals with the rapidly growing and emerging technology in the construction industry. The most important construction material for the construction work in the construction industry is concrete. Now a days, due to the over exploitation our natural resources of conventional material of the concrete, there is scarcity and increase in price of the conventional materials. Annually billions of tons of conventional material mined which results in the environmental pollution and huge emission of carbon dioxide [2]. The solution of various problem such as environmental pollution, scarcity of concrete material and reduction of carbon footprint is Green Concrete. The use of recycled concrete aggregate and fly ash in the green concrete reduces the adverse effect of environmental pollution and material scarcity. The use of recycled aggregate will solve the problem of construction and demolition waste disposal. Fly ash, a waste generated by thermal power plants is as such a big environmental concern. The investigation reported in this paper is carried out to study the utilization of fly ash in cement concrete as a partial replacement of cement as well as an additive so as to provide an environmentally consistent way of its disposal and reuse and compare their strength parameter [4]. The aim of this research project is to determine the strength characteristic of recycled coarse aggregate concrete by using different percentage (0%, 5%, 10%, 15% & 20%) of fly ash in M45 Grade.**

Keywords*— Green Concrete, Recycled Concrete Aggregate, Eco-Friendly, Fly Ash, Compressive Stength, Split Tensile Strength, Flexural Strength Conventional Aggregate.

INTRODUCTION

Green concrete can be defined as the concrete with material as a partial or complete replacement for cement or fine or coarse aggregates. The substitution material can be of waste or residual product in the manufacturing process. This revolutionary topic of Green Concrete was first introduced by Dr. WG, from Denmark in 1998,[5] who diverted world's attention towards the use of recycled and by-product of industries in the construction industry. Now a days, the biggest problem is the disposal of construction and demolition waste in the construction industry. In India, annually millions tons of demolition waste generated, vast area of land converted into the dumping yard of these waste.

The use of green concrete will utilize the waste and by-products of such industries. The main ingredient of green concrete are recycled aggregate, which is replacing the conventional aggregate, recycled sand which is replacing the natural sand and the use of pozzolanic materials for the replacement of the cement [3]. The present study outlines literature related to green concrete manufactured from some industrial wastes such as fly ash, silica fume, slag modified, glass modified, rubber modified and recycled aggregate concrete. Cement is the main binding material in concrete. Over the past 3 decades, the production of cement has grown rapidly all over the world. The cement production in India is expected to grow three-folds by 2050, as can be seen in Figure 1 (WBCSD-IEA 2006) [2].

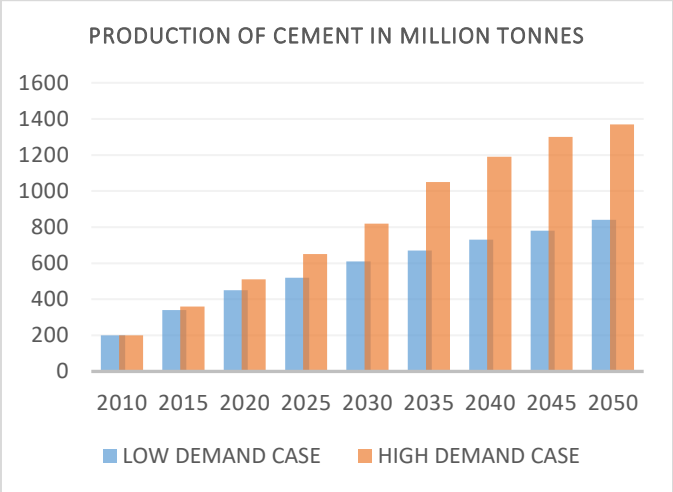

Figure 1 Estimated cement production (WBCSD-IEA 2006)

During the manufacturing of cement, in calcination process of calcium carbonate, large amount of fuel consumed to maintain the temperature of 1000 degree centigrade. In the production of 1 kg cement, 900 gms of carbon dioxide emission in the atmosphere [3]. To reduce the harmful effect of CO_2 the consumption of cement has to be reduced by using pozzolanic materials. Fly ash is very much similar to volcanic ashes used in production of the earliest known hydraulic cements about 2,300 years ago[1]. Those cements were made near the small Italian town of Pozzuoli - which later gave its name to the term "pozzolan". A pozzolan is a siliceous or siliceous / aluminous material which when mixed with lime and water forms a cementitious compound [8]. Fly ash is the best known, and one of the most commonly used, pozzolans in the world. Fly ash is the notorious waste product of coal based electricity generating thermal power plants, known for its ill effects on agricultural land, surface and sub-surface water pollution, soil and air pollution and diseases to mankind.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

MATERIAL USED

A. CEMENT

Cement is the main ingredient of concrete, having the binding properties, which binds the aggregate and sand in presence of water. Various tests conducted on them such as initial setting time final setting time soundness test fineness test etc. give below:

Table 1: Physical Properties of Cement [9]

S. No.	Physical Properties of PPC 43 Grade	Observed Result	As Per IS 1489 (Part 1)1991
1	Specific Gravity	3.13	3.15
2	Initial Setting Time	45 min	>30 min
3	Final Setting Time	445 min	<600 min
4	Fineness Test (Sieve Method)	3%	5%

B. COARSE AGGREGATE

Nominal Size Aggregate: 20 mm and Shape: Angular

The coarse aggregate used in this study are of two different type: 1- Conventional Coarse Aggregate & 2- Recycled Concrete Aggregate. The conventional aggregate are the natural fresh coarse aggregate which is used in the concrete. It has the better durability less water absorption and good binding properties. Due to the scarcity of conventional aggregate, recycled aggregate are used. The recycled concrete aggregates are the aggregates which are extracted from the construction and demolition waste. The properties of recycled aggregates differ for washed and unwashed condition of recycled aggregates. Various test are performed to determine the physical properties of aggregate. The physical properties of coarse aggregates are as following:

Table 2: Properties of Coarse Aggregate[8]

S. No.	Physical Properties of Coarse Aggregate	Conventional Aggregate	Washed Recycled Aggregate	Unwashed Recycled Aggregate
1	Specific Gravity	2.71	2.67	2.62
2	Water Absorption	0.9%	1.32%	1.22%
3	Apparent Specific Gravity	2.75	2.73	2.70
4	Flakiness Index	2.78%	1.53%	1.27%
5	Elongation Index	20.67%	18.56%	17.56%

C. SAND

The natural sand deposited by rivers are used as the fine aggregate. The fine aggregate is used to fill the voids between coarse aggregate and provide more surface area for binding of cement. Various tests are performed to determine the physical properties of fine aggregates are as following:

Table 3: Physical Properties of Sand [8]

S. No.	Physical Properties of Sand	Observed Value
1	Specific Gravity	2.69
2	Apparent Specific Gravity	2.78
3	Water Absorption	1.49%
4	Surface Moisture	NIL
5	Zone { conforming IS 383: 1989}	2
6	Fineness Modulus	2.47

D. WATER

Water used in for the purpose to cause the hydration of cement. The water in excess of that required for hydration acts as a lubricant between coarse and fine aggregate and produces a workable and economical concrete. It is very important ingredient so look into very carefully as excess will result in loss of strength.

E. FLY ASH

Fly ash is the residue from the combustion of pulverised coal collected by mechanical or electrostatic separators from the flue gases or power plant. The physical properties of fly ash have a greater influence on the performance of fresh concrete such as workability, bleeding, segregation etc. The fineness of fly ash influences pozzolanic activity and workability of concrete. [6]

Table 4: Physical Properties of Fly Ash as per BIS [10]

SN.	**Characteristics**	**Requirements (Siliceous and Calcareous Fly ash)**
1	Fineness- Specific surface in m2/kg, (Min.)	320
2	Particle retained- on 45-micron IS sieve in % (Max.)	34
3	Lime reactivity- in N/mm2, (Min.)	4.5
4	Compressive strength-at 28 days in N/mm2, (Min.)	Not less than 80% of the strength of plain cement mortar cubes
5	Soundness by auto clave test- Expansion in % (Max.)	0.8

Various test performed for the physical proerties of fly ash are as following:

Table 5: Experimental Physical Properties of fly ash [11]

S. No	Physical Properties Of Fly Ash	Observed Value
1	Specific gravity	2.2
2	Fineness sieve method	10%
3	Consistency	30%

Fly ash is a fine particulate material with the main chemical constituents being SiO_2, Al_2O_3, Fe_2O_3 and CaO. These chemicals are responsible for its pozzolanic activity. The general variation in three principal constituents will be as follows: SiO_2 (25-60%), Al_2O_3 (10-30%) and Fe_2O_3 (5-25%). The chemical properties of fly ash as per the BIS is given in the Table 6. [10]

Table 6: Chemical Properties of Fly Ash as per BIS

SN	Characteristics	Requirements	
		Siliceous Fly Ash	Calcareous Fly Ash
1	SiO2+Al2O3+Fe2O3 (% by mass, Min.)	70	50
2	SiO2 (% by mass, Min.)	35	25
3	Reactive silica (% by mass, Min.)	20	20
4	MgO (% by mass, Max.)	5	5
5	SO3 (% by mass, Max.)	3	3
6	Na2O (% by mass, Max.)	1.5	1.5
7	Total Chlorides (% by mass, Max.)	0.05	0.05
8	Loss on Ignition (% by mass, Max.)	5	5

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

F. ADMIXTURE[12]

The admixture use to increase the workability of concrete i.e. superplasticizer. It is the chemical admixture used to produce the high workability concrete requiring little or no vibration during placing. "CONPLAST SP430 G8" used in our study. The properties of CONPLAST SP430 G8 are as following:

Table 7: Properties of Admixture: CONPLAST SP430 G8

S. No.	Properties of Admixture	Standard Value of Product
1	Specific gravity	1.24-1.26
2	Chloride content	Nil to is:456
3	Air entrainment	1%
4	Dosages	2% of wt. of Cementitious Material

MIX PROPORTION

To achieve the target strength of M30, the mix design is conducted as per the IS10262: 2009. [13] The target strength of M30 at the age of 28 days is 38.25 MPa. The mechanical mixer (drum type) are used to mix the concrete. The mixing time is 5min. The slump value is recorded and mentioned in table 9.

The mix proportion for concrete with conventional aggregate and 0% fly ash designated as CAC0, concrete with recycled aggregate and 0% fly ash designated as RAC0, concrete with recycled aggregate and 5% fly ash designated as RAC5, concrete with recycled aggregate and 10% fly ash designated as RAC10, concrete with recycled aggregate and 15% fly ash designated as RAC15 and concrete with recycled aggregate and 20% fly ash designated as RAC20.The mix proportion for M30 are as following for 1 cubic meter concrete as following:

Table 8: Mix Proportion for M30

Designation	Cement (kg/m^3)	Fly Ash (kg/m^3)	CA (kg/m^3)	FA (kg/m^3)	WATER (lit/m^3)	Superplasticizer (lit/m^3)	w/c ratio
CAC0	385	0	1285.40	723.03	140	7.7	0.364
RAC0	385	0	1286.50	724.83	140	7.7	0.364
RAC5	365.75	19.25	1283.78	721.56	140	7.7	0.364
RAC10	346.50	38.50	1280.13	720.08	140	7.7	0.364
RAC15	327.25	57.75	1276.62	718.10	140	7.7	0.364
RAC20	308.00	77.00	1271.36	715.14	140	7.7	0.364

RESULT

A. SLUMP TEST [14]

The slump test is performed to measure the workability of the concrete mix designed. Theoretically, the slump value of the mix design is 100 mm, but practically the slump value is less than 100. The reason of not getting the slump of 100 mm environmental condition which affect the moisture content of aggregates (coarse and fine both). The slump value of different are as following:

Table 9: Slump Value of Different Mix (in mm)

S. No	Designation	Slump Value (mm)
1	CAC0	65
2	RAC0	60
3	RAC5	45
4	RAC10	40
5	RAC15	28
6	RAC20	10

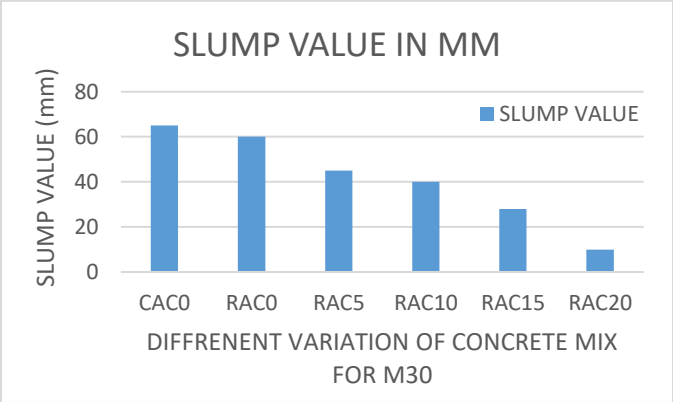

Figure 2: Observed slump value of different mix proportion during our study

During study, it is found that as the percentage of fly ash increase the slump value of concrete mix decreases. Hence it can be concluded that the workability of concrete decrease as the percentage of fly ash increases in the concrete mix.

B. COMPRESSION TEST OF CONCRETE CUBE

The compressive strength test is the test to determine the compressive strength. This test consist of set of 3 cube of dimension 150x150x150 mm at the age of 7 and 28 days. Theoretically, it is desirable to obtain the target compressive strength at the end of 28 days by using the following formula:[16]

Target compressive strength fck' = fck+ 1.65 * s

where, fck': target characteristic strength

fck: characteristic strength of concrete mix

s: standard deviation

for M30: **fck'= 30 + 1.65 * 5= 38.25 MPa.**

Hence, the target strength for M30 is 38.25 MPa.

Compression test result of cube specimen performed on the compression testing machine after 7 days and 28 days tabulated in table 10.

Table 10: Average Compressive Strength (MPa)

S. No	Average Compressive Strength (MPa)		
	Designation	7 Days	28 Days
1	CAC0	26.78	40.18
2	RAC0	23.80	35.70
3	RAC5	23.37	35.06
4	RAC10	23.11	34.67
5	RAC15	24.89	37.33
6	RAC20	23.56	35.35

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

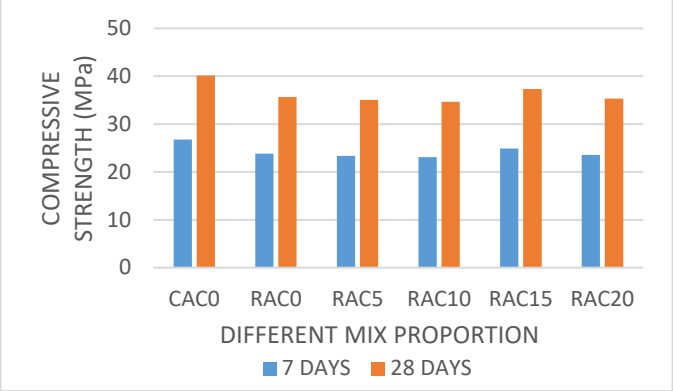

Figure 3: Average compressive strength of different mix proportion

The study shows that initially the compressive strength of concrete cube increases with increase in the percentage of fly ash till 15 % i.e RAC5, RAC10 & RAC15 mix of concrete, but on further addition of fly ash beyond 15 %, the compressive strength of concrete cube started decreasing can be clearly seen in RAC15 mix has greater strength than the RAC20 mix. While comparing the CAC0 and RAC0, compressive strength of conventional aggregate is greater than recycled aggregate concrete. The study suggests that up to 15% to 20 % of cement can be replaced by the fly ash. In this way the waste from thermal power plants also utilized and the consumption of cement also be reduced which in chain result in the reduction in CO_2 emission during manufacturing of cement.

C. SPLIT TENSILE STRENGTH[17]

The split tensile strength test is the indirect method of determine the tensile strength of concrete specimen in such a way that the specimen fails due to induced tensile stresses in the specimen. The result of the split tensile strength test for various composition are as following:

Table 11: Average Split Tensile Strength (MPa)

S.No.	Split Tensile Strength MPa	
	Designation	*28 Days*
1	CAC0	2.76
2	RAC0	2.69
3	RAC5	2.56
4	RAC10	2.67
5	RAC15	2.75
6	RAC20	2.69

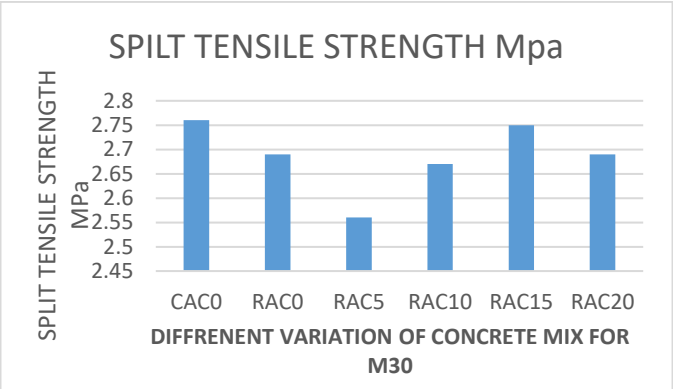

Figure 4: Average spilt tensile strength of different mix proportion

The test result shows that split tensile strength of various concrete mix is near about the 10% of the compressive strength of M30 mix. It is found that the as the percentage of fly ash increase the split tensile strength increases initially up to 15% i.e. for RAC5, RAC10 & RAC15 mix of concrete, but on further increasing the percentage of fly ash beyond 15%, the split tensile strength decrease can be seen in mix RAC15 greater split tensile strength than RAC20. While comparing the CAC0 and RAC0, tensile strength of conventional concrete is greater than that of recycled aggregate concrete. But the strength of recycled aggregate concrete is sufficient to use as concrete.

D. FLEXURAL STRENGTH TEST[16]

The flexural strength test is the test to determine the flexural strength of concrete in such a way that applied flexural strength which result in the failure of specimen on flexural testing machine. The test specimen beam dimension 150x150x700 mm. This is an indirect test assessing the tensile strength of concrete. The result of flexural strength test of the various mix proportion are as following:

Table 12: Average Flexural Strength (MPa)

S. No.	FLEXURAL STRENGTH (MPa)	
	Designation	*28 Days Aged*
1	CAC0	69.40
2	RAC0	67.45
3	RAC5	64.22
4	RAC10	65.62
5	RAC15	67.90
6	RAC20	65.78

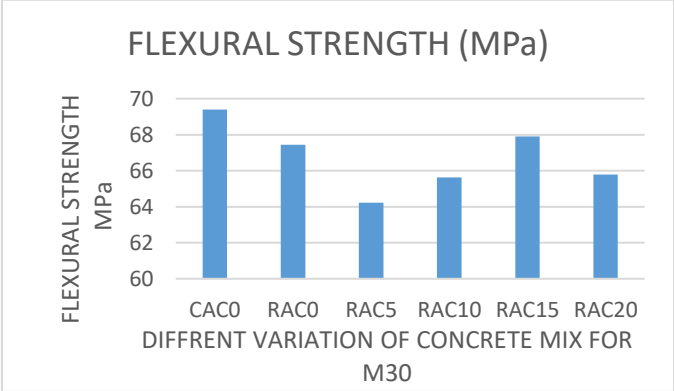

Figure 5: Average flexural strength of different concrete mix proportion of M30

The test result shows that as the percentage of fly ash increase the flexural strength increases initially up to 15% i.e. for RAC5, RAC10 & RAC15 mix of concrete, but on further increasing the percentage of fly ash beyond 15%, the flexural strength decrease can be seen in mix RAC15 greater flexural strength than RAC20. While comparing the CAC0 and RAC0, flexural strength of conventional concrete is greater than that of recycled aggregate concrete. But the strength of recycled aggregate concrete is sufficient to use as concrete.

CONCLUSION

A comparative study of strength parameter and physical parameters of green concrete which is composed of recycled aggregates and partial replacement of cement with fly ash conducted in this study. The following conclusion are drawn from the studies are as following:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 8 Issue 04, April-2019

- Physical parameter of recycled aggregates (washed and unwashed) and conventional aggregates like Water Absorption, Specific Gravity, Flakiness And Elongation Index of coarse aggregates are compared. It is found in the study that physical parameter of washed recycled aggregates better than that unwashed recycled aggregates shown in table 2. But as we compare the recycled aggregates with conventional aggregates then it is found that the properties of conventional aggregates are found better.
- It is found in the study that the workability of concrete decrease as the percentage of fly ash replacement increases, it can be clearly seen in the table 9. In order to maintain the proper workable concrete, chemical admixture required. For the proper compaction of concrete mechanical machine required at such a workability like slump value of 10mm in RAC20 mix.

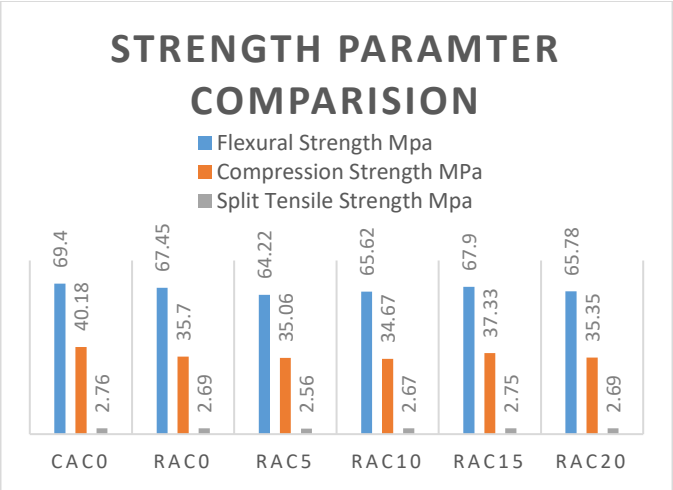

Figure 6: Strength Parameter comparison of different concrete mix proportion of M30

- After observing the strength parameter of various mix proportion of concrete, which is composed of recycled aggregates with fly ash as the replacement of cement in the variation of 0%, 5%, 10%, 15%, 20% and compared them with the conventional concrete. In the comparison it is found that the strength of conventional aggregates without addition of fly ash i.e. CAC0, is maximum at the age of 28 days. But the strength of recycled aggregates concrete with fly ash is sufficient enough to use, the target strength is differ more or less as compare to target strength of M30 i.e. 38.25.
- After comparing the strength parameter of recycled aggregate concrete mix proportion of different variation of fly ash i.e. 0%, 5%, 10%, 15%, 20%, it is found that concrete mix with 15% replacement of fly ash i.e. RAC15 has the maximum strength in recycled aggregates concrete shown in table 10,11and 12.

This research work can be extended in future with different pozzolanic material and higher grade concrete.

REFERENCES

[1] Manik Goyal and Harish Kumar, " Green Concrete: A Literature Review", Special Issue - 2018 ISSN: 2278-0181, International Journal of Engineering Research & Technology (IJERT).
[2] Amarpreet Kaur, " The Effect of Properties of Flyash on Strength and Microstrructre Develpoment of Mortars" Department Of Civil Engineering ,Indian Institute Of Technology Delhi, May 2016.
[3] Abhijeet Baikerikar, " a revier on green concrete" Nov 2014 (Volume 1 Issue 6) JETIR (ISSN-2349-5162) Journal of Emerging Technologies and Innovative Research (JETIR)
[4] Utility Bonanza from dust, fly ash, published in parisara envis newsletter by Depoartment Of Forests Ecology Abd Environment, Government Of Karabataka, 2:2007 p6
[5] Roushan Kumar, Deepak Kumar, and Sahil Hussain, "green concrete", (ICETETSM-17) ISBN: 978-93-86171-38-2, International conference on Emerging Trends in Engineering, Technology, Science and Management.
[6] Dr S L Patil, J N Kale and S Suman, "Fly Ash Concrete: A Technical Analysis For Compressive Strength", International Journal of Advanced Engineering Research and Studies E-ISSN2249–8974
[7] Diamond, S. (1984). "The utilization of fly ash," Cement and Concrete Research 14, 455-462.
[8] IS 2386-3 (1963) Methods for test for aggregartes for concrtete, part 3.
[9] IS 1489 (Part 1) 1991 Specification for Portland Pozzolana Cement , Part 1: fly ash based (cement and concrete)
[10] IS 3812-Specification for fly ash for use as pozzolona and admixture, Part-I (2003), Part-II (2003)
[11] IS 1727-Methods of test for pozzolanic materials.(Reconfirmed 2004)
[12] IS 9103: 1999 Specification For Concrete Admixture (BIS)
[13] IS 10262: 2009 : Guidelines For Concrete Mix Design Proportioning (BIS)
[14] IS 7320 (1974) : Specification for Concrete Slump Test Apparatus(BIS)
[15] IS 516 (1959) : Method of Tests for Strength of Concrete (BIS)
[16] IS 456:2000 Specifications for plain and reinforced concrete.(BIS)
[17] IS 5816 (1999) : Methods of Test Spliting Tensile Strength of Concrete for Cylindrical Specimen (BIS)