A COMPARATIVE STUDY ON DURABILITY AND PROPERTIES OF LIGHT WEIGHT CONCRETE

RASHMIYA R[1], PRAVEENRAJ M[2], VENNILA R[3], ARIVAZHAGN R[4], MAGESHWARI R[5]

[1]Assistant Professor of Civil Engineering
[2,3,4,5] under graduate final year Civil Engineering students
Sembodai Rukmani Varatharajan Engineering College, Sembodai-614 809,
Vedaraniyam (Tk), Nagapattinam (Dt).

---***---

Abstract- *Light Weight Concrete is not a new invention of concrete world.it has been known since ancient times. It is made by replace of fly ash and natural aggregates like volcanic origin, saw dust. LWC has light weight and has high durability and mechanical properties. In this concrete has high strength and effectively low density. We are using 53 grade of cement and 10 mm size aggregates. The mix ratio of LWC is M_{25} grade. The production of this concrete partially replacement of fly ash in cement and partially replace of saw dust in fine aggregate. This paper briefly presents the compressive strength development of fly ash and saw dust concrete at different ages. The split tensile strength and flexural strength of all the concrete mixes were also investigated at different days of curing.*

Key Words: **LWC - Lightweight concrete, FASD - Fly ash and Saw Dust, Fly ash; coarse aggregates ,compressive strength, split tensile strength , flexural strength.**

1.INTRODUCTION

Concrete is most important construction materials. Concrete is a material used in building construction, consisting of a hard, chemically inert particulate substance, known as an aggregate that is bonded together by cement and water. In upcoming years there has been an increasing worldwide demand for the construction of buildings, roads and an airfield which has mitigate the raw material in concrete like aggregate. Light Weight Concrete has a surprisingly long history and was first patented in 1923, mainly for use as an insulation material. Although there is evidence that the Romans used air entertainers to decrease density, this was not really a true Light weight concrete. Significant improvements over the past 20 years in production equipment and better quality surfactants (foaming agents) has enabled the use of foamed concrete on a larger scale. Compressive strengths range from up to 40 MPa down to almost zero for the really low densities. Generally it has more than excellent thermal and sound insulating properties, a good fire rating, is non-combustible and features cost savings through construction speed and ease of handling. The other main specialties of lightweight concrete are its low density and thermal conductivity. So its advantages are that there is a reduction of dead load, faster building rates in construction and lower transport and handling costs. Light Weight Concrete maintains its large voids and not forming laitance layers or cement films when placed on the wall. Sufficient water cement ratio is vital to produce adequate cohesion between cement and water. Insufficient water can cause lack of cohesion between particles, thus loss in strength of concrete.

2. LITERATURE REVIEW

Manish Awana and Chandan Kumar (2017), has studied a Cellular Lightweight Concrete. In this paper, parametric experimental study for producing CLWC using fly ash is presented. The performance of cellular lightweight concrete in term of density and compressive strength are investigated. From the result, it can be seen that compressive strength for cellular light weight concrete is low for lower density mixture.. Sieve IS 2.36 mm, The specific gravity 2.65.The coarse aggregate with maximum size of 10mm having the specific gravity value of 2.68.Sieve IS 2.36 mm, The specific gravity 2.65 Normal concrete has a density of 2,400 kg/m^3 while densities range from 1,800, 1,700, 1,600 down to 300 kg/m^3.To compare the conventional concrete and light weight aggregate concrete using mix M_{30} with poly carboxyl ether admixture. Light Weight Concrete is made by Partial replacement of Coarse Aggregate with different ratios of fly ash ranging from 20%, 50%, 80% and 100%. This project is focused to determine the compression strength and split tensile strength parameters of light weight aggregate concrete to find the favorable replacement with the above mentioned replacements.

2.1 Experimental Study:-

Materials Properties:

Properties of fly ash Specific gravity 2.27 53 Grade Ordinary Portland cement. The specific gravity of Cement was 3.14. The initial and final setting times were found as 27 minutes and 512 minutes respectively. Standard consistency of cement was 41.12%. *IS: 383 – 1970,* Specification for Coarse and Fine Aggregates from Natural Sources for Concrete. Methods of Test for Aggregates for Concrete. Local River sand confirming to Grading Zone-II of IS: 383-1970 Fly ash Fine aggregate (FAFA) obtained from cement fly ash proportions 20:80 and 25:75.Hard Broken Granite stone (HBG) confirming to graded aggregate of size 10mm as per IS: 383-19790.Fly ash and saw dust aggregate (FASDA) obtained from cement fly ash proportions 21:65 and 26:25. Fresh water was used for mixing process and curing.

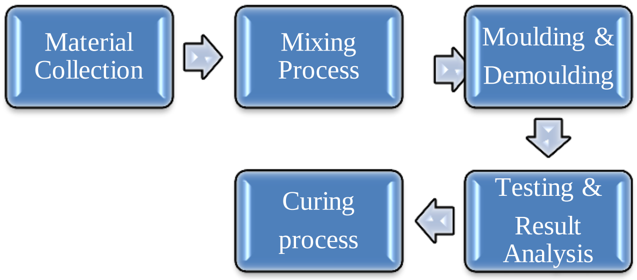


Fig 1 working procedure of this study

2.2- Material used:

- *Cement*
- *Fly ash*
- *Saw dust*
- *Fine aggregate*
- *Coarse aggregate (10 mm).*

Properties of saw dust:

Table-2.1: Chemical composition of saw dust

Saw Dust Oxide	Percentage (by weight)
SiO_2	68.30
Al_2O_3	3.5
Fe_2O_3	2.23
MgO	5.4
CaO	5.0

Properties of cement:

Table 2.2: Approximate Oxide Composition Limits of Ordinary Portland cement.

Oxide	Per cent content
CaO	60–67
SiO_2	17–25
Al_2O_3	3.0–8.0
Fe_2O_3	0.5–6.0
MgO	0.1–4.0
Alkalies (K_2O, Na_2O)	0.4–1.3
SO_3	1.3 – 3.0

Properties of fly ash:

Table-2.3: Chemical composition of fly ash

Compounds (%)	Fly Ash
SiO_2	38-63
Al_2O_3	27-44
TiO_2	0.4-1.8
Fe_2O_3	3.3-6.4
MnO	b.d-0.5
MgO	0.01-0.5
CaO	0.2-8
K_2O	0.04-0.9
Na_2O	0.07-0.43
LOI	0.2-5.0
pH	6-8

Material specifications:

Table 2.4: Materials specification

Materials	Specifications
Cement	53grade of ordinary Portland cement
Fine aggregate	Sieve IS 2.36 mm,The specific gravity 2.65
Coarse aggregate	The coarse aggregate with maximum size of 10mm having the specific gravity value of 2.68
Fly ash	Passing through 90 micron sieve
Saw dust	Sieve IS 2.36 mm, The specific gravity 2.65
Water	Fresh water was used for mixing process and curing

2.3-Physical properties of materials:-

Table-2: materials specification

1	Properties of cement Specific gravity Initial setting time	3.15 & 35-45 minutes
2	Properties of fly ash Specific gravity	2.27
3	Property of fine aggregates Specific gravity	2.68

2.4 Collection of Materials:-

Cement- The cement used in this experimental works is Portland cement 53 Grade Ordinary Portland cement. All properties of Cement are tested by referring IS12269-1987 Specification for 53 Grade Ordinary Portland cement. The specific gravity of Cement was 3.14.

Fly Ash- Fly ash is a by-product of the combustion of pulverized coal in thermal power plants. The fly ash from boilers at some older plants, where mechanical collectors alone are employed, is coarser than from plants using electrostatic precipitators.

Saw dust- In this is a natural material, it is from the waste of wooded works. Thus the material is has low specific gravity and has low binding property. It has only one thing of water store capacity so the concrete is well durability.

Coarse aggregate- Crush granite 10 mm size to 4.75 mm aggregate taken and used and the specific gravity value of 2.67 and fineness modulus of 6.21 were used as a coarse aggregate. The loose and compacted Bulk Density values of coarse aggregate are 1501 kg/m^3 respectively, the water absorption is 0.15%.

Table- 3: Material Mixing Proportions

content	Wt of cement (kg)	Wt of fly ash (kg)	Wt of saw dust (kg)	Wt of aggregates (kg)
0%	5.700	-	-	10.27
30% fly ash and 10 % saw dust	4.000	1.700	1.710	10.27
40% fly ash and 10 % saw dust	3.480	2.340	1.710	10.27

Mixing process:

At first beginning replace of fly ash in cement and mix with less water. And adding of coarse aggregate with thus mixtures. (Mix a slurry concrete).Mixture of concrete is ready and makes a cube for testing of mechanical and durability of concrete. Different water cement ratio are used and finally we choose the high value and the mix proportions to apply the procedure in field.

Moulding:

The mixing of fresh concrete is then filled into the cubes. The moulds are cleaned and applied oil on both sides of mould.

Then the fresh LWC is filled and compacted correctly. The concrete evenly distributed on mould and the top of the surface is cleaned and evenly maintained. Cubes and cylinders are making same procedure.

De-Moulding:

Moulded concrete cubes and cylinders are de-moulded to next stage of curing. Easily de-moulded the cubes and cylinders with the help of spanners.

Curing Process:

De-moulded LWC cubes and cylinders are allowed to curing process. The cubes and cylinders are immersed into the water for 7 days, 14 days and 28 days. The concrete cubes are absorbing the water and increasing strength by itself.

Advantages of LWC:

- ✓ Rapid and relatively simple construction
- ✓ Economical in terms of transportation as well as reduction in manpower
- ✓ Significant reduction of overall weight results in saving structural frames, footing or piles.
- ✓ Most of lightweight concrete have better nailing and sawing properties than heavier and stronger conventional concrete

Disadvantages of LWC:

- ✓ In the mixtures very sensitive with water content, Difficult to place and finish because of the porosity and angularity of the aggregate. In some mixes the cement mortar may separate the aggregate and float towards the surface.
- ✓ Mixing time is longer than conventional concrete to assure proper mixing.

2.5-Details of Specimens:

The experimental program consists of casting and testing of 25 (150 mm × 150 mm × 150 mm) cubes for determining compressive strength (fcu), 25 cylinders (100 mm × 300 mm) for determining indirect tensile strength (fct).

The specimens classify into 5 groups, each group contains 3 cubs, 3 cylinders. The first group is planned to study the compressive, indirect tensile and flexural strength. Groups used to study the same parameters as group one, but with 10% saw dust as partial replacement, in concrete mix instead of natural aggregate. Groups three and four, in contrast, are used to study the same parameters, but with 30% and 40% fly ash as partial replacement, in concrete mix instead of natural aggregate respectively. Adding 30% and 40% fly ash are used to study the same parameter but with 10% saw dust as partial replacement, in concrete mix instead of natural aggregate respectively.

2.6 Material for 1 M³

content	Cement (kg/m³)	Fly ash	FA (kg/m³)	Saw dust	CA
Replace 30% Fly ash and 10% Saw dust	412	176	518.4	57.6	1027
Replace 40% Fly ash and 10% Saw dust	353	225	518.4	57.6	1027
Replace only 30% Fly ash.	412	176	576	-	1027
Replace only 10% Saw dust	588	-	518.4	57.6	1027

2.6-Application of Light Weight Concrete

Light Weight Concrete is ideal for roof deck repairs, stair pan fill, elevated floor slabs or overlays on existing floor decks. It can also be used for appliance platforms, curbs, down spout gutters, balconies, floors, fish ponds, walls, setting posts, castings, steps, or virtually any job that would normally be done with standard weight concrete. Use it where ease in lifting and carrying is important.

Lightweight Concrete also offers slower temperature transfer rates than standard weight concrete, resulting in improved insulation factors. Nowadays with the advancement of technology, lightweight concrete expands its uses, for example, in the form of perlite with its outstanding insulating characteristics.

It is widely used as loose-fill insulation in masonry construction where it enhances fire ratings, reduces noise transmission, does not rot and termite resistant. It is also used for vessels, roof decks and other applications.

3. ANALYSE AND TEST RESULTS

3.1 Testing Process:-

Preparation of fresh concrete should find out the consistency by slump test of concrete to check workability of concrete by compaction factor test. After removing of moulds concrete cubes and cylinders are tested in laboratory compressive strength and flexural strength should find out in compressive testing machine.

3.3 Setting time and consistency:

Table-5: setting time of LWC

Content	Wt of cement (grams)	Wt of fly ash (grams)	Wt of saw dust (grams)	Initial setting time (minutes)
0%	5700	-	-	35
30% fly ash and 10 % saw dust	4000	1700	1710	40
40% fly ash and 10 % saw dust	3480	2340	1710	55

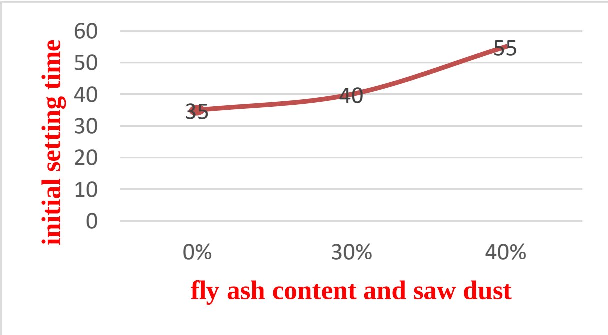


Chart No-1: setting time of fresh LWC

Thus the result it can see that as amount of fly ash increased in cement, initial setting time also increased and it take more time to settle.

3.4-Testing of Concrete

- Slump cone test
- Compaction factor test

Slump Test

The amount of fly ash content and water cement ratios are fixing the slump values. The water content increased slump values increased. Fly ash also has not more binding property so the slump values increased. Adding of saw dust also has no binding property so the slump is increased. Water/cement ratio also plays an important role in preparing of concrete, amount of water for concrete mix can be determined according standard consistency of cement. It water is added more it will wet concrete which have less workability and strength.

Compaction Factor Test

This the test decide the workability of concrete. Fresh concrete should pass the top of the container to bottom cylinder. The passing capacity and compaction of concrete is measured to decide the water cement ratio. Repeat the procedure with increasing water content. Saw dust and fly ash are had low binding properties with cement so the water cement ratio is increased and more water is added and the setting time also increased.

3.4 Slump of Concrete:-

Fig-2: slump of concrete

3.4.1- If replacing of 30 % fly ash in cement and 10% saw dust in fine aggregate:

Table-6: Slump test of fresh concrete

S.N	w/c Ratio	Water content		Height		
		%	ml	Initial (mm)	Final (mm)	Average (mm)
1	0.40	40	2280	300	300	0
2	0.45	45	2565	300	280	20
3	0.50	50	2850	300	230	70
4	0.55	55	3135	300	30	270

The slump value of the concrete is: 70 mm
Graphical representation for slump height vs w/c ratio:

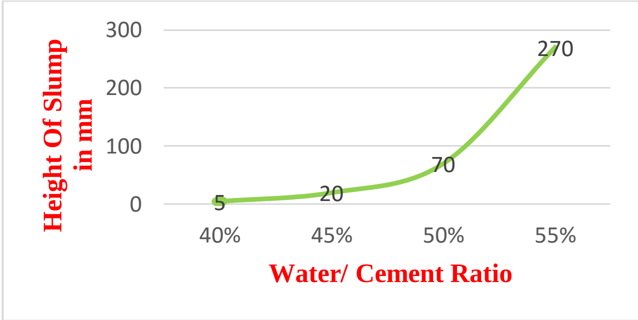


Chart No-2: slump of concrete

3.4.2-If replacing of 40 % fly ash in cement and 10% saw dust in fine aggregate:

Table-7: Slump test of fresh concrete

S.N	w/c Rato	Water content		Height		
		%	ml	Initial (mm)	Final (mm)	Average (mm)
1	0.40	40	2280	300	300	0
2	0.45	45	2565	300	270	30
3	0.50	50	2850	300	210	100
4	0.55	55	3135	300	0	0

The slump value of the concrete is: 100 mm
Graphical representation for slump height vs w/c ratio:

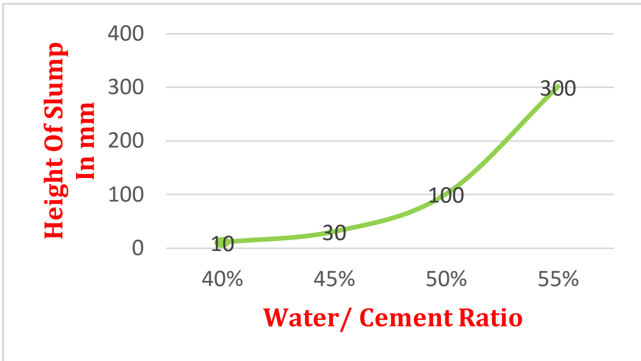


Chart No-3: Slump of concrete

3.4.3-If replacing of 30 % fly ash in cement:

Table-8: Slump test of fresh concrete replacing of 30 % fly ash in cement

S. No	w/c ratio	Water content		Height		
		%	ml	Initial (mm)	Final (mm)	Average (mm)
1	0.40	40	2280	300	300	0

2	0.45	45	2565	300	225	75
3	0.50	50	2850	300	180	120
4	0.55	55	3135	300	0	300

The slump value of the concrete is: 75 mm
Graphical representation for slump height vs w/c ratio:

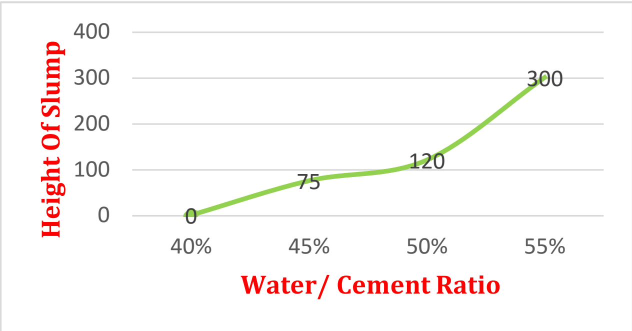


Chart No-4: Slump of concrete

3.4.4-If replace only 10% saw dust in fine aggregate:

Table -9: Slump test of fresh concrete replace only 10% saw dust in fine aggregate

S.No	w/c ratio	Water content		Height		
		%	ml	Initial (mm)	Final (mm)	Average (mm)
1	0.40	40	2280	300	300	0
2	0.45	45	2565	300	250	50
3	0.50	50	2850	300	240	70
4	0.55	55	3135	300	190	110

The slump value of the concrete is: 70 mm
Graphical representation for slump height vs w/c ratio:

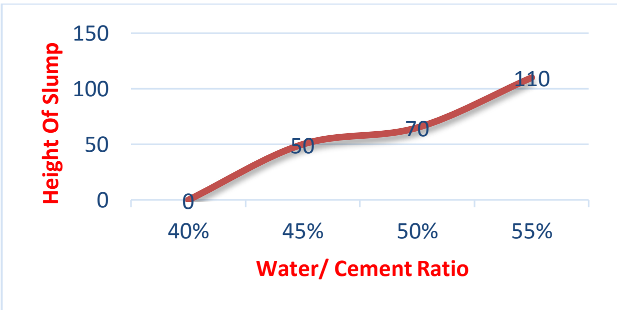
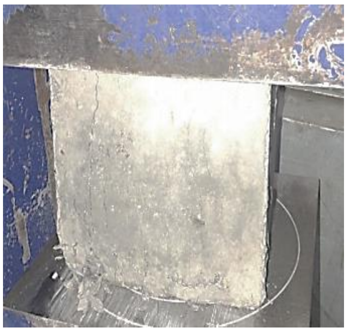


Chart No-5: Slump of concrete

3.5 COMPRESSIVE STRENGTH OF LWC:



3.5.1- 30% of Fly Ash And 10 %Saw Dust,

Size of cube = 150 x150x 150 mm,
Size of cylinders = 150 x 300 mm,
Area of cube = 22.5×10^3 mm^2
Area of cylinders= 17.67×10^3 mm^2

Table -*10*: Compressive strength of LWC, 30% of Fly Ash And 10 % Sa-w Dust

S.N	Test day	Mean Value (N/mm^2)	
		Cube	Cylinder
1	7 days	19.16	15.54
2	21 days	20.93	16.84
3	28 days	22.00	18.89

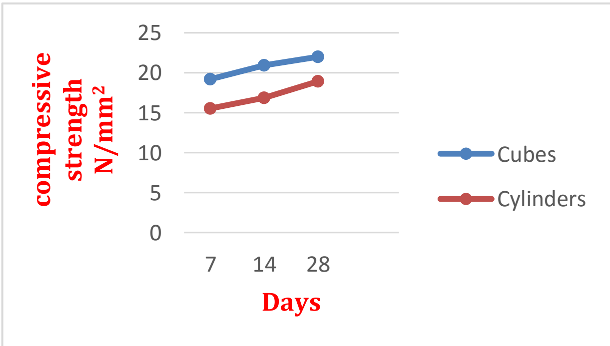


Chart No- 6: Compressive stress

3.5.2- 40% of Fly Ash And 10 %Saw Dust:

Table-11: compressive strength of LWC, 40% of Fly Ash And 10 % Saw Dust

S.N	Test day	Mean Value (N/mm^2)	
		Cube	Cylinder
1	7 days	18.75	15.18
2	21 days	19.55	15,59
3	28 days	21	16.70

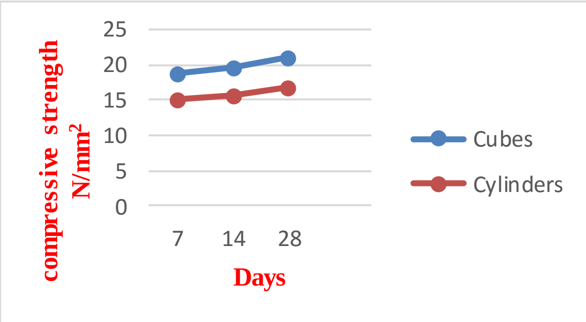


Chart No-7: Compressive Stress

Thus it can that as amount of fly ash and saw dust increased compressive strength slidly varied. Up to 20-40 % fly ash and 10-20 % saw dust is safe to use in concrete mix.

3.5.3-Compressive strength of LWC, Conventional Concrete:

Table-11: Compressive strength of LWC, Conventional Concrete:

S.N	Test day	Mean Value (N/mm^2)	
		Cube	Cylinder
1	7 days	19.67	16.86
2	21 days	21.21	18.59
3	28 days	21.90	19.31

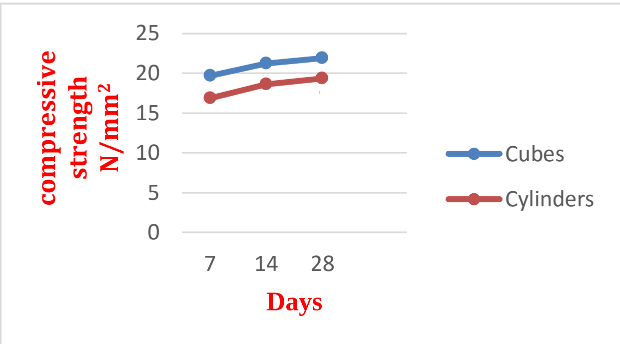


Chart No-7: Compressive Stress

3.6-Durability Testing:-

- ✓ Saturated Water Absorption
- ✓ Aggression by CO_2: Carbonation induced corrosion

3.6.1-Saturated Water Absorption:

Water absorption of M $_{25}$ grade of concrete with 100% natural sand, 40% manufactured sand and the optimum replacement level of 10% manufactured sand and also 30% & 40% replacement of fly ash content in cement appear. The concrete with manufactured sand has less water absorption, when compared to the conventional concrete. This is due to the less voids of better packing and it is also found that the water absorption is low for concrete with 70% manufactured sand due to the presence of less amount of micro fines in it.

3.6.2 Aggression by CO_2: Carbonation induced corrosion

Cement paste contains 25-50 wt% ($Ca(OH)_2$), pH » 13 The carbonation process requires the presence of water because CO_2 dissolves in water forming H_2CO_3. If the concrete is too dry (RH <40%) CO_2 cannot dissolve and no carbonation occurs. If on the other hand it is too wet (RH >90%) CO_2 cannot enter the concrete and the concrete will not carbonate. Optimal conditions for carbonation occur at a RH of 50% (range 40-90%).

MIX DESIGN

Mix design for M_{25} grade of concrete

Mix proportions:

M25 Grade of concrete, mix ratio of 1:1:2

Target mean strength:

Water ratio = 0.45 (severe)

Size of Coarse Aggregate = 10mm

Selection of water content and sand:

Water content = 208 kg/m3

Determination of cement = 535 Kg/m^3

Calculation of Fine Aggregate:

FA = 576 Kg/m^3

Calculation of coarse Aggregate:

CA = 1027 Kg/m^3

3. CONCLUSIONS

From the experimental investigation, it was found that the compressive strength was increased for fly ash concrete cubes with cement, fly ash and saw dust proportion when compared to the conventional concrete cubes at all the ages of curing. The Light Weight Concrete cubes containing fly ash aggregates made using cement fly ash proportions 10%, 30% and 40% showed reduction in compressive strength when compared to the conventional concrete at all the ages.

REFERENCES

[1] Fine aggregate Grading zone selected as per the code provision of IS 383 -1986.M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] The compressive and tension test results are tabulated and were tested IS 516-1959.

[3] IS: 516-1959 Methods of Tests for Strength of Concrete.

[4] Mix design for M25 grade concrete proportion has been developed as per IS 10262-2009.