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Experimental Study on Structural Lightweight Concrete Utilizing Cinder and Pumice as Replacement of Coarse Aggregate

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ABSTRACT

Concrete material is been widely used with basalt coarse aggregate throughout the world were the properties and behavior of concrete changes with the materials used, admixtures, water content and w/c ratio. Conventional concrete weight ranges from 2300kg/m^3 to 2450kg/m^3 and reinforced concrete ranges from 2500 kg/m^3 to 2600kg/m^3. The self weight of the structure is an important criterion in design point of view and also for economy of construction. Light weight concrete is been popular due to advantages over the conventional concrete, used widely in precast concrete structures. In this project work M30 grade concrete with three mix proportions are considered with granite, pumice and cinder aggregates with proportions of 50%, 75% and 100%.

INTRODUCTION

Concrete is composite material manufactured using fine aggregate, coarse aggregate, water and cement the properties of concrete will change with the percentages of coarse and fine aggregate mix proportions of materials, water content and temperature. The cement reacts with the water and other ingredients to form hard rock like material. Concrete generally required vibration to reach every part of the corners of shuttering to avoid leakages and honey combs etc. Most concretes used are Portland cement concrete, when aggregate is mixed together with dry Portland cement and water, the mixture forms fluid slurry that is easily poured and molded into shape.

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Types of aggregates

Aggregates are classified according to shape into the following types

- Rounded aggregates
- Irregular or partly rounded aggregates
- Angular aggregates
- Flaky aggregates
- Elongated aggregates
- Flaky and elongated aggregates

Aggregates are classified into two types according to size

- Fine aggregate
- Coarse aggregate

Fine Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate passed through it called as fine aggregate. Natural sand is generally used as fine aggregate, silt and clay are also come under this category. The soft deposit consisting of sand, silt and clay is termed as loam. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

Table: gradation of fine aggregates

Fine aggregate	Size variation
Coarse Sand	2.0mm – 0.5mm
Medium sand	0.5mm – 0.25mm
Fine sand	0.25mm – 0.06mm
Silt	0.06mm – 0.002mm
Clay	<0.002

Coarse Aggregate

When the aggregate is sieved through 4.75mm sieve, the aggregate retained is called coarse aggregate. Gravel, cobble and boulders come under this category. The maximum size aggregate used may be dependent upon some conditions. In general, 40mm size aggregate used for normal strengths and 20mm size is used for high strength concrete. the size range of various coarse aggregates given below.

Table: gradation of coarse aggregates

Coarse aggregate	Size
Fine gravel	4mm – 8mm
Medium gravel	8mm – 16mm
Coarse gravel	16mm – 64mm
Cobbles	64mm – 256mm
Boulders	>256mm

Pumice aggregate

These are rocks formed in volcanic eruptions and found in many places around world. They are light weight and also strong enough and have high crushing value. Pumice aggregate is light weight is due to gas escaping from molten lava. Pumice is mostly light or weight colored and it is mostly used light weight aggregate in construction industry. Pumice is mined and washed thoroughly and then used in concrete.

Cinder aggregate

Cinder, clinker and breeze are used for particles arrived from combustion of coal. Cinder type aggregates undergo high drying shrinkage and moisture movement, cinder aggregates are widely used in building blocks for partition walls and flooring etc. The cinder aggregates have less unsoundness value because having excessive unburnt coal particles upto 15-25%.

Advantages of light weight concrete

- self weight of the structural members is reduced results in lighter sections
- ease in lifting and placing of precast members
- reduction in construction cost by 25-30%
- light weight concrete have less tendency to spall
- coefficient of thermal expansion is lesser than the conventional concrete

Disadvantages of light weight concrete

- more brittle than conventional concrete
- special care to be taken in pumping concrete
- mixing time is more than conventional concrete
- Difficult to place and finish because of the porosity and angularity of the aggregate.

Applications of light weight concrete

- precast constructions
- in bridge decks and long span girders
- heat insulators on roof and terrace soling
- construction of partition walls in framed structures
- used widely in low cost housing
- shotcrete of damaged areas

LITERATURE SURVEY

Saritha .B[1],J.Chamundeeswari[2] " Experimental Study Of Light Weight Concrete By The Partial Replacement Of Coarse Aggregate By Thermo Plastics" We had replaced the coarse aggregate partially by the plastic aggregates (in the light weight concrete) which are having the properties of the thermoplastics." beams in both the conventional concrete and also in the light weight concrete (using plastic aggregates). We are going to cast 18 cubes, 18 cylinders and 18 beams. On these 18 cubes, 9 cubes for the conventional concrete and 9 cubes for the light weight concrete, on the 18 cylinders, 9 cylinders for the conventional concrete and 9 cylinders for the light weight concrete, on the 18 beams, 9 beams for the conventional concrete and 9 beams for the light weight concrete. The compressive strength of the partially light weight concrete is lower than the ordinary conventional concrete. Therefore this light weight concrete will be used in the places where the structure is not belonging to any external force. This light weight concrete is only capable to carry its self weight only. The partially light weight concrete may also be used as structural concrete on some cases because it is having the compressive strength value which is suitable for structural (greater than 17.44N/mm^2).

Lakshmi Kumar Minapu[1], M K M V Ratnam[2], Dr. U Rangaraju[3], "Experimental Study on Light Weight Aggregate Concrete with Pumice Stone, Silica Fume and Fly Ash as a Partial Replacement of Coarse Aggregate**"** In this study, an attempt has been made to study the Mechanical Properties of a structural grade light weight concrete M30 using the light weight aggregate pumice stone as a partial replacement to coarse aggregate and mineral admixture materials like Fly Ash and Silica Fume. For this purpose along with a Control Mix, 12 sets were prepared to study the compressive strength, tensile strength and flexural strength. Each set comprises of 4 cubes, 2 cylinders and 2 prisms. Slump test were carried out for each mix in the fresh state. 28-days Compressive test, Tensile Strength and Flexural Strength tests were performed in the hardened state. By using 20% of light weight aggregate as a partial replacement to natural coarse aggregates the compressive strength is promising. The density of concrete is found to decrease with the increase in percentage replacement of natural aggregate by pumice aggregate. The compressive strength of concrete is found to decrease with the increase in pumice Content. With the addition of mineral

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admixtures, the compressive, split-tensile and flexural strengths of concrete are increased. Light weight aggregate is no way inferior to natural coarse aggregate and it can be used for construction purpose.

N. Sivalinga rao1, V. Bhaskar Desai2 and B.L.P.Swamy3 "Structural Properties of Silica Fume Modified Light Weight Aggregate (Cinder) Concrete" The conventional mix has been designed for M**20** grade concrete and is adopted with a water cement ratio 0.50. With 100% cinder aggregate in the normal course aggregate and cement replaced with silica fume in weight percentages of 0%, 5%, 8%, 10%, 15% and 20%, compressive strength, split tensile strength, flexural strength , moment carrying ,modulus of elasticity and strain energy stored capacity of concrete specimens increase up to 10% of silicafume and then decrease. The optimum recommended combination for this strength is 40% cinder and 60% natural aggregate along with 10% silica fume. The moment carrying capacity of slabs is found to vary from 14.23KN-m to 9.82KN-m with the replacement of natural aggregate by cinder from 0 to 100 percent. Between 8 to 10 percent replacement of cement with silicafume gives the optimum values of moment carrying capacity. The optimum recommended combination for this strength is 40% cinder and 60% natural aggregate along with 10% silica fume.

Anju Ramesan[1], Shemy S. Babu[2], Aswathy Lal[3] "Performance of Light-Weight Concrete with Plastic Aggregate**"** Effect of replacement of coarse aggregate with various percentages (0% to 40%) of plastic aggregate on behaviour of concrete was experimentally investigated and the optimum replacement of coarse aggregate was found out. The results showed that the addition of plastic aggregate to the concrete mixture improved the properties of the resultant mix. Plastic aggregate is a lightweight material with specific gravity 0.94. Compressive strength and splitting tensile strength of concrete increased till 30% replacement of natural aggregate with plastic aggregate and on further replacement they tend to decrease but not below the target mean strength. Compressive strength increased by 9.4% and splitting tensile strength by 39% for a mix with 30 % replacement of natural aggregate by plastic aggregate when compared to control mix. Flexural strength of PCC beam and breaking load of RCC beam increased till 40% replacement. There was an improvement of 20% and 31% strength respectively. The optimum percentage replacement of natural coarse aggregate using plastic aggregate was obtained as 30%

Table: proportion of M30 concrete mixes

Grade	Designation	Normal aggregate %	Light weight aggregate %
M30	NWAC-100	100	0
M30	LWCAC-50	50	50
M30	LWCAC-75	25	75
M30	LWCAC-100	0	100
M30	LWPAC-50	50	50
M30	LWPAC-75	25	75
M30	LWPAC-100	0	100

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NWAC-100: Normal Weight Aggregate Concrete (100% normal aggregate)

LWCAC-50: Light Weight Cinder Aggregate Concrete (50% Cinder + 50% normal aggregate)

LWCAC-75: Light Weight Cinder Aggregate Concrete (75% Cinder + 25% normal aggregate)

LWCAC-100: Light Weight Cinder Aggregate Concrete (100% Cinder Aggregate)

LWPAC-50: Light Weight Pumice Aggregate Concrete (50% Pumice + 50% normal aggregate)

LWPAC-75: Light Weight Pumice Aggregate Concrete (75% Pumice + 25% normal aggregate)

LWPAC-100: Light Weight Pumice Aggregate Concrete (100% Pumice Aggregate)

Tests on concrete

Compressive strength of concrete

Compressive strength of concrete is found by testing cube in compressive testing machine and the stress at which the cube will fail is noted.

- Cube are taken out from the curing tank after 28days and dried to remove moisture from the cube surface.
- Cubes are placed in between the upper and lower plates in compressive testing machine.
- Load is applied on the cube at an increasing rate.
- Load at which the cube fails and cracks is noted as the compressive strength of the cube and the grade of concrete is decided.
- Series of cubes of around three specimens are tested and the compressive strength is taken as average value.

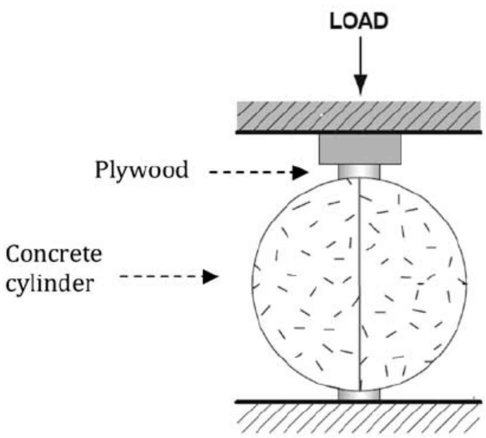

Fig: testing of cubes and cylinders

Split Tensile Strength Of Concrete:

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Splitting Tensile Strength Test On Concrete Cylinder Is A Method To Determine The Tensile Strength Of Concrete.

- Cylinder Of Size 150mm Diameter And 300mm Long Is Casted In A Cylindrical Mould.
- Cylinder Is De-Molded And Curing For 28days.
- Were After The Cylinder Is Placed In Compressive Testing Machine In Between The Plywood Sheets.
- The Cylinder Is Placed Such That The Longitudinal Axis Horizontal.
- Load Is Applied On The Cylinder.
- Stress At Which The Cylinder Cracks Is Noted Split Tensile Strength Of The Concrete.

Standard Consistency Test:

In This Test Used To Find Out The Percentage Of Water Required To Produce A Cement Paste Of Standard Consistency. This Is Also Called Normal Consistency.

- The Consistency Is Measured By The Vicat Apparatus Using A 10mm Diameter Plunger.
- A Trial Paste Of Cement And Water Is Mixed And Placed In The Mould Having An Inside Diameter Of 70mm At The Base And 60mm At The Top, And A Height Of 40mm.
- The Plunger Is Then Brought Into Contact With The Top Surface Of The Paste And Released. Under The Action Of Its Weight The Plunger Will Penetrate The Paste. The Depth Depending On The Consistency.
- When The Plunger Penetrates The Paste To A Point 5 To 7mm From The Bottom Of The Mould. The Paste Is Considered To Be At “Normal Consistency.
- The Water Content Of The Paste Is Expressed As A Percentage By Weight Of Dry Cement. The Usual Range Of Values Being Between 26% And 33%.

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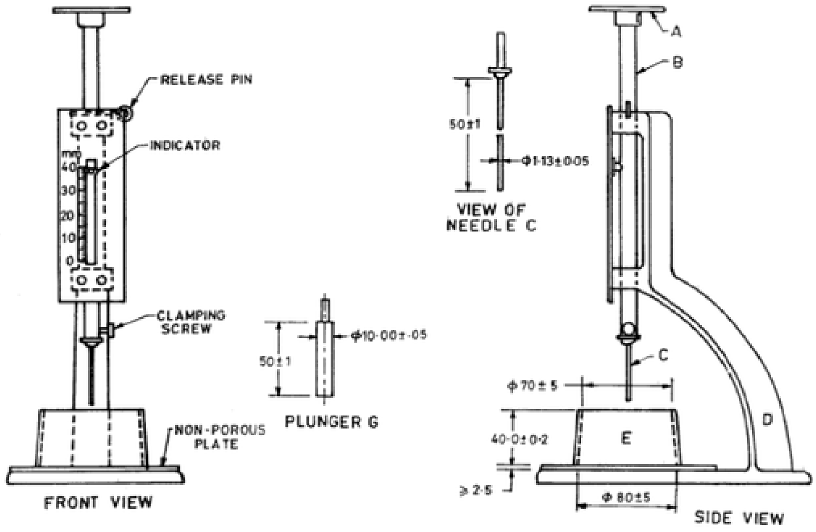

Fig: vicat's apparatus

Table: physical characteristics of 53 grade ordinary Portland cement (OPC)

S.NO	PROPERTY	TEST RESULTS
1	Normal consistency	29%
2	Initial setting time	32 min
3	Final setting time	495 min
4	Fineness of cement(m^2/kg)	231
5	Specific gravity of cement	3.20
6	Soundness	9mm

Table: slump and unit weights of concrete

Mix	Slump(mm)	Unit weight(kg/m^3)
NWAC-100	90	2360
LWCAC-50	70	1980
LWCAC-75	60	1870
LWCAC-100	50	1650
LWPAC-50	80	1850
LWPAC-75	50	1680
LWPAC-100	40	1540

Table: Test results of concrete with normal aggregate

Mix	7 days compressive strength(N/mm^2)	14 days compressive strength(N/mm^2)	28days compressive strength(N/mm^2)
NWAC-100	12.05	21	34.5

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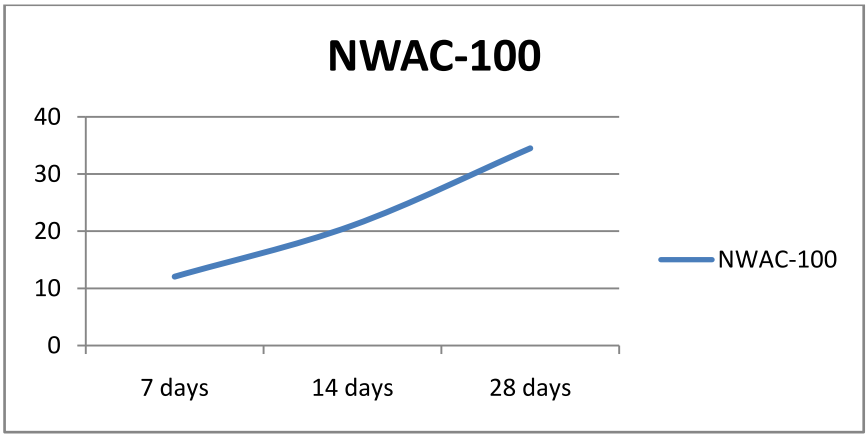

Fig : Test results of concrete with normal aggregate

Table : Test results of concrete with cinder aggregate

Mix	7 days compressive strength(N/mm^2)	14 days compressive strength(N/mm^2)	28days compressive strength(N/mm^2)
LWCAC-50	11	19.5	33
LWCAC-75	10.5	18	32.5
LWCAC-100	9	19	30.5

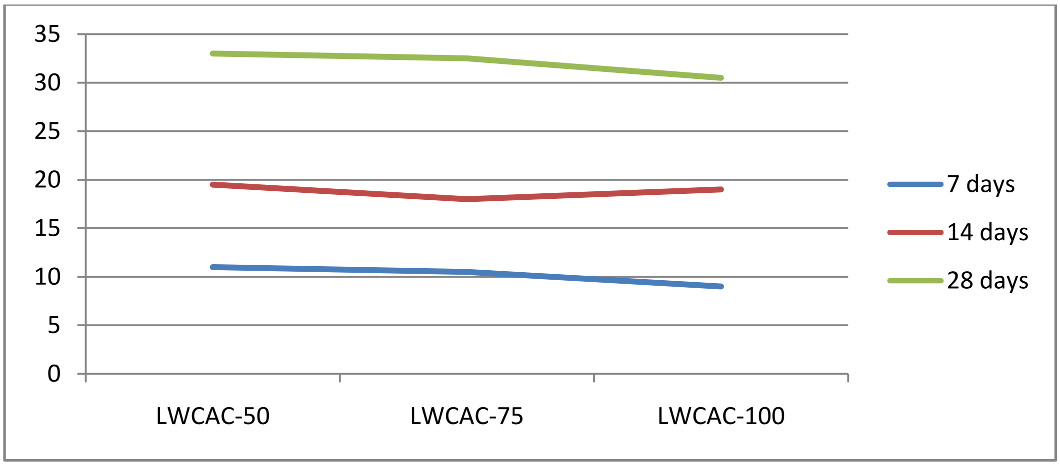

Fig : Test results of concrete with cinder aggregate

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Table: Test results of concrete with pumice aggregate

Mix	7 days compressive strength(N/mm^2)	14 days compressive strength(N/mm^2)	28days compressive strength(N/mm^2)
LWPAC-50	13	23.5	34.5
LWPAC-75	12	22	32
LWPAC-100	10.5	20	31

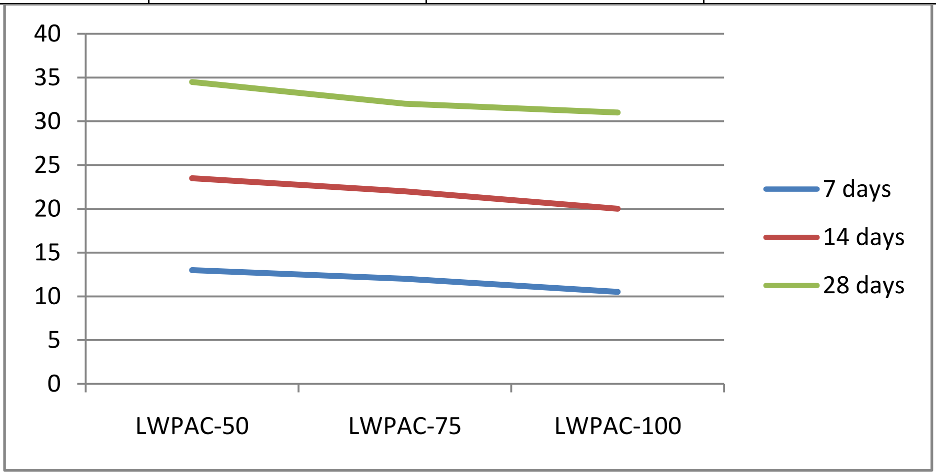

Fig: Test results of concrete with pumice aggregate

Table: Test results of concrete with different types of aggregates

Mix	7 days compressive strength(N/mm^2)	14 days compressive strength(N/mm^2)	28days compressive strength(N/mm^2)
NWAC-100	12.05	21	34.5
LWCAC-50	11	19.5	33
LWCAC-75	10.5	18	32.5
LWCAC-100	9	19	30.5
LWPAC-50	13	23.5	34.5
LWPAC-75	12	22	32
LWPAC-100	10.5	20	31

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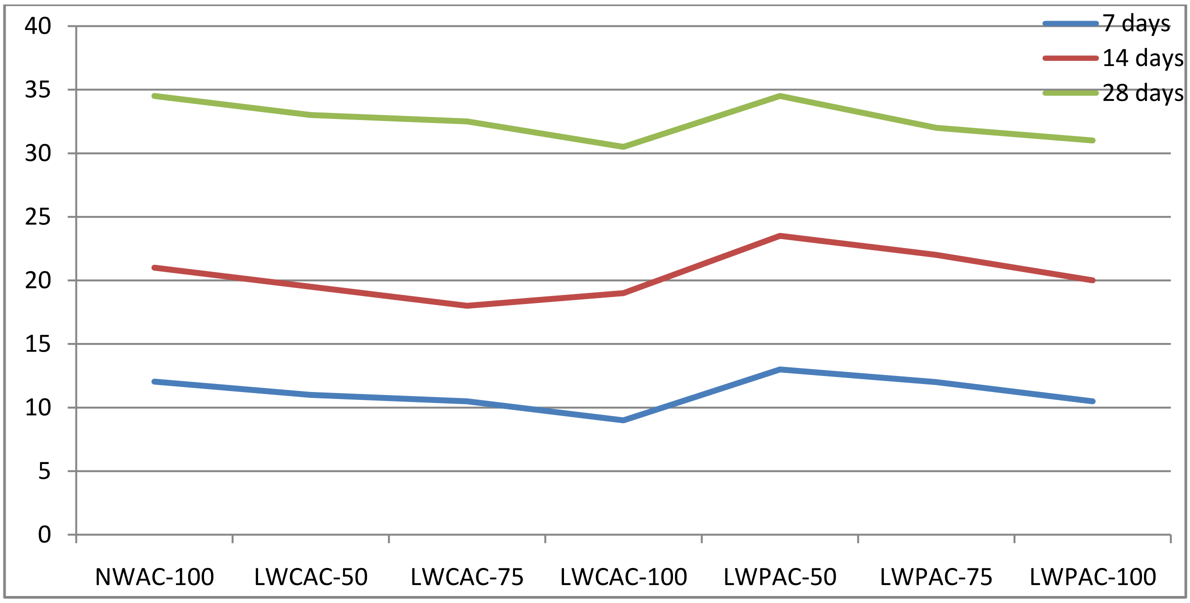

Fig : Test results of concrete with different types of aggregates

CONCLUSIONS

The following are the conclusions from project work of M30 grade concrete with three mix proportions are considered with granite, pumice and cinder aggregates with proportions of 50%, 75% and 100%.

NWAC-100: Normal Weight Aggregate Concrete (100% normal aggregate)

LWCAC-50: Light Weight Cinder Aggregate Concrete (50% Cinder + 50% normal aggregate)

LWCAC-75: Light Weight Cinder Aggregate Concrete (75% Cinder + 25% normal aggregate)

LWCAC-100: Light Weight Cinder Aggregate Concrete (100% Cinder Aggregate)

LWPAC-50: Light Weight Pumice Aggregate Concrete (50% Pumice + 50% normal aggregate)

LWPAC-75: Light Weight Pumice Aggregate Concrete (75% Pumice + 25% normal aggregate)

LWPAC-100: Light Weight Pumice Aggregate Concrete (100% Pumice Aggregate)

1. The fine modulus of the aggregates is observed to be 7.13, 7.01 and 7.86 for granite, pumice and cinder coarse aggregates.
2. unit weights of concrete using granite coarse aggregate is 2360kg/m^3, unit weight using cinder aggregate is 1650kg/m^3 and unit weight using pumice aggregate is 1540kg/m^3

3. The unit weight of concrete is reduced by 30% using cinder aggregate and by 34.75% using pumice aggregate.
4. the compressive strength of the concrete is found to be increasing with age of concrete
5. The 28 days compressive strengths for the mix NWAC is 34.5N/mm^2
6. The 28 days compressive strengths for the mix LWCAC-50 is 33N/mm^2, LWCAC-75 is 32.5N/mm^2 and , LWCAC-100 is 30.5N/mm^2
7. The 28 days compressive strengths for the mix LWPAC-50 is 34.5N/mm^2, LWPAC-75 is 32N/mm^2 and , LWPAC-100 is 31N/mm^2
8. The compressive strength of cinder aggregate concrete is reduced when compared with natural aggregate concrete by 4.34%, 5.8% and 11.6%
9. The compressive strength of pumice aggregate concrete is reduced when compared with natural aggregate concrete by 0%, 7.25% and 10.14%
10. Pumice aggregate concrete has shown higher strength results when compared with cinder aggregates.
11. Higher percentages of light weight aggregates had given lesser compression strength.

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