Study of Cellular Light Weight Concrete

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Abstract— Cellular Light Weight Concrete is a versatile material which is made up of cement, fly ash and protein based foam. Basically it is a new material which is currently using in India for walling purpose. Cellular Light Weight Concrete gives better sound insulation, thermal insulation, durable, lightweight, uniform size & shape, reduce permeability. It is non-load bearing structural element which has lower strength than conventional concrete. Cellular concrete is popular because of its light weight which reduces self-weight of structure. In this paper light weight cellular concrete blocks are casted with 65% of Fly ash and 35% of cement with foam content 1.5% of total weight and to increase its strength sand and quarry dust is added in its composition which replace fly ash upto 30% at an interval of 5%. to check properties of these cellular lightweight concrete (CLC) blocks test like compressive strength, density and water absorption is done in the laboratory.

Key words: Cement, Fly ash, Cellular Light Weight Concrete

I. Introduction

Lightweight concrete has been widely used in different structural applications and its consumption grows every year on a global basis. The reason for this is that using lightweight concrete has many advantages. These include: a reduction in the dead load of the building, which minimizes the dimensions of structural members; the production of lighter and smaller pre-cast elements with inexpensive casting, handling and transportation operations; the provision of more space due to the reduction in size of the structural members; a reduction in the risk of earthquake damage; and increased thermal insulation and fire resistance.

In India, among the multiple construction applications, masonry structures form the largest proportion of the uses of conventional burnt clay bricks, fly ash bricks, hollow concrete block, which have many drawback (like heavy weight, non-uniform shape and size, low thermal insulation and fire resistance etc.), that can be improved by using lightweight concrete. The utilization lightweight concrete, provides improved thermal insulation and fire resistance, thereby it is considered an effective approach not only in fire protection but also in reducing the U-values (it's the measure of heat loss through a structural element) of structures.

Lightweight concrete can be produced in a practical range of densities between about 300 and 2000 kg/m3, using three methods. The first is so-called no fines, where the fine portion (sand particles) of the total concrete aggregate is omitted. The second method is by introducing stable air bubbles inside the concrete body through mechanical foaming and chemical admixture. This type of concrete is known as aerated, cellular or gas concrete. The third and most popular method is by using lightweight aggregate. This may come from either a natural or an artificial source.

The main objective of this dissertation is to study the properties of cellular lightweight concrete blocks. light weight cellular concrete blocks are casted with 65% of Fly ash and 35% of cement with foam content 1.5% of total weight and to increase its strength sand and quarry dust is added in its composition which replace fly ash upto 30% at an interval of 5%.

II. Material used

1) Cement

In this project, for the production of cellular light weight concrete, Ordinary Portland Cement 53 grade is used.

2) Fly Ash

In this project, for the production of cellular light weight concrete, fly ash is used which is collected from Satpura Thermal Power Station, Sarni, Betul, Madhya Pradesh with specific gravity 2.56 and fineness 3.5%.

3) Quarry Dust

Quarry dust is collected from nearest crusher plant.

4) Water

Water should be avoided if it contains large quantities of suspended solids, excessive amounts of dissolved solids, or appreciable amounts of organic materials. Water which is used in this project is confirming to the specification of IS 456: 2000.

5) Foam agent

Protein based standard foaming agents or hydrolysed protein agents are made by protein hydrolysis from animal proteins such as keratin (horn meal and hoof), cattle hooves and fish scales, blood and saponin, and casein of cows, pigs and other remainders of animal carcasses. This leads not only to occasional variations in quality, due to the differing raw materials used in different batches, but also to the very intense stench of such foaming agents. Their self-life is about 1 year under sealed conditions.

III. Mix proportion

Concrete mix design is the manner of selecting suitable constituents of concrete and determining the relative amount of the materials with the objective of producing the most economical concrete while holding the specified minimum properties such as strength, consistency and durability. There is no standard method of for proportioning the cellular light weight concrete like conventional concrete. From the literatures reviewed, it is quite significant that the density is the prime factor to be considered for manufacturing the cellular light weight concrete. The properties of cellular light weight concrete are directly or indirectly related to its density, such as the strength of the cellular light weight concrete decreases exponentially with the reduction in its density. Thermal and sound insulation is increased with the reduction in density. There are also some other factors like cement filler ratio and foam percentage, which indirect effects the density of the concrete. So that the density is prime concern for the production of cellular light weight concrete rather than target mean strength in conventional concrete. Six trail mix is casted with target density of approximately 1500 kg/m3. The details of mix proportion for cellular light weight concrete are given in Tables below.

Mix Name	Cement Content (%)	Fly Ash Content (%)	Quarry Dust (%)
CC	35	65	0
T1	35	60	5
T2	35	55	10
T3	35	50	15
T4	35	45	20
T5	35	40	25
T6	35	35	30

Table 4: Mix Proportion of cellular light weight concrete

A. *Mix Procedure:*

The manufacturing procedure is thoroughly different from conventional concrete because mix design is not fit for light weight cellular concrete. It's done by trial and error process.

The manufacturing of cellular light weight concrete finishes in two stages.

1) Preparation of cement based slurry with fly ash and silica fume.
2) Formation of foam by using pre-foaming method.

Start with the first stage, fly ash and water mixed thoroughly for few minutes to attain good consistency. Add cement and mix well again for few minutes until the cement based slurry is attained homogenous consistency. The second stage is started with hydrolyzed protein based foaming agent. The foaming agent is diluted with water (the dilution ratio is 1:35) and make the solution. Prepared foaming agent and water solution send into the foam generator which is mainly a foam producing unit. Foam generator sucks the solution and compressed air is blown. Compressed air expands the foaming agent when it goes through the foam lance and converted into the stable foam.

Lastly, the foam is mixed thoroughly with the cement based slurry. Stable foam makes the cellular matrix in it and cellular light weight concrete is prepared.

B. *Casting of Moulds:*

After mixing foamed concrete the material should be placed in moulds as soon as possible to maximize the time available for the mortar to set around the voids before the foam that forms the voids starts breaking down. The time available before stable foam starts breaking down varies, but experience has shown that it is not advisable to place foamed concrete more than half an hour after mixing. Foamed concrete is used where a reduction in density is required and no compaction is required. The formation of large voids as a result of entrapped air rather than entrained air can be prevented by softly tapping the outside of the mould with a rubber hammer during the filling operation. Moulds are generally filled to overflowing to compensate for some subsidence due to bleeding of water through the bottoms of the moulds.

For smooth surfaces clean moulds completely before casting, form oil was applied to the moulds to make sure concrete will not stick to it. Since, foamed concrete is self - levelling and self – compacting, vibration was not required. The specimens were then left to set for 24 hours. The specimens were demoulded after 24 hours with necessary tools and were transferred for curing to the curing room.

C. *Curing:*

The curing of the cellular light weight concrete is done by usually two methods, one is moist curing and other is steam curing at atmospheric pressure. In the moist curing, the concretes are usually given a short period of moist curing, generally about 1 to 7 days and then allowed to air dry, prior to application of a moisture-proofing material. The time required for satisfactory air drying is smallest in the material of lowest density.

Steam curing at atmospheric pressures at 50 to 80oC accelerates the hardening of cellular concretes. Drying shrinkage and moisture movement of concretes after atmospheric-pressure steam curing of various durations, up to 24 hours, differ little from those properties of similar concretes after moist curing for 28 days at 21oC. Steam curing at atmospheric pressure produces strengths generally near those attained after 3 days of the moist curing at 21oC. In this project moist curing is done for 28 days.

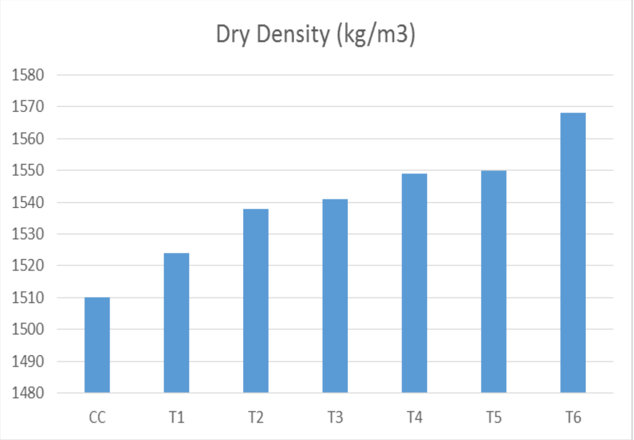
IV. RESULT AND DISCUSSION

A. *Dry Density:*

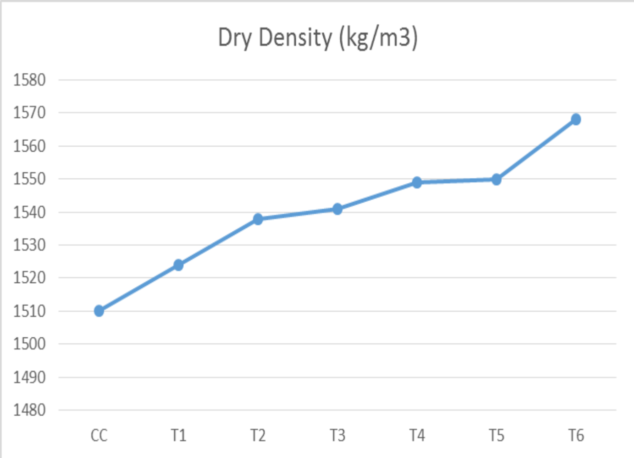
For this project target density is 1500 kg/m3, density of the cubes totally depend upon foam content as foam content is increased in mix dry density decreased. 1.5% of the foam is mixed for this study. Result of dry density is given in table 1 and graph 1-2. It is also observed that quarry dust content increases the density of the CLWC.

Mix	Density (kg/m^3)
CC	1510
T1	1524
T2	1538
T3	1541
T4	1549
T5	1550
T6	1568

Table 2: Result of Dry Density of Cellular Light Weight Concrete



Graph 1: Result of Dry Density of Cellular Light Weight Concrete (Bar Chart)



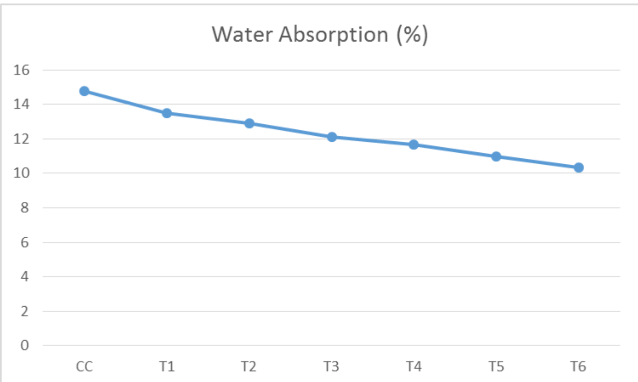
Graph 2: Result of Dry Density of Cellular Light Weight Concrete (Line Graph)

B. *Water Absorption:*

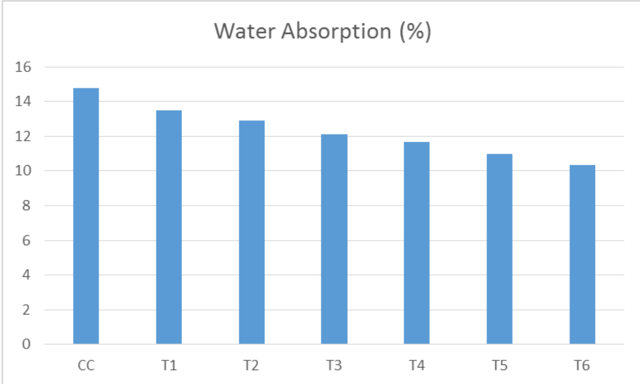
Result of water absorption test of cellular light weight concrete is given below in table 2 and graph 3-4. Result of water absorption shows introduction of quarry dust in CLWC proportion reduces the water absorption of CLWC. Fly ash : Cement (65:35) CC mix gives water absorption of 14.78% and T6 mix which contains 30% quarry dust possess 10.34% of water absorption.

Mix	Water Absorption (%)
CC	14.78
T1	13.52
T2	12.91
T3	12.11
T4	11.67
T5	10.97
T6	10.34

Table 3: Result of Water Absorption of Cellular Light Weight Concrete



Graph 3: Result of Water Absorption of Cellular Light Weight Concrete (Line Graph)



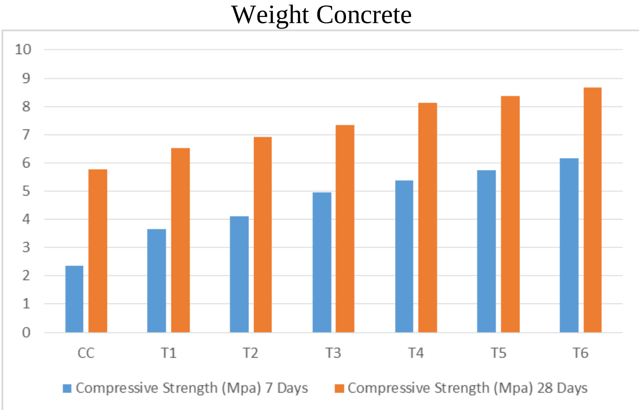
Graph 4: Result of Water Absorption of Cellular Light Weight Concrete (Bar Chart)

C. *Compressive Strength:*

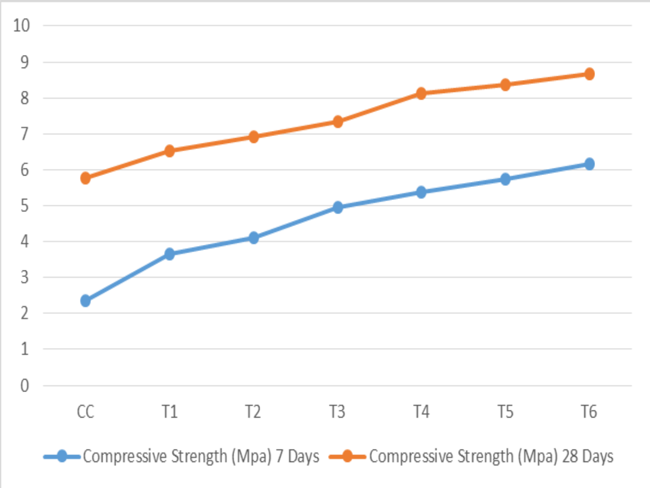
Result of compressive strength test of CLWC is given in table 3 and graph 5-6. Introduction of quarry dust in CLWC proportion increases the compressive strength of CLWC. Compressive strength increases as quarry dust content in proportion is increases. Fly ash : Cement (65:35) CC mix gives compressive strength of 5.78 MPa after 28 days of curing and T6 mix which contains 30% quarry dust possess 8.67 MPa of compressive strength after 28 days of curing.

Mix	Compressive Strength (Mpa)	
	7 Days	28 Days
CC	2.35	5.78
T1	3.67	6.51
T2	4.12	6.92
T3	4.95	7.34
T4	5.37	8.12
T5	5.74	8.38
T6	6.17	8.67

Table 4: Result of Compressive Strength of Cellular Light Weight Concrete



Graph 5: Result of Compressive Strength of Cellular Light Weight Concrete (Bar Chart)



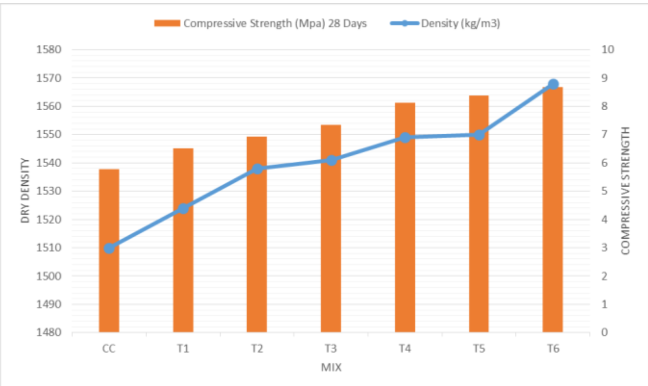
Graph 6: Result of Compressive Strength of Cellular Light Weight Concrete (Line Graph)

D. Combined Result:

Table 4 shows combined test result, which carried out in this project, graph 7 shows combined result of dry density and compressive strength, graph 8 shows combined result of dry density and water absorption, graph 9 shows combined result of water absorption and compressive strength.

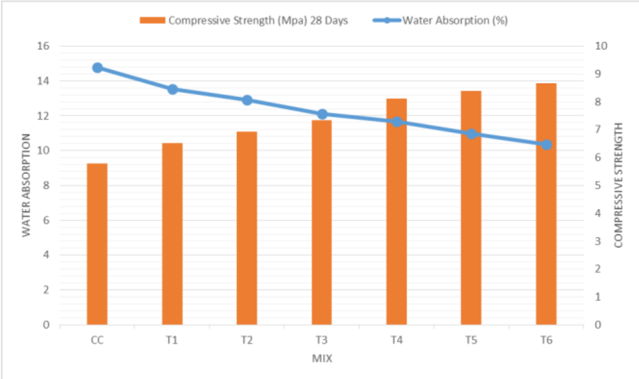
Mix	Dry Density (kg/m3)	Water Absorption (%)	Compressive Strength (Mpa) 28 Days
CC	1510	14.78	5.78
T1	1524	13.52	6.51
T2	1538	12.91	6.92
T3	1541	12.11	7.34
T4	1549	11.67	8.12
T5	1550	10.97	8.38
T6	1568	10.34	8.67

Table 5: Combined Test Result of Cellular Light Weight Concrete



Graph 7: Combined result of Compressive Strength and Density

Graph 8: Combined result of Density and Water Absorption



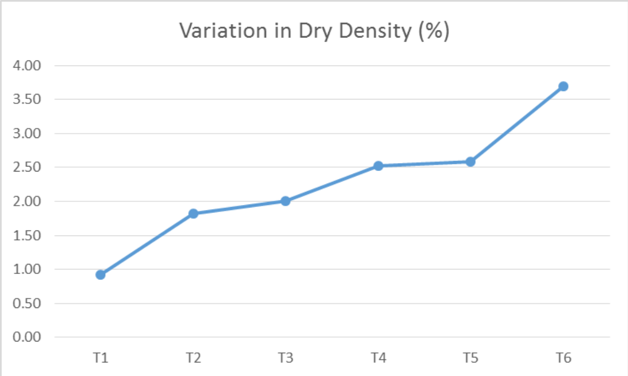
Graph 9: Combined result of Compressive Strength and Water Absorption

E. Variation in Results:

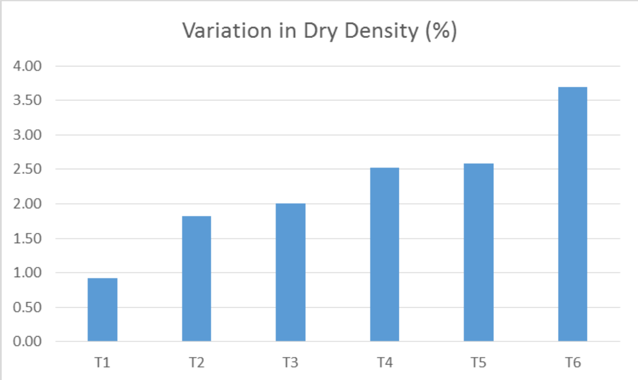
Variation of results of dry density given in table 5 and graph 10-11 and it has been observed that dry density increases with increase of quarry dust content in CLWC mix, T1 gives 0.92% increment in dry density and it goes on increasing, achieves 3.70% increment in dry density. Variation of results of water absorption given in table 6 and graph 12-13 and it has been observed that water absorption decreases with increase of quarry dust content in CLWC mix, T1 gives 8.53% decrement in dry density and it goes on decreasing, achieves 30.04% decrement in dry density. Variation of results of dry density given in table 6 and graph 14-15 and it has been observed that compressive strength increases with increase of quarry dust content in CLWC mix, T1 gives 11.21% increment in dry density and it goes on increasing, achieves 33.33% increment in compressive strength.

Mix	Variation in Dry Density (%)
T1	+0.92
T2	+1.82
T3	+2.01
T4	+2.52
T5	+2.58
T6	+3.70

Table 6: Variation of Result of Dry Density



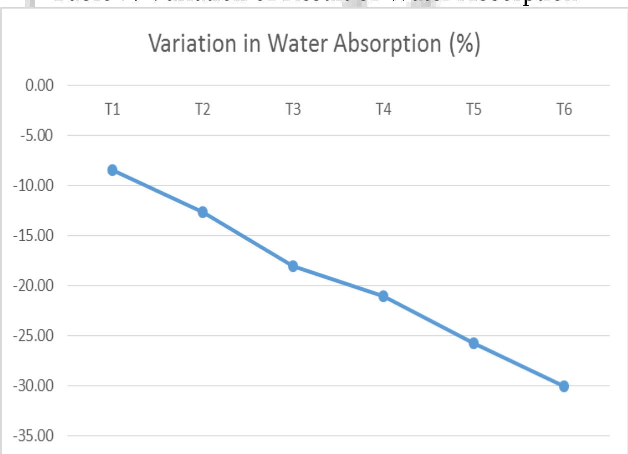
Graph 10: Variation of Result of Dry Density (Line Graph)



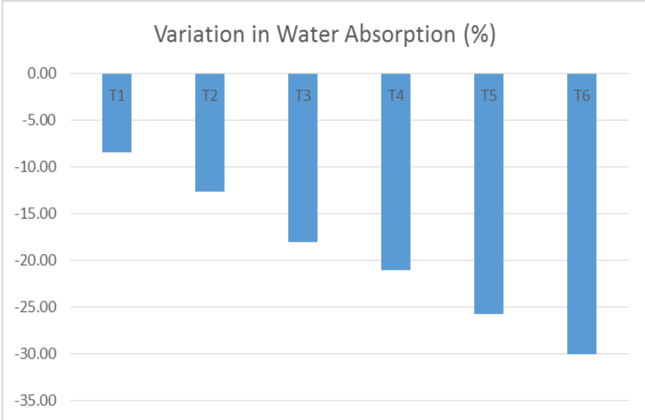
Graph 11: Variation of Result of Dry Density (Bar Chart)

Mix	Variation in Water Absorption (%)
T1	-8.53
T2	-12.65
T3	-18.06
T4	-21.04
T5	-25.78
T6	-30.04

Table 7: Variation of Result of Water Absorption



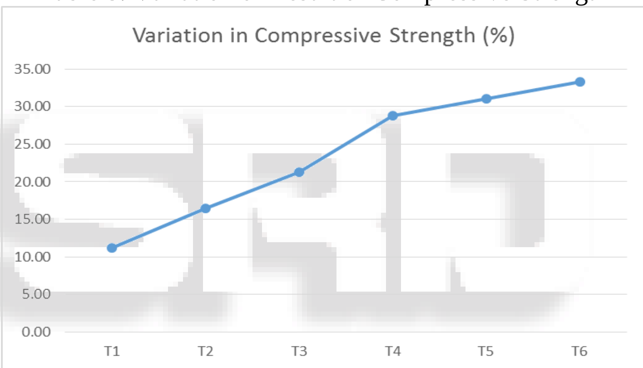
Graph 12: Variation of Result of Water Absorption (Line Chart)



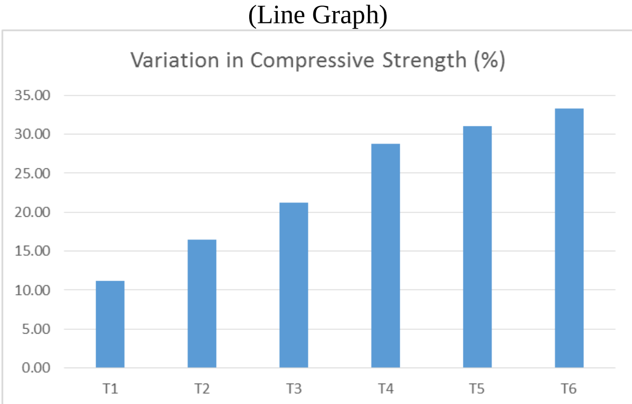
Graph 13: Variation of Result of Water Absorption (Bar Chart)

Mix	Variation in Compressive Strength (%)
T1	+11.21
T2	+16.47
T3	+21.25
T4	+28.82
T5	+31.03
T6	+33.33

Table 8: Variation of Result of Compressive Strength



Graph 14: Variation of Result of Compressive Strength (Line Graph)



Graph 15: Variation of Result of Compressive Strength (Bar Chart)

V. Conclusion

Present study contains a study of properties of Cellular light weight concrete and also the utilization of quarry dust in the proportion of Cellular light weight concrete. Conclusions is drawn from the present study is given below:

1) Dry density of the CLWC is increased when quarry dust is partially replaced by fly ash content in it. It is also concluded that increasing content of quarry dust in the

composition, increases the density of CLWC, replacement of fly ash by quarry dust upto 30% possess increment of 3.70% in dry density.

2) Water absorption of CLWC is decreased when quarry dust is partially replaced by fly ash content in it, when increasing content of quarry dust in the composition, decreases the water absorption of CLWC, replacement of fly ash by quarry dust upto 30% possess decrement of 30.04% in water absorption.
3) Compressive Strength of the CLWC is increased when quarry dust is partially replaced by fly ash content in it. It is also observed that increasing content of quarry dust in the composition, increases the compressive strength of CLWC, replacement of fly ash by quarry dust upto 30% possess increment of 33.33% in compressive strength.
4) Study shows that increase in the density of CLWC decreases the water absorption and increases the compressive strength and when water absorption is increased of CLWC compressive strength and dry density is decreased.

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