Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 3, Issue 3; January-March, 2016, pp. 208-211

http://www.krishisanskriti.org/Publication.html

Effective uses of Light Weight Concrete

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Abstract—*Light weight concrete (LWC) is the building material used in the construction of building using latest technology to reduce the self weight of the building. By reducing the self weight or dead load of the building or prismatic dimensions, it can minimize the destruction or casualties during the earthquake or any environmental impact. Light weight concrete can be produced using light weight aggregates (Pumice stone) or volcanic stone or by using admixture aluminum powder as an air entraining agent to the normal mix concrete with or without coarse aggregate. This paper presents the light weight concrete of nominal mix of M20 grade using admixture aluminum powder mixed with various quantities and water cement ratios. After curing for 7, 14 and 28 days, the compressive strength developed in the concrete cubes and weights were measured and compare with the various quantities of aluminum added in percentage. By observing, the light weight concrete using the nominal size of the aggregate still can be effectively used as they are lighter in weight, greater in compressive strength but limit to the quantity of aluminum powder beyond which they are useless.*

1. INTRODUCTION

Concrete is a composite element composed of coarse aggregate, fine aggregate (sand), cement and water. Often, additives and reinforcements are included in the mixture to achieve the desired strength of the concrete. When these ingredients are mixed together, they form a fluid mass that is easily molded into any shape. After few hours, the cement forms a hard matrix which binds the rest of the ingredients together into a durable stone-like material with various uses. Some plasticizer are added as ingredients which may speed up or slow down the rate at which the concrete hardens, and to impart other useful properties including increased tensile strength and water resistance.

2. IMPACT AND USE OF MODERN CONCRETE

Concrete is widely used for making architectural structures, foundations, brick or block walls, pavements, bridges or overpasses, highways, runways, parking structures, dams, pools or reservoirs, pipes, fences, poles, even boats etc.. Concrete is used in large quantities for development of infrastructures. The amount of concrete used worldwide by weight is twice that of steel, wood, plastics, and aluminum combined. So, manufacturing concrete is become a large commercial industry. Giving the size of the concrete industry, and the fundamental way using concrete is ultimately to shape the infrastructure of the modern world. It is difficult to overstate the role this material plays today.

3. NOMINAL MIX CONCRETE AND ITS BEHAVIORS

There are many types of concrete, designed to suit a variety of purposes coupled with a range of compositions, finishes and performance characteristics. The choice of the concrete depends upon the type of the construction project. These requirements considered the weather conditions that the concrete will be exposed, and the required design strength. The compressive strength of a concrete is determined by taking standard molded and cured cylindrical or cube samples.

A 50 kg cement bag has a volume of 0.035 cum, a batch box of aggregate is made of size 35 x 25 x 40cm which corresponds to one bag of cement. Nominal mix concretes with Cement (C) : Fine aggregate (FA): Coarse aggregate (CA) ratio of 1:5:10, 1:4:8, 1:3:6, 1:2:4 and 1:1.5:3 roughly correspond to M 5, M 7.5, M 10, M 15 and M 20 grades of concrete as mentioned in the IS Code 456 in regard to their compressive strength is concerned.

Use of finely powdered aluminum with the slurry and reaction caused with the calcium hydroxide liberated during the hydration process to give out large quantity of hydrogen gas as mentioned by **Keertana et al. (2011).** [1]. **Radhakrishna et al. (2011)** [2] explained about the re-proportioning of light weight concrete with pumice stone along with fly ash as per ACI method as coarse aggregate by law of mixtures known as Abrams law. The fracture of the concrete cubes was found through the pumice aggregate and the characteristic strength of pumice was the same irrespective of age and other parameters. **Desai D. (2012)** [3] also explained about development of two types of lightweight concrete using lightweight aggregate (Pumice stone) and water floating type stone using aluminum powder as an air entraining agent. The paper shows the importance of water/cement ratio as in first type of concrete relate to the smoothness of the concrete surface and in second type is detailed about major factor which controls the expansion of concrete.

4. LIGHT WEIGHT CONCRETE

Lightweight concrete generally include an expanding agent that increases the volume of the mixture while reducing the dead weight. It is lighter than the conventional concrete. The main specialties of lightweight concrete are its low density and low thermal conductivity. There are many types of lightweight concrete which can be either by using :-

a). Lightweight aggregate b). Air entraining agent (Aluminum Powder or foaming).

4.1 Light weight concrete using light weight aggregate

Light weight concrete using light weight aggregates can be of two type depending upon the type of the aggregate uses such as : (a) using Pumice stone as an aggregate and (b) using volcanic rock as lightweight aggregates. In pumice stone, the stone aggregates are having low specific gravity, highly porous material with high water absorption percentage.

When using the volcanic rock, the aggregate are expanded clay therefore, they are lighter than normal aggregates (bulk density in the range of 880 kg/m^3)

4.2 Lightweight concrete by using Aluminum powder

Light weight concrete is also made of introducing air or gas entraining into slurry composed of Portland cement, coarse aggregate and sand and the mix is set and harden with uniform cellular structure. Fine powder of Aluminium can be used as air entraining agent mixed with the slurry and reacts with the calcium hydroxide present in slurry, thereby producing hydrogen gas. This hydrogen gas contained in the slurry form cellular structures and thus makes the concrete lighter than the conventional concrete.

Light weight concrete is also produced by addition of a foaming agent in cement mortar. They create a fine cement matrix which has air voids throughout its structure. Aerated cement mortar is produced by the introduction gas into cementations slurry so that after hardening a cellular structure is formed.

4.3 Properties of light weight concrete

The LWC density ranges from 650 Kg/m^3 to 1850 Kg/m^3 as compared to 1800 kg/m^3 to 2400Kg/m^3 for conventional brick and concrete respectively. Despite millions of tiny air filled cells, it is strong and durable. They are excellent in acoustic performance, earthquake resistant, good insulation, workability, long life span due to termite and fire resistance, weather proof and, material savings, low modulus of elasticity (0.5%– 0.75%) than that of the normal concrete and therefore they are more pronounced to deflection. Good eenvironmental impact due to thermal efficiency and thus it makes a major contribution to environmental protection by heating and cooling in buildings. However, light weight concrete cannot be used as reinforced concrete as it has a cellular structure and therefore rusting to steel reinforcement is quite proactive.

5. PREPARATION OF THE SAMPLES

Experiments were conducted on production of light weight concrete by using Aluminum powder as an air entraining agent. In order to examine the compressive strength of lightweight concrete, we prepared 18 nos. of light weight concrete cube samples of size 150 mm x 150 mm x 150 mm of grade M20 (nominal mix) with varying water-cement ratio in addition to varying percentage of Aluminum powder by weight of cement. We also prepared 9 nos normal concrete cube samples of grade M_{20} (nominal mix) of the same size with varying water-cement ratio. Table-1 shows the experimental data conducted in the concrete lab.

Table 1: Samples prepared for test

Number of Samples	Concrete Mix						Aluminum	
	C- Cement, FA-Fine agrrt., CA-Coarse aggrt							
	Grade	C	FA	CA	w/c		%	gm.
nos.		gm	gm	gm	%	ml		
3	M_{20}	1361.10	2041.65	4083.30	0.40	544.44	0.00	0.00
3	M_{20}	1361.10	2041.65	4083.30	0.45	612.49	0.00	0.00
3	M_{20}	1361.10	2041.65	4083.30	0.50	680.55	0.00	0.00
3	M_{20}	1361.10	2041.65	4083.30	0.40	544.44	0.40	5.44
3	M_{20}	1361.10	2041.65	4083.30	0.45	612.49	0.45	6.12
3	M_{20}	1361.10	2041.65	4083.30	0.50	680.55	0.50	6.81
3	M_{20}	1361.10	2041.65	4083.30	0.40	612.49	1.00	13.61
3	M_{20}	1361.10	2041.65	4083.30	0.45	612.49	1.20	16.33
3	M_{21}	1361.10	2041.65	4083.30	0.50	612.49	1.50	20.42

After casting the concrete samples in the lab, the samples were kept inside the water tank for curing in three phases. 1st phase is for 7 days curing, 2nd phase is for 14-days curing and 3rd phase is 28-days curing.

6. RESULTS AND DISCUSSIONS

The results obtained from the experiments mentioned above are categorized in to three (3) groups following the norms as mentioned in the IS-Code 456, 2000. This can be grouped in to 7days curing, 14 days curing and 28 days curing. Thus the results can be examined and discussed as follows:-

6.1 7- Day compressive strength

NC- Normal concrete, LWC-Lightweight concrete

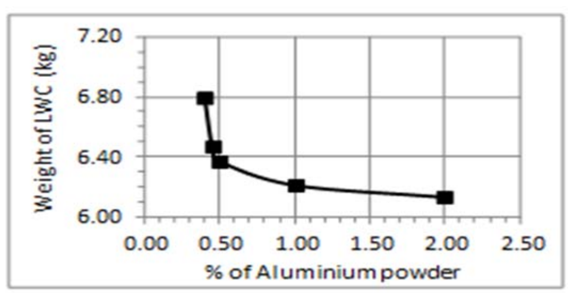

Fig. 1: Variation of LWC weight due to variation in percentage of Al powder

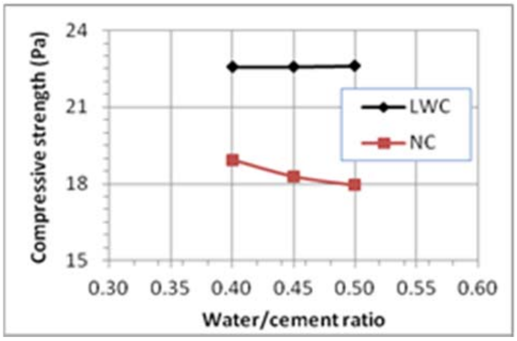

Fig. 2: Comparison of Compressive strength

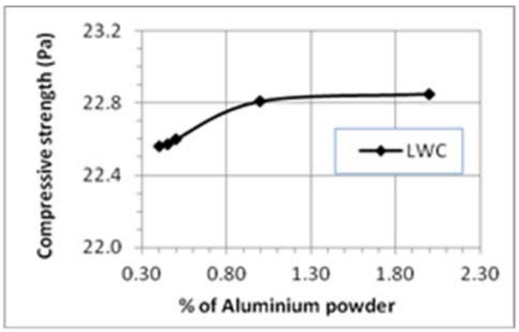

Fig. 3: Effect of Aluminum content

6.2 14-Day compressive strength

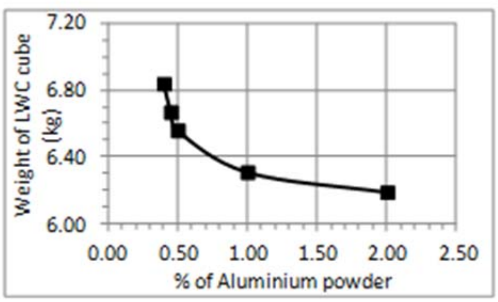

Fig. 4: Variation of LWC weight due to variation in percentage of Al powder

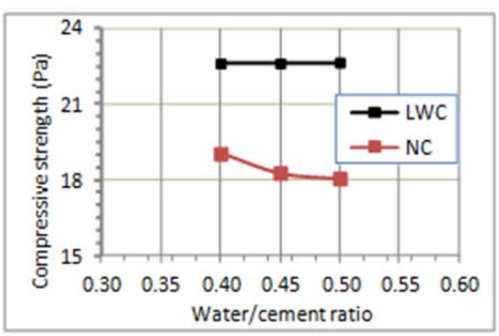

Fig. 5: Comparison of compressive strength

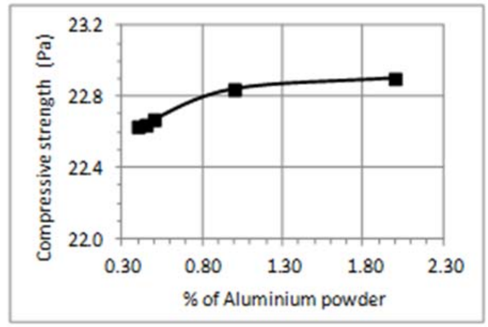

Fig. 6: Effect of Aluminum content

6.3 28-Day compressive strength

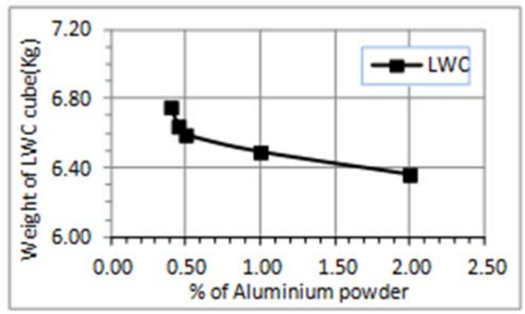

Fig.7: Variation of LWC weight due to variation in percentage of Al powder

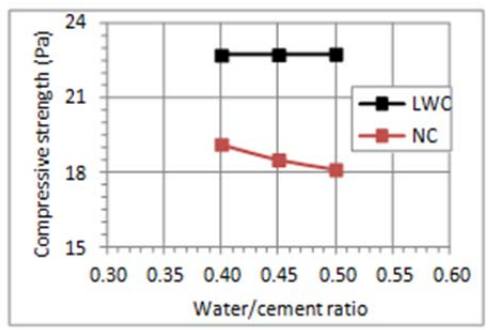

Fig. 8: Comparison of compressive strength

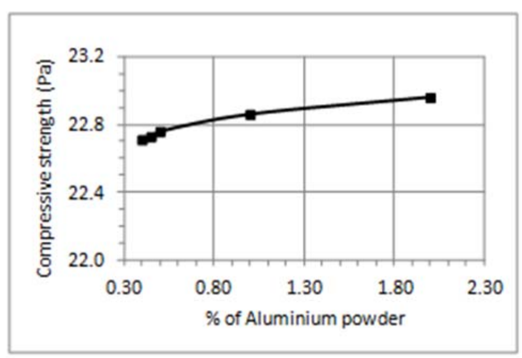

Fig. 9: Effect of Aluminum content

Fig. 10: Preparation of concrete mix

Fig. 11: Removal from cube mold and ready for curing

Fig. 12: Effect of Aluminum powder (effervescence)

7. CONCLUSION

Light weight concrete using normal aggregates are having 19% to 28% less weight than that of the normal concrete. The compressive strength of the light weight concrete is greater than the normal same grade concrete. When started placing the slurry mixed with Aluminum powder in cube mould, the expansion in the volume was observed along with evolution of gas forming pores inside to expel the hydrogen gas from the mixture in the concrete. Because of the pores, it is become a good insulator, sound absorbent and less weight. It can be used in place of conventional bricks or at the places. However, LWC is contained cellular structure and pores; it may not advisable for used as reinforced concrete. Lightweight concrete must also be coated with some form of protective material, as it tends to degrade over time because of its porous nature.

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