CHARACTERISTIC STUDY ON BEHAVIOUR OF LIGHTWEIGHT CONRETE USING ALUMINIUM DROSS AND ALUMINIUM POWDER

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Abstract - *This paper aims to study about the strength of concrete using aluminium dross and aluminium powder. In this research, an attempt has been made to develop light weight concrete by the partial replacement of cement with aluminium dross and powder. Dross obtained from aluminium refining is not entirely a waste material as it can be recycled and used in secondary steel making for slag deoxidation. Furthermore, much energy is consumed to recover the Al from the dross; this energy can be saved if the dross could be diverted and utilized as an engineering material preferably in the form of non-aerated concrete. Another form of aluminum used in this study is its powder. The fine powder of aluminium reacts with the calcium hydroxide in the cement matrix produces hydrogen gas. This hydrogen gas in the mix gives the cellular structure and makes the concrete lighter than the conventional concrete thereby reducing the dead weight of concrete. The objective of this work is to eliminate waste and instead utilize the waste in a natural cycle by using it as an engineered material and also to produce a light weight concrete. Replacement of aluminium powder and dross (5, 10, and 15 %) by weight of cement are used to produce aerated (gas) concrete. The result obtained shows that optimum of 10% Aluminium dross can be replaced with cement to obtain required compressive strength and split tensile strength for concrete.*

Key Words: **Lightweight concrete, Waste Material, Aluminium Dross, Aluminium Powder.**

1.INTRODUCTION

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nailibility and lessened the dead weight. It is lighter than the conventional concrete. It was first introduced by the Romans in the second century where 'The Pantheon' has been constructed using pumice, the most common type of aggregate used in that particular year. From there on, the use of lightweight concrete has been widely spread across other countries such as USA, United Kingdom and Sweden. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates. Lightweight concrete (LWC), with its reduced weight and improved durability, enables longer spans, fewer piers, and longevity for bridge structures. The current emphasis on upgrading structures makes LWC highly desirable as a construction material since superstructures with wider shoulders or more lanes can be upgraded without major work on the substructure.

Aluminum dross is a mixture of free metal and non-metal substances (e.g., aluminum oxide and salts). Aluminum nitrides and carbides may also be present, as well as metal oxides derived from the molten alloy (Manfredi *et al.* 1997). Drosses may be classified by means of their metal content and drosses with a high metal content (white, or wet, dross that is rich in free metal) typically occurs when scrap is re-melted with salts in an open – hearth furnace. This black, or dry, dross is usually granular with a high metal content in the coarse fraction and chiefly oxides and salt in the fines. The possibility for non-waste utilization of aluminum dross and converting it into commercially useful products was investigated by Lucheve *et al.* (2005). There is also a need to develop technologies to cost-effectively convert various wastes into usable feedstock and thus, new technologies that would minimize or eliminate the formation of dross and salt cake are encouraged. Minimization of dross and salt cake formation and the development of new uses for wastes and byproducts should be the primary focus. The first can be accomplished by developing new melting processes that eliminate or minimize the formation of these wastes and, the development of economical technologies for turning aluminum waste such as red mud into usable feedstock for other processes that could eliminate this environmental problem.

Aluminum powder is usually used to obtain autoclaved aerated concrete by a chemical reaction generating a gas in fresh mortar, so that when it sets it contains a large number of gas bubbles. Aluminum is used as a foaming agent in AAC production worldwide and it is widely proven as the best solution for its purpose. The Aluminum powder can be classified into three types: atomized, flake and granules. In case of an atomized particle, its length, width and thickness are all of approximately the same order where the length or width of a flake particle maybe several hundred times it thickness. Aluminum powder in the AAC industry is often made from foil scrap and exists of microscopic flake-shaped aluminum particles. Aluminum powder with grain size less than 100μm and particularly with fractions less than 50μm, can easily form highly flammable aero suspensions.

2. Methodology

2.1 .Material used

Following materials are generally used to produce concrete:

i. Cement,

ii. Fine aggregates and

iii. Coarse aggregates

iv. Aluminium dross,

v. Aluminium powder

i Cement.

Ordinary Portland Cement (OPC) is manufactured by burning siliceous materials like limestone at 1400 degree Celsius and thereafter grinding it with gypsum. The chemical components of Ordinary Portland Cement are magnesium (MgO), Alumina (AL2O3), silica (SiO2), Iron (Fe2O3), and sulphur trioxide (SO3). For the present investigation, 53 grade OPC conforming to BIS: 12269-1987 was used.

Table 1: Physical Properties of Fine OPC

Specific gravity	3.15
Fineness test	5%
Normal consistency	36%
Initial setting time	30 minutes

ii. Fine aggregate.

Table 2: Physical Properties of Fine Aggregate

Specific gravity	2.60
Fineness modulus	2.46
Bulk density	1.65 Kg/m3
Zone	Zone II

iii. Coarse aggregate

Table 3: Physical Properties of Coarse Aggregate

Specific gravity	2.74
Fineness modulus	1.96.
Bulk density	2498.7 kg / m^3

iv. Aluminium dross

Aluminium dross represents a residue from primary and secondary aluminium production. Drosses are classified according to aluminium metal content into white and black dross. White dross has higher metal aluminium content and it is produced from primary and secondary aluminium smelters, whereas black dross has a lower metal content and is generated during aluminium recycling (secondary industry sector). Black dross typically contains a mixture of aluminium oxides and slag with recoverable aluminium content ranging between 12–18%. The conventional rotary furnaces heated with a fuel or a gas burner is used to recover the extra aluminium from black or white dross. This treatment process produces the non-metal product called aluminium recycling waste containing alumina, salts, impurities and a little amount (3–5 %) of metallic aluminium. The dross used for the experimentation is of white dross because of its lower salt content. The dross has an egg odour. The collected dross was finely powdered and then it is used in production of concrete. The Specific Gravity of the respective dross is 3.39.

Table 4: Chemical Properties of Aluminium Dross

CHEMICAL COMPONENT	Percentage by weight (%)
MgO	0.5
Fe2O3	0.3
CaO	18.2
Al2O3	15.9
SiO2	56.6
TiO2	Trace
Na2O	0.36
ZnO	0.8
MnO	0.6
CuO	Trace
CdO	Trace
LOI	6.4

v. Aluminium powder:

The Aluminum powder can be classified into three types: atomized, flake and granules. In case of an atomized particle, its length, width and thickness are all of approximately the same order where the length or width of a flake particle maybe several hundred times it thickness. Aluminum powder in the AAC industry is often made from foil scrap and exists of microscopic flake-shaped aluminum particles. Aluminum powder with grain size less than 100μm and particularly with fractions less than 50μm, can easily form highly flammable aero suspensions. The aluminium powder confirming to IS:438-2006 is used in this investigation. Fine, uniform, smooth metallic powder of specific surface area 9000cm2/gm is used. Density - 0.12 gm/cc.

2.2 Mix design

Concrete mix design is a process of attaining various proportions of raw materials of concrete with a minimum strength requirement and to achieve durable concrete. The Concrete mix design can be defined as the art of obtaining a concrete of the required properties, at the lowest cost, by suitable choice and proportions of available materials. The purpose of mix proportioning is to obtain a product that will perform according to certain predetermined requirements, the most essential requirements being the workability of fresh concrete, strength and durability of hardened concrete.

Table 5: Mixing Ratio

Cement (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)	W/C ratio
1	1.47	2.74	0.4

Table 6: Mix Proportions

Mix ID	Cement (kg)	A.D (kg)	A.P (Kg)	F.A (kg)	C.A (kg)
M	350	0	0	691.45	1288.92
A5	332.5	17.5	0	691.45	1288.92
A10	315	35	0	691.45	1288.92
A15	297.5	52.5	0	691.45	1288.92
AP5	332.5	0	17.5	691.45	1288.92
AP10	315	0	35	691.45	1288.92
AP15	297.5	0	52.5	691.45	1288.92

3. Test Result Report and Analysis

3.1 Density of Cubes:

Table 7: Density of Cubes

Mix id	Density kg/m³
M	2370
A5	2222
AP5	1778
A10	2103
AP10	1630
A15	1926
AP15	1481

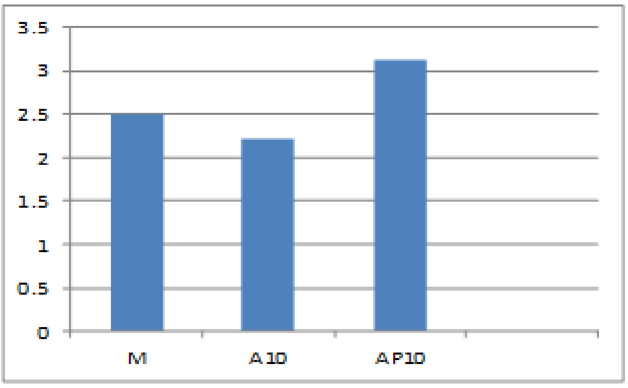

Fig 1: Density of Cubes

3.2 Compressive strength Test:

The compressive strength test for is carried out for six samples each mix proportions and the value obtained is shown in table 8 and the comparison of 7th and 28th day is shown in figure 2.

Table 8: Compressive Strength Results

Mix id	7th day (N/mm^2)	28th day (N/mm^2)
M	23.28	40.45
A5	20.66	30.20
AP5	19.16	29.03
A10	27.38	43.15
AP10	24.24	40.70
A15	18.46	28.71
AP15	17.57	27.49

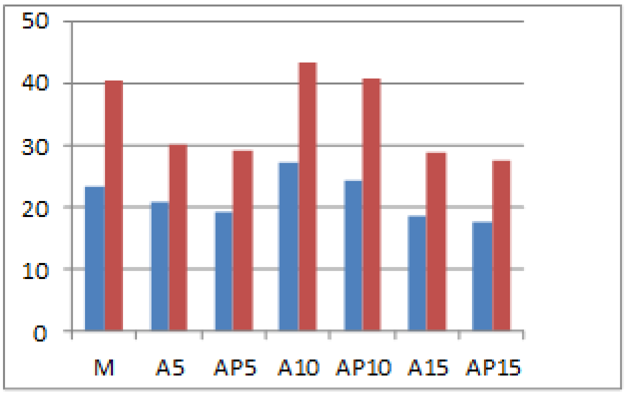

Fig 2: Compressive Strength

3.3 Split Tensile Strength

Split tensile strength test results obtained for various mix proportion at 7th and 28th day is shown in the table 9. The comparison of split tensile strength for various mix proportion is shown in figure 3.

Table 9: Split Tensile Strength Results

Mix id	7th day (N/mm^2)	28th day (N/mm^2)
M	2.41	2.67
A5	0.72	0.93
AP5	0.44	0.56
A10	1.07	1.42
AP10	0.73	0.95
A15	0.39	0.51
AP15	0.29	0.39

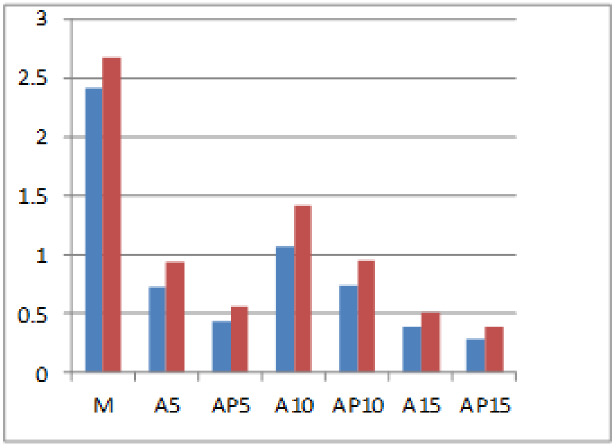

Fig 3: Split Tensile Strength

3.4 Water Absorption Test

Saturated water absorption tests were carried out on 150 mm cube specimens at the age of 28 days curing. The specimens were weighed before drying. The drying was carried out in a hot air oven at a temperature of 110˚C. The dried specimens were cooled at room temperature and then immersed in water. The specimens were taken out after 24 hours surface dried using a clean cloth and weighed.

Table 10: Water Absorption Test

Mix Id	Water Absorption (%)
M	2.50
A10	2.21
AP10	3.12

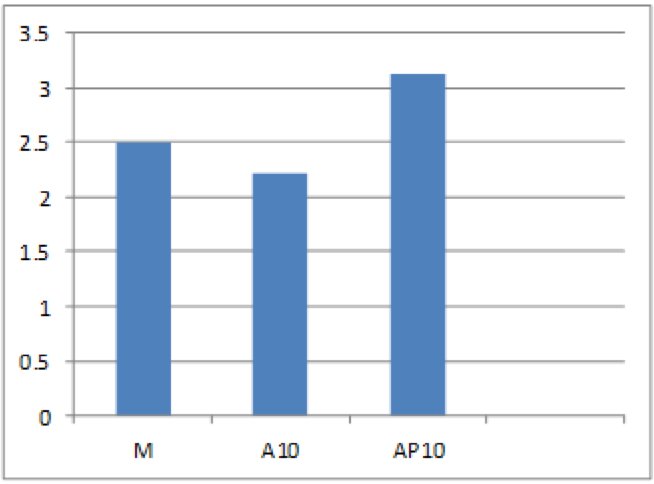

Fig 4: Water Absorption Test

3.5 Flexural strength test for Beams

In the second phase flexural test were conducted on beam with the optimum results which is obtained from the compression test of the cubes. A comparative study between the optimum replacements with the conventional was also done. In order to study the performance of the beam with partial replacement of cements and addition of sisal fibre, the experiment is to be carried out as below. The aim of this work is to study the flexural behavior and splitting tensile strength of the beams. All the tests have been carried out in loading frame with a capacity of 800 KN. The beam is simply supported and the two point loading is applied. The mountable mechanical strain gauges are used to measure the strains in the beam specimens. Then LVDT is used to measure deflection of the beams. Also loads are calculated using load cell. The load is to be applied in small increments of 5KN. At each load increment the deflection measured is recorded. All the specimens are loaded up to the failure.

Table 11 Flexural strength test results

M_{25} mix	Load (KN)	Flexural strength (N/mm^2)(Pl/bd^2)
M	49.7	27.61
A10	54.9	30.5
AP10	48.8	27.11

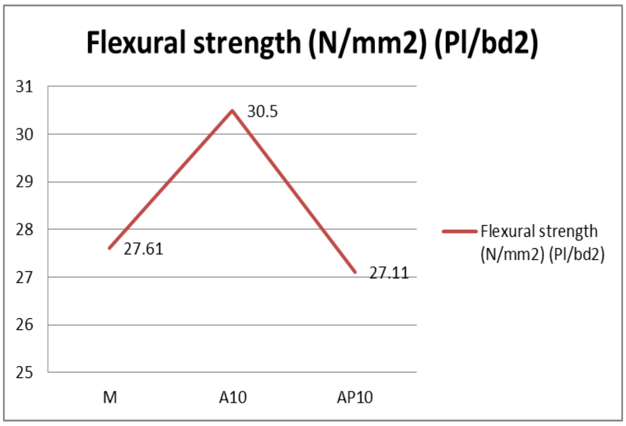

Fig 4: Flexural strength Test

4. Results and Discussion

1. The density of the concrete decreased when the content of aluminium powder and aluminium dross is increased.

2. Density of the concrete decreased due to the evolution of hydrogen gas when aluminium is mixed with the cementitious material.

3. The compressive strength of aluminium dross 10% replaced concrete showed better result when it is compared with aluminium powder replaced concrete.

4. The compressive strength of specimen decreased due to the formation of air voids.

5. Conclusion

The compressive strength value of concrete decreases with increasing aluminium dross and powder content. As the replacement percentage of aluminium dross and powder is increased, more entrapped air occurs and this causes a negative effect on strength. Replacement of aluminium powder (5, 10, and 15 %) by weight of cement is used to produce aerated (gas) concrete. From comparative study of concrete the optimum of 10% Aluminium dross can be replaced with cement to obtain required strength of concrete.

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