© 2016 IJSRSET | Volume 2 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

An Experimental Investigation on Use of Secondary Aluminium Dross in Cement Concrete

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ABSTRACT

In the production of Aluminium production, Aluminium dross is a by-product. At present, dross is processed in rotary kilns to recover the Aluminium. Aluminium dross in the form of salt cake is sent to landfills, although it is sealed to prevent from leaching. Leaching of Aluminium dross could harm the environment as it contains fluorides and other salts. Furthermore, much energy is consumed to recover the Aluminium from the dross, this energy can be saved if the dross could be diverted and utilized as an engineering material.

The objective of present work is to utilize the Aluminium dross in the natural cycle (closed loop) by using it as an engineered material and to investigate the mechanical properties of new concrete type obtained by adding Aluminium dross, which is an impure Aluminium mixture, obtained from metals melting and mixing with flux. The main advantage of this type of concrete over the conventional ones is the reduction in the quantity of raw materials. 5%, 10%, 15%, 20% and 30 % by weight of cement is being replaced by dross. Then using this concrete, concrete cubes are casted. The casted cubes are tested for compressive strength for 3 days, 7days, 28 days. It is found that 7 days compressive strength has been increased when compared with 3 days compressive strength for 5% replacement. But for rest of the replacements (10%, 15%, 20%& 30%), 7 days compressive strength has been decreased when compared with 3 days compressive strength. Hence, 5% replacement is preferable. The results of this study indicate that Aluminium dross can be used as an ingredient up to 5% to improve expanded concrete/mortar.
Keywords: Rotary Kilns, Fluorides, Flux, Compressive Strength

I. INTRODUCTION

Concrete is a construction material composed of Portland cement and water combined with sand, gravel, crushed stone, or other inert material such as expanded slag or vermiculite. The major constituent of concrete is aggregate, which may be natural (gravel or crushed rock with sand) or artificial (blast furnace slag, broken brick and steel shot). Another characteristic of Aluminium dross/OPC Concrete constituent is the binder, which serves to hold together the particles of aggregate to form concrete. Commonly used binder is the product of hydration of cement, which is the chemical reaction between cement and water. Admixtures may also be added to concrete mixes to change some of its properties.

Aluminium dross is a mixture of free metal and non metal substances (e.g., Aluminium oxide and salts). Drosses as well as salt slags (or: salt cakes) are residues from Aluminium industry. Aluminium dross is formed during refining and by air-oxidation of the liquid metal during melting, holding and casting operations. It consists of a complex conglomerate, including metallic oxides (e.g.: Al_2O_3, $Al_2O_3 \cdot MgO$, $Al_2O_3 \cdot SiO_2$, $Al_2O_3 \cdot FeO$ etc.), nitrides (e.g.: AlN), chlorides (e.g.: $AlCl_3$, NaCl, KCl), fluorides (e.g.: CaF_2, NaF, AlF_3, Na_3AlF_6 etc.), carbides (e.g.: Al_4C_3), sulphides (e.g.:

Al_2S_3), phosphides (e.g.: AlP), dirt and impurities appart from metallic Aluminium (between 80-20%). The formation of dross and the amount of dross formed depend on different factors like type and quality of input material (e.g.: Aluminium scraps in secondary industry) operating conditions and type of technology and furnace applied. Depending on different conditions during charging, melting, refining as well as skimming, the metal-content of dross may vary between 20-80% Al (average value: 60% Al). According to Organisation for Economic Co-operation and Development (OECD) definition, residues with more than 45% Al are called "skimmings" and materials containing less than 45% Al are called "dross".

Figure 1. Black Alluminium Dross

Aluminium nitrides and carbides may also be present, as well as metal oxides derived from the molten alloy (Manfredi et al. 1997)[12]. Dross may be classified by means of their metal content and dross 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. Lack of comprehensive information on the characteristics of by-products is a major barrier to increased use of these materials. Minimization of dross and salt cake formation and the development of new uses for wastes and by-products 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 Aluminium waste such as red mud into usable feedstock for other processes that could eliminate this environmental problem. Valuable Aluminium metal, oxides, salts, and other materials have been wasted because of the lack of viable processing technologies to convert this material to useful products (Ramesh 1999)[15]. Therefore, this research work is on the development of a technology to divert the salt cake into valuable feedstock materials for concrete works.

II. METHODS AND MATERIAL

1. Experimental Procedure

1.1. MATERIALS: The following are the materials used in this investigation.

- Cement
- Fine aggregate
- Coarse aggregate
- Water
- ALUMINIUM dross

2.2 Materials Description and Their Properties

2.2.1 Cement

Cement may be described as a material with adhesive and cohesive properties that make it capable of bonding, mineral fragments into a compact whole. The OPC (53 grade) used in the present work is of Anjani cement.

Table 1. Properties of Cement

S. No	TEST	RESULT
1.	Normal Consistency (%)	34
2.	Initial setting time(min)	50
3.	Final setting time(min)	320
4.	Specific gravity	3.15

2.2.2 Fine Aggregate

Naturally available sand is used as fine aggregate in the present work. The most common constituent of sand is silica, usually in the form of quartz, which is chemical inert and hard. The sand is free from clayey matter, silt and organic impurities etc. Hence used as a fine aggregate in concrete. The size of sand is that passing through 4.75 and retained on 150 micron IS sieve. The specific gravity of Sand is taken as 2.62. Sand is tested for specific gravity, in accordance with IS: 2386-1963.

Table 2. Properties of Fine Aggregate

Sl. No	Properties	Results
1	Specific gravity	2.7
2	Bulking of sand	4%
3	Particle size variation	0.15 to 4.75 mm

2.2.3 Coarse Aggregate

The coarse aggregate is free from clayey matter, silt and organic impurities etc. Coarse aggregate is tested for specific gravity, in accordance with IS: 2386-1963. The maximum size of 20 mm is used as a coarse aggregate in concrete. For most of building constructions, the coarse aggregate consists of gravel or crushed stone up to 20mm size. However, in massive structures, such as dams, the coarse aggregate may include natural stones or rock.

Table 3. Properties of Coarse Aggregate

Sl. No	Properties	Results
1	Specific gravity	2.8
2	Particle size variation	6.3 to 20 mm
3	Fineness modulus	8.47

2.2.4 Water

The water used for the study was free of acids, organic matter, suspended solids, alkalis and impurities which when present may have adverse effect on the strength of concrete. Water is an important ingredient of concrete, which not only actively participates in the hydration of cement but also contributes to the workability of fresh concrete.

2.2.5 Aluminium Dross

The aluminium waste (AW) used for this study was obtained from an Aluminium extrusion company (VAKKAL IMPEX PVT LMT), Hindupur, Anantapur(dist). The wastes are irregular in shape, black in colour and contain lumps and small particles of ALUMINIUM produced by burning aluminium scraps (raw material) in a furnace at about 1900°C. The total waste produced per day is approximately 18 tonnes. Before using the waste with concrete it was ground and sieved using sieve size 150μm. This sieved dross is used as cement replacement in concrete production.

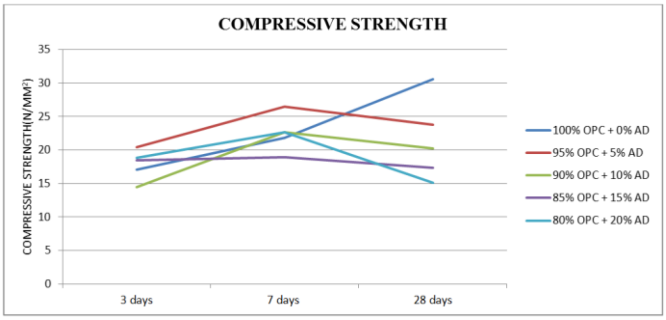
III. RESULTS AND DISCUSSION

Compressive Strength Test Result

Table 4. Compressive Strength Test Result

Sl.No	Cementitious material	W/C	Compressive strength (N/MM²)		
			3 days	7 days	28 days
1	100% OPC + 0% AD	0.5	17.1	21.78	30.6
2	95% OPC + 5% AD	0.5	20.44	26.5	23.77
3	90% OPC + 10% AD	0.5	14.44	22.66	20.22
4	85% OPC + 15% AD	0.5	18.44	18.89	17.33
5	80% OPC + 20% AD	0.5	18.88	22.66	15.12

The replacement of aluminium dross in cement, it is clearly observed that when the percentage of aluminium dross is increased in concrete, the compressive strength of concrete decreases. The strength of concrete of 5% AD in cement after 28 days is 23.77N/mm^2, strength of concrete of 10 % AD in cement after 28 days is 20.22N/mm2, and strength of concrete of 15% AD in cement after 28 days is 17.33N/mm^2.Similarly with increase in dross content, strength goes on decreasing.



IV. CONCLUSION

Aluminium dross is used in production of concrete cubes by replacement levels of 5%,10%,15%,20%&30% by weight of cement. These cubes were cured and tested for compressive strength for 3 days, 7 days, 28 days and results were noted. Based on the experimental investigation conducted following conclusions are made.

- The compressive strengths for
  - ★ 100% cement + 0% aluminium dross at 3 days, 7 days, 28 days were17.1N/mm^2,21.78N/mm^2,30.6N/mm^2.
  - ★ 95% cement + 5% aluminium dross at 3 days, 7 days, 28 days were 20.44 N/mm^2,26.5 N/mm^2,33.77 N/mm^2.
- By replacement of 5% aluminium dross, the compressive strength increases by 19.53% for 3 days, 20.78% for 7 days and 10.35% for 28 days.
- Replacement level of 5% can be used to achieve good quality concrete. So, it is not preferable more than 5% replacement.

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