



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 9, Issue 11, November 2020

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 7.512

9940 572 462

6381 907 438

ijirset@gmail.com

www.ijirset.com

The Properties and Uses of Aluminum Dross in the Concrete Industry: Review

Khaled Abdelsamie

Assistant Professor, Faculty of Engineering, Sohag University, Egypt

ABSTRACT : Considerable efforts have been taken worldwide to utilize local natural waste and by-products materials as supplementary cementing materials to improve the properties of concrete, as well as that, the use of these materials leads to the proper disposal of natural waste results in the less impact on environment. This paper is attention to classified of Aluminum. Also, it is exhibits the raw materials product in aluminum and properties and applications. The production method is classified for Aluminum waste. The literature review of aluminum dross properties focuses on the porosity, permeability, compressive strength and splitting strength.

KEYWORDS: Percentages added, concrete mixes, Coarse Aggregate (CA), Fine Aggregate (FA), compressive strength test, Aluminum dross.

I. INTRODUCTION

Solid waste constitutes a big environmental problem for the landscape, soil, atmosphere and ground water. It is also the source of many health and hygiene problems. For centuries people have been getting rid of it by organizing a collection, transport and dump system in old Egypt, Greece and Rome [1]. Concrete is a construction material used at long run and range around the world. It has low tensile strength, low ductility and low energy absorption. Therefore, improving Concrete properties and reducing the size and amount of defects in concrete would lead to better concrete performance [2]. Aluminum is present almost everywhere around us in a vast number of applications. We may not even be conscious about its presence, but we would definitely miss it. The use of aluminum has many advantages, including from an environmental perspective[3]. Strong and light Aluminum is a very light metal, with a specific weight of 2.7 (g/cm³), which is one-third of that of steel the strength of the metal can be increased by adding small quantities of other metals (alloys)[4] . Dross is the inevitable waste product generated by the world-wide primary and secondary aluminium industries. Around 3.5 million tonnes of white dross and 0.85 million tonnes of black dross are produced per year. Drosses are classified depending on metal content. White dross contains 40% and black dross contains 10% of aluminium [5] .

II. PROPERTIES OF ALUMINUM MATERIALS, [4]

▪ Strong and light

Strong and light Aluminum is a very light metal, with a specific weight of 2.7 (g/cm³), which is one-third of that of steel the strength of the metal can be increased by adding small quantities of other metals (alloys). The low weight reduces energy consumption related to transportation, and hence also emissions of greenhouse gases and other pollutants as shown in figure (1).

▪ Highly corrosion resistant

As the metal itself forms a protective oxide coating (That is immediately reformed if the metal is cut or scratched), It is highly corrosion resistant. this property can be further improved by various types of surface treatment. this property prolongs the useful life of aluminum in cars and buildings and reduces the need for maintenance. this also reduces environmental impacts related to replacement and maintenance.

▪ Good conductivity

Aluminum is a good conductor of heat and electricity, and in relation to its weight, is almost twice as good a conductor as copper. these properties make aluminum the material of choice to achieve energy efficient systems for electrical transmission systems and other applications, such as heat transfer components.

▪ **Good reflective qualities**

Aluminum can reflect both heat and light, and together with its low weight, makes it an ideal material for reflectors in, for example, light fittings. High energy efficiency in the reflectors contributes to reduced environmental burden.

▪ **Easy to form and process**

Aluminum is ductile, and has a low melting point. It can easily be processed in a number of ways - both in a cold and hot condition. Its great ductility allows design flexibility and aluminum products to be integrated in advanced applications in transport and buildings industries.

▪ **Impermeable, non-toxic and odorless**

Aluminum foil, even when rolled to just a 0.007 mm thickness, is still completely impermeable and lets neither light, aroma nor taste substances in or out. Moreover, the metal itself is non-toxic, and releases no aroma or taste substances. Aluminum is therefore widely used in food and drink packaging. - efficient conservation of food reduces wastage of food, which is an important environmental and resource advantage. Furthermore, the low weight of the packaging reduces energy in transportation. The impermeability of aluminum foil also reduces cooling needs.

▪ **Non-combustible**

Aluminum used in buildings, constructions and transport equipment is non-combustible. It will only burn in a fire powder form or as very thin lm. Aluminum will melt when temperatures exceed 660 °C - without releasing any gases.

▪ **Abundant resources**

Aluminum is the third most abundant element in the earth's crust, after oxygen and silicon, constituting about 7 percent by weight of the earth's crust. Bauxite is the only commercial ore used for the production of alumina today, but other sources may be feasible in the future. Known bauxite reserves will last more than 100 years at current rate of extraction.

▪ **Easy to recycle**

The re-melting of aluminum requires little energy, and metal loss in the re-melting process is less than 3 percent. Only about 5 per cent of the energy required to produce the primary metal initially is needed in the recycling process. Around 75 per cent of the aluminum ever produced is still in use, and constitutes a resource bank for use in the future.



"Fig. 1" The casting process of metal aluminum produced from dross reprocessing [5]

III. THE USES OF ALUMINUM

Aluminum is the third most abundant element in the earth's crust after oxygen and silicon. It accounts for about 8% (by weight) of the earth's crust⁴. It is however, a comparatively new industrial metal that has been produced in commercial quantities for over 100 years. Measured either in quantity or value, aluminum's use exceeds that of any other metal except iron, and it is important in virtually all segments of the world economy. Aluminum is a versatile metal with a range of valuable properties. It is moderately soft and weak when pure, but it is much stronger when alloyed with other metals⁶ Its main advantage is its lightness (low density 2.73g cm⁻³). Some of its alloys are used for special purposes: duralumin, which contains about 4~o Cu, and several aluminium bronzes(alloys of Cu and Al with other metals such as Ni, Sn and Zn). There are many uses for aluminum and its alloys [5] :

1. Because of its lightness and also toughness, aluminum is very useful to the aircraft, space vehicle, ship and car industries.
2. The outer layer of aluminum forms a natural coating of aluminum oxide when exposed to air. This protects aluminum from corrosion (rusting) so it is used frequently in outdoor applications, such as the framework of windows and doors.
3. It is the most commonly used metal in the electronics industry because of its excellent electrical and thermal conductivity (on a weight for weight basis it conducts twice as well as copper).
4. It is very familiar material in the home with products such as thin flexible aluminum foil, containers such as cans for drinks, tubes for toothpaste, cooking utensils etc.
6. Finely divided aluminum powder IS called "aluminum bronze", and IS used m preparing aluminium paint.
7. Its compounds: $Al(OH)_3$ is widely used as an anti-acid treatment for indigestion and $Al_2(SO_4)_3$ is used to treat drinking water .

IV. THE EFFECT OF ALUMINUM DROSS ON MECHANICAL AND PROPERTIES OF CONCRETE, [6]

In the literature, there are several studies to use this residue in construction applications as the replacement of sand or cement, to produce concrete blocks, to manufacture aluminate cement or as filler in asphalt products. The results proved that the concrete products can be prepared by using the salt as the replacement of sand or cement without causing deleterious effects on concrete characteristics, and the calcium aluminate cement can be produced by using the salt cake as sources of CaO and Al_2O_3 . For example, Puertas et al. proved that aluminum dross including high alumina may be used as raw material in cement production industry. Also, Pereira et al. studied the effect of aluminum dross on the mechanical properties of Portland cement mortar and demonstrated that aluminum dross can be used as partial replacement material for cement in certain limits to obtain environmental and economic advantages .



"Fig. 2" the picture shows aluminum dross

• Experimental Procedure, [6]

1) Mixture Proportions:

The concrete mixture proportions of the mixes are given in Table (2-29). As seen from the table, within the scope of the experimental program five concrete mixtures were prepared. The control mixture included only the Portland cement (PC) as a binder, and named as AS0 which means that there is no aluminum slag. The remaining mixtures had different aluminum slag contents of 5%, 10%, 15% and 30% by weight of Portland cement and named as AS5, AS10, AS15 and AS30, respectively. For all the mixtures, the total amount of cementitious material (PC+AS) content and slump value were kept constant. Since the slump value was kept constant, water was gradually added to the mixtures and therefore the water to cementitious ratio (w/cm) was not kept constant and changed from 0.45 to 0.53.

2) Specimen Preparation

Concrete mixtures were prepared using an electrically driven mechanical mixer with a 200 kg capacity. The preparation procedure was the same for all mixtures. For all concrete mixture, first of all, the fine and coarse aggregates were mixed for 1 minute and the cementitious materials (cement or cement and aluminium dross) were added and mixed for 1 more minute. Eventually, the water was gradually added. After completing the mixing procedure, the air content, slump and setting time were determined for the fresh concrete properties. From each concrete mixture, fourteen 100x200 mm cylinder specimens and two 15x15x15 cm cube specimens were cast to determine the hardened properties like compressive strength, permeability tests and corrosion test. After 24 hours, the specimens were removed from the molds and cured in water at a temperature of $20\pm 2^{\circ}\text{C}$ until the date of testing.

"Table 1" - Mixture proportions

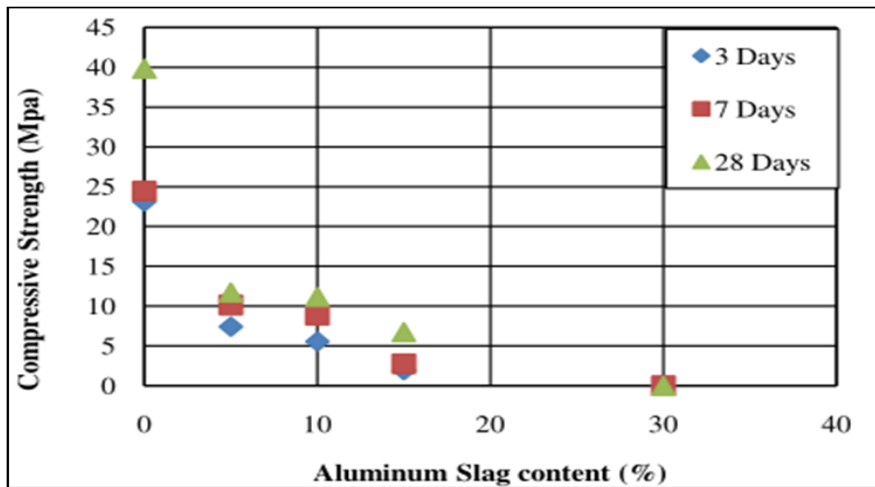
Mix id	Mix design label	W/CM	Water kg/m ³	Pc kg/m ³	As kg/m ³	aggregate	
						Fine kg/m ³	Coares kg/m ³
1	AS 0	0.46	183	400	0	666	615
2	AS 5	0.45	180	380	20	685	640
3	AS 10	0.46	188	360	40	685	640
4	AS 15	0.50	197	340	60	685	640
5	AS 30	0.53	213	280	120	685	640

3) Compressive Strength

The mean compressive strength of cylindrical concrete specimens at 3, 7 and 28 days of age is presented in Table (2). Also the coefficients of variations calculated from an average of three specimens at each age are included in the presented table. However, for the mixture 5 labelled as AS30 which means that 30% of cement is replaced by aluminum dross, the compressive strength test results could not be obtained since all the samples were broken during casting as seen in table (2). Therefore it can be concluded that high volume aluminium dross replacement is not appropriate. Figure (3) presents the effect of aluminium dross content on the compressive strength at 3, 7 and 28 days of age. As seen from the figure, the compressive strength value decreases with increasing aluminium dross content and this is related with the mixtures including high amount of aluminium dross have higher air content. It is concluded that curing for more than 7 days has a positive effect on strength gain. This result is consistent with those of other studies and suggest that strength characteristic of cement mortar can be increased by adding nano-particles after curing. Thus, for further studies, curing effect on the strength gain of aluminium dross added mortar/concrete should be considered.

"Table 2 " - compressive strength test result

Mix id	w/cm	3days		7days		28days	
		mean	Cov(%)	mean	Cov(%)	mean	Cov(%)
1	0.46	23.15	39.95	24.43	20.55	39.84	2.36
2	0.45	7.42	8.60	10.15	19.89	11.73	7.34
3	0.46	5.55	13.22	8.86	3.00	11.17	23.69
4	0.50	1.95	2.24	2.74	16.85	6.74	15.90
5	0.53	1.85	2.14	2.14	15.55	5.64	14.90



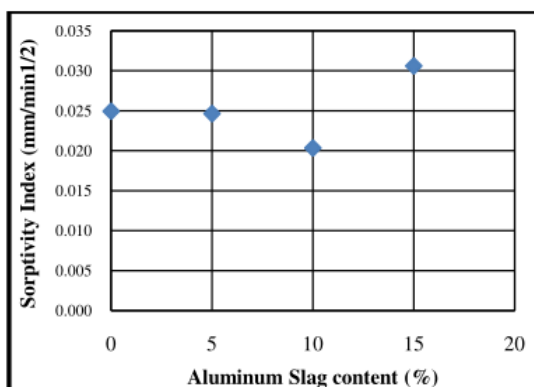
"Fig. 3" The relationship between the compressive strength and aluminum dross content

4) Permeability

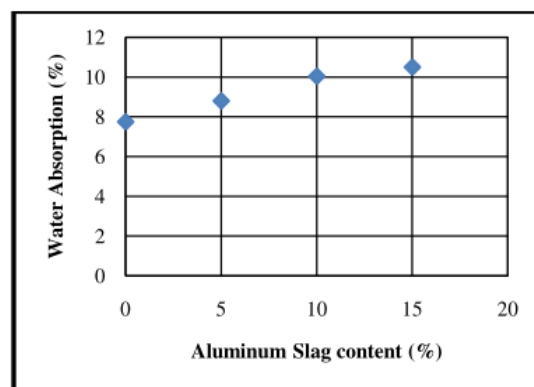
In this project, the permeability properties of concrete samples were evaluated by performing water absorption and sorptivity tests and the results are given in Table (3). The effect of aluminium dross content on the sorptivity index and water absorption capacity of concrete samples can be seen in Figure (4) (a) and (b), respectively. In these figures, it can be observed that increase in the aluminium dross content results in the increase in permeability values of concrete samples and this result is also compatible with the compressive strength results.

"Table 3 " - Permeability test results

Mix id	Mix design label	W/CM	Sorptivity index (mm/mm ²)	Water absorption (%)
1	AS 0	0.46	0.025	7.75
2	AS 5	0.45	0.0247	8.8
3	AS 10	0.46	0.0204	10.04
4	AS 15	0.50	0.0306	10.5
5	AS 30	0.53	0.0206	9.8



(a)



(b)

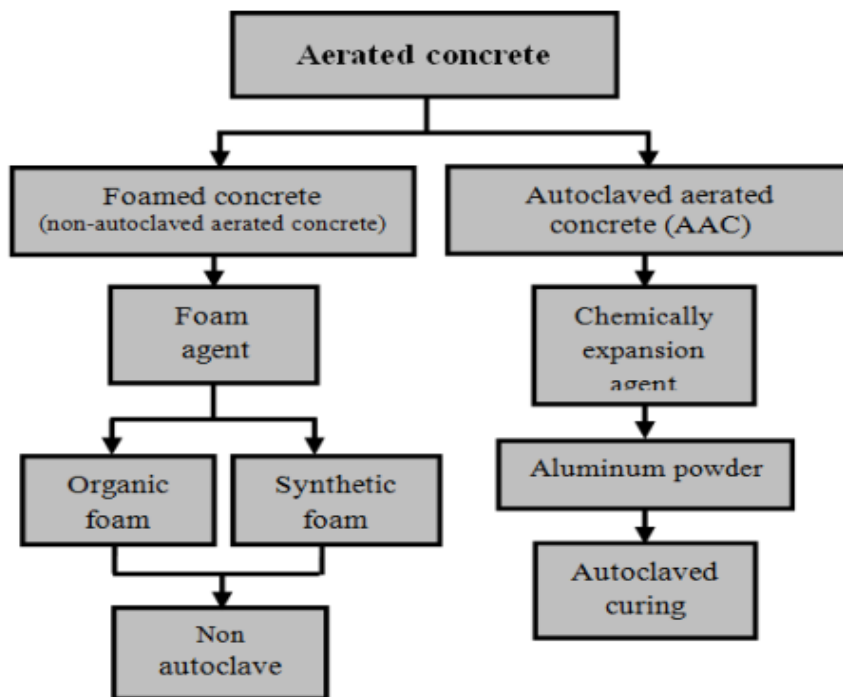
"Fig. 4" The relationship between the aluminium dross content and (a) sorptivity index (b) water absorption capacity

V. RELATIONSHIP BETWEEN ALUMINUM FIBER IN CONCRETE AND LIGHTWEIGHT CONCRETE

Aerated lightweight concrete have many advantages when compared with conventional concrete such as advanced strength to weight ratio, lower coefficient of thermal expansion, and good sound insulation as a result of air voids within aerated concrete. This paper is attention to classified of aerated lightweight concrete into foamed concrete and autoclaved concrete. Also, it is exhibits the raw materials used in aerated concrete, types of agent, properties and applications. The production method is classified for each foamed and autoclaved concrete. The literature review of aerated lightweight properties is focuses on the porosity, permeability, compressive strength and splitting strength.

The aerated concrete is a one types of lightweight concrete. Aerated concrete is also well-known as a cellular concrete. It can be divided into two main types according to the method of production. They are foamed concrete (non-autoclaved aerated concrete (NAAC)) and autoclaved aerated concrete (AAC). i) Foamed concrete is produced by injecting preformed stable foam or by adding a special air-entraining admixture known as a foaming agent into a base mix of cement paste or mortar (cement+ water or cement+ sand+ water). ii) The AAC is produced by adding in a predetermined amount of aluminum powder and other additives into slurry of ground high silica sand, cement or lime and water ,as shown in Fig.(2-22). The background of foamed concrete began much later than lightweight aggregate concrete. Foamed concrete is not a particularly new material, it is first recorded use date back to the early 1920s. The application of foamed concrete for construction works was not recognized until the late 1970s. Beside the AAC began approximately 100 years ago. In 1914, the Swedes first discovered a mixture of cement, lime, water and sand that was expanded by the adding aluminum powder to generate hydrogen gas in the cement slurry. Prior to that, inventive minds had tried beaten egg whites, yeast and other unusual methods of adding air to the concrete. It was reported that foamed concrete was developed in Europe over 60 years ago and has since then been on the Manuscript received January 31, 2014; revised March19, 2014.

international market for more than 20 years. Foamed concrete have high flow ability, low self-weight, minimum consumption of aggregate, controlled low strength, and excellent thermal insulation properties. The density of foamed concrete has wide range (1600-400kg/m3), with appropriate control in the dosage of the foam, can be obtained for application to structural, partition, insulation, and filling grades .



"Fig. 4" Classification of aerated lightweight concrete

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. When aluminum is added (usually at about 0.2% to 0.5% by dry weight of cement) to the mixing ingredients, 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 its 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 $100\mu\text{m}$ and particularly with fractions less than $50\mu\text{m}$, can easily form highly flammable aero suspensions (dust clouds) during pouring or vibration. The production of AAC requires aluminum powders that contain fractions finer than 100 or $50\mu\text{m}$. This is important in order to obtain required mechanical properties of the aerated concrete, [7].

VI. CONCLUSIONS

In this project, the objective was to investigate the mechanical and chemical behaviour of new concrete type obtained by adding aluminum dross. It was also aimed to investigate the effect of harsh environmental conditions in the Gulf region on the durability properties of aluminium dross added concrete. Within the scope of the project, many tests were performed to evaluate the properties of aluminium dross waste generated from Qatalum and the amount and the method that should be used to obtain a proper concrete was investigated. The main tasks performed during the project can be listed as the chemical and physical tests on aluminium dross, determination of the properties of fresh and hardened aluminium dross added concrete and corrosion test.

The following conclusions are drawn as a result of this experimental program:

- 1- When aluminum slag is used in the range of certain limits (i.e. up to 15% replacement of cementitious material), increasing aluminum dross content accelerates the hardening which can be understandable since the nano particles of aluminum dross has higher surface area.
- 2- study has proved that the use of aluminum dross manufactured from refractory material increases the mechanical properties of concrete when it is used as filler
- 3- High volume aluminum dross replacement is not appropriate because of its high water absorption capacity.
- 4- Since aluminum dross acts as an expanding agent, it can be used in the manufacturing of building subfloors, blocks and pre-molded panels.
- 5- The compressive strength value and permeability properties of concrete decreases with increasing aluminum dross content. As the replacement percentage of aluminum dross is increased, more entrapped air occurs and this causes a negative effect on strength and permeability properties.
- 6- Curing effect on the strength gain of aluminum dross added mortar/concrete should be further studied.
- 7- Increasing the dross volume from 0 to 10% resulted in a decrease of the total halides' ion concentration/hydroxide ion concentration ratio from 1300 to 787 which is reflected in a decrease in the corrosion rate from 0.44 to 0.2 mpa. A further increase in the dross volume to 30% resulted in an increase in the ratio to 1580 which consequently led to a significant increase in the corrosion rate to 1.2 mpy for the samples of dross volumes higher than 10%.

REFERENCES

- 1- Amin Zayani, "Solid Waste Management: Overview and current state in Egypt", Egypt , February 2010.
- 2- H. Mohammad hosseini and A.S.M. Abdul Awal, "PHYSICAL AND MECHANICAL PROPERTIES OF CONCRETE CONTAINING FIBERS FROM INDUSTRIAL CARPET WASTE", International Journal of Research in Engineering and Technology, Malaysia, Dec-2013.
- 3- Svein Richard, " aluminum environment and society" , data sheet , USA, December 2012.



- 4- Elvis .M. Mbadike and N.N Osadere , "Effect of Incorporation of Aluminium Waste in Concrete Matrix Using Different Mix Ratio and Water Cement Ratio", International Archive of Applied Sciences and Technology, Nigeria, March 2014.
- 5- Rehana Siddique Pasley, "The Physical and Chemical Reclamation and Recycling of Elements from Black Aluminium Furnace Residues" , Brunel, June 2003.
- 6- Nesibe Gozde Ozerkan at all , "The Effect of Aluminium Dross on Mechanical and Corrosion Properties of Concrete" , International Journal of Innovative Research in Science, Engineering and Technology , Qatar , March 2014.
- 7- Beatrix Kerkhoff ," Effects of Substances on Concrete and Guide to Protective Treatments " , Portland Cement Association, Skokie . illinois, 2007 .
- 8- Svein Richard, " aluminum environment and society" , data sheet , USA, December 2012.
- 9- Radwa defalla , the use of aluminum , December 2014.



INNO SPACE
SJIF Scientific Journal Impact Factor

**Impact Factor:
7.512**

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details