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Construction Materials From Industrial Wastes-A Review of Current Practices

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Abstract

Nowadays, natural resources are depleting worldwide, while at the same time the generated wastes from the industries are increasing substantially. The aim of this paper is to describe the industrial and natural waste utilization in construction materials. According to their fineness and specific gravity the wastes are partially or fully replaced with the construction materials (cement, fine and coarse aggregates). The industrial wastes contain high pH and they are calculated under the different temperatures to improve its reactivity. Generally the wastes contain the pozzolonic properties due to its fineness and plasticity, so it increases the strength of the materials. The pozzolonic characteristics may partially replace the materials and known benefits on the durability of the products. The physical, mechanical and chemical characteristics are analyzed by SEM, XRD and XRF analysis. Under this the wastes are partially or fully replaced to the construction material and using an different grades of concrete mix and tests were conducted for various proportions to analysis or finding the strength attainments (compressive, flexural, tension etc.,) tests are followed under the standard setup procedures and machines. Nowadays, the wastes are not having any industrial applications, so it can be innovatively using these wastes as a raw material in the civil engineering field. By using these wastes as the non-conventional and reuse or recycling of waste material in order to compensate the lack of the natural resources. So, wastes can be used to produce new products or can be used as admixtures in the civil engineering field. So the environment is protected from waste deposits.

Keywords – *Fly ash, Red mud, Copper slag, Silica fumes, Cement, Aggregates*

1. Introduction

In our country, there is a great demand for construction materials in civil engineering field. So, it is a very difficult problem for availability of materials. The researchers have developed the waste management strategies to apply for replacement of materials for their specific need. This paper deals with the review of industrial wastes like fly ash, red mud, copper slag and silica fumes.

1.1 Fly ash

Fly ash is an industrial waste generated from the thermal power plants. Over the years the fly ash produced were lying in the yard not without any usage. In a break through the researchers have discovered that fly ash could be tried as additives for the cement production. [10]

1.2 Red mud

Red mud generated out of Bayer's process for alumina production from Bauxite is a high volume solid waste, doesn't have any wide industrial applications. So the red mud is used as an alternative material in the construction industries. [16]

1.3 Copper slag

Copper slag is a by product obtained during the smelting and refining of copper. It is brought from the sterlite industries. Utilization of copper slag in application such as Portland cement substitution and as aggregates has advantages of eliminating the costs of dumping and minimizing the air pollution. [15]

1.4 Silica fumes

Silica fumes are the waste generated from the production of silicon and ferrosilicon alloys. It has wider application in the construction industries due to its pozzolonic properties. [9] The industrial wastes (fly ash, red mud, copper slag and silica fumes) have already been tried in the application of cement production and partial replacement of construction materials in civil engineering field. But it doesn`t have the large scale use of wastes anywhere in the industries except fly ash. So, the authors have shared their experience of successfully substituting the use of wastes in an effective manner.

2. Composition of Wastes and Its Properties

2.1 Fly ash

Table 1. The following is the composition of the fly ash by XRF analysis [10]

Components	**Weight %**
Al_2O_3	60.09
SiO_2	18.63
MgO	1.10
SO_3	1.54
Na_2O_3	0.31
K_2O	0.05
LOI	2.41

Specific gravity: 2.04

2.2 Red mud

Red mud contain up to 70% of solids remaining with moisture.

Table 2. The following is the composition of the dry red mud [3, 4]

Components	**Weight %**
Al_2O_3	20-22
SiO_2	40-45
Fe_2O_3	12-15
CaO	1.8-2.0
Na_2O	1.0-2.0
TiO_2	4-5

Particle size : 44 microns
Odour & appearance : Red, Earthy odour
pH : 11 to 12 [16]

2.3 Copper slag

Copper slag doesn't have a composition. It has the fineness and hardness properties so; it can be used as an alternative material for the fine aggregates.
Fineness modulus: 3.38 [1]
It has been done by the sieve analysis method.

2.4 Silica fumes

Table 3. Composition of the silica fumes [9]

Components	**Weight %**
Al_2O_3	0.06
SiO_2	85.72
LOI	1.96
Fe_2O_3	0.45

Specific gravity : 2.02
Fineness modulus : 85 [10]

All of the above wastes contain Al_2O_3 SiO_2 and Fe_2O_3. These are the main components that are present in the cements. The wastes also containing these components in one proportions so it can be used as a raw materials for the construction industries. [5, 7, 16]

3. Common Materials used in Construction

3.1 Cement

Ordinary Portland cement and plain Portland cement are by far the most important types of cement. In that the OPC was classified into three grades, namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days. The PPC and OPC 53 grade of cements were being used for the experimental works.

3.2 Fine aggregates

The sand particles should come under the zone II. It should be free from any clay and inorganic materials and found to be hard and durable. The sand particles less than 4.75mm are called as fine aggregates.

3.3 Coarse aggregates

The aggregate sizes are bigger than 4.75mm is considered as coarse aggregate. It has been available in different shapes and free from organic impurities.

The above materials are commonly used in the construction field. Due to the inadequacy of these materials the solid wastes are partially or fully replaced with the common materials according to their properties and mix proportions.

4. Experimental Investigation

4.1 Fly ash in Ferro cement

Fly ash and silica fume on properties of Portland cement mortar have been analyzed. These wastes replacing the cement content with super plasticizers. Ferro cement laminates have been used as reinforcement material due to its unique properties of strength and serviceability. Flexure strength has been observed. [10].

Table 4. Mix proportion of mortar for Ferro cement slab [10]

Proportions	**Contents**
Binder: sand	1:2
Silica fume	5% of total weight
Fly ash	10%, 15%, 20%, 25% and 30% 0f total wt.
Water ratio	0.35
Super plasticizer	0.6% 0f total weight
Design strength	60 Mpa
Mesh	1 to 4 layers

The specimens Ferro cement slab of size 500×150×25mm to 1:2 mix, 0.35 water ratio and partial replacement of cement with a total percentage of its weight.

From this set up procedures Ferro cement laminates have been casted under the 1 layers, 2 layers, 3 layers, and 4 layers with the replacement of the industrial wastes and 72 specimens were casted. Flexural study parameters such as first crack load, ultimate load, maximum deflection, and crack pattern were observed.

4.2 Fly ash in cement

And fly ash have been replaced the cement content up to 50% in the Portland cement and casted the cubes of mortars and concrete. The fly ash has wider application in the production of the cement. Nowadays all the industries are adding the fly ash 25% in the production of the cement. [9].

Researchers and authors have been founded that the fly ash has wider applications in the construction materials. In that the authors have experimentally found that 5% of silica fumes, 20% fly ash, can successfully produce the adequate strength. So it can be effectively used for the rehabilitation of the reinforced concrete structures, particularly in the Ferro cement composites. [13]

4.3 Red mud as a mortar

The red mud is a waste derived from the caustic soda digestion of bauxite ore, before calcinations to generate alumina by the Bayer process. [16]. Due to its chemical composition it was 30% replaced to the cement as a mortar. The red mud is calcinated at distinct temperatures (450, 650, and 1000□ C) to improve its reactivity. The chemical composition has been analyzed by the X-ray Fluorescence spectrometer. [3, 4, 5]

Table 5. Mix proportions [5]

Composition	Cement (g)	Sand (g)	Red mud (g)	H_2O (g)
Standard mixture	450.0	1350.0	0.0	225.0
RM mortar	337.5	1350.0	112.5	225.0

The compressive strength and pozzolonic activity index have been tested after 28 days curing in that 1000□C calcinated red mud mixture is the effective manner in the cement mortars. The results are only satisfactory. [4, 5]

4.4 Red mud as bricks

The application of Bauxite residue in the building industry, by the physico-mechanical properties of red mud and clay bricks are presented. [7]. The compositions of RM–AC bricks are 90-10%, 80-20%, 70-60%, 60-50%, 50-50%, 40-60% prepared and fired at sintering temperatures of (800, 900 and 1100□C). According to their compositions the 6 samples were cast in that 50-50% sample 5 is the best application in the field. [9].

4.5 Red mud in cement production

Generally cement production involves two stages clinker production and conversion of clinker into cement it has been done by wet process or dry process. The basic raw materials are limestone, gravel and are mixed to form the clinker [17, 19]. Gypsum is mixed to increase the setting time of the cement at the last stage of the production. Thus the authors have identified that red mud can be used as a substitute for in cement production in varying ratios. [18]

It can be seen from the comparison of the results that the red mud does not affect the cement properties and improved the cement quality in the way of reducing the setting time and improving the compressive strength. So, the authors have stated that red mud can be used as a basic raw material in the cement production. [20]

4.6 Copper slag as fine aggregate

Copper slag has the high toughness so it can be used to partially replacing the fine aggregate. The proportions by weight of copper slag added to concrete mixtures were as follows 0%, 10%, 20%, 30%, 40%, 50%, 60%, 75% and 100%. [11]

Table 6. Mix ratio [2]

Cement	Water	Fine aggregate	Coarse aggregate
368.42	191.58	741.39	1192.42
1	0.5	2.01	3.23

The compressive strength test has been conducted by applying a load at a constant rate on a cube (150×150×150mm). The sample was tested for compression testing at 7, 28 days of curing. The mix M-25 was used for the experimental procedures. The strength of concrete has increased by at 40% of replacement of fine aggregate by copper slag, up to 75% replacement. [15]

The flexural strength also tested at 28 days of curing. The sample size 5×1×1cm was prepared and casted 3 samples for each proportion. The flexural strength of concrete at 28 days is higher at the 20% of replacement. So, the author investigated the compressive strength and flexural strength is improved or increased due to high toughness of copper slag [15].

4.7 Copper slag in mortars

Copper slag is partially or fully replaced to the fine aggregate to obtain the durability and the strength. The standard mix ratio has been used for the mortars. The strength has been increased substantially. The authors are investigating the copper slag, only to the replacement of the fine aggregate due to its fineness and toughness properties. And also some authors investigated the copper slag in the replacement of fine aggregate. [11]

5. Conclusions

Based on the review of papers the industrial wastes are having a different industrial application and usages in the construction field. Fly ash, red mud, silica fumes and copper slag are replaced with the construction materials according to the similar percentages and undergone the strength tests. The industrial wastes are turned into a valuable by products and reduce the environmental pollution. Thus, all the wastes are having adequate strength and improved durability in their compressive strength and flexural strength in the concrete. Some of the wastes have been calcinated and improved their strength. So the authors have been conserving its valuable mineral into a great breakthrough in replacing the construction materials in the civil engineering field. So, all the industrial wastes have improved their quality without affecting their strength.

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