International Journal of Enhanced Research in Science, Technology & Engineering
ISSN: 2319-7463, Vol. 9 Issue 7, July-2020, Impact Factor: 6.754

Influence of Red Mud and Fly Ash on the Strength of Concrete

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ABSTRACT

Rapid industrialization leads to the maximum discharge of waste products which in turn causes the environmental hazards. These wastes can be a substitute for conventional material, when utilized in a best way. Red mud is a waste generated by the aluminum industry (an average of 4 million tons/year) in a Bayer's process and their disposal is a major problem for these industries because of the complex Physiochemical properties of waste products which are highly caustic and causes ground water contamination, leading to health hazards. Fly ash is obtained from thermal power station. To overcome this problem it is very much essential to utilize the industrial waste materials and by-products generated, in manufacturing of cement and in concrete construction. The aim of the present research work was to investigate the possibility of adding fly ash and red mud because of storing issues, the waste negatively affect the environment. To solve this problem Portland cement was replaced by mixture of Red mud & Fly ash by weight of cement. The mixture of fly ash and red mud shows maximum similar properties of cement. So we find compressive strength of concrete block by adding the mixture of fly ash and red mud partially in place of cement. Main objectives of this work are to study the effects of red mud and fly ash on compressive strength of concrete of M30 grade. The ratio of cement, fly ash and red mud are going to be employed in proposed percentage for partially replacement of cement is as - (C: FA: RM as 50%: 30%: 20%, 50%: 25%: 25%, 0%: 80%: 20)

I. INTRODUCTION

This paper presents a study that investigates partially replacement of cement with using red mud which is a major industrial waste from alumina refining, and fly ash which is industrial waste from coal combustion. In this project we are using very limited non-waste materials.

The findings suggest that the two major industrial wastes, red mud and fly ash can be reused and may replace Portland cement and hence be applied in civil infrastructure construction.

Red Mud

Red mud is a by-product of the Bayer process which is used for the production of alumina from bauxite. Washed and crushed bauxite is treated with a solution of hydroxide at an elevated temperature and pressure. This process brings all the recoverable alumina from bauxite into solution and the residue known as red mud. For each part of alumina produced by this process, about one part of red mud is generally discarded as a waste. In Western countries about 35 million tons of red mud is produced yearly. Due to its caustic nature, it poses a major environmental problem. Disposal of this waste was the first major problem encountered by the alumina industry after the adoption of the Bayer process.

Fig. 1: Red mud as a by product

Fly Ash

Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric power generating thermal plant. Fly ash is a beneficial mineral admixture for concrete. It influences many properties of concrete in both fresh and hardened state. Moreover, utilization of waste materials in cement and concrete industry reduces the environmental problems of power plants and decreases electricity generation costs.

Objectives

1.To find the workability of concrete.
2. To find the optimum replacement of cement by the mix of red and fly ash in concrete.
3. To find the compressive strength of red mud and fly ash used concrete and conventional concrete.
4. To compare the compressive strength of red mud and fly ash used concrete and conventional concrete.

2. LITERATURE REVIEW

A search over Internet may say that the Red Mud has already been tried for usage of Cement manufacturing but there is not enough evidence to support the large scale use of red mud anywhere in the cement industries. With this paper the authors want to share MALCO's experience of successfully substituting the use of LGB (Low grade Bauxite) with Red mud which hitherto, the nearby cement industries have been buying from us to make up for the deficiency in their raw material for cement production and the local cement industries continued usage of Red Mud instead of LGB. Besides the most important fact the authors want to underline is the neutralization of soda in Red Mud with Sulphur in pet coke leading to better cement properties.

V Kumar, BD Nautiyal, AK Jha - Indian Concrete Journal, 1989 - trid.trb.orgDisposal of large quantities of red mud, which is a solid waste generated at aluminum plants all over the world, poses increasing problem of storage, land cost and pollution. The economic utilization of red mud has evaded practical solutions because of its complex physico-chemical properties. Z Pan, L Cheng, Y Lu, N Yang - Cement and Concrete Research, 2002–Elsevier Anew kind of alkali–slag–red mud cementitious material, abbreviated as ASRC, with both high early and ultimate strength and excellent resistance against chemical attacks has been developed by the application of composite solid alkali activator into slag–red mud mixture system. The hydration products of this cement at ambient temperature have been investigated by means of XRD, IR, TG-DTA, TEM, EDXA, etc.

Z Pan, D Li, J Yu, N Yang - Cement and Concrete Research, 2003 – ElsevierA new kind of alkali–slag–red mud cementitious (ASRC) material, with both high early and ultimate strength and excellent resistance against chemical attacks, has been developed by the introduction of composite solid alkali activator into slag–red mud mixture system. Tests on strength development and other properties such as resistance.

J Pera, R Boumaza, J Ambroise - Cement and Concrete Research, 1997 - ElsevierRed mud is a waste generated by the aluminium industry, and its disposal is a major problem for this industry. Very rich in iron, it can be used as cheap pigment for coloured concrete. The red coloration can be enhanced by calcination in the range of 600 to 800° C. Such operation also transforms the aluminium hydroxides (goethite and boehmite) and clays minerals into pozzolanic admixtures that are able to consume the calcium hydroxide.

M Singh, SN Upadhayay, PM Prasad - Waste Management, 1996 – Elsevier Red mud from HINDALCO (Hindustan Aluminum Corporation) Industries Limited, Renukoot, India, contains significant quantities of alumina, iron oxide and silica. Presence of the said constituents makes it a suitable ingredient for the preparation of special cements. Preparation of three varieties of cements was investigated, namely:(a) aluminoferrite (C4AF)-belite (β-C2S) using lime+ red mud+ fly ash;(b) aluminoferrite-ferrite (C2F)-aluminates

KAUSHAL KISHORE Materials Engineer, Roorkee Fly ash or pulverized fuelash (pfa) is a finely divided powder thrown out as a waste material at the thermal power plants using pulverized coal for raising steam in the boilers. In the building industry, the use of fly ash a part replacement of cement in mortar and concrete at the construction site has been made all over the world including India and is well known.

Tarun R. Naik (et.al) "High early strength containing large quantities of fly ash concluded that concrete mix with type c fly ash can be used with confidence to produce high early strength as the amount of fly ash used in a mix increases, the water required for the same workability decreases. Fly ash improves the workability if the concrete.

3. MATERIALS AND METHODOLOGY

Material: SThe binder materials used in mixes were ordinary Portland cement (OPC) 53 grade conforming to IS: 8112 – 1989, Red mud used for the replacement of cement is brought from aluminum industry obtained by Bayer 's process, HINDALCO, Singrauli , MP. Fly ash from coal industry, locally available river sand belonging to zone II of IS383-1970 was used. Locally available crushed aggregates confirming to IS 383-1970 was used. Water fit for drinking and commercially available high performance super plasticizing admixture,

Methodology-Casting of specimen Cement, sand and aggregate were taken in mix proportion 1:1.192:3.308 which correspond to M30 grade of concrete. Cement is replaced with red mud and fly ash ratio as (50%-30%-20%, 50%-35%-15%, 0%80%20%). All the ingredients were dry mixed homogeneously. To this dry mix, required quantity of water was added (W/C= 0.43) and the entire mix was again homogeneously mixed. This wet concrete was poured into the moulds which was compacted through hand compaction in three layers and then kept into the vibrator for compaction. After the compaction, the specimens were given smooth finishes After 24 hours, the specimens were remolded and transferred to curing tanks wherein they were allowed to cure for 28 days. Cubic specimens of 150 mm size were casted for compressive strength test. The cubes were casted in stainless steel moulds and wet cured at standard temperature until the time of test. The cubes were cured for a time period of 7, 21 and 28 days.

4. EXPERIMENTATION

Casting of concrete cube specimen (IS: 10086-1982)

- The cube moulds are of 150×150×150mm in size confirming to IS: 10086-1982.
- In assembling the mould for use, the joints between the section of mould shall be thinly coated with mould oil and a similar coating of mould oil shall be applied between the contact surface of the bottom of the mould and the base plate in order to ensure that no water escape during the filling.
- The interior surface of the assemble mould shall be thinly coated with mould oil to prevent adhesion of the concrete.
- Compaction of test specimen shall be made as soon as practicable after mixing, and in such way as to produce full compaction of the concrete with neither segregation nor excessive laitance.
- The concrete filled into the mould in layers approximately 5cm deep.
- In placing each scoopful of concrete, the scoop shall be moved around the top edge of the mould as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete within the mould.
- Needle vibrator is used to do compaction, the surface of the concrete shall be finished level with the top of the mould, using a trowel, and covered with a metal to prevent evaporation.
- The vibrator shall penetrate into the underlying layer and the bottom layer shall be compacted with a tamping rod throughout its depth.

Testing of Concrete Specimen

Test for compressive strength on concrete cube specimen (IS: 516)-1959

- Specimen is taken out one day prior to the day of testing.
- The bearing surfaces of the testing machine wiped clean and loose sand or other material removed from the surface of the specimen, which are to be in contact with the compression platens.
- The cube specimen placed in the machine in such a manner that the load applied to opposite sides of the cube as cast.
- The axis of the specimen carefully aligned with the centre of thrust of the spherically seated platen.

Fig. 2: Testing Of Concrete Block

- As the spherically seated block is brought to bear on the specimen, the movable portion rotated gently by hand so uniform seated may be obtained.
- The load applied without shock and increased continuously until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.
- The maximum load applied to the specimen then recorded and the appearance of the concrete and any unusual features in the type of the failure recorded.

Fresh Concrete

Following table represents the slump value of the all concrete mix. The slump decreased with the increase in red mud content. red mud absorbed less water as compared to cement and hence decreases the workability of concrete admixture. The variance of a slump with glass content is described in graph no.1

Table 1: Slump value of fresh concrete

Sr. No	Mix	Slump (Mm)
1	Normal Mix	29
2	Mix 1	26
3	Mix 2	24
4	Mix 3	14

Hardened Concrete

A laboratory study were performed to determine the compressive strengths of 36 cubes for 7 days, 21 days, 28 days of casting of different trail of concrete with 0, 20, 25 and 80% replacement of cement by red mud .the various test results are analyzed below.

Table 2: average strength values of concrete mix blocks

Sr. No.	Design Mix	Average load Taken			Average Strength		
		7 Days	21 Days	28 Days	7 Days	21 Days	28 Days
		KN	KN	KN	MPa	MPa	MPa
1	Normal Mix	465	520	670.67	20.49	23.11	29.80
2	Mix 1	395	439.875	493.333	17.55	19.55	21.93
3	Mix 2	345.67	396.222	438.667	15.363	17.61	19.496
4	Mix 3	0	0	0	0	0	0

It is observed that when 50% of cement is replaced by mixture of red mud and fly ash (20% red mud & 30% fly ash) the compressive strength at 7 days was decrease by 14.35% but when 50% of cement is replaced by mixture of fed mud and fly ash (25% red mud & 25% fly ash) the compressive strength at 7 days was decreased by 25.02% in strength on average with comparison to conventional concrete (graph no 6) from observation of 21days compressive strength 0% replacement was much ahead with comparison to 20% , 25% . However, compressive strength at 28 days of 20% red mud and 30% fly ash was decrease by 26.41% followed by 25% red mud and 25% fly ash with 34.58%. However when cement is fully replaced with the mixture of red mud and fly ash (80% red mud and 20% fly ash) it does not give any compressive strength. Hence from the experimentation and observation we can conclude that as the percentage of red mud increases the compressive strength decreases.

CONCLUSION

On the base of outcomes received the following conclusion can be made:

- ✓ 50% replacement of cement by 20% red mud and 30% fly ash showed a 15.40% decrease in compressive strength at 21 days and 26.41% decrease in compressive strength at 28 days.
- ✓ 50% replacement of cement by 25% red mud and 25% fly ash showed a 23.79% decrease in compressive strength at 21 days and 34.58% decrease in compressive strength at 28 days.
- ✓ Cement replaced by red mud below 20% and by adding some binding admixtures will give more good compressive strength with comparison to 0% replacement.
- ✓ Utilization of red mud and fly ash in concrete can turn out to be economical as it is no useful waste and spare of cost.
- ✓ Utilization of red mud and fly ash in concrete will eradicate the disposal problem of red mud and fly ash and proved to be environment friendly.
- ✓ Utilization of red mud in concrete will help in increasing fertility of soil as disposal of red mud in soil decreases fertility.
- ✓ Large quantity of waste (red mud and fly ash) can be utilized where strength doesn't matter more.

FUTURE SCOPE

The project work emphasized on use of waste material red mud and fly ash as partially replacement of cement. Further one can extended this work as follows-

- ✓ Tensile and flexural strength of concrete can be compared with red mud replacing cement concrete.
- ✓ Texture and structure of concrete can be studied
- ✓ Shear strength of concrete can be compared with red mud concrete.
- ✓ Fully replacement of cement can be studied by adding binding admixtures.
- ✓ Replacement of cement only with percentage of red mud can be studied.

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