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# APPLICATION OF INDUSTRIAL WASTE- IN THE MANUFACTURING OF SELF COMPACTING CONCRETE


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**Abstract:** To study red mud for the making of self-compacting concrete (SCC) is to explore and assess the feasibility, performance, and environmental impact of incorporating red mud as a supplementary material in SCC mixtures. Self-compacting concrete (SCC) is a flowing concrete that does not require vibration and, indeed, should not be vibrated. It uses superplasticizers and stabilizers to significantly increase the ease and rate of flow. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate.

## I. INTRODUCTION

### SELF COMPACTING CONCRETE

The development of new technology in the material science is progressing rapidly. In last three decades, a lot of research was carried out throughout globe to improve the performance of concrete in terms of strength and durability qualities. Consequently, concrete has no longer remained a construction material consisting of cement, aggregate, and water only, but has becomes an engineered custom-tailored material with several new constituents to meet the specific needs of construction industry. The growing use of concrete in special architectural configurations and closely spaced reinforcing bars have made it very important to produce concrete that ensures proper filling ability, good structural performance and adequate durability. In recent years, a lot of research was carried out throughout the world to improve the performance of concrete in terms of its most important properties, i.e. strength and durability. Concrete technology has under gone from macro to micro level study in the enhancement of strength and durability properties from 1980's onwards. Till 1980 the research study was focused only to flow ability of concrete, so as to enhance the strength however durability did not draw lot of attention of the concrete technologists. This type of study has resulted in the development of self-compacting concrete (SCC), a much-needed revolution in concrete industry. Self-compacting concrete is highly engineered concrete with much higher fluidity without segregation and is capable of filling every corner of form work under its self-weight only (Okamura 1997). Thus SCC eliminates the needs of vibration either external or internal for the compaction of the concrete without compromising its engineering properties.

This concrete was first developed in Japan in late 80's to combat the deterioration of concrete quality due to lack of skilled labours, along with problems at the corners regarding the homogeneity and compaction of cast in place concrete mainly with intricate structures so as to improve the durability of concrete and structures. After the development of SCC in Japan 1988, whole Europe started working on this unique noise free revolution in the field of construction industry. The last half of decade 1991-2000 has remained very active in the field of research in SCC in Europe. That is why, Europe has gone ahead of USA in publishing specifications and guidelines for self-compacting concrete (EFNARC 2002). Now, all over the world, a lot of research is going on, so as to optimize the fluidity of concrete with its strength and durability properties without a drastically increase in the cost. The first North American conference on design and use of self-consolidation concrete was organized in November 2002. At present many researchers are working in numerous universities and government R&D organizations (material<0.1mm) ratio and provide adequate segregation resistance. Super plasticizer and air entraining admixtures give the required deformability.

Viscosity agent type self-compacting concrete: This type is proportioned to provide self-compaction by the use of viscosity modifying admixture to provide segregation resistance. Super plasticizers and air entraining admixtures are used for obtaining the desired deformability.

## RED MUD

Red mud is one of the major solid wastes coming from Bayer process of alumina production. At present about 3 million tons of red mud is generated annually, which is not being disposed or recycled satisfactorily.

The conventional method of disposal of red mud in ponds has often adverse environmental impact and during monsoon, the wastes may be carried by runoff to the surface waters course and a result of leaching may cause contamination of ground water; further disposal of large quantities of red mud dumped, poses increasing problems of storage occupying a lot of space.

## WHAT IS RED MUD?

Red mud is the iron rich residue from the digestion of bauxite. It is one of the major solid wastes coming from Bayer process of alumina production. In general, about 2-4 tons of bauxite is required for production of each tone of alumina ($Al_2O_3$) & about one tone red mud is generated. Since the red mud is generated in bulk it has to be stored in large confined & impervious ponds, therefore the bauxite refining is gradually encircled by the" storage ponds. At present about 60 million tons of red mud is generated annually worldwide which is not being disposed or recycled satisfactorily.

In the most common method of dumping that is the impoundment on land in a diked impervious area called ponds. The mud slurry is pumped to the ponds situated close to the bauxite refinery. The mud accumulates & settles in the pond in due course of time. In order to reduce alkali pollution through red mud a number of methods using drainage decantation & special technique such as dry disposal have been developed. Dry disposal is expensive & not yet installed anywhere in India. However, the dry disposal can only conserve the land to a considerable extent, but the conservation of minerals remains attempted.

## EFFECT OF RED MUD ON ENVIRONMENT

In the last decade, the production of aluminium Inspite of some stagnancy and even set back periods has shown a steady rise of about 1%.

The ecological consequences of aluminium production are well known; land devastation by bauxite exploitation usurpation of big land areas by erection of disposal sites for red mud, threatening of surface & underground water & air pollution by waste gases from aluminum electrolysis plant & rolling mills. The degree of damage inflicted to ground water & air during the single production stages from bauxite to aluminium depends on a couple of tacts of which those connected with the alumina winning & red mud disposal.

## POSSIBLE IMPACT ON ENVIRONMENT

The impact of red mud impoundment can be manifest in several ways, the biggest danger is water pollution. Ground usurpation especially in case of cultivable soil or densely populated regions disturbance of landscape harmony can sometimes assume trouble-some relations. There is some danger, too by air pollution by dust spreading from dry parts of impoundment. In order to prevent possible damages depending on the peculiarities of each disposal site already in the planning stage & then during the exploitation & after its end it is necessary to make efforts for avoiding of damages or reducing them to least amount.

## GROUND WATER POLLUTION

After rinsing & compacting, the red mud is transported to the impoundment usually with a content of 3.5 to 5% even upto 7% Na- oxide. It was found that the water with such content sometimes rises the alkalinity of the underground water so that pH index can become larger than 11.5 what was registered by piezometer located around the sedimentation basins at Podgorical. In the wells from which water is supplied to the surrounding population the pH of water is 10.5.

## ENVIRONMENTAL RISK OF STORING RED MUD

Storage of red mud has a few inherent problems. Water stored in raised up dyke System may over flow or cause change breach of the dykes during heavy rains and high gales. Such breaches of the dykes have been found to occur in red mud ponds causing surface pollution and pollution of the nearby river, despite close vigil on the dykes. With water stored at unnatural high level compared to the surroundings there has been induction of caustic seepage to nearby unused wells, confirming possible pollution of subsoil water system by seepage. In the red mud pond classification of red mud particles takes place during settling. The finer particles being on top consequently the pond with exposed surface of dry mud becomes source of dust nuisance to the adjoining locality during dry seasons. The people of the locality near the pond have to bear the nuisance of dust which also carries fine particles of soda & other residual Bayer chemicals.

## UTILIZATION OF RED MUD

In order to protect the complete ecosystem, which is exposed to the impact of the discharged red mud, it is indispensable to utilize in mass quantity. Red mud has been used for different commercial purposes. Some of the commercial uses of red mud in different fields are as follows: -

## CONSTRUCTION INDUSTRY

Cement, building blocks, or bricks to a lesser extent lightweight aggregates and rubble are potential large volume applications where red mud might be used. It is expected that a minimum pretreatment (dewatering) would be required for use of red mud in bricks and lightweight aggregates. For use in cement and as rubber filler, acid washing would be required & complete drying and powdering would be necessary for filler application. Cement and brick manufacturing plants are fairly, widely distributed throughout the United States, with light weight aggregate plants being less numerous. There is potential for such plants being located near the source of red mud which is considered necessary to minimize transportation costs.

Other application for red mud, such as application in exothermic mixes as a scouring or polishing medium or as a drilling mud, are considered of low potential for either technical, economic or low-volume reasons.

## RED MUD AS CONCRETE MATERIAL

Red mud has been used to produce synthetic dense aggregate in U.S.A & Japan (U.K. patent 1976) by pelletizing firing at temperature of 1200-1316 °C. The compressive, tensile and bending strengths of concrete made with red mud aggregate have been found to be considerably higher than those of concrete made with river gravel.

Light weight aggregates have been manufactured from mixture of red mud and various other materials like fly ash, blast furnace slag etc. Lightweight aggregate is used with cement to make a lightweight strong concrete.

## PLASTIC & RESIN FILLERS

Though numerous materials can be used as fillers it was considered significant that red mud as a filler in rubber gave a rupture strength higher than all other fillers excepting carbon black. It should thus be a suitable substitute for carbon black in some applications. Thus use as filler requires that the red mud slurry be acid washed, dried & powdered.

## RED MUD PLASTIC

The recent development of a new material; red mud plastic (RMP) made by combining polymer (PVC) and red mud waste, aims at overcoming the negative qualities of PVC, while preserving & enhancing its advantage.

## CEMENT

Oxides of calcium, aluminium, silicon & to a minor extent iron make up the major portion of the cement. A typical red mud contains CaO, $SiO_2$ and $Fe_2O_3$ in the range around 5 to 10 percent, 2 to 10 percent and 40 to 50 percent, respectively. Thus, its potential use as a raw material for cement manufacture has been of interest. However, the amount of red mud that might be incorporated directly as a raw material would be low because it contains a relatively high iron oxide.

Addition of 15 percent of treated red mud to Portland cement were reported to increase strength & affect settling time. Greater additions decrease the strength.

## METALLURGICAL

Literature references on metal recovery total 140 articles. It is seen that approximately half the reference pertain to recovery of iron.

Recovery of Titania and additional alumina is also proposed. The higher value metals such as niobium, gallium and vanadium have received attention but are present in such low concentration that their commercial recovery has not been tried.

Several processes have been developed to recover iron from the red mud residues. One method is the carbon lime soda sinter process which can be applied either to ore or to the red mud. In this process the iron is reduced & recovered by magnetic separation from the waste residues after alumina leaching. A U.S. patent has been issued describing the application of fluidized bed to produce sponge granted for a process to treat high iron content bauxite ores involving reductive roasting with magnetic separation of iron form the leach residues.

Direct electric arc smelting of the red mud has been proposed for recovery of iron from high-iron content bauxites. In this case, pig iron can be produced with upto 98 percent recovery of iron value in the bauxite. The slag from the smelting operation can also be further treated to recover up to 84 percent of the alumina lost by the Bayer process. This particular process was recently advocated by the McDowell Wellmen Engineering Company as being both technically & economically feasible and they have developed the process through a pilot scale stage. The economics assume thai the pig iron or steel would be produced near the bauxite refining plant to take advantage of low cost iron units in the red mud.

## ALUMINA & TITANIA RECOVERY

Alumina & Titania recovery from the red mud are only of secondary interest. However, if the mud is smelted from iron recovery, the slag from the smelting operation can be leached with sodium carbonate solution to recover most of the alumina values. Titania can be recovered by leaching the residue of carbonate leach with sulfuric acid. The recovery of titanium from the red mud is technically feasible but the complicated processing is too costly to compare with the recovery from natural titanium ores such as ilmenite and rutile.

## MATERIAL PROPERTIES

### Chemical Properties

Spent foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residual binder (bentonite, sea coal, resins) and dust. Table 7-2 lists the chemical composition of a typical sample of spent foundry sand as determined by x-ray fluorescence.

Silica sand is hydrophilic and consequently attracts water to its Surface. This property could lead to moisture-accelerated damage and associated stripping problems in an asphalt pavement. Antistripping additives may be required to counteract such problems.

Depending on the binder and type of metal cast, the pH of spent foundry sand can vary from approximately 4 to 8. It has been reported that some spent foundry sands can be corrosive to metals.

Because of the presence of phenols in foundry sand, there is some concern that precipitation percolating through stockpiles could mobilize leachable fractions, resulting in phenol discharges into surface or ground water supplies. Foundry sand sources and stockpiles must be monitored to assess the need to establish controls for potential phenol discharges. (4,6,7)

**Table 6.1 Foundry sand sample chemical oxide composition, %. (1)**

| Constituent | Value (%) |
|---|---|
| **SiO2** | 87.91 |
| **Al2O3** | 4.70 |
| **Fe2O3** | 0.94 |
| **CaO** | 0.14 |
| **MgO** | 0.30 |
| **Na2O** | 0.19 |
| **K2O** | 0.25 |

## SYNOPSIS

**Title of the Project: -** APPLICATION OF INDUSTRIAL WASTE- IN THE MANUFACTURING OF SELF COMPACTING CONCRETE

**Objective of the study: -** To study red mud for the making of self-compacting concrete (SCC) is to explore and assess the feasibility, performance, and environmental impact of incorporating red mud as a supplementary material in SCC mixtures.

Self-compacting concrete (SCC) is a flowing concrete that does not require vibration and, indeed, should not be vibrated. It uses superplasticizers and stabilizers to significantly increase the ease and rate of flow. It achieves compaction into every part of the mould or formwork simply by means of its own weight without any segregation of the coarse aggregate.

**Rationale for the study: -**

1. **Waste Utilization:**
Red mud, a byproduct of alumina refining, is often disposed of as waste. Studying its use in SCC aims to repurpose this industrial waste, turning it into a valuable resource for the construction industry.
2. **Environmental Impact Reduction:**
Reducing reliance on traditional cementitious materials by incorporating red mud in SCC can lower the environmental impact of concrete production, as traditional cement production is associated with high energy consumption and emissions.
3. **Resource Conservation:**
The study seeks to promote resource efficiency by substituting traditional raw materials with red mud, thus conserving natural resources and minimizing the overall environmental footprint of concrete production.
4. **Enhanced Concrete Properties:**
Red mud contains minerals and compounds that may influence concrete properties. The research aims to determine whether incorporating red mud can improve the fresh and hardened properties of SCC, potentially enhancing overall performance.
5. **Circular Economy Principles:**
Integrating red mud into SCC aligns with circular economy principles by repurposing industrial waste. This approach supports the reuse and recycling of resources within the production cycle, reducing the need for virgin materials.
6. **Sustainable Construction Materials:**
The construction industry's growing focus on sustainability drives the study to contribute to the development of eco-friendly materials. Red mud in SCC aligns with broader efforts to create sustainable construction practices.
7. **Economic Benefits:**
Reducing dependence on traditional cementitious materials may lead to cost savings in concrete production. If red mud proves to be a viable alternative in SCC, it could have economic benefits for the construction industry.
8. **Innovation in Concrete Technology:**
Researching the behavior of red mud in SCC offers an opportunity for innovation in concrete technology. Understanding how red mud interacts with concrete may lead to advancements in the field and novel approaches to enhance SCC performance.

i. **Methodology: -** The cement, sand and coarse aggregates were weighed according to the mix proportion 1:1:0.5. The fly ash and cement proportion used in the experimentation was 1:3.5. To this dry mix the required quantity of red mud (0%,1%, 2%, 3%, 4%, 5%, 6%, 7% and 8%) was added and homogenously mixed. To this dry mix the required quantity of water was added and thoroughly mixed. To this the superplasticizer was added at the rate of 700ml/100Kg of cementitious material and mixed intimately. Now the viscosity modifying agent (VMA) was added at the rate of 100ml/100Kg of cementitious material. The entire mix was thoroughly mixed once again. At this stage, almost the concrete was in a flow able state.

ii. After conducting the flow characteristic experiments the concrete mix was poured in the moulds required for the strength assessment. After pouring the concrete into the moulds, no compaction was given either through vibrated or through hand compaction. Even the concrete did not require any finishing operation. After 24 hours of casting, the specimens were demoulded and were transferred to the curing tank wherein they were allowed to cure for 28 days.

**The expected contribution from the study:-**

1. Health and safety benefits (as no vibration is required).
2. Faster construction times.
3. Increased workability and ease of flow around heavy reinforcement.
4. Excellent durability.
5. Reducing residues of industrial waste.

**List of activity to be carried out to complete the project: -**

i. Project Guidance
ii. Synopsis preparation
iii. Data collection
iv. Study about the Project
v. Mix Design for Self-Compacting concrete.
vi. Analysis the results and data of Mix design test.
vii. Final project report preparation.

**Places/labs/equipment and tools required and planning of arrangements: -**

References taken from below given codes and manual along with case studies: -

1. IS Code 456 and IS code 10262: - Concrete mix design

2. Quality Testing Lab: For performing test and analysis.

➢ Books: CHAMPION, J. M. and JOST, P., 'Self-compacting concrete: Expanding the possibility of Concrete Design and Placement', Concrete International, Vol.22, No.4, pp. 159-178, June 1998.

➢ KAMESWARA RAO, C.V.S (1983) "Analysis of Some Common Workability Tests". Indian Concrete Journal, 57 (3): 71-73 and 75.

**Report reference from Internet websites:**

www.acclimited.com
www.pozzcrete.co.in
www.hindalco.com
www.redmudproject.org
www.tfhrc.gov/hnr20/recycle/waste/fs1.htm

**AIM OF EXPERIMENTATION**

Self-compacting concrete is a high-performance concrete that can flow under its own weight to completely fill the formwork without segregation and self-consolidate without any mechanical vibrations, even in the presence of congested reinforcements. Such concrete can accelerate placement and reduce labour required for consolidation and finishing.

In other words, “Self-compacting concrete is a highly flowable, yet stable concrete that can spread readily into place and fill the formwork without any consolidation and without undergoing any significance separation”.

Self-compacting concrete offers a rapid rate of concrete placement, with faster construction times and ease of flow around congested reinforcement. The fluidity and segregation resistance of self-compacting concrete ensures a high level of homogeneity, minimum concrete voids and uniform concrete strength, providing the potential for a superior level of finish and durability to the structure.

In addition, following are some more points, which makes self-compacting concrete more reliable in concreting works-

- ➢ Improved compaction around congested reinforcement.
- ➢ Potential to enhance durability through improved compaction of cover concrete.
- ➢ Improved build ability (e.g.: concreting deep elements in single lifts).
- ➢ Elimination of vibration leading to environmental, health and safety benefits.
- ➢ Quicker and easier concrete placement.

The field of concrete technology has seen miraculous changes due to the invention of various admixtures. The admixtures modify the properties of fresh concrete and offer many advantages to the user.

The main aim of this experimentation is to find out the effect of addition of red mud, which is a waste product from the aluminium industries, and foundry waste sand, which is a waste product from foundry, on the properties of self-compacting concrete containing two admixtures. In this experimentation combinations of admixtures which is taken-.

Super plasticizer + VMA.

The flow characteristics and strength characteristics of self-compacting concrete produced from different waste material and different percentages of that material are found. The different percentages of red mud used in experimentation are 0%, 1%, 2%, 3%, 4%, 5%, 6%, 7% and 8% and The different percentages foundry waste used in experimentation are 2%, 4%, 6%, 8%.

## COST ANALYSIS

| Particulars | Rates (Rs.) |
|---|---|
| **Rate of Cement per bag** | 350/- |
| **Crushed Sand: Rate/ Cum** | 700/- |
| **12mm aggregate/ Cum** | 500/- |
| **Rate of Superplasticizer/kg** | 150/- |
| **Rate of VMA/ kg** | 80/- |
| **Red Mud/Ton** | 300/- |
| **FWS/Ton** | 200/- |
| **other** | 350/- |

- It observed from the cost analysis the cost of conventional concrete is Rs.4090/cum and cost of concrete with blending by optimum percentages of foundry waste and red mud are Rs.4040/cum. and Rs.4045/cum. respectively.

- Because of these results we conclude that, the SCC with blending by red mud and foundry waste sand which are industrial wastages causing hazards to the ecosystem enhance the strength and reduces the cost than the normal SCC.

## CONCLUSIONS

In present scenario there is a greater need for self-compacting concrete due to sickness of member and architectural requirement, also to improve durability of the structure.

Now the world is going to facing greater need of high-performance concrete, durability point of view and SCC where the conventional way of compacting may not be always useful under different site condition. So instead of going for the conventional concrete let us mix the concrete compacting on its own which is called as self-compacting concrete.

Now due to industrialization there is greater increase in the foundry activity in at around Satara district, mainly in case of Kolhapur area. Similarly there is big project near Kolhapur of foundry sand. Hidalgo there is huge amount of Red mud is produced every day and dumped on the ground it is threat environment. This waste is used for dumping for filling the low lying areas causing the environment in deterioration in long run, so this mix should be used for the construction activity it will reduce the problem of environmental pollution at the same time it reduces the cost of the construction and add it makes the concrete high performing from the durability point of view. So from these three points the project is under taken.

Based on the experimentation conducted, the following observations were made and hence some conclusions.

It has been observed that the compressive strength of self-compacting concrete produced with the combination of admixtures such as (SP+VMA) goes on increasing up to 2% addition of red mud. After 2% addition of red mud, the compressive strength starts decreasing, i.e. the compressive strength of self-compacting concrete produced with (SP+VMA) is maximum when 2% red mud is added. The percentage increase in the compressive strength at 2% addition of red mud is +9.11 Thus, it can be concluded that maximum compressive strength of self-compacting concrete with the combination of admixtures (SP+VMA) may be obtained by adding 2% red mud which is a waste material from aluminum industry.

It has been observed that the compressive strength of self-compacting concrete produced with the combination of admixtures such as (SP+VMA) goes on increasing upto 2% addition of foundry waste sand. After 2% addition of foundry waste sand, the compressive strength starts decreasing, i.e. the compressive strength of self-compacting concrete produced with (SP+VMA) is maximum when 2% foundry waste sand is added. The percentage increase in the compressive strength at 2% addition of foundry waste sand.

Thus, it can be concluded that maximum compressive strength of self-compacting concrete with the combination of admixtures (SP+VMA) may be obtained by adding 2% foundry waste sand which is a waste material of ferrous industry (foundry).

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