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EXPERIMENTAL INVESTIGATION ON CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY USING RED MUD AND FLY ASH

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ABSTRACT

The raw materials used in cement are limited and also non- renewable. So it is been need to be conserved for future generations. With this goal of attaining sustainable construction in concrete is emerging throughout the world. Fly ash from coal based power plants is one such waste which is abundantly available in the different parts of India. Red mud is the composed of a mixture of solid and metallic oxide-bearing impurities, and disposal problems the red mud caused by the oxidized iron. Red mud cannot be disposed of easily.

To find the optimum replacement of cement by red mud & fly ash. To find the compressive strength, split tensile strength and flexural strength of red mud & fly ash used concrete. To identify various industrial wastes suitable for utilization in cement manufacture.

For concrete to be durable, careful selection of the mix and materials is necessary, so that deleterious constituents do not exceed the limits. So it is very essential to conduct tests regarding cement, fine and coarse aggregate to know their strength, consistency and stability and durability. Good quality materials will increase the strength of the concrete.The mix proportions shall be selected to ensure

theworkability of the fresh concrete and when concrete is hardened, it shall have the required strength, durabilityand surface finish.

The grade of the concrete used in this project is M35 and we adopted design mix concrete. The mix shall be designed to produce the grade of concrete having the required workability and a characteristic strength. IS 10262-2009 is used for calculating the quantity of materials and its proportion. Quality assurance should be made to ensure the quality of the materials used for mix of concrete.

Key words: CC-conventional concrete, W/c-water content

Chapter-1

Introduction

1.1 General

Worldwide the use of CC has gained wide acceptance in the pre-cast industry, which has many advantages such as; reduces the total time of construction and the costs, improves work conditions by eliminating vibration makes easier to achieve a better final product, allows the use of complex moulds and parts with congested reinforcement.

Nowadays, the ecological trend aims at limiting the use of materials in the field of building materials and hence there is an increase in interest in the use of alternate materials (waste) from industrial activities, which presents significant advantages in economic energetic and environmental terms. Concrete's performances have continuously risen in order to accomplish the society needs. Many studies have been made concerning the use of additives and super plasticizers in the concrete for passing the frontier minimum water content for a good workability of concrete. As a result of this high performance concretes developed having a superior durability.

CC is an innovative concrete that does not requires vibration and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete.

Usually CC mixtures having high contents of fines in order to obtain the required ecological properties to achieve self-compatibility, which usually results in mixtures with high content of Portland cement, and consequently, high values of initial and final strength, much higher than those strictly required by the project. Thus the costs of the components that constitute a CC are higher than those of conventional concrete of equal strength.

Red mud & Fly ash is the insoluble product after bauxite digestion with sodium hydroxide at elevated temperature and pressure. It is a mixture of compounds originally presents in the parent mineral, bauxite and of compounds forms or introduced during Bayer cycle. It is disposed as slurry having a solid concentration in the range of 10-30% pH in the range of 13 high ionic strength.

Now a days the ecological trend aims at limiting the use of natural raw materials in the field of building materials and hence there is an increased interest in the use of alternative waste materials from industrial activities which presents significant advantages in economic, energetic and environmental terms. Concrete performances have continuously rise in order to accomplish the society needs.

Many studies have been made the concerning use of additives and super plasticizers in the concrete for passing the frontier of minimum water content for a good workability of a concrete. As a result of this high performance concrete developed having a superior durability. Conventional concrete is an innovative concrete that does not requires vibration for placing and compaction.

It is able to flow its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense homogeneous and has the same mechanical properties and durability as traditional vibrated concrete. Usually the chemical admixtures used are high range water reducers (super plasticizers) and viscosity modifying agents which change the rheological properties of concrete.

Other researchers, actuating on the fines contents obtained medium strength CC using different types of additions in partial replacement of cement. The aim of this work is to study CC of medium characteristics strength, in order to encourage by replacing of Red mud & Fly ash & with cementations materials.

Limited work has been carried out on the application of Red mud & Fly ash in the CC. A Red mud & Fly ash of which the fineness was not mentioned but which exhibited higher pozzolanic reactivity in a light weight CC without segregation and visual bleeding. Red mud & Fly ash is an unconventional material for CC but it is certainly promising considering its recognized feasibility in concrete and potential environmental benefits.

1.1.1Cement demand

World cement demand at a glance (million metric tons)

Item	2000	2005	2010	Annual growth	
				05/00	10/05
Cement demand India	1630.0	2250.0	2830.0	6.7	4.7
North America	149.6	170.0	196.0	2.6	2.9
Western Europe	197.7	208.5	233.0	1.1	2.2
Asia / pacific	954.5	1470.0	1895.0	9.0	5.2
Other regions	328.2	401.50	506.0	4.1	4.7

World consumption of cement is forecast to continue to increase throughout the next 15 years taking the annual volume up from the 2250 MT of 2005 to around 3130MT by 2015 and 3560MT by 2020 representations overall forward expansion of approximately 56%.

According to the GLOBAL CEMENT to 2020 world production and consumption of cement approximated 2250MT in 2005 this representing an increase of approximately 5.75%(124MT) on the previous year and a continuation of the annual underlying expansion which has seen year on year growth in almost every year since the 1970’s.

1.1.2 Applications

Red mud & Fly ash has pozzolanic properties hence increasing the binding properties and gives the better strength at the same time it reduces the cost problems. And also reduces the following problems.

1.2 Advantages of CC

1.2.1 Improved Concrete Quality

- CC yields homogeneous concrete in situations where the castings are difficult due to congested reinforcement, difficult access etc.
- CC shows a good filling ability especially around reinforcement.

- CC is very well suited for special and technically demanding structures such as tunnel linings, as the possibility to compact the concrete is limited in the closed space between formwork and rock.
- Shows narrow variation in properties on site.
- Most suitable for concrete filled tubes (CFT) technology construction for high rise buildings.
- It ensures better quality of in-situ pile foundation.

1.2.2 Environmental & Human Health Protection

- Reduces noise at sites, the pre-cast factory, and neighbourhood and hence, it is a silent Concrete.
- Eliminates problems with blood circulation leading to "white fingers" caused by Compacting equipment, hence called a healthy concrete.
- CC gives noise protection in precast industry, by introducing no restrictive measures like ear protection, marked areas, and safety instructions are necessary.
- Shortens the construction time by accelerating construction process, especially in pre-cast industry.

1.2.3 Economy & Time Reducing

- Its ease of placement improves the productivity and the cost saving through reduced equipment and labor equipment.
- Reduction in wear and tear of forms, therefore, it extends the service life of forms.
- Reduction in the number of worker. Normally one cum requires 1.5 man-hours; with CC this is reduced to 0.35 man-hours.
- It reduces the consumption of resources and cost, even considering a higher price per cubic meter for the concrete. Okamura has reported that it is possible to reduce the overall bridge cost by 5-15%.
- Because of its high fluidity, this concrete does not need any vibrations so that it allows saving energy and ensuring suitable cost in place.
- Reduction of expenses and manpower needed for patching finished precast elements.
- It can enable the concrete supplier to provide better consistency in delivering concrete, which reduces the interventions at the plants or job sites.
- Construction with CC is not affected by the skill of the workers, and shape and arrangement of reinforcing bars of the structures.
- CC use at construction sites reduces the chance of accident by reducing number of cables needed for the operation of compacting equipment, hence, reduces the workers compensation premiums.
- It gives wide opportunity for the use of high-volumes of by-products materials

- Such as Red mud, fly ash, lime stone powder, quarry dust etc., since a higher volume of powder material is required for enhancing the cohesiveness and reducing the amount of super plasticizer and viscosity modifying agents.

1.3 DISADVANTAGES OF CC

The production of CC places more stringent requirements on the selection of materials in comparison with conventional concrete.

An uncontrolled variation of even 1% moisture content in the fine aggregate will have a much bigger impact on the ecology of CC at very low W/C (~0.3) ratio. Proper stock piling of aggregate, uniformity of moisture in the batching process, and good sampling practice are essential for CC mixture,

A change in the characteristics of a CC mixture could be a warning sign for quality control and while a subjective judgment, may sometimes be more important than the quantitative parameters.

The development of a CC requires a large number of a trial batches. In addition to the laboratory trial batches, field size trial batches should be used to simulate the typical production conditions. Once a promising mixture has been established, further laboratory trial batches are required to quantify the characteristics of the mixture.

CC is costlier than conventional concrete initially based on concrete materials cost due to higher dosage of chemical admixtures, i.e. high range water reducer and viscosity enhancing admixture (VEA). Increase in material cost can be easily offset with improvement in productivity, reductions in vibration cost and maintenance and proper uses of mineral admixtures.

Key words: CC-conventional concrete, W/c-water content

Chapter-2

LITERATURE REVIEW

[1] Development of conventional concrete by industrial waste

Mohan kushwaha , Dr.salimakhtarsurveshrajput, vol 3, issue-4 aug-2013

The experimentation is to find out the effect of addition of Red mud & Fly ash, which is a waste product from the aluminium industries on the properties of conventional concrete containing three admixtures.

In this experimentation combinations of admixtures which is taken super plasticizer + VMA. The Red mud & Fly ash +CC should be used for the construction activity it will reduce the problem environmental pollution at the same it reduce the cost of the construction and it makes the concrete high performing from the durability of point of view.

The compressive strength of conventional concrete produced with the combination of admixtures such as (sp+vma) goes on increasing upto 2% addition of Red mud & Fly ash. After addition 2% of Red mud & Fly ash the compressive strength starts decreasing compacting concrete produced with (SP+VMA) is maximum when 2% is added.

The percentage increase in compressive strength at 2% addition of Red mud & Fly ash is +0.11 thus it is observed the maximum compressive strength of conventional concrete with the combination of admixtures.

The compressive strength of concrete increases with the addition of Red mud & Fly ash up to 2% then reduces and comes to no increase at almost 4% addition. So it can be concluded that on addition of 4% may be made to cc without any loss to its compressive strength.

[2] Evaluate the performance of CC made with high volumes of fly ash. Bouzoubaa and Lachemi(2010)

It carried out an experimental investigation to evaluate the performance of cc made with high volumes of fly ash. Nine cc mixtures and one control concrete were made during the study. The content of cementations material was maintained constant (400kg/m^3) while the water and cementations material ratios ranged from 0.35 to 0.45. The Self compacting mixtures had a cement replacement of 40%50% and 60% by class F fly ash.

Tests were carried out on all mixtures to obtain the properties of fresh concrete in terms of viscosity and stability .the mechanical properties of hardened concrete such as compressive strength and drying shrinkage were also determined. The CC mixes developed 28-day compressive strength ranging from 26 to 48 mpa.

[3] Experimental studies on concrete utilizing Red mud as a partial replacement of cement with hydrated lime. Ashok, m.p.sureshkumar-2012

After testing of 5 blended cement samples with an increment of 5% it can be said that the optimum use of NRM is 15% as a partial replacement of cement by NRM. The cost of M_{30} grade concrete is around

7.48% less than the conventional concrete within increase up to 21.712% in the 28 days of compressive strength. The percentage economy is increase in the grade of concrete but the same time there is a reduction in percentage increase in the compressive strength.

Red mud & Fly ash can be effectively used as replacement material for cement and replacement enables the large utilization of waste product. Used for road construction as an embankment landfill is an attractive option with a high potential for a large volume reuse. Replacement of 20% OPC by Red mud & Fly ash is possible.

This thermal treatment changes the phase composition of the material, mainly by promoting the elimination of hydrated phases and improves its amorphous character. The results of pozzolanic activity by chemical and physical methods were very satisfactory and indicate the feasibility of Red mud & Fly ash use as a pozzolanicin addition to Portland cement.

[4]**A Review On Effect Of Partial Replacement Of Cement By Fly Ash In Concrete Rakesh kumar, Abhishek Kumar, Mohd. Afaque Khan**

Raw materials used in cement are limited and also non- renewable. So it is been need to be conserved for future generations. With this goal of attaining sustainable construction and a strong trend favouring the increased use of admixtures in concrete is emerging throughout the world. The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of fly ash are generated in thermal industries with an important impact on environment and humans.

[5] Experimental Study on Red Mud, Fly Ash and GGBFS based Geopolymer Concrete, Supriya Kulkarni

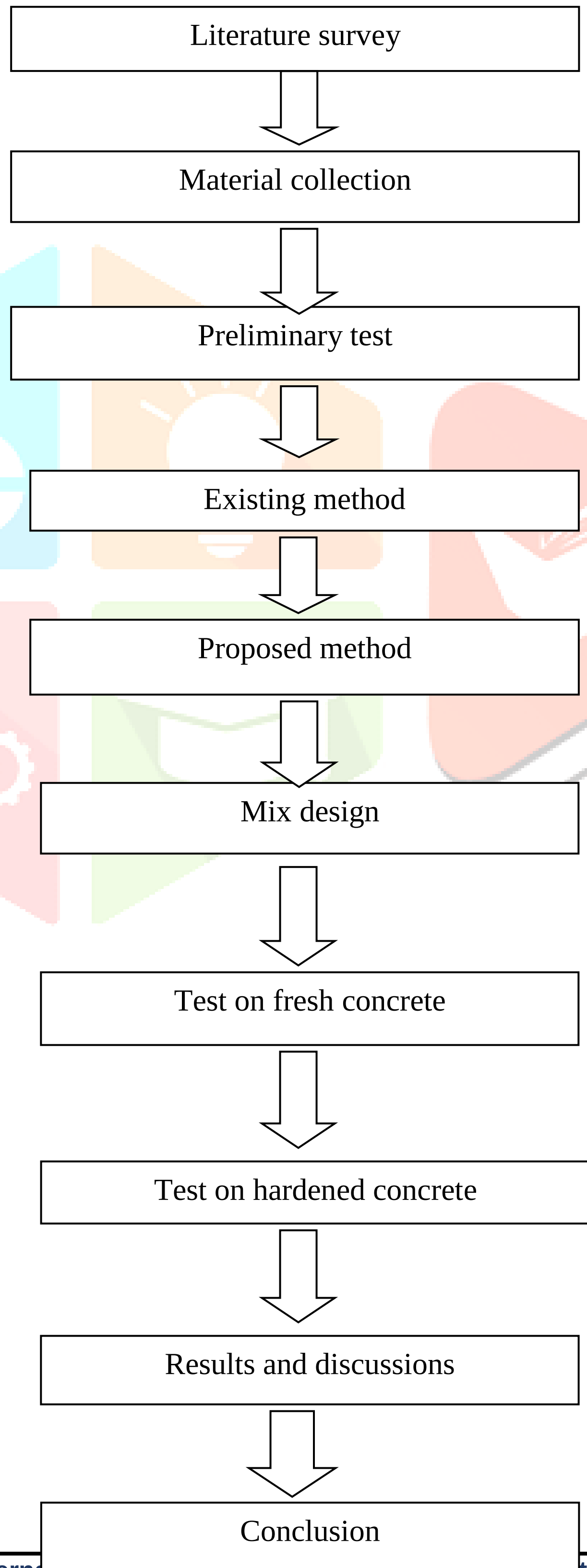
The objective of this study is to investigate a green alternate material for conventional concrete using geopolymerization of industrial wastes. In this study geopolymer concrete using RM, FA and GGBFS was tested for various physical and mechanical properties. The properties that were tested include water absorption, compressive strength, flexural strength, tensile splitting strength. The test results indicated that geopolymerization of industrial wastes can be a good and sustainable alternative to conventional concrete.

[6] Experimental Investigation of Concrete by Red Mud as Replacement of Cement and Using Admixture R.Mariadoss , J.Nanthagopal , V.Saravanakumar

Red mud is an industrial waste material generated during production of alumina from bauxite by Bayer process. These industrial wastes hold some heavy aim of the paper is to investigate the possibility of partially replacing Portland cement in concrete by red mud and evaluating its compressive and splitting tensile strength. The test results revealed that 15% of cement can be optimally replaced by red mud beyond which compressive strength, split tensile and flexural strength starts decreasing.so adding the admixture the harden concrete strength it will be increase two fold strength.

Chapter-3

Methodology



Chapter-4

Materials

4.1 CEMENT

Cement is a material that has cohesive and adhesive properties in the presence of water. Such cement is called hydraulic cements. These consist primarily of silicates and aluminates of lime obtained from limestone and clay. There are different types of cement; out of that I have used one type (i.e.)

- Ordinary Portland cement

Ordinary Portland cement (OPC) is the basic Portland cement and is best suited for use in general concrete construction. It is of three types, 33 grades, 43grade, 53 grade. One of the important benefits is the faster rate of development of strength. Cement is a fine, grey powder. It is mixed with water and materials such as sand, gravel, and crushed stone to make concrete.

The cement and water form a paste that binds the other materials together as the concrete hardens. The basic composition of cement is provided in table. In the present work 53 grade cement was used for casting.

4.2 AGGREGATES

Aggregate properties greatly influence the behaviour of concrete, since they occupy about 80% of the total volume of concrete.

The aggregate are classified as

- Fine aggregate
- Coarse aggregate

4.2.1 Fine aggregate

Fine aggregate are material passing through an IS sieve that is less than 4.75mm gauge. Usually natural sand is used as a fine aggregate at places where natural sand is not available crushed stone is used as a fine aggregate. The sand used for the experimental works was locally procured and conformed to grading zone II.

Sieve Analysis of the Fine aggregate was carried out in the laboratory as per IS383-1970 and results are provided in table. The sand was first sieved through 4.75mm sieve to remove any particle greater than 4.75mm sieve and then was washed to remove the dust. According to Is 383-1970 the fine aggregate is being classified in to four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV.

4.2.2 Coarse aggregate

The materials which are retained on a 4.75mm sieve called coarse aggregate. Coarse aggregate form the main matrix of the concrete. The nature of work decides the maximum size of the coarse aggregate. Locally available having the maximum size of 20mm was used in the present work.

4.3 Red mud & Fly ash

The Red mud & Fly ash in the experimentation was obtained from hidalgo, Belgaum. The fineness of Red mud & Fly ash was found to be 35 m^2/gm with particle size of 75 microns and its density is found to be 3gm/cc.

4.3.1 Production and composition

It is a side product of the Bayer process the principal means of refining bauxite en route to alumina. The resulting alumina is the raw material for producing aluminium. A typical bauxite plant produces one to two times as much Red mud & Fly ash as alumina. This ratio is dependent on the type of bauxite used in the refining process. Red mud & Fly ash is composed of a mixture of solid and metallic oxides. The red colour arises from iron oxides, which comprise up to 60 % of the mass of the Red mud & Fly ash.

The mud is highly basic with a pH ranging from 10 to 13 in addition to iron the other dominant components include silica, Un leached residual aluminium and titanium oxide. Making one tone of aluminium requires about two tons of alumina. The production of two tons of alumina creates two to four tones of Red mud & Fly ash or bauxite residue, which is presently regarded as waste from the Bayer process – but it is potentially a valuable resources.

4.3.2EFFECT OF RED MUD & FLYASH ON ENVIRONMENT

In the last decade, the production of aluminium in spite 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 & Fly ash, threatening of surface & Underground water & air pollution by waste gases from aluminium 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 facts of which those connected with the alumina winning & Red mud & Fly ash disposal.

4.3.3POSSIBLE IMPACT ON ENVIRONMENT

The impact of Red mud & Fly ash 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 has many 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.

4.3.4 GROUND WATER POLLUTION

After rinsing & compacting, the Red mud & Fly ash is transported to the impoundment usually with content of 3.5 to 5% even up to 7% Na oxide. It was found that the water with such content sometimes raises the alkalinity of the underground water so that pH index can become larger than 11.5 what was registered by pyrometer located around the sedimentation basins at Pedagogical. In the wells from which water is supplied to the surrounding population the pH of water are 10.5.

4.4 ENVIRONMENTAL RISK OF STORING RED MUD & FLY ASH

Storage of Red mud & Fly ash 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 & Fly ash 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 & Fly ash pond classification of Red mud & Fly ash 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.

4.4.1 Red mud & Fly ash Neutralization

Neutralization of Red mud & Fly ash will help to reduce the environmental impact caused due to its storage and also lessen significantly the ongoing management of the deposits after closure.

It will also open opportunities for re-use of the residue which to date have been prevented because of the high pH. The cost of neutralization will, to some degree at least, be offset by a reduction in the need for long-term management of the residue deposits.

Instead of accruing funds to deal with a future liability, the funds can be invested in process improvements, which reduce or remove the liability. As per the Guidelines of Australian and New Zealand Environment and Conservation Council (ANZEX) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), the liquor being strongly alkaline with a high pH, requires neutralization to a pH below 9 with an optimum value of 8.5-8.9 before becoming environmentally.

Neutralization of Red mud & Fly ash to pH around 8.0 is optimal because the chemically adsorbed Na is released, alkaline buffer minerals are neutralized and toxic metals are insoluble at this pH.

Efforts are being carried out to study the amelioration of Red mud & Fly ash by possibly incorporating a pH-reduction processing step during disposal of Red mud & Fly ash and include studies on processes based on acid neutralization, CO_2 treatment, seawater neutralization, bioleaching and sintering.

4.4.2 Acid neutralization

Various aqueous acidic solutions have been considered for neutralization of alkalinity, including acidic industrial wastewater. The use of carbonic acid has also been considered. A number of studies have been done to assess the feasibility of treating bauxite residue with acid as for instance on Red mud & Fly ash slurry. Large volumes of reagent are required to fully neutralize the residue at a relatively high cost, even if spent (waste) acid could be used. The use of acid also introduces large volumes of impurities to the process water stream (sulphate) in the case of sulphuric acid, chloride in the case of hydrochloric acid. It is therefore likely that the return of any water from the residue deposits to the production process will be unacceptable without further treatment to remove these added impurities.

Treating Red mud & Fly ash with acidic spent pickling solutions (SPSs), derived from the steelmaking process, provides a coagulant – a mixture of aluminium and iron salts- for waste water treatment.

4.4.3 CO_2 treatment

Gas phase CO_2 or CO_2-containing flue gas has been bubbled through aqueous slurries to form carbonic acid in the aqueous phase. Mechanisms of neutralization of Red mud & Fly ash & by carbon dioxide gas have been studied. The carbonic acid reacts with basic components of the Red mud & Fly ash lowering its pH.

At the short contact times which industrial process rates demand, only a fraction of the alkaline material in Red mud & Fly ash is neutralized using gaseous CO_2. Hence although the pH of the aqueous phase drops rapidly upon exposure to CO_2 gas, it soon rises again to unacceptable levels as additional alkaline material leaches from the mud.

The pH of water exposed to gaseous CO_2 is not likely to drop below 5.5 (approximately), and hence the rate of neutralization of the solids in the aqueous slurry is typically not fast enough to satisfy industrial needs. Hence researchers have investigated the use of high-pressure liquid carbon dioxide rather than vapour phase carbon dioxide for the pH reduction of Red mud & Fly ash. A laboratory study on neutralization of Red mud & Fly ash & using CO_2 in multiple cycles has been investigated.

4.4.4 Seawater neutralization

When seawater is added to caustic Red mud & Fly ash, the pH of the mixture is reduced causing hydroxide, carbonate or hydroxyl carbonate minerals to be precipitated. Average seawater contains 965 gm of water and 35 gm of salts (i.e. 3.5% salinity). The concentration of various salt ions in seawater is 55% Chlorine (Cl^-), 30.6% sodium (Na+), 7.7% sulphate (SO_4^{2-}), 3.65% magnesium (Mg^{2+}), 1.17% calcium

(Ca^{2+}), 1.13% potassium (K+) and 0.7% others [28]. Seawater neutralization does not eliminate hydroxide from the system but converts the readily soluble, strongly caustic wastes into less soluble, weakly alkaline solids.

The carbonate and bicarbonate alkalinity of the waste is removed primarily by reaction with calcium to form aragonite and calcite. The neutralizing effect of the calcium and the magnesium ions is initially large but decreases rapidly as pH 8.5 is approached and calcium and magnesium carbonates precipitate. Neutralization is considered to be complete when the liquid that can be separated from the treated Red mud & Fly ash has a pH less than 9.0 and a total alkalinity less than 200 mg/l (as calcium carbonate equivalent alkalinity) and decant of seawater neutralized Red mud & Fly ash can be safely discharged to the marine environment .

4.5 Bioleaching

Bioremediation of bauxite residue in Western Australia by Alcoa of Australia has been carried out by adding some organic substrate to the Red mud & Fly ash for growth of microorganisms which generate different organic acids and CO_2 (in some cases) which in turn neutralize the Red mud & Fly ash. Similar work has also been carried out by using microbes.

4.5.1 Sintering

Sintering of residue can be carried out to fix all leachable soda, but the cost would be very high due to the elevated energy consumption required for high temperature sintering of Red mud & Fly ash. But the mechanism can be made use of in making bricks and blocks from Red mud & Fly ash.

4.5.2 Red mud & Fly ash Utilization

A considerable research has been done on the utilization of Red mud & Fly ash as a raw material for production of a range of products. It can be used as a constructional/building material in bricks, blocks, light weight aggregates, in cement industry as cements and special cements and in concrete industry. Bauxite residues can be used for soil remediation, as geo polymers and as a clay material.

It can also be used as an additive to cements, mortars and concretes, construction of dykes and as ceramic/refractory product. In iron and steel industry it can be used after recovery of iron and titanium. In environmental field, it can be utilized in pollution control by acting as adsorbent for cleaning of industrial gases, as synthetic coagulants in waste water treatment and as a catalyst especially for coal hydrogenation. Red mud & Fly ash can as well be used in paints and pigments.

4.5.3 Building Materials

Among the uses standing out, are those reported on the utilization of Red mud & Fly ash for building materials production such as cement, bricks, roofing tiles and glass- ceramics. The bulk production of building materials could eliminate the disposal problem. Red mud & Fly ash is considered as a raw material for production of these materials.

Preparation of construction materials from bauxite residues. A successful pilot project of a road embankment construction using Greek bauxite residue has been carried out by laboratory of Road Engineering of the Aristotle University of Thessaloniki, Greece. The performance of the embankment with regards to its deformability was studied by means of the elastic behaviour theory. This is an attractive option with a high potential for large volume reuse of Red mud & Fly ash use. Bauxite residues have other options for its reuse in preparation of construction materials

4.5.4 Geo polymers

Geo polymer is a term covering a class of synthetic alumino silicate materials with potential use in a number of areas, essentially as a replacement for Portland cement and for advanced high-tech composites and ceramic applications. The geo polymerization process involves a chemical reaction between Red mud & fly ash and alkali metal silicate solution under highly alkaline conditions.

The product of this reaction is an amorphous to semi-crystalline polymeric structure, which binds the individual particles of Red mud & Fly ash transforming the initial granular material to a compact and strong one.

The potential use of Red mud & Fly ash for synthesis of inorganic polymeric materials through a geo polymerization process was studied to use it in the construction sector as artificial structural elements such as massive bricks. Red mud & Fly ash was reacted with fly ash, sodium silicate via geo polymerization reaction to get Red mud & Fly ash geo polymers which are a viable cementations material that can be used in roadway constructions.

Giannopouloueta studied the geo polymerization of the Red mud & Fly ash and the slag generated in the ferronickel production, in order to develop inorganic polymeric materials with advanced mechanical and physical properties. The inorganic polymeric materials produced by the geo polymerization of the Red mud & Fly ash developed compressive strength up to 21 MPa and presented water absorption lower than 3 %. They stated that Red mud & Fly ash may be viewed as alternatives in the industrial sectors of construction and building materials.

4.6 Clay material

Investigations of the use of Red mud & Fly ash and fly ash for the production of heavy clay products have been extensively undertaken at the Central Building Research Institute, Roorkee, India. Ekrem studied the potential use of Red mud & Fly ash for the preparation of stabilization material. The test results show that compacted clay samples containing Red mud & Fly ash and cement–Red mud & Fly ash additives have a high compressive strength, decreased hydraulic conductivity and swelling percentage as compared to natural clay samples.

Consequently, it was concluded that Red mud & Fly ash and cement–Red mud & Fly ash materials can be successfully used for the stabilization of clay liners in geotechnical applications. Study on the exploitation of Red mud & Fly ash as a clay additive for the ceramic industry or as a compound for self-binding mortars in the fabrication of stoneware was carried out at National Institute of Technology, Rourkela, Orissa, India.

It aimed at using bauxite residue in heavy clay industry in which the plasticity of clay mixtures with bauxite residue and polymer addition was evaluated. They found that addition of 30 wt% bauxite residue substituting the clay mixture increases the max. Cohesion of the mixture.

4.6.1 Cements

Red mud & Fly ash from HINDALCO, Renukoot, India was investigated for its application in cements and they found that cements made from lime + Red mud & Fly ash+ bauxite + gypsum exhibit strengths comparable or superior to ordinary Portland cement (OPC). It was stated that as Red mud & Fly ash is very rich in iron, Red mud & Fly ash can be used as cheap pigment for coloured concrete. Also a uniform and durable coloured concrete could be obtained using white cement interground with 11% of burnt Red mud & Fly ash & Fly ash.

The red coloration could be enhanced by calcination in the range of 600 to 800°C. They found that such operation transforms the aluminium hydroxides (goethite and boehmite) and clays minerals into pozzolanic admixtures that are able to consume the calcium hydroxide produced by cement hydration. Thus, it is possible to develop a new admixture for concrete: a pozzolanic pigment.

The addition of Red mud & Fly ash residue by 1% in the raw mix for the production of Portland cement and found that it did not affect either the sintering or the hydration process and concluded that the Red mud & Fly ash can be utilized as a raw material in cement production, at no cost to the producer, contributing in reduction of the process cost.

Preparation of building materials from bauxite residues vast usage of Red mud & Fly ash can be made in preparation of building materials such as ceramics, glass ceramic products, fired and non-fired bricks and concretes.

4.6.2 Ceramics

Red mud & Fly ash is made into useful ceramics articles by mixing 51-90% by weight of Red mud & Fly ash with 49-10% by weight of at least one mineral and/or silicate containing material, shaping the mixture and firing it at a temperature of 950°-1250°C. The investigators have successfully converted Red mud &Fly ash into glass ceramic products which involves addition of a small quantity of glass former along with traces of nucleating agents to a specific mixture of Red mud & Fly ash & Fly ash, fly ash, followed by melting at around 1200°C and nitrification by cooling.

The feasibility of recycling Red mud & Fly ash and fly ash by producing glasses and glass-ceramics has also been investigated by Yanga Glass has been obtained by melting Red mud & Fly ash from Shandong Province in China with different additives. Suitable thermal treatments were employed to convert the obtained glass into nano-crystal glass-ceramics.

X-ray diffraction (XRD) patterns showed that the main crystalline phase in both the glass-ceramics is wollastonite (CaSiO3). These crystals are homogeneously dispersed within the parent glass, with an average crystal size of less than 100 nm. The size of nano-crystals varies when different thermal processes were used. These glass-ceramics have potential for a wide range of construction application.

4.6.3 Fired building materials

United States Patent 3886244 claims a process for manufacturing fired bricks wherein 50-90 wt % of Red mud & Fly ash can be used along clay and a water fixing agent. The raw bricks are dried with heated gases at a temperature below 70°C, and subsequently fired at a temperature between 900°-1,100°C. Efforts have been made at Central building Research Institute, CBRI, India [51] to produce burnt clay bricks by partially replacing the clay with Red mud & Fly ash(from the Indian Aluminium Company), lime and fly-ash.

4.6.4 Non-fired building materials

Efforts have also been made at CBRI to incorporate a small percentage of lime in Red mud & Fly ash and compress the mix at optimum moisture content in the form of bricks with the purpose of examining their strength and stability to the erosive action of water. A maximum wet compressive strength of 3.75 MPa with 5% lime and 4.22 MPa with 8% lime has been obtained after 28 days of casting and humid curing of these bricks in the month of August. Studies were carried out at Jamaica Bauxite Institute and the University of Toronto using Red mud & Fly ash to make bricks for inexpensive housing. The Red mud & Fly ash was pressed into bricks using a standard brick press, immersed in sodium silicate followed by drying in the sun.

Non-fired bricks by mixing Red mud & Fly ash, Portland cement and river sand were also made by the researchers at the institute. Liue al. studied the recovery of iron from Bayer Red mud & Fly ash with direct reduction roasting process followed by magnetic separation, and then building materials were prepared from aluminosilicate residues. Then brick specimens were prepared with aluminosilicate residues and hydrated lime and the mean compressive strength of specimens was 24.10 MPa. It was indicated that main mineral phase nepheline (NaAlSiO4) in aluminosilicate residues transformed into gehlenite (Ca2Al2SiO7) in brick specimens as demonstrated by X-ray diffraction (XRD) technology.

Combining the recovery of iron with the reuse of aluminosilicate residues, it can realize zero-discharge of Red mud &Flyash from Bayer process. Unsintered bricks have been developed from Red mud

&Fly ash disposed from Chinese sintering alumina process cured at ambient conditions. The optimal proportions of Red mud & Fly ash brick are suggested as the following: 25–40% Red mud Fly ash, 18–28% fly ash, 30–35% sand, 8–10% lime, 1–3% gypsum and about 1% Portland cement.

4.7 Concrete industry

Red mud & Fly ash from Birac Alumina Industry, Serbia was tested as a pigment for use in the building material industry for standard concrete mixtures. Red mud & Fly ash was added as a pigment in various proportions (dried, not ground, ground, calcinated) to concrete mixes of standard test blocks (ground limestone, cement and water). The idea to use Red mud & Fly ash as pigment was based on extremely fine particles of Red mud & Fly ash(upon sieving: 0.147 mm up to 4 wt%, 0.058 mm up to 25 wt% and the majority smaller than 10 microns) and a characteristic red colour. Compressive strengths from 14.83 to 27.77 MPa of the blocks that contained Red mud & Fly ash between 1 and 32% were considered satisfactory.

The reported tests have shown that neutralized, dried, calcined and ground Red mud & Fly ash is usable as pigment in the building materials industry. Red oxide pigment containing about 70 % iron oxide was prepared from MALCO Red mud &Fly ash by after hot water leaching filtration, drying and sieving.

4.8 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it help to form the strength giving cement gel, the quantity and quality of Water is required to be looked into very carefully. Potable water is generally considered satisfactory. In the present investigation, tap water was used for both mixing and curing.

4.8.1 Viscosity modifying agent

A viscosity modifying agent admixture called glenium stream-2 was used to introduce the flow without segregation. Glenium stream -2 is dosed at the rate of 50 to 500ml /100kg of cementations material. Glenium stream -2 is a chloride free admixture .It should be added to the concrete after mixing of all other components.

4.8.2 Super plasticizer

A commercially available melamine-based super plasticizer was used in all mixes. It’s a high range water reducer, commonly referred to as a super plasticizer. It is an anionic melamine poly condensate. It’s one of the best existing concrete admixtures in comprehensive properties.

Chapter -5

Preliminary test

5.1Properties of Red mud & Fly ash

I. Physical properties of Red mud

The following tests were conducted to evaluate physical properties.

- Generally fineness of Red mud & Fly ash is varies in between 1000-3000cm$^{2/}$gm. The samples are collected from the hindalco industries limited, belgaum , Karnataka (India) Malco industries mettur (tamilnadu).The Red mud & Fly ash passing through 300 micron I.S. sieve.
- Its PH is varies in between 10.5 to 12.5 hence alkaline in nature.
- Specific gravity of Red mud & Fly ash is found to be 2.51.

II. Chemical properties of Red mud

Chemical properties of Red mud & Fly ash are shown in table. It indicates that percentage of CaOis very less hence it has no cementations properties but when it with water and cements it starts gaining cementations properties. Also percentage of silica available contributes to strength(referred).

Ingredients	Red mud in Percentage
Fe_2O_3	38.3
Al_2O_3	21.6
SiO_2	11.4
CaO	1.47
Na_2O	6.87

Table No: 5.1chemical properties of Red mud

Cement

5.1.2Composition and limits for ordinary Portland cement

(Reference: book concrete technology M.S. shetty)

Ingredient	**Percentage of content**
CaO(lime)	60-67
SiO_2 (silica)	17-25
Al_2O_3(alumina)	3-8
Fe_2O_3(iron oxide)	0.5-6
MgO(magnesia)	0.1-4
Alkalies	0.4-1.3
Sulphate	1-3

Table No: 5.2chemical properties of cement

5.1.3 Test results of cements

Physical properties of cement	**Values**
Specific gravity	3.15
Normal consistency	32%
Initial setting	24mins
Final setting time	10 hrs
Fineness	10%

Table No: 5.3Properties of cement

5.2 Physical properties of aggregates

5.2.1 Sieve analysis of fine aggregate

The natural river sand having fineness modulus of 4.76 and it corresponds to grading zone II of IS 383-1970 grading requirements. The specific gravity of fine aggregate is 2.63. It is found that sand with a fineness modulus give the concrete a sticky consistency.

Sieve size (mm)	Weight of sand retained (gm)	Percentage of sand retained (gm)	Cumulative percentage retained	Percentage passing
4.75mm	60	3.055	3.055	96.945
2mm	40	2.055	5.11	94.88
1mm	340	17.055	22.165	77.835
425µ	1020	51.05	73.22	26.78
300 µ	60	3.055	76.27	23.45
125 µ	440	22.055	98.33	1.67
90 µ	10	0.555	98.885	1.115
75 µ	10	0.555	99.44	0.56
Pan	10	0.555	-	-

Table No: 5.4 sieve analysis of fine aggregate

Fineness modulus = cumulative percentage retained /100 = 476.48/100 = 4.76

5.2.2 Specific gravity of fine aggregate

Specific gravity of aggregate is used of in the design calculation of concrete of mixes. With the specific gravity of each constituent known its weight can be converted in to solid volume and hence a theoretical yield of concrete per unit volume can be calculated.

Description	**Weight of material**
Weight of pycnometer (W1)	615 gms
Weight of pycnometer + sand (W2)	1100 gms
Weight of pycnometer + sand +water (W3)	1750 gms
Weight of pycnometer + water (W4)	1450 gms

Table No: 5.5 shows that specific gravity of fine aggregate

$$\text{Specific gravity of sand} = \frac{(W2-W1)}{(W4-W1) - (W3-W2)}$$

$$= 2.63$$

5.2.3 Bulk density of fine aggregate

The bulk density of an aggregate gives valuable information regarding the shape and grading of aggregate. The parameter of density is also used in concrete mix design for converting the proportion by weight into proportion by volume when batching equipment's is not available at the site.

Bulk density of fine aggregate

Sl.no	Particulars	Loose	Compact
1	Weight of container (W1) kg	6.680	6.680
2	Weight of container + water (W2) kg	11.800	11.800
3	Weight of container +aggregate (W3) kg	14.880	15.560
4	Weight of container + aggregate + water (W4)kg	16.700	17.140
5	Volume of container (V1) lit	5.120	5.120
6	Volume of water added = volume of voids (V2) lit	2.000	1.780
7	Weight of aggregate (W3-W1) kg	8.200	8.880
8	Volume of solids (V1-V2)lit	3.100	3.340
9	Bulk density = weight of aggregate/total volume of aggregate	1.563	1.695
10	Void ratio = volume of void/volume of solids	0.651	0.533
11	Porosity = volume of voids/total of volume aggregate	0.396	0.349

Table No: 5.6 shows that bulk density of fine aggregate

Result

Loose		Compact
Porosity	0.396	0.349
Bulk density	1.563	1.695

Table No: 5.7 Result shows that bulk density of fine aggregate

5.2.4 Physical properties of fine aggregate.

S.No	Characteristics	Values
1	Type	Natural sand
2	Specific gravity	2.63
3	Fineness modulus	4.76
4	Grading zone	II

Table No: 5.8 show that physical properties of fine aggregate.

5.3 Sieve analysis of coarse aggregate

The maximum size of aggregate is fixed based on sieve analysis. This influences the requirement of sand and water in concrete and also the spacing between the reinforcement.

The sample is brought to an air dry condition before weighing and sieving condition. This is achieved by drying at room temperature. The air dry sample is weighed and sieved on the appropriate sieves starting with the largest at the top. Each sieve is separately over a clean tray until not more than.

Sieve analysis result of coarse aggregate

Sieve size (mm)	Weight retained (gm)	Percentage retained	Cumulative percentage retained	Percentage passing
80	0	0	0	100
63	650	21.67	21.67	78.33
50	1080	36.0	57.67	42.33
40	480	16.0	73.67	26.33
25	510	17.0	90.67	9.33

10	200	6.67	97.34	2.66
Pan	80	2.4	99.81	0.19

Table No: 5.9shows that sieve analysis of coarse aggregate

Fineness modulus =cumulative percentage retained /100 = 259.17/100 =2.5917

5.3.1 Specific gravity of coarse aggregate

Description	**Weight of material**
Weight of container(W1)	6.670
Weight of container +weight of aggregate(W2)	15.580
Weight of container +aggregate +water(W3)	17.400
Weight of container +water(W4)	11.580

Table No: 5.10 shows that specific gravity of coarse aggregate

Specific gravity of aggregate is used of in the design calculation of concrete of mixes. With the specific gravity of each constituent known its weight can be converted in to convert into solid volume and hence a theoretical yield of concrete per unit volume can be calculated.

Specific gravity of aggregate = (W2-W1)/ (W4-W1)-(W3-W2)

=(15.580-6.670)/(11.580-6.670)-(17.400-15.580)

=2.80

5.3.2 Physical properties of coarse aggregate

S.no	Characteristics	Value
1	Type	Crushed
2	Specific gravity	2.80
3	Maximum size	20mm

Table No: 5.11 physical properties of coarse aggregate

5.3.3 Bulk density of coarse aggregate

The bulk density of an aggregate gives valuable information regarding the shape and grading of aggregate. The parameter of density is also used in concrete mix design for converting the proportion by weight into proportion by volume when batching equipment's is not available at the site.

Sl.no	Particular	Loose	Compact
1	Weight of container (W1) kg	6.670	6.670
2	Weight of container + water (W2) kg	11.580	11.580
3	Weight of container +aggregate (W3) kg	14.300	15.580
4	Weight of container + aggregate + water (W4)kg	16.610	17.400
5	Volume of container (V1) lit	4.910	4.910
6	Volume of water added = volume of voids (V2) lit	2.300	1.820
7	Weight of aggregate (W3-W1) kg	7.530	8.910
8	Volume of solids (V1-V2)lit	2.616	3.080
9	Bulk density = weight of aggregate/total volume of aggregate	1.554	1.818
10	Void ratio = volume of void/volume of solids	0.884	0.731

Table No: 5.12 bulk density of coarse aggregate

Result

Loose		Compact
Porosity	0.532	0.628
Bulk density	1.554	1.818

Table No: 5.13 Result shows that density of coarse aggregate

Chapter -6

6.1 Existing Methodology

Conventional concrete (CC) is an innovative concrete that does not require vibration for placing and compaction. Aluminum is now consumed during manufacture Red mud & Fly ash, which is used. Red mud & Fly ash is industrial waste and causing threat to environment.Development of conventional concrete (CC) is a desirable achievement in the construction industry in order to overcome problems associated with cast-in-place concrete.

Conventional concrete was developed at that time to improve the durability of concrete structures. Since then, various investigations have been carried out and CC has been used in practical structures in Japan, mainly by large construction companies. Investigations for establishing a rational mix-design method and self-compact ability testing methods have been carried out from the viewpoint of making it a standard concrete. It flows like “honey” and has a very smooth surface level after placing usually, the chemical admixtures used are high-range water reducers (super plasticizers) and viscosity-modifying agents, which change the rheological properties of concrete.

In this study, the cement content was partially replaced with mineral admixtures, e.g. fly ash, slag cement, and silica fume, Red mud & Fly ash admixtures that improve the flowing and strengthening characteristics of the concrete.

In the experimentation PPC was used. Locally available sand and coarse aggregates were used. The specific gravity of sand was found to be 2.55 and was Zone II sand. The specific gravity of coarse aggregates used was found to be 2.61. The coarse aggregates were 12mm and downsize. The mix proportion adopted in the experimentation was 1:1:0.5 with a water/binder ratio 0.31. The fly ash cement ratio used was 1:3.5. The fly ash used in the experimentation is pozzocrete 60 was obtained from Dirk India Private Ltd.

The chemical composition of fly ash

Oxides	Percentage
$SiO_2+Al_2O_3+Fe_2O_3$	70 min
SiO_2	35 min
Reactive silica	20 min
MgO	05 max
SO_3	03 max
Na_2O	1.5 max
Total chlorides	**0.05 max**

Table No: 6.1 Percentage of chemical content in fly ash

The Red mud & Fly ash used in the experimentation was obtained from HINDALCO, Belgaum. The fineness of Red mud & Fly ash was found to be 35 m^2/gm with particle size of 75 microns and its density is found to be 3gm/cc.

A viscosity modifying admixture called Glenium Stream 2 was used to induce the flow without segregation. Glenium Stream 2 is dosed at the rate of 50 to 500ml/100Kg of cementations material. Other dosages may be recommended in special cases according to specific job site conditions.

Ingredients	Red mud
Fe_2O_3	38.3
Al_2O_3	21.6
SiO_2	11.4
CaO	1.47
Na_2O	6.87

Table No: 6.2 chemical composition of Red mud

Glenium Stream 2 consists of a mixture of water soluble polymers which is absorbed on to the surface of cement granules thereby changing the viscosity of water and influencing the rheological properties of the mix.

It also resists the segregation due to aggregation of the polymer chains when the concrete is not moving. Glenium Stream 2 is a chloride free admixture. It should be added to the concrete after all the other components of the mix. This is particularly important in order to obtain maximum efficiency. It is a colour less free flowing liquid and manufactured by BASF Construction Chemicals (India) Pvt. Ltd., Pune.

A high performance concrete super plasticizer based on modified poly carboxylic ether was used in the experimentation. The trade name of the super plasticizer is Gleniumtm Sky. It greatly improves the cement dispersion. It is manufactured by BASF Construction Chemicals (India) Pvt. Ltd., Pune. Optimum dosage of Gleniumtm Sky should be determined in trial mixes. As a guide a dosage range of 300ml to 1200ml per 100kg of cementations material is normally recommended.

EXPERIMENTAL PROCEDURE

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 &Fly ash (0%, 1%, 2%, 3%, 4%, 5%, 6%, 7%, 8%, 10%, 12%, 15% and 16%) was added and homogenously mixed. To this dry mix the 33% of water was added and thoroughly mixed.

To this the super plasticizer was added at the rate of 700ml/100Kg of cementations material and mixed intimately. Now the viscosity modifying agent (VMA) was added at the rate of 100ml/100Kg of cementations material. The entire mix was thoroughly mixed once.

6.2 Proposed system

In existing system they replacing Red mud & Fly ash for cementations material and determine that compressive strength in conventional concrete for design mix. The compressive result shows that after 2% addition of Red mud & Fly ash the compressive strength starts decreasing compacting concrete produced with (SP+VMA) is maximum when 2% Red mud & Fly ash is added and comes to no increase at almost 4% of addition.

In existing system PPC is used with the specific gravity of sand 2.55 and with zone II sand. The coarse aggregate were 12mm and down size.

Now the proposed method should partially replace with Red mud & Fly ash to cementations materials. In this mixture 1% to 18% of both nominal and design mix in the experiment OPC, locally available sand and coarse aggregate were used. The specific gravity of sand is 2.63 and the specific gravity of coarse aggregate 2.80. The mix proportion of Red mud & Fly ash is depend upon the percentage of content. The tests are determined to find the behavior and strengthening characteristics of concrete after replacing the Red mud & Fly ash on cementations material.

Super plasticizer

A commercially available melamine-based super plasticizer was used in all mixes. It's a high range water reducer, commonly referred to as a super plasticizer. It is an anionic melamine poly condensate. It's one of the best existing concrete admixtures in comprehensive properties. To reduce the water content on the concrete the super plasticizer are to be used.

Chapter -7

7.1 MIX DESIGN

Mix design is the process of selecting suitable ingredient if concrete and determines their relative proportion with the object of certain minimum strength and durability as economically as possible.

7.1.1 OBJECTIVE OF MIX DESIGN

- The first objective is to achieve the stipulated minimum strength.
- The second objective is to make the concrete in the most economical manner. Cost wise all concrete's depend primarily on two factors, namely cost of material and cost of labour.
- Labour cost, by way of formworks, batching, mixing, transporting and curing is namely same for good concrete.

There are attention is mainly directed to the cost of materials. Since the cost of cement is mainly times more than the cost of their ingredients, optimum usage of cement is sought for by deigning the mix.

Mix Proportion designations

The common method of expressing the proportions of ingredients of a concrete mix is in the terms of parts or ratios of cement, fine and coarse aggregates. For e.g., a concrete mix of proportions 1:2:4 means that cement, fine and coarse aggregate are in the ratio 1:2:4 or the mix contains one part of cement, two parts of fine aggregate and four parts of coarse aggregate. The proportions are either by volume or by mass. The water-cement ratio is usually expressed in mass.

Factors to be considered for mix design

- The grade designation giving the characteristic strength requirement of concrete.
- The type of cement influences the rate of development of compressive strength of concrete.
- Maximum nominal size of aggregates to be used in concrete may be as large as possible within the limits prescribed by IS 456:2000.
- The cement content is to be limited from shrinkage, cracking and creep.

- The workability of concrete for satisfactory placing and compaction is related to the size and shape of section, quantity and spacing of reinforcement and technique used for transportation, placing and compaction.

MIX DESIGN PROCEDURE

1. Determine the mean target strength f_t from the specified characteristic compressive strength at 28-daysf_{ck} and the level of quality control.

   $f_t = f_{ck} + 1.65\ S$

Where S is the standard deviation obtained from the Table of approximate contents given after the design mix.

2. Obtain the water cement ratio for the desired mean target using the emperical relationship between compressive strength and water cement ratio so chosen is checked

Against the limiting water cement ratio for the requirements of durability given in table and adopts the lower of the two values.

3. Estimate the amount of entrapped air for maximum nominal size of the aggregate from the table.
4. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) from table.
5. Determine the percentage of fine aggregate in total aggregate by absolute volume from table for the concrete using crushed coarse aggregate.
6. Adjust the values of water content and percentage of sand as provided in the table for any difference in workability, water cement ratio, grading of fine aggregate and for rounded aggregate the values are given in table.
7. Calculate the cement content form the water-cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
8. From the quantities of water and cement per unit volume of concrete and the percentage of sand already determined in steps 6 and 7 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations:

$$V = \left[w + \frac{C}{S_c} + \frac{1}{p}\frac{f_a}{S_{fa}}\right] \times \frac{1}{1000}$$

$$V = \left[w + \frac{C}{S_c} + \frac{1}{1-p}\frac{C_a}{S_{ca}}\right] \times \frac{1}{1000}$$

Where V = absolute volume of concrete gross volume ($1m^3$) minus the volume of entrapped air

S_c = specific gravity of cement

W = Mass of water per cubic metre of concrete, kg

C = mass of cement per cubic metre of concrete, kg

p = ratio of fine aggregate to total aggregate by absolute volume

f_a, C_a = total masses of fine and coarse aggregates, per cubic metre of concrete, respectively, kg,

S_{fa}, S_{ca} = specific gravities of saturated surface dry fine and coarse aggregates, respectively

9. Determine the concrete mix proportions for the first trial mix.
10. Prepare the concrete using the calculated proportions and cast three cubes of 150mmsize and test them wet after 28-days moist curing and check for the strength.
11. Prepare trial mixes with suitable adjustments till the final mix proportions are arrived.

7.1.2 MIX DESIGN STIPULATIONS: M35

For M35 grade of concrete characteristic

Strength at 28 days	: 35Mpa
Compaction factor	: 0.9
Degree of quality control	: Good
Type of exposure	: very severe
Type of cement	: OPC (53 grade)
Specific gravity	: 3.15

Fine aggregate

Specific gravity	: 2.63
Bulk density of fine aggregate	: 1.695
Fineness of modulus	: 4.76

Coarse aggregate:

Specific gravity	: 2.80
Bulk density of coarse aggregate	: 1.818

Fineness of modulus : 2.591

1. Target mean strength of concrete

fck‘ = fck + 1.65s

= 35 + 1.65*5

= 43.25Mpa

2. Selection of water/cement ratio

For fck‘= 43.25Mpa, the water cement ratio 0.38

0.38<0.45, hence prescribed for very severe exposure

3. Selection of water and sand content

Aggregate size = 20mm

Water content/m^3 = 180 Kg, Sand content = 25%

Corrections

Description	**Percentage Adjustment required**	
Increasing content	Water content	%Sand in Total aggregate
Increase in compaction factor by 0.1	+3	0
For Increase in w/c ratio by 0.03	0	0.6
For sand conforming to grading zone II of table 4. IS:383-1979	0	0
Total	+3	0.6

Table No: 7.1 mix design correction

From the corrections,

The required content as % of total aggregate by absolute volume = 25.2 %

The required water content = 185.53 lit

4. Determination of cement content

W/C ratio = 0.38

Cement = 185.53/0.38

= 488.23

This cement is adequate for very severe exposure

5. Determination of fine aggregate

V = [WW + (WC/SC) + (1/P) *{Wfa/Sfa}]*1/1000

0.98 = [191.58 + (445.53/3.15) + (1/0.252)*(Wfa/2.63)*1/1000

fa = 430kg/m^3

6. Determination of coarse aggregate

V = **[**WW + (WC/SC) + (1/1-P) * {Wca/Sca}]*1/1000

0.98 = [191.58 + (515/3.15) + (1/1-0.252)*(Wca/2.80)]*1/1000

ca = 1331 kg/m^3

7.1.3Design mix for M_{35}

Water l/m^3	Cement kg/m^3	Fine aggregate kg/m^3	Coarse aggregate kg/m^3
191.58	515.53	485	1536
0.43	1	0.9	2.939

Table No: 7.2 design mix

Chapter -8

EXPERIMENTAL PROGRAM

8.1 VARIOUS STAGES IN MAKING CONCRETE

The various stages involved in making a concrete are as follows:

1. Material selection
2. Mixing
3. Casting of freshly mixed concrete
4. Compaction of concrete
5. Curing of concrete
6. Testing of hardened concrete

8.1.1 MATERIAL SELECTION

The basic materials involved in making concrete i.e., cement. Fine aggregate, and coarse aggregate are taken in quantity as per the mix proportion. Before selecting the materials, their physical properties should be studied.

8.1.2 MIXING

There are two type of mixing

a) Hand mixing

b) Machine mixing

a) HAND MIXING:

Sand and cement in appropriate proportions are mixed first in a dry state. Then coarse aggregate is added and whole mixture is mixed thoroughly with the help of shovels. The amount of water is then sprinkled over the mix. This operation is continued till such a time a good uniform and homogenous concrete is obtained.

Fig.8.1 shows the hand mixing of concrete

b) MACHINE MIXING

Mixing of concrete is almost invariably carried out by machine, for reinforced work and for medium or large scale mass concrete work. Machine is not only efficient but also economical when the quantity of concrete to be produced is large. Coarse aggregate should be fed first, then sand and finally cement. In the revolving state, when three get thoroughly mixed, water should be added. Optimum number of revolutions over which concrete is required to mix in a mixer machine is 20

8.1.3 PLACING OF CONCRETE

Placing of concrete is almost important that the concrete must be placed in a systematic manner to yield optimum results. The following precautions are taken while placing concrete

1. Concrete should be placed in horizontal layer not thicker than 30 to 45 cm for mass concrete and 15 to 30 cm for RCC.

2. Concrete should be laid continuously to avoid irregular and unsightly lines.

3. Concrete should not be placed in heavy rains unless suitable shelter is provided.

4. Working on freshly laid concrete should be avoided.

5. The fresh concrete was filled in the mould.

Fig 8.2- shows that the moulding of concrete

8.1.4 COMPACTION OF CONCRETE

The compaction of concrete is adopted in case of unimportant concrete works of small magnitude. Sometimes this method is also applied of reinforcement is used which cannot be normally compacted by mechanical means. Hand compaction consists of Roding, ramming or tamping. When hand compaction is adopted at a higher level the thickness of the layer of concrete is limited to about 15 to 20 cm.

Concrete should be thoroughly compacted during the operation of casting and thoroughly worked. Concrete may be compacted manually by Roding, tamping or hammering for thin vertical member-Roding. For slabs, temping is done for compacting concrete.

8.1.5 CURING OF CONCRETE

The concrete surfaces are kept wet for a certain period after casting of concrete so as to promote hardening of cement. It consists of a control of temperature and moisture movement from and into the concrete. Curing of concrete depends on the type of cement and nature of work. An ordinary Portland cement, the curing period is about 7 to 28 days. There are various methods of curing.

1. Ponding with water of depth 50mm
2. Covering concrete with wet jute bags.
3. Covering concrete with wet sand saw dust etc.
4. Covering concrete with water proof paper or polyethylene sheets.
5. Intermittent spraying with water and continuous sprinkling of water.

Fig 8.3 shows that the curing process of concrete specimen

8.2 TESTING OF HARDENED CONCRETE

After curing for 7, 14 and 28 days, the concrete specimens are taken out and kept out in the atmosphere for drying. After drying these specimens are kept on the Universal Test Machine (UTM) for testing to calculate the compressive, split tensile and flexural strengths.

8.2.1 TESTING DETAILS

s.no	Type of test	Properties studied	Size of specimen
1.	Concrete strength related properties	Compressive strength	150x150x150mm in cube

Table: 8.1 shows the testing details

8.2.2 TESTS ON HARDENED CONCRETE

The following tests are conducted on hardened concrete.

1. Compressive strength test
2. Split tensile strength test
3. Flexural strength test

8.2.3 COMPRESSIVE STRENGTH

The compression test is used to determine the hardness of cubical and cylindrical specimens of concrete. The strength of a concrete specimen depends upon cement, aggregate, bond, W/C ratio, curing temperature and size of specimen.

Mix design is the major factor controlling the strength of concrete. Cube of size 150mmx150mmx150mm (as per IS: 10086-1982) should be cast. The specimen should be given sufficient time for hardening and then it should be cured for 28 days. After 28 days, it should be loaded in the compression testing machine and tested for maximum load. Compressive strength should be calculated by dividing maximum load by the cross-sectional area.

BEFORE TESTING **AFTER TESTING**

Fig8.4 shows that the testing of cube specimens

Chapter-9

RESULTS AND DISCUSSION

9.1 TEST RESULTS FOR COMPRESSIVE STRENGTH:

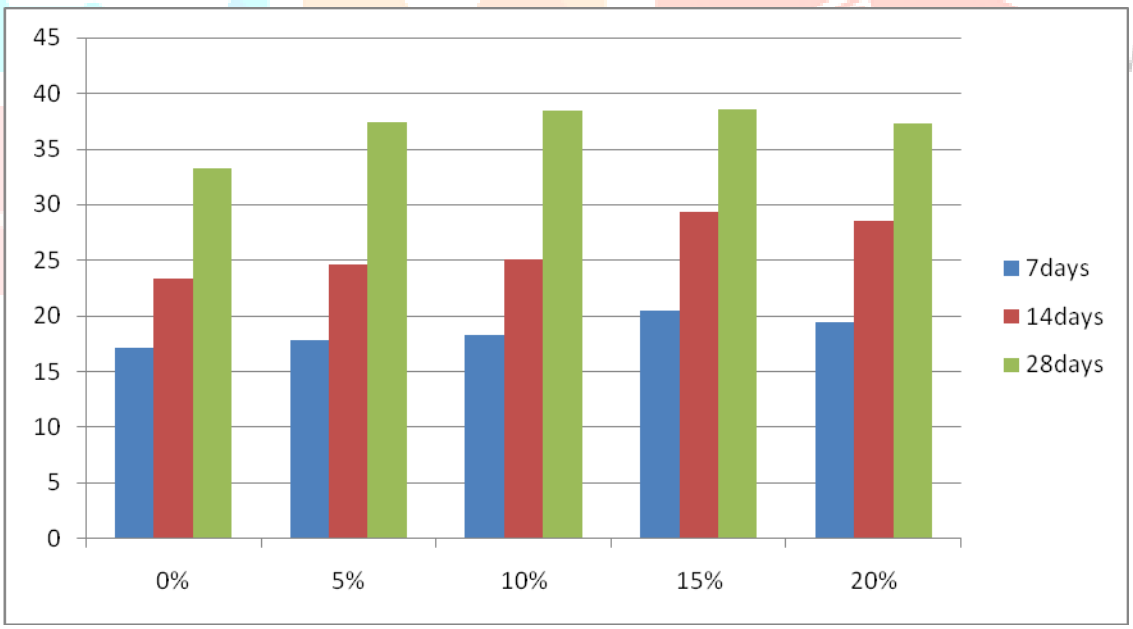
S.no	Specimen sample	% of Red mud & Fly ash replacement	Compressive strength		
			7 days	14days	28days
1.	S1	0%	17.13	23.28	33.27
	S2		17.11	23.47	33.20
	S3		17.15	23.41	33.30
Average compressive strength			17.13	23.42	33.25
2.	S4	Red mud=2.5% Fly ash=2.5%	17.65	24.61	37.41
	S5		17.90	24.59	37.39
	S6		17.83	24.62	37.42
Average compressive strength			17.80	24.60	37.40
3.	S7	Red mud=5% Fly ash=5%	18.21	25.14	38.44
	S8		18.30	25.18	38.50
	S9		18.32	25.11	38.52
Average compressive strength			18.27	25.14	38.48
4.	S10	Red mud=7.5% Fly ash=7.5%	20.53	29.39	38.50
	S11		20.49	29.42	38.51
	S12		20.51	29.41	38.49
Average compressive strength			20.51	29.40	38.50
5.	S13	Red mud=10% Fly ash=10%	19.31	28.45	37.31
	S14		19.42	28.61	37.28
	S15		19.61	28.48	37.25
Average compressive strength			19.44	28.51	37.28

Table 9.1 shows that the Compressive strength for concrete cube

9.1.2 Average compressive strength.

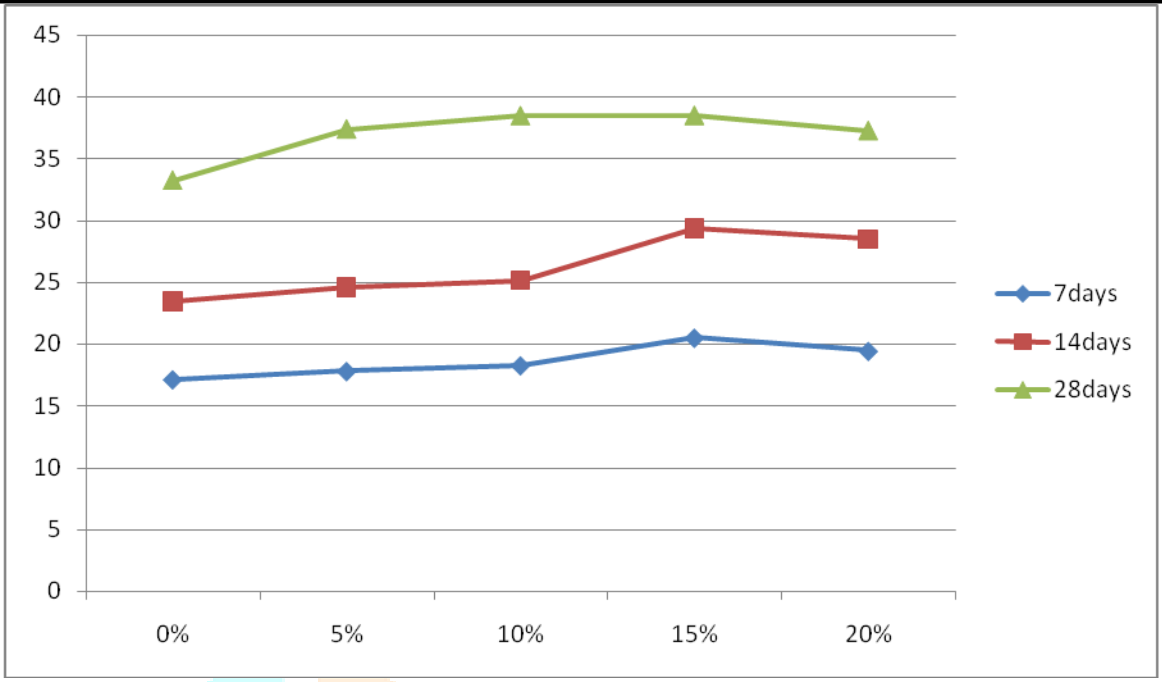
Grade of concrete	% of Red mud & Fly ash replaced	Compressive strength in N/mm^2		
		7days	14days	28days
M35	0	17.13	23.42	33.25
	Red mud=2.5% Fly ash=2.5%	17.80	24.60	37.40
	Red mud=5% Fly ash=5%	18.27	25.14	38.48
	Red mud=7.5% Fly ash=7.5%	20.51	29.40	38.50
	Red mud=10% Fly ash=10%	19.44	28.51	37.28

Table 9.2 shows that the average Compressive strength for concrete cube



9.1.2(a)Bar chart shows the average compressive strength for concrete cube.

Chart that shows the variation of compressive strength between 7days, 14 days and 28 days



9.1.2(b)line chart shows that the variation of compressive strength in concrete cubes

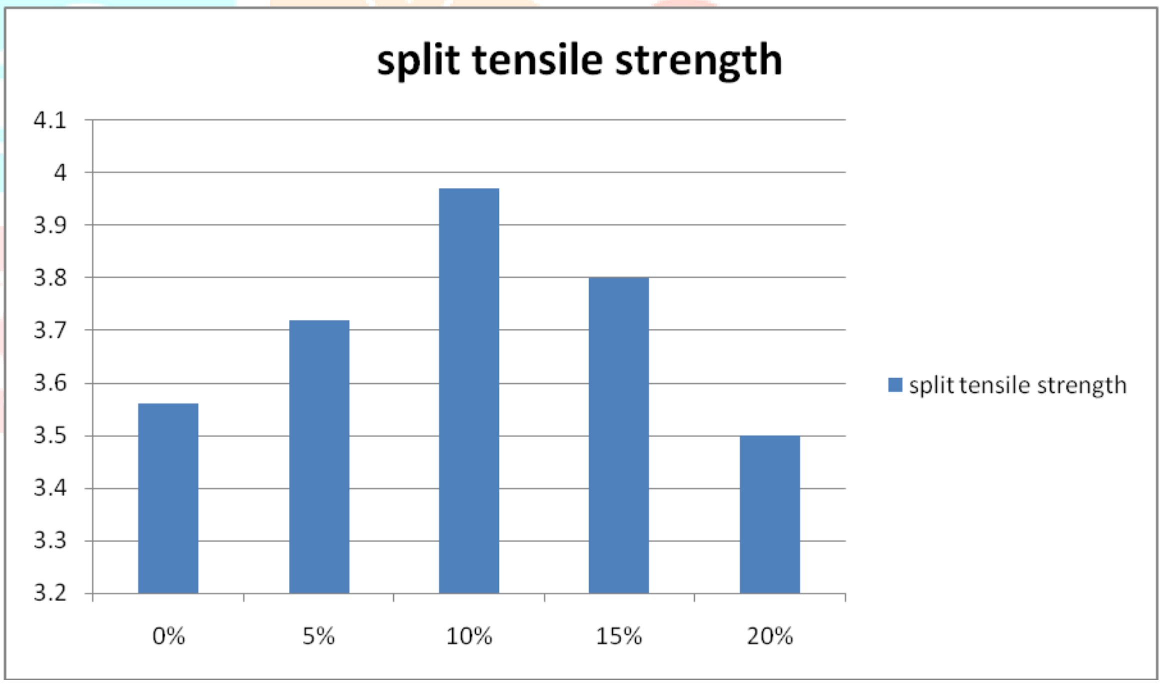
9.2 Discussion for compressive strength

- The compressive strength results showed that the up to 15% of Red mud & Fly ash replacement which with cement gives ultimate strength.
- The 28 days of compressive strength of OPC is 33.25N/mm^2.
- The 28 days of compressive strength of OPC concrete with Red mud & Fly ash is 38.50N/mm^2.
- The compressive strength mainly depends on activated Red mud & Fly ash because of excellent pozzolanic properties to produce high strength concrete.
- The replacement of 10% and 15% the compressive strength are increased with the increase in replacement of cement by NRM. Then after for 20% replacement of cement by NRM there was a decrease in the compressive strength as the replacement of cement by NRM increased.
- Hence by observing all graphs of concrete design mix it can be said that the 15% replacement of cement by NRM gives the maximum compressive strength.

9.3 TEST RESULT FOR SPLIT TENSILE STRENGTH

Grade of concrete	% of Red mud & Fly ash	28 days average split tensile strength (N/mm^2)
M35	0	3.56
	Red mud=2.5% Fly ash=2.5%	3.72
	Red mud=5% Fly ash=5%	3.97
	Red mud=7.5% Fly ash=7.5%	3.80
	Red mud=10% Fly ash=10%	3.50

Table No: 9.3 shows the split tensile strength



Bar chart 9.3 shows that the 28 days Split tensile strength

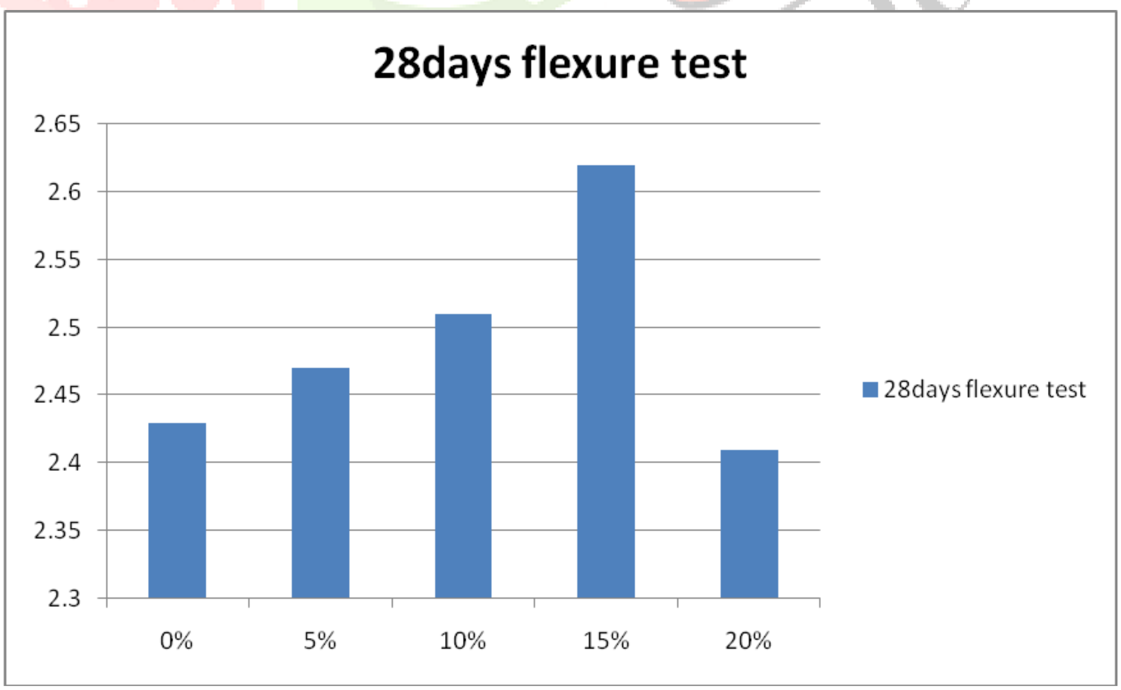
9.3.1 Discussion on split tensile strength.

- The 28 days split tensile strength of OPC is 3.56MPa.
- The 28 days split tensile strength of OPC with replacing of Red mud & Fly ash 10% is higher 3.97Mpa.

9.4 TEST RESULT FOR FLEXURAL STRENGTH

S.no	Grade of concrete	% of replacement	Average flexural strength (28days)in N/mm^2
1.	M35	0	2.43
2.		Red mud=2.5% Fly ash=2.5%	2.47
3.		Red mud=5% Fly ash=5%	2.51
4.		Red mud=7.5% Fly ash=7.5%	2.62
5.		Red mud=10% Fly ash=10%	2.41

9.4Table shows that various results of flexural tensile test



Bar chart 9.4(a)shows that the flexure test strength

9.4.1 Discussion for flexure strength

- The 28 days flexural strength of OPC is 2.43MPa.
- The 28 days flexural strength of CRFA is 2.62MPa.
- The 28 days flexural strength is high for replacing with Red mud & Fly ash compare than the OPC cement concrete.

Chapter -10

CONCLUSIONS

From this experimental study following points can be drawn:

After testing of 5 blended cement samples 0% to 20% replacement of cement by neutralized Red mud & Fly ash with an increment of 5% it can be said that the optimum use of Red mud & Fly ash is 15% as a partial replacement of cement by Red mud & Fly ash.

The cost of M35 grade concrete (i.e. 15% replacement) is around 7.48% less than the conventional concrete.

The percentage economy is increased with the increase in the grade of concrete but at the same time there is a reduction in the percentage increase in the compressive strength.

Considering all the above point that the optimum utilization of neutralized Red mud & Fly ash in concrete is 15% as a partial replacement of cement by neutralized Red mud & Fly ash.

Red mud & Fly ash can be effectively used as replacement material for cement and replacement enables the large utilization of waste product.

Red mud & Fly ash did not effect of cement properties rather improved the cement quality by way reducing the setting time and improved compressive strength.

Used for road construction as an embankment landfill is an attractive option with a high potential for large volume reuse.

In building material industry as a raw material in manufacture of building and pavement blocks and road surfacing.Dewatered (ferro alumina) as a raw material in cement manufacture.

Physical parameters of Red mud & Fly ash are affected by calcinations process the surface area and the unitary mass decrease and the specific gravity increase. The results of pozzolanic activity by chemical and physical methods were very satisfactory and indicate the feasibility of Red mud & Fly ash uses a pozzolan, in addition to Portland cement.

Chapter -11

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