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Concrete Utilization of Red Mud as A Partial Replacement of Cement with Hydrated Lime

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ABSTRACT
In present scenario the professional competition has been increased on the other hand environment concerns has also been increased that is why it has become essential to find alternative sustainable materials that can be broadly and continuously used. Industrial wastes can be a good substitute for conventional material, when utilized in a smart way. Red mud is a waste material generated by the Bayer Process used worldwide to form alumina from bauxite ore the Raw materials needed to produce cement and concrete are in short supply, making it difficult to meet demand. Cement manufacturing and concrete building generate industrial waste and byproducts that must be utilized to solve this problem. Experiments In order to evaluate the aluminum red mud's strength, tests were carried out in a lab setting. The project work focuses on the suitability of red mud obtained for construction. Five test groups were constituted with the replacement percentages 0%, 5%, 10%, 15%, 20% of red mud and 5% of hydrated lime with cement in each series. To achieve Pozzolanic property of red mud, hydrated lime was added. This paper points out another promising direction for the proper utilization of red mud.
Key words: Bayer process, Red mud, Compressive Strength test, Split tensile test

1.0 INTRODUCTION
Concrete is a material which is a combination of cement and aggregates mixed with water and sometimes admixtures and that literally forms the basis of our modem history [1]. With more than 15 billion tonnes of concrete produced annually, it is considered to be the most important building material. This concrete generation evolves 5-8% of the whole planet's human produced CO2 [2]. It has been predicted that with the increasing world's population, the demand for concrete is expected to grow to approximately 20 billion tonnes a year by 2050. Concrete is absolutely indispensable in modem society's fascination with new roads/super-highways, high- rise buildings and other consumptions. Concrete stockturns are used for living, playing and working, movements on roads and bridges, transportation by trucks travelling on concrete superhighways, by trains that mn on rails supported on concrete sleepers, by ships that moor (to tie a ship/boats so that it stays in the same place) at concrete piers in harbours protected by concrete breakwaters, or by airplanes that uses concrete manways for landing and taking off Water for drinking and growing crops is stored behind massive concrete dams and is distributed by systems of concrete conduits, pipes and waterways. Environmental balance, costs constructions [3]. In order to satisfy these components, several replacements are needed to be made in concrete. The use of Self-compacting concrete will also achieve notable impacts in expanding business since it overcomes some challenges and the mentioned major components are satisfied [4].

Utilization of Red mud:

Many efforts are being made globally to find suitable uses for red mud so that the alumina industry may end up with no residue at all. Red mud may be used in the following way:

- Building/construction materials such as bricks. Brick-making is the largest building industry, and can consume most of the red mud waste to solve the disposal and pollution problem.
- The use of red mud for brick making can save the agricultural land, partly. Red mud improves the quality of bricks made from inferior clays.
- The presence of 4-5% of alkali in red mud provides good fluxing action resulting in good plasticity and better bonding in the bricks. ii. In the cement industry, cements made from lime, red mud, bauxite and gypsum exhibit strengths comparable or superior to Ordinary Portland cement.

Strengths of Red Mud:

- It is evident from the literature survey that red mud increases the strengths of concrete to a considerable extent.
- It reduces the capillary pores of concrete and hence reduces permeability.
- Red mud's pH value varies from 10 to 12 and as a result of which it prevents corrosion of reinforcement.
- Use of red mud proves to be economical as it comes free of cost.
- Red mud also serves as a decorative material.
- It serves as a good binder material.

The Nature of Fly Ash:

Fly ash is a by-product of burning pulverized coal in an electrical generating station. Specifically, it is the unburned residue that is carried away from the burning zone in the boiler by the flue gases and then collected by either mechanical or electrostatic separators The heavier unburned material drops to the bottom of the furnace and is termed bottom ash; this material is not generally.

Objectives:

The main objectives of this research are:

- To investigate the effect of fly ash characteristics on the rate of hydration of cement.
- To determine the process for production of red mud concrete for M40 grade.
- To use red mud and fly ash as a Partial replacement of cement in rural building construction in order to make it eco-friendly as well as reduce the cost of construction.

2.0 LITERATURE REVIEW

[5] Rathod et al. (2012) examined the effect of red mud on the properties of hardened concrete of grade M30. Portland cement was replaced with red mud by wt of cement and its compressive strength & splitting tensile strength was evaluated. The test result showed that the strength decreases with increase in red mud content. It was concluded that optimum percentage of the replacement of cement by weight with red mud was 25%, which gave strength equal to the strength of control concrete mix. [6] Ribeiro et al. (2012) reported that the high alkalinity of red mud, which was initially a factor of environmental concern, had proved to be the main advantage of using red mud as a rebar corrosion inhibitor in reinforced concrete without affecting its passivity. In the study, the chloride concentration was monitored by measuring the conductivity of the anolyte. Red mud proved to be a promising additive for concrete to inhibit the corrosion process. [7] Sawant and Kumthekar (2013) studied the effect of replacement of cement by neutralized red mud on design mix concrete of grade M50. The water-cement ratio 0.36 was kept

constant for different percentage of replacement of cement by neutralized red mud. The average compressive strength decreases with increase in neutralized red mud content, except for few percentages of replacement. For M 50 concrete mix, the optimum replacement was 15 %.[8] Yogananda et al. (1988) examined the pozzolanic properties of rice husk ash (RHA), burnt clay (BC), and red mud (RM). It was observed from the compressive strength that they satisfy the requirement for secondary construction applications like masonary and plastering. Lime-RHA mortars with RHA containing a mixture of amorphous and crystalline silica lead to higher long terni strengths. [9] Senff et al. (2010) reported the effect of red mud addition on the rheological behavior and on hardened state characteristics of cement mortars. Red mud decreases the workability and increases the torque but causes lower impact than water variation. Redmud did not change the hydration process, but above 20% the maximum temperature decreases.

3.0 MATERIALS AND METHODS

Concrete: As a solid substance, concrete is a mixture of aggregated stones or other hard materials embedded in cement mortar, which is a cement-and-sand mortar blend. It is composed of 60 to 65 percent aggregates in regular concrete and the remaining 25 percent is past. As of this point in time, the term "paste" signifies a mixture of cement and water. A combination of concrete's strength, adaptability, and affordability has made it the most frequently used building material in the world

Cement: As a construction material, cement is a popular choice for holding things together. It is possible to make cement by first burning and then grinding together two different types of rock, one containing calcium and one containing argillaceous (clay). By far the most common and widely used form of cement is Ordinary Portland Cement (OPC)

Table 3.1: The Physical properties of 53 Grade Cement

S.No	Characteristics	Values
1	Standard consistency	**53**
2	Fineness of cement as Retained on 90 micron sieve	**3%**
3	Initial setting time	30 minutes
4	Specific gravity	3.15
5	7days compressive Strength	7MPA

Aggregates: Concrete's most significant component, aggregates give the material structure and help keep it from shrinking. 70 to 80 percent of the concrete's volume is made up of aggregates. The classification of aggregates is dependent on the shape and size of the concerns that are being analyzed

Fine aggregate:

After being sieved via 4.75mm sieves, the aggregates known as fine aggregate are referred to as such. Typical fine aggregates include sand, clay, and silt, which are all naturally occurring. Filling up the gaps in the coarse aggregate and acting as a workability agent are the primary functions of fine aggregates

Hydrated lime: Limestone is ground into a fine powder and used to make hydrated lime. The chemical name for hydrated lime is calcium hydroxide. Slaked lime is a brand name for calcium hydroxide, which is also known as calcium hydroxide. The white dry powder produced by the controlled slacking of quick lime with water is then caught and the additional slaking water removed. Ca(OH)2 is the chemical formula for pure line. Higher

purity hydrated lime (90 percent calcium hydroxide) than lower purity hydrated lime (65 percent purity).

Figure 3.1 Hydrated lime

Red Mud: In the aluminum industry, red mud is a complex mixture of solid and metallic oxide-bearing contaminants that must be dealt with. The red color is generated by the presence of oxidized iron, which can make up to 60% of the bulk of the red mud. In addition to iron, silica, unbleached residual aluminum, and titanium oxide are all major constituents in this mixture. It's difficult to get rid of red mud.

Figure 3.2: Sample of Red mud

Test data for materials:

Type of cement	=	OPC
Grade of cement	=	53 grade
Specific gravity of cement	=	3.15
Replacing material	=	Red mud sludge, Hydrated lime
Dosage	=	0%, 5%
S.P of replacing material	=	2.86, 2.24
Coarse Aggregate	=	20 mm
Fine Aggregate	=	Zone II

Design For M_{40} Grade with Replacement Materials Of 5% Red Mud And 5% Hydrated Lime

Design stipulations:

Characteristics of compressive strength	=	40 N/mm^2
Maximum size of aggregate	=	20 mm
Degree of quantity of aggregate	=	Good
Maximum cement content	=	480 kg/m^3
Minimum cement content	=	300 kg/m^3
Maximum water cement ratio	=	0.4
Proposed water cement ratio	=	0.4
Slump	=	50 - 125

4.0 RESULTS AND DISCUSSIONS

Compaction factor test:

The ratio of the mass of concrete compressed in the compaction factor apparatus to the mass of fully compacted concrete is known as the compaction factor. Pouring the concrete into successive silos and measuring the volume of concrete in the final silo against a standard volume of thoroughly compacted concrete is the method used.

Table 4.1: Compaction factor Values for M_{40} Concrete

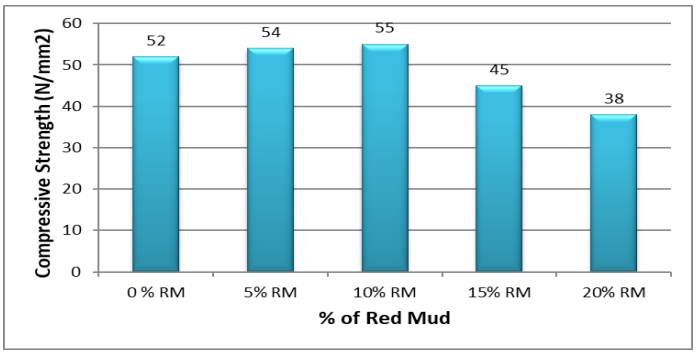
% Replacement of cement	**Hydrated Lime**	Compaction factor
00	5	0.85
05	5	0.87
10	5	0.91
15	5	0.92
20	5	0.94

COMPRESSIVE STRENGTH TEST:

Test to determine the maximum compressive load a material can withstand before failing mechanically. A compression-testing machine uses a gradually applied load to compress the test object, which is often in the shape of a cube, prism, or cylinder. Although brittle materials like granite, cast iron, and concrete have high compressive strengths, they eventually break down. Breaking a cube tests the crushing strength of concrete, which is sometimes referred to as "cube strength." The cubes are 150mm x 150mm x 150mm in dimension

Table 4.2 Compressive Strength values for M_{40} Concrete without hydrated lime

Grade of concrete	% of red mud used	28 days
M40	00	52
	05	54
	10	55
	15	45
	20	38



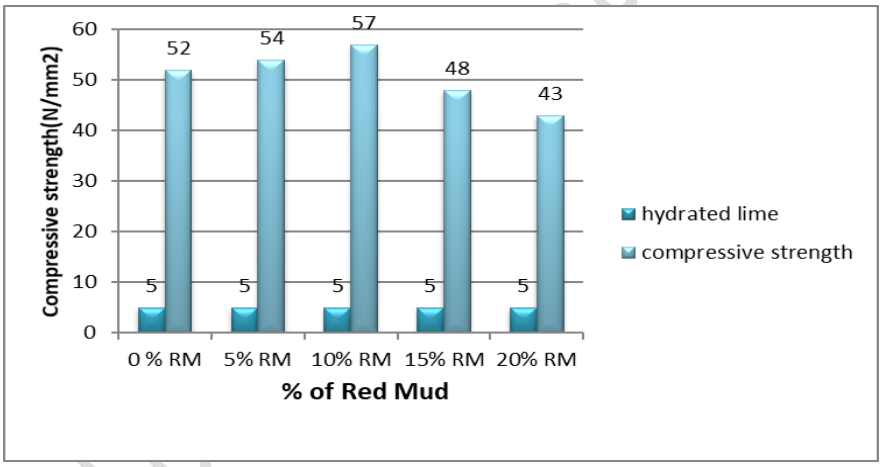
Graph 4.1: Relation between % of red mud sludge and compressive strength

Without hydrated lime

Red mud concrete cubes containing hydrated lime have 28-day compressive strengths that are shown in a table and a graph

Table 4.3: Compressive Strength values for M_{40} Concrete with 5% hydrated lime

Grade of concrete	% of red mud used	Hydrated lime	28 days
M40	00	5	52
	05	5	54
	10	5	57
	15	5	48
	20	5	43



Graph 4.2: Relation between % of red mud sludge and compressive strength With hydrated lime

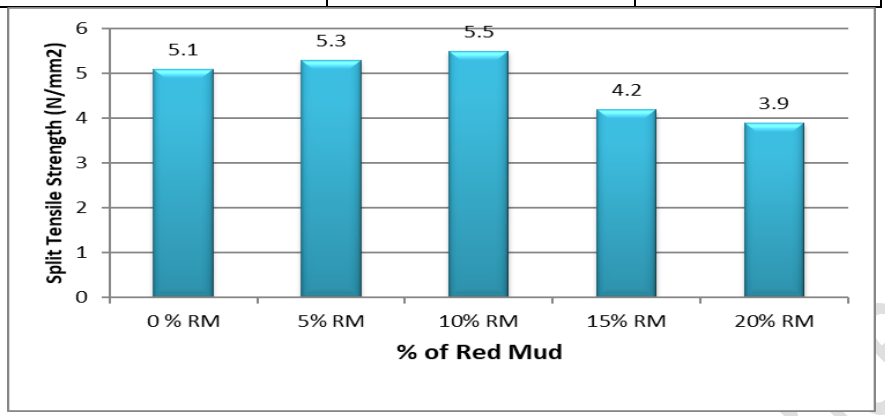
Split tensile strength test:

Concrete's tensile strength is a critical and fundamental property. Because of its low tensile strength and brittle nature, concrete is normally not expected to withstand direct tension. Because concrete members might crack under certain loads, it is vital to assess the tensile strength of red mud and hydrated lime cement. Tension failure is the cause of the cracking. Molded and drill core specimens are included in this test technique for the determination of the splitting strength of cylindrical concrete samples such as cylinders.

Table 4.4: Split Tensile Strength values for M_{40} Concrete without hydrated lime

Grade of concrete	% Of red mud used	28 days
M40	00	5.1
	05	5.3
	10	5.5

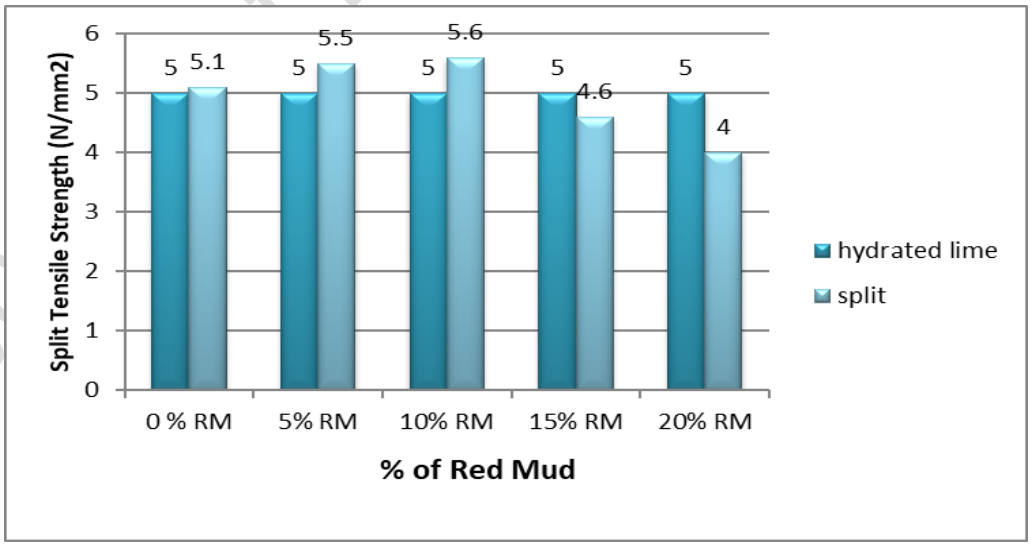
	15	4.2
	20	3.9



Graph 4.3: Relation between % of red mud sludge and split tensile strength Without hydrated lime

Table 4.5: Split Tensile Strength values for M_{40} Concrete with 5% hydrated lime

Grade of concrete	% Of red mud used	% of hydrated lime	28 days
M40	00	5	5.1
	05	5	5.5
	10	5	5.6
	15	5	4.6
	20	5	4.0



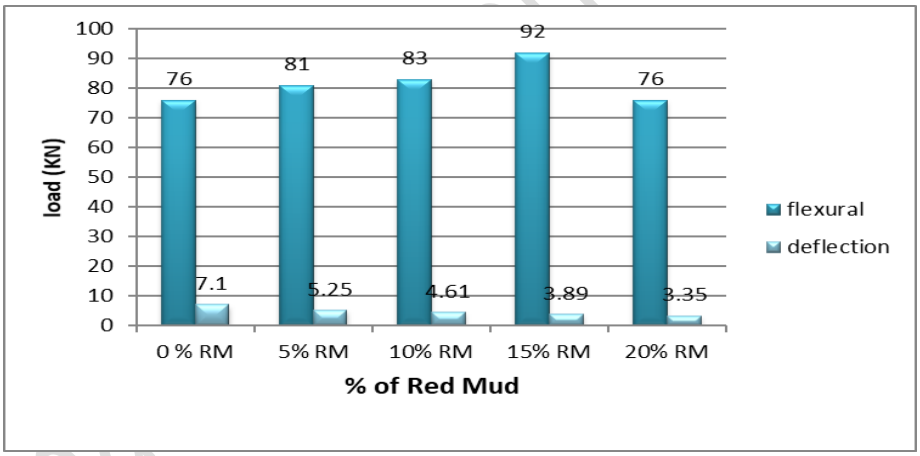
Graph 4.4: Relation between % of red mud sludge and split tensile strength With hydrated lime

Flexure Strength Test:

Cylindrical concrete specimens are tested using this approach to determine their strength. A cylindrical specimen is subjected to a diametral compressive force along its whole length. Tensile strains are created in the plane where the load is applied. Tensile rather than compressive failure occurs. The load is distributed evenly along the cylinder's length thanks to the usage of plywood strips. In order to calculate the split tensile strength, the maximum load has to be divided by the relevant geometrical factors

Table 4.6: Flexural Strength for red mud concrete without hydrated lime

% Replacement of cement	Ultimate Flexural Strength (KN)	Deflection (mm)
00	76	7.10
05	81	5.25
10	83	4.61
15	92	3.89
20	76	3.35

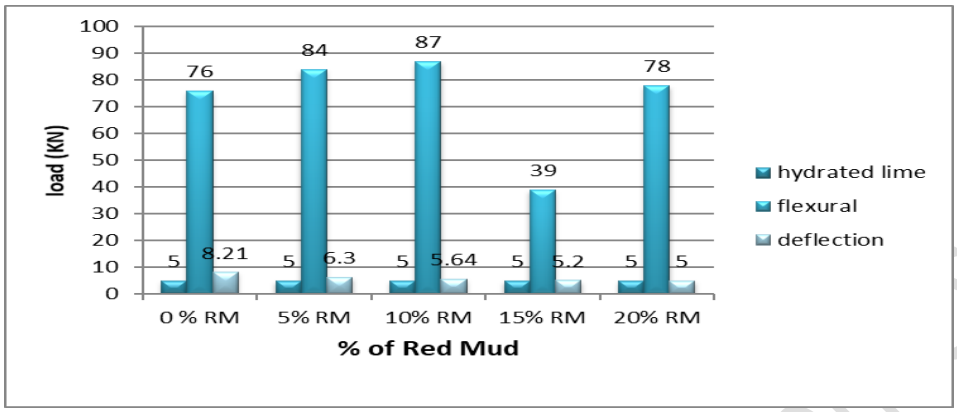


Graph 4.5: Relation between % of red mud sludge and Flexural strength, deflection Without hydrated lime

Table 4.7: Flexural Strength for red mud concrete with 5% hydrated lime

% Replacement of cement	% Of hydrated lime	Ultimate Flexural Strength (KN)	Deflection (mm)
00	5	76	8.21
05	5	84	6.3
10	5	87	5.64
15	5	39	5.2

20	5	78	5.0



Graph 4.6: Relation between % of red mud sludge and Flexural strength, deflection with hydrated lime

Conclusion:

From this research the following conclusions are:

The slump value is increasing with increase in the percentage of red mud in concrete for 5% hydrated lime. Due to increase in the red mud leads to decrease in the quantity of cement results in increase in the workability of concrete.

- The compressive strength of M20for 28 days at 0%,5%,10%,15%,20% is 51kN/m2,53 kN/m2,55 kN/m2 ,44 kN/m2, 38 kN/m2respectively.
- The compressive strength of M20with 5% hydrate lime for 28 days at 0%,5%,10%,15%, and 20% is 51kN/m2,54 kN/m2, 56 kN/m2, 48 kN/m2, 42kN/m2respectively.
- The optimum value of the compressive strength of red mud concrete for 7 days curing was observed at 10% red mud replacement. And also, for 28 days compressive strength observed at 10% red mud replacement. The compressive strength of concrete using 5% hydrated lime is more as compared with the concrete without hydrated lime.
- Theoptimumvalueofsplittensilestrengthbyusinghydratedlimeandwithoutusinghydrated lime are observed at 10% red mud replacement. And also split tensile strength is high for 5% hydrated lime concrete.
- The optimum value of flexural strength was observed at 0% replacement of red mud concrete for both using hydrated lime and without using hydrated lime at 28days of curing. 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.
- Red mud can be effectively used as replacement material for cement and replacement enables the large utilization of waste product. Red mud did not affect of the cement properties, rather improved the cement quality by way reducing the setting time & improved compressive strength. Physical parameters of red mud are affected by calcination process
- The surface area and the unitary mass decrease and the specific gravity increases, the results of pozzolanic activity by chemical and physical methods were very satisfactory and indicate the feasibility of red mud use as a pozzolan, in addition to Portland cement.

REFERENCES:

1. Prathyusha, P., Jugal Kishore, M., Siva Kiran, K., Saravanan, M., "Mechanical Properties of Glass Fiber Reinforced Concrete Using Silica Fume & Quarry Waste as Partial Replacements", International Journal of Advanced Science and Technology Vol. 29, No. 5, (2020), pp. 8230-8243.
2. Prathyusha, P., Venu, M., J.S.R. Prasad, "Efficacy of glass fiber reinforced concrete by using Supplementary cementitious materials", International Journal of Innovative Technology and Exploring Engineering, vol. 8, (2019), pp. 4262-4268.
3. Sai Mahesh Reddy, P., Siva Sankara Reddy, D.V., Jugal Kishore, M., and Siva Kiran, K., "Analyzing Strength Characteristics of Self Compacting Concrete by using Hair Fiber as a Partial Replacement of Cement", International Journal of Innovative Technology and Exploring Engineering, vol. 8, (2018), pp. 183-189.
4. Sai Kumar, G.H.L.S., Jugal Kishore, M, "Experimental Study of Fly Ash based Steel Fiber Reinforced Self Compacting Concrete", Journal of Interdisciplinary Cycle Research", vol. 12, No. 7, (2020), pp. 1367-1372.
5. Rathod R.R., Suryawanshi N.T., Memade P.D., "Evaluation of the properties of red mud concrete", ISOR Journal of Mechanical and Civil Engineering, (2012), 31-34.
6. Ribeiro D.V., Labrincha J.A., Morelli M.R., "Effect of the addition of red mud on the corrosion parameters of reinforced concrete", Cement and Concrete Research, 42(2012), 124-133.
7. Sawant A.B., Kumthekar M.B., Sawant S.G., "Utilization of neutralized red mud (industrial waste) in concrete", International Journal of Inventive Engineering and Sciences, 1, 2(2013), 9-13.
8. Yogananda M.R., Jagadish K.S.,"husk ash, burnt clay and red mud". Building and Environment, 23(1988) 303-308.
9. Senff L., Hotza D., Labrincha J.A., "Effect of red mud addition on the rheological behavior and on hardened state characteristics of cement mortars". Construction and Building Materials, 25(2010), 163-170.
10. Sankara Reddy, D.V.S., Kowshik, K, Jugal Kishor, M., Vijaya Durga, R., Pavan Kumar Reddy, V., "Enhancement of Soil Properties by Using Fly Ash and Metakaolin" in International Journal of Innovative Technology and Exploring Engineering (IJITEE), Volume-8 Issue-2S, (2018), pp. 01-06.