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EXPERIMENTAL INVESTIGATION TO CHECK THE STRENGTH PROPERTIES OF CONCRETE BY USING CLAYS AND ALUM AS PARTIAL REPLACEMENT OF CEMENT

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Abstract: *Concrete is one of the most popular construction materials used since hundred years ago. Concrete production needs natural resources like water, coarse aggregates, fine aggregates and cement, whose production is not only costly due to natural resources but also energy efficient. Cement manufacturing is mostly responsible for CO2 emission in atmosphere and tends to pollute the air. Several studies have been carried out to investigate the possibility of using dissimilar materials for partial replacement of cement to reduce pollution as well as achieve healthy environment. By considering all these aspects and need, thought that Alum, Kaolin clay and Bentonite clay can be beneficial as partial replacement of cement in concrete. The present paper is an effort to quantify the 7 and 28 days cementitious efficiency of Alum, Kaolin clay and Bentonite clay in concrete at the various replacement levels with the help of literature review studied. This paper consists of a complete study of concrete strength by partial replacing the cement by using clay and Alum. These all replacements have been tested for 7 and 28 days to conclude the strength parameters. Utilization of natural materials as partial replacement of cement with an intention to develop an Eco-friendly concrete is having similar or higher strength.*

Keywords: Alum, Kaolin clay, Bentonite clay, Ordinary Portland cement (Grade 53)

I. INTRODUCTION

Every year, there are huge demands of components of the raw materials for the production of Ordinary Portland cement concrete turning into to extensive exploring natural resources. Efforts have been made to recycled, cheaper, environment friendly materials worldwide to produce durable, high strength life cycle, cost effecting long lasting concrete. Therefore, it is always encourages to find new technologies for the construction industries. The construction industry has taken considerable strides forward over the last two or three decades with regard to trials in the use of one or another Cementitious materials generally identified as Pozzolanas, for the compounding of various cement based products. These have not only resulted an improving the compressive strength value attained thereby but also in qualities like ability to set and harden under water. Among these Coal fly-ash, Blast furnace slag, Rice hulk ash, Silica fume, or Meta-kaolin are the most common ones. Other like Gypsum, Gypsum fines, Portland cement, Cement kiln dust, Lime dust, Stone dust, and Calcined clay are also in used, due to economic and environmental concerns. By considering all these aspects and need , it is thought that some substances like Alum, Kaolin clay and Bentonite clay can be beneficial to some properties of Portland Cement Concrete (both fresh and hardened). These three materials are easily available in market and natural resources so less expensive also. Kaolin clay is very fine and smooth clay. When it is wet, became sticky and preventing the segregation and increase the compressive strength since the particles of Kaolin are fine so and suspending the aggregate uniformly. Bentonite clay is having swelling properties so when it is wet, it swells and filled up the air voids in concrete to avoid cracks in concrete. Alum (Aluminium sulphate) is mostly used as accelerator for concrete. Alum is a major component in concrete accelerator and wide application in concrete as an accelerator.

II. AIM AND OBJECTIVES

A. Aim

Experimental investigation to check the strength properties of concrete by using Alum and clays as partial replacement of cement

B. Objectives

The experimental study is to be conducted to determine the working limits of Alum (Aluminium Sulphate), Bentonite clay and Kaolin clay as partial replacement of Cement, so that the results can be contributed to certain property changes of concrete and beneficial for future construction aspects.

- Experimental study for determination of the effects of Alum on concrete.

- Experimental study for determination of the effects of Bentonite clay and Kaolin clay mixture on concrete
- Experimental study for determination of the combined effects of Bentonite clay, Kaolin clay and Alum mixture on concrete.
- Experimental determination of the Compressive strength, Split Tensile strength and Flexural strength of concrete having Alum, Kaolin clay and Bentonite clay as partial replacement of cement.
- Study and comparisons between the results of strengths of concrete.

III. MATERIAL SPECIFICATIONS

a. Ordinary Portland cement:

The main binder used in this experimental study is Ordinary Portland cement of 53 Grade conforming to IS 12269:1987. The properties of cement have been tested as fineness 5%, Normal consistency 30%, initial and final setting time 45 min and 330 min by considering IS 4031:1968

b. Fine aggregates:

River sand has been used as fine aggregates. Fine aggregates have passed through 4.75 mm IS sieve, conforming to grading Zone-II of IS 383-1970.
Physical properties of fine aggregates -Fineness modulus -2.39 , Specific gravity- 2.65 and Water absorption – 1.4%.

c. Coarse Aggregates

Coarse aggregates with nominal size 20 mm as per IS: 2386-1963(part-I, II, III) have been used.
The physical properties of aggregates - fineness modulus-7.28, specific gravity- 2.76, water absorption-1.47%.

d. Alum

Aluminium Sulphate is commercially known as Alum. It is white coloured powder, having many industrial uses. Basically Al2 (SO4)3 is a chemical agent and mostly used in water purification, pH regulation of garden soil, and other commercial or industrial applications. Alum (Aluminium sulphate) is a major component in concrete accelerator and wide application in concrete as waterproofing agent, expansive and accelerator. The general appearance of Alum powder is shown in fig no.1

Fig no.1.Alum powder

Lab tested chemical composition of Alum are given in table no.1.

Table no 1. Chemical composition of Alum

Al^2O^3 (%)	PH	Insoluble matter (%)
16.2	3.2	0.12

- Specific gravity of Alum = 2.35

e. Kaolin clay

Kaolin clay commonly referred to as china clay, is clay that contains 10-95% of mineral Kaolinite and usually mainly consists of Kaolinite (85-95%). Kaoline is insoluble in water but darkens and develops an earthy odour when wet. Basically Kaolin clay is odourless. Kaolin is basically very fine clay so it is added after the water and initial mixing. This was done to keep the kaolin from the coating in aggregate or clumping together. Partical size of kaolin clay is between silica fumes and the fly ash. Fly ash partical size is almost 25-26µ and silica fumes partical size is nearer to 0.3-0.4µ and Kaolin clay partical size is 1.5-2.0µ. So when this clay is mixed with cement in concrete as fine particles, it increases the shrinkage and reduces compressive strength so it is used with sand and water for better results. The general appearance of Kaolin clay is shown in fig 2.

Fig no. 2 Kaolin clay

Lab tested chemical composition of Kaolin clay are given in table no.2

Table no.2.Chemical composition of Kaolin clay

SiO_2	Al_2O_3	Fe_2O_3	MgO	CaO	K_2O	TiO_2	Na_2O_3	LOI
49.08	36.1	0.6	0.3	0.07	1.38	0.92	0.08	10.8

- Specific gravity of Kaolin clay =2.65

f. Bentonite Clay :

Bentonite usually forms from weathering of volcanic ash, most often in the presence of water. The transformation of volcanic ash to Bentonite clay basically takes place in presence of water only. Bentonite clay is having two types: Sodium Bentonite and Calcium Bentonite. Sodium Bentonite is usually referred to as Bentonite and swelling Bentonite and whereas calcium Bentonite is called Fuller's earth. Bentonite feels greasy and soap like in touch. Freshly exposed Bentonite is white to pale green or blue, turns darken with the time to yellow, brown or red. Sodium Bentonite chemical formula is [Al2 H2 Na2 O13 Si4]. It has ability to form thixotrophic gels with water, an ability to absorb large quantity of water with an increase in volume of as much as 12-15 times its dry volume. The general appearance of clay is shown in fig no.3

Fig no.3. Bentonite powder

Lab tested chemical compositions are given in table no.3

Table no. 3. Chemical composition of Sodium Bentonite clay

SiO^2	Al^2O_3	Fe^2O_3	MgO	CaO	Na^2O_3	K^2O	TiO^2	Other	LOI
52.63	24.11	3.235	3.61	0.64	1.45	2.091	0.45	0.48	8.22

- Specific gravity of Bentonite clay = 2.55.

g . Water

According to IS 3025(part 21)-2009, water to be used for mixing and curing should be free from injurious or deterious materials. Potable water is generally considered satisfactory. In the present research work, water available within campus is used for both mixing and curing purposes.

IV. CONCRETE MIX DESIGNING

Based on trial mixes for different proportions of ingredients, the final design mix have been prepared for M20 grade concrete as per 10262-2009.
The mix proportion ratio has come as 1:1.72:2.93 with water cement ratio 0.5. The calculated mix design ratio is given in table no.4.

Table no.4.Mix design ratio

Cement	Fine aggregates	Coarse aggregates	Water
396	684	1162	0.5

V. CASTING OF SPECIMENS

The specimens have been casted as per calculated mix design. In casting of specimens, three combinations of materials have used. Alum and combination of Kaolin clay and Bentonite clay mix and combination of Alum and clay mix have been used in various proportions as given below-

Alum has used as 3%, 5% and 7% for replacement of cement.

Combination of Kaolin clay and Bentonite clay has used as 3%,5% and 7% for replacement of cement.

Alum, Kaolin clay and Bentonite clay mix has used as 3%, 5% and 7% for replacement of cement.

These all replacements have done by considering weight of cement.

The different specimens like cubes, cylinders and beams as per requirement of work have been casted. Cubes of size 150 mm X150mm X 150mm, cylinders of sizes 150 mm X 300mm have been casted and kept in water for 7 and 28 days curing. The casted specimens are shown in fig no. 4.

Fig no. 4.Casted specimens

VI. TESTING OF SPECIMENS

Workability test of conventional concrete and cementatious materials mixed concrete have been performed with the help of slump cone apparatus and Compressive strength, split tensile strength have found on compression testing machine while flexural strength were found on universal testing machine.

Fig no. 4. Testing of Cube

VIII. RESULT AND DISCUSSIONS

1. Workability Test :

Workability of concrete mixtures has been measured by performing slump cone test. The variation in slump of different % replacement of Alum, Clay combination and Alum and clay combination in concrete is given in table no.5

Table no.5.Workability in terms of slump (mm)

Sr no	Mix proportions	Slump values in mm		
		Alum	Kaolin clay + bentonite clay mix	Kaolin clay + bentonite clay +Alum mix
1	0%	68	68	68
2	3%	70	66	67
3	5%	72	65	65
4	7%	7 1	62	63

1. Workability is increased with increasing adding percentages of Alum. No segregation and bleeding were observed.
2. Workability is decreased with increasing adding percentages of Kaolin and Bentonite clay mix. No segregation is observed but bleeding is observed. This is due to extra fineness of both clays.
3. Workability is decreased with increasing adding percentages of Kaolin, Bentonite clay and Alum mix.
4. If adding proportion of alum is increased, it may cause workability increase. But adding percentages of Bentonite clay is high as compared to others, concrete respond more like Bentonite concrete and shows decreases result.

2. For OPC

OPC M20 grade concrete specimens were casted and tested for 7 and 28 days strength determination in college concrete lab. The results of testing are given in table no.9.

Table no. 6. OPC concrete tests results

Sr no.	Days	Compressive strength	Split tensile strength
1	7	14.35	2.10
2	28	28.25	2.48

a) Compressive strength-

The compressive strengths for various proportions and combinations have been tested on tension machine. And the tested results of compressive strength for 7 and 28 days are given in table no.7

Table no.7.Results of compressive strength for 7 and 28 days

Days	7 days			28 days		
Replacing Proportion	Alum (N/mm²)	Clay mix (N/mm²)	Alum and clay mix (N/mm²)	Alum (N/mm²)	Clay mix (N/mm²)	Alum and clay mix (N/mm²)
3%	13.68	13.10	13.69	28.56	28.264	28.92
5%	15.10	14.35	14.56	29.5	29.006	29.261
7%	14.658	15.50	15.68	28.96	29.460	29.86

Graphical representations of compressive strength for 7 and 28 days are shown in fig. 6 and 7.

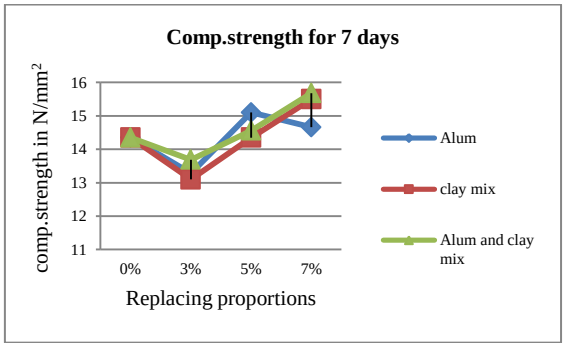

Fig no.6. Compressive strength for 7 days

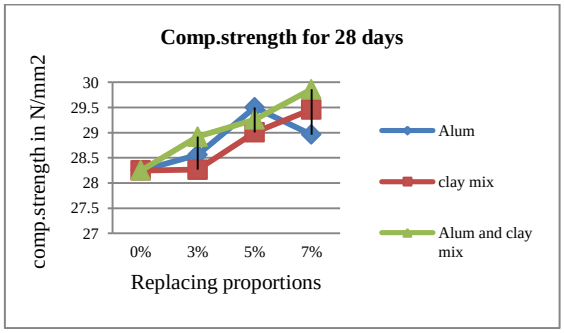

Fig no.7. Compressive strength for 28 days

a. 5% of Alum replacement with cement gives higher result for compressive strength for 7 days and 28 days.
b. 7% of Kaolin and Bentonite clay mix replacement with cement gives higher result for compressive strength for 7 and 28 days.
c. 7% of Alum, Kaolin and Bentonite clay mix replacement with cement gives higher result for compressive strength for 7 and 28 days

b) Split tensile strength for 7 and 28 days

The split tensile strengths for various proportions and combinations have been tested on tension machine. And the tested results are given in table no.11.

Table no.11.Results of Split tensile strength for 7 and 28 days

Days	7 days			28 days		
Replacing Proportion	Alum (N/mm²)	Clay mix (N/mm²)	Alum and clay mix (N/mm²)	Alum (N/mm²)	Clay mix (N/mm²)	Alum and clay mix (N/mm²)
3%	2.18	2.05	2.13	2.45	2.50	2.60
5%	2.24	2.15	2.20	2.65	2.53	2.72
7%	2.20	2.25	2.35	2.55	2.62	2.80

Graphical representations of compressive strength for 7 and 28 days are shown in fig.8 and 9

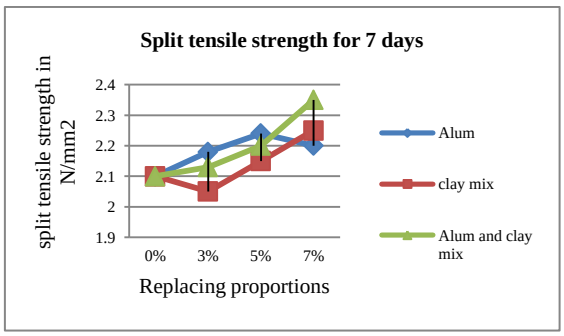

Fig no.8 Split tensile strength for 7 days

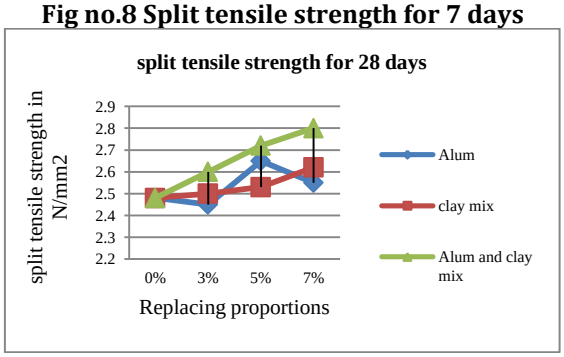

Fig no.9. Split tensile strength for 28 days

a. 5% of Alum replacement with cement in concrete gives higher result for split tensile strength for 7 and 28 days.
b. 7% of Kaolin and Bentonite clay mix replacement with cement in concrete gives higher result for split tensile strength for 7 and 28 days.
c. 7% of Alum, Kaolin and Bentonite clay mix replacement with cement gives higher result for split tensile strength for 7 and 28 days

IX. CONCLUSIONS

According to results of tested specimens of Alum, combination of Kaolin clay and Bentonite clay and combination of Alum, Kaolin clay and Bentonite clay without addition of any admixture in concrete gives higher strength than OPC concrete strength.

A. By addition of 5% of Alum in concrete increases compressive strength, tensile strength by 1.75 N/mm^2 as compared to OPC concrete strength.

B. 7% addition of Kaolin clay and Bentonite clay combination increases the compressive strength and split tensile strength by 1.21 N/mm^2 as compared to OPC concrete strength values.

C. 7% addition of combination of Alum, Kaolin clay, Bentonite clay increases compressive, tensile strength by 1.53 N/mm2 as compared to OPC strength properties.

D. Workability of Alum mixed concrete gives better result for increasing percentages of Alum mix while Kaolin clay and Bentonite clay mix concrete and Alum, Kaolin clay and Bentonite clay mix concrete show decreasing result as percentages of mixing increases.

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