MECHANICAL AND DURABILITY STUDY ON CONCRETE MADE WITH ALKALI ACTIVATED FLY ASH AGGREGATES

Marreddy Himanth Reddy[1], Susheel Raja K[2], E Dhanesh[3], V Vasugi[4]

1,2. PG Student, SMBS, VIT University, Chennai
3. Manager-Technical Services, JSW Cements Pvt. Ltd. Chennai
4. Associate professor, SMBS, VIT University, Chennai

ABSTRACT. In present situation, replacement of coarse aggregate is necessary, as natural resources are limited. Hence, usage of artificial aggregates is recommended as a replacement of conventional coarse aggregates in making sustainable concrete. In this work, alkali activated fly ash aggregates have been synthesized and its properties are reported. Aggregates thus prepared are used as coarse aggregates in M30 grade concrete. The specimens are casted and tested for its fresh properties, hardened properties like compressive strength, split tensile strength, flexure strength and durability properties like sorptivity, water permeability, rapid chloride penetration, sulphate resistance chloride attack, and acid resistance. It is observed that concrete with synthetic aggregates yielded the desired strength i.e., around 35 MPa.

Keywords: Fly ash, Alkali activated aggregates, Artificial aggregates, Mechanical and Durability studies.

Marreddy Himanth Reddy is a post graduate student doing his Masters in Structural Engineering, School of Mechanical and Building Sciences, VIT University, Chennai Campus, Tamil Nadu, India. His research interest includes concrete durability, Alkali activate fly ash aggregates.

Susheel Raja K is a post graduate student doing his Masters in Structural Engineering, School of Mechanical and Building Sciences, VIT University, Chennai Campus, Tamil Nadu, India. His research interest includes concrete durability, Alkali activate fly ash aggregates.

E.Dhanesh is a Manager –Technical Services, JSW Cements Pvt. Ltd, Chennai, Tamil Nadu, India. His research interest in Advance Concrete technology.

V.Vasugi is an Associate Professor of Structural Engineering Division, School of Mechanical and Building Sciences, VIT University, Chennai Campus, Tamil Nadu, India. Her research interests are light weight aggregate concrete, sustainable materials for construction, Concrete durability.

INTRODUCTION

In recent years, we are facing much problem in coarse and fine aggregates. Aggregate such as gravel and granite drastically reduce the natural stone deposits and this has damaged the environment, thereby causing ecological imbalance. So, usage of artificial aggregates is necessary. Materials having pozzolanic activity it can be used as a fine additive to concrete in the building industry. It has not only environmental aspect, but also an economic way. It had been reported that rapid hardening and high compressive strength was produced with alkali activators. Using alkali-activation technique, fly ash artificial aggregates were produced by granulating hardened paste of fly ash. Specific gravities, absorption capacities, sieve analysis, environment stability, and other properties of the alkali activated aggregates were determined for different mix proportions and best was used. Mechanical properties were investigated for concrete which was made with the artificial aggregates. Results are compared with those of traditional aggregates. The alkali activation of fly ash is a particular procedure by which the powder is mixed with certain alkali activators (alkaline solution) and then the mixture is cured under a certain temperature to make solid materials. In spite of these advantages of alkali activated fly ash, the utilization of these materials has been limited so far. In general alkali activated fly ash needs high temperature curing to help the activation due to its low activates at low temperature. For the purpose of evaluating the ability of fly ash aggregates durability studies were done. So that effective usage, limitations of concrete made of these aggregates were determined.

MATERIALS

Fly ash

Fly ash is a by product of coal based industry. Fly ash can be used as a mineral admixture, filler, synthetic aggregate. According to ASTM-C 618 fly ash is classified as two types

I. Class F Fly ash
II. Class C Fly ash

Class F fly ash also called as Low Calcium fly ash.

Table.1 Chemical and physical characteristics of class F fly ash

PARAMETERS	Class F Fly ash
SiO_2	55.0
Al_2O_3	26.0
Fe_2O_3	7.0
CaO	9.0
MgO	2.0
SO_3	1.0
Fineness, m^2/kg	300
Bulk Density, kg/m^3	900
Specific Gravity, g/cm^3	2.3

Alkaline activators

It consists of sodium hydroxide (NaOH) 12 molarities, Sodium silicate (Na_2SiO_3) to react with fly ash to form geopolymer mortar.

Cement

Cement is the main material used as binder in concrete. OPC 53 grade was used to mate concrete.

Table.2 Chemical and physical characteristics of ordinary Portland cement.

PARAMETERS	OPC
SiO_2	20.0
Al_2O_3	5.0
Fe_2O_3	3.0
CaO	65.0
MgO	1.1
SO_3	2.4
Na_2O	0.2
K_2O	0.9
Fineness, m^2/kg	340
Loss on Ignition, %	1.0
Bulk Density, kg/m^3	1400
Specific Gravity, g/cm^3	3.1

Fine aggregates

M sand was used as fine aggregate

Table.3 Physical characteristics of M sand.

Property	Result
Specific gravity	2.64
Moisture content	2%
Water content	1.9%

Coarse aggregates

Alkali activated fly ash aggregates are used as coarse aggregates which is 100% replacement of natural coarse aggregates.

METHODOLOGY

In phase 1, to preparation of alkali activated fly ash aggregates, Preparation of alkaline solution with sodium hydroxide and sodium silicate. Mixing fly ash with alkaline solution into mortar. Breaking dried mortar into aggregates. Tests on aggregates are done.

In phase 2, Preparation mix proportion. Replacing coarse aggregates with alkali activated aggregates. Casting and curing of specimens. Durability Tests on specimens.

Making of aggregates

Fly ash is mixed with alkaline activators at a ratio of 12% NaOH, 25% Na_2SiO_3, and 5% water and fly ash past is made. Fly ash paste is casted in 100X100X100 mm^3 steel moulds. During casting, all of the specimens were compacted by Tamping and vibration.

During the first 24 h, the specimens were left in the moulds. Specimen were granulated into aggregates of required size after 7 days from casting and oven dried for 6 hrs at 60ºC and collected.

The specific gravity, sieve analysis, water absorption, shape test (elongation and flakiness index) impact test were done on aggregates prepared.

Fig 1 Fly ash alkali activated aggregates.

Making of concrete

As per IS: 10262-2009 concrete mix proportion guidelines, M30 grade concrete is made by mixing cement, fine aggregate, coarse aggregate (alkali activated fly ash aggregates) in the ratio 1:2.7:2.3. Here conventional aggregates are completely replaced by fly ash aggregates. Ratio taken was 1:2.7:2.3.

As per IS: 516-1959 method of test for strength of concrete.

- Compressive test
- Split tensile test and

- flexure test

Compressive test of concrete cube test provide an idea about all characteristic of concrete. compressive strength of concrete is effected by factors like water cement ratio, cement strength, quality of concrete materials, quality control production of concrete. Strength at various ages at 7days-65%, 14 days-95% and 28 days-99%.

Split tensile strength. This test is done to determine the tensile strength of concrete. Concrete is brittle in nature so it is very week in tension. Resistance of direct tension is not expected in concrete. Cracks were developed in concrete when it was subjected to tensile force.

The flexure represents highest stress that experienced within the material at the time of yielding moment; it is to determine flexure strength of concrete.

RESULTS

Tests on fly ash aggregates

Oven dried fly ash aggregates have better properties than normal fly ash aggregates.

Table 4 Tests on aggregates

Test	7 days +oven dried
Water absorption	6.4%
Specific gravity	1.6
Impact Test	37

TEST ON CONCRETE

Compressive strength

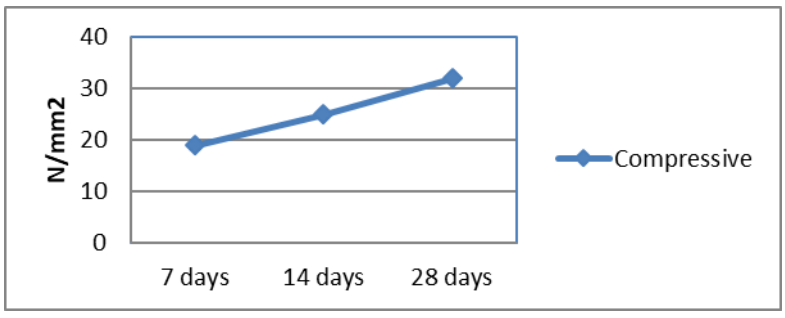

Fig 2 Compressive strength.

Acid Attack

To carry the acid attack in the present investigation immersion techniques is adopted.

After casting and curing, specimens are immersed in H_2SO_4 solution. The concentration of sulphuric acid solution is 2%. The evaluation is conducted after 28, 56, 90 and 180 days from the date of immersion. The weight of concrete is decreased. The weight of specimen before and after immersion is shown. The compressive strength of concrete immersed in H_2So_4 is tested.

Split tensile & Flexure test

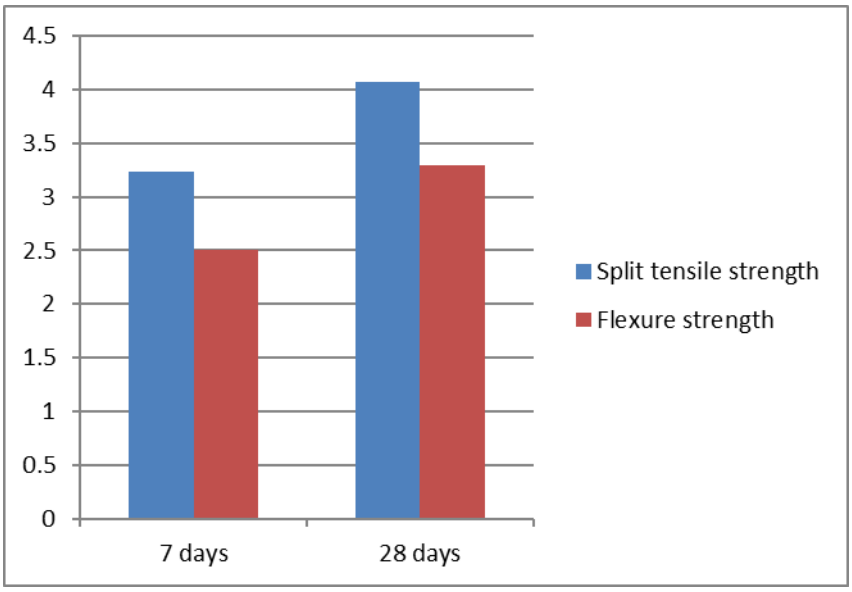

Fig 3 Split tensile & Flexure test.

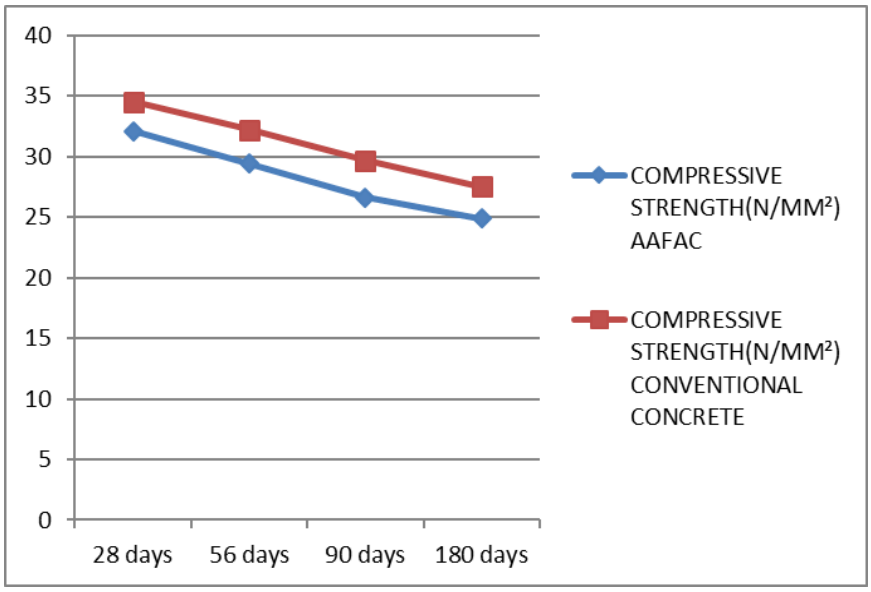

Fig 4 Acid Attack compressive strength test.

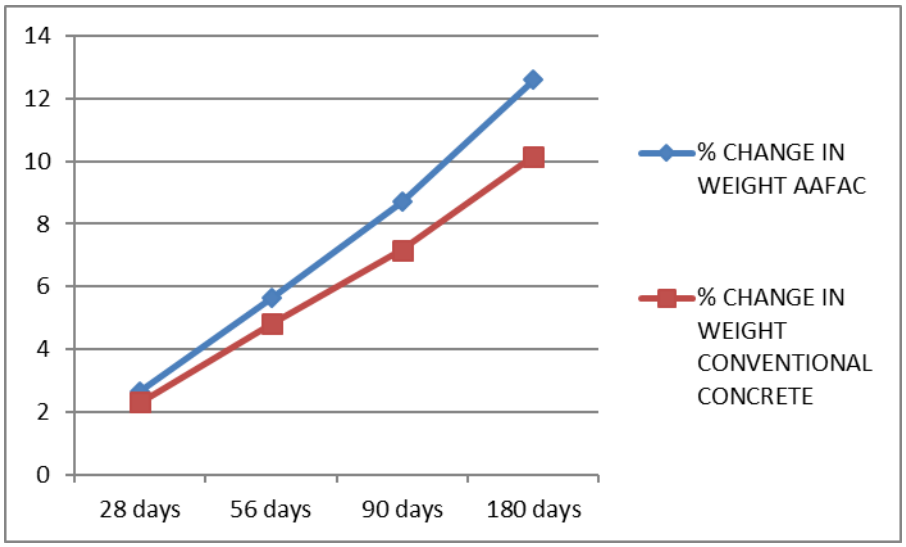

Fig 5 Acid Attack % change in weight.

Chloride attack

After casting and curing, specimens are immersed in NaCl solution. The evaluation is done after 28, 56, 90 and 180 days from the date of immersion. The weight of concrete decreased when the days increased. The weight of specimen before and after immersion is shown

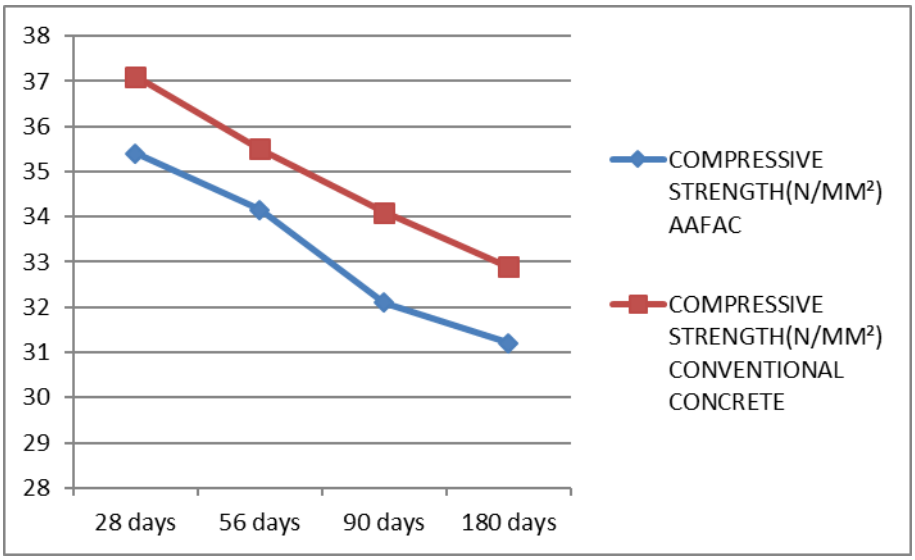

Fig 6 Chloride attack compressive strength test.

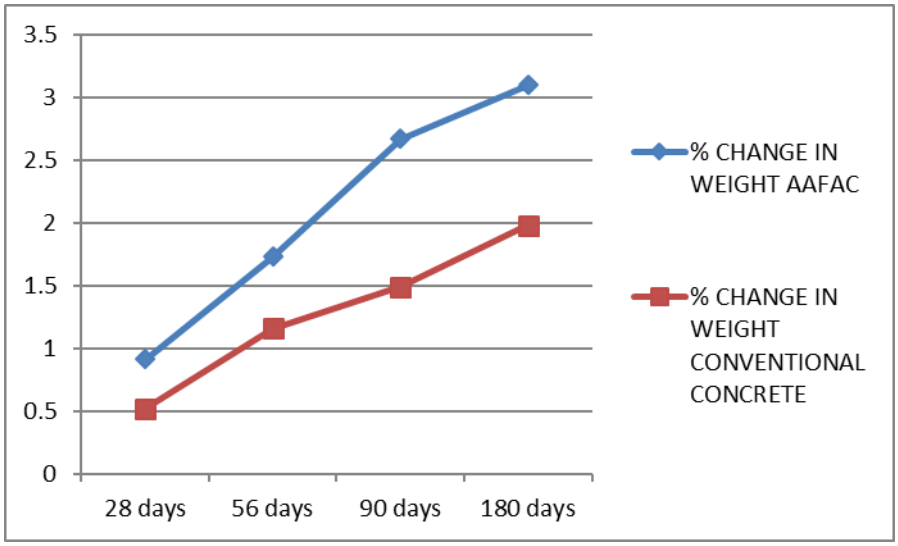

Fig 7 Chloride attack % change in weight.

Sulphate Attack

The sulphate is present in the soil in many forms such as calcium, sodium, potassium and magnesium

The sulphate attack is a common occurrence in natural and industrial situations. Sodium sulphate salt of 99% purity is taken as 5%. The compressive strength of concrete immersed in Na_2SO_4 is tested.

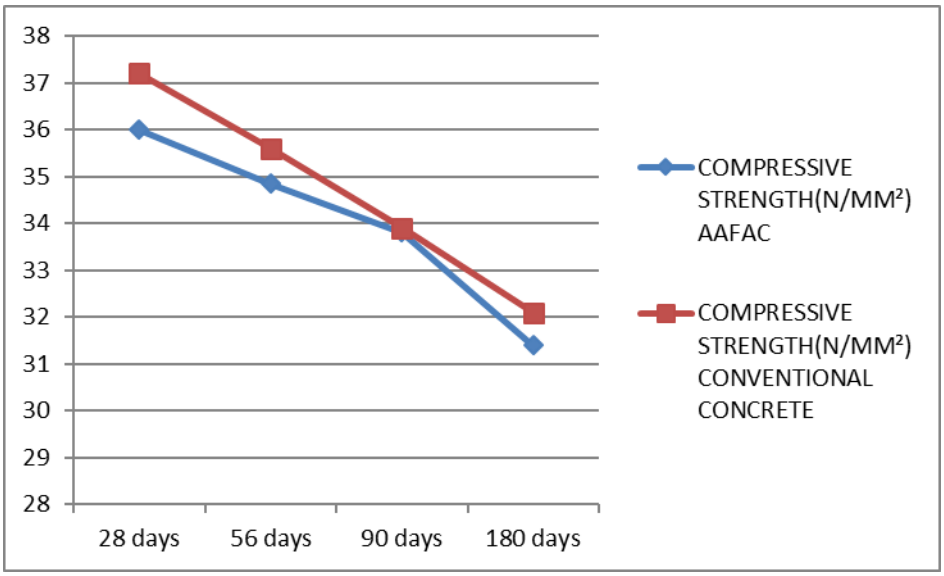

Fig 8 Sulphate attack compressive strength test.

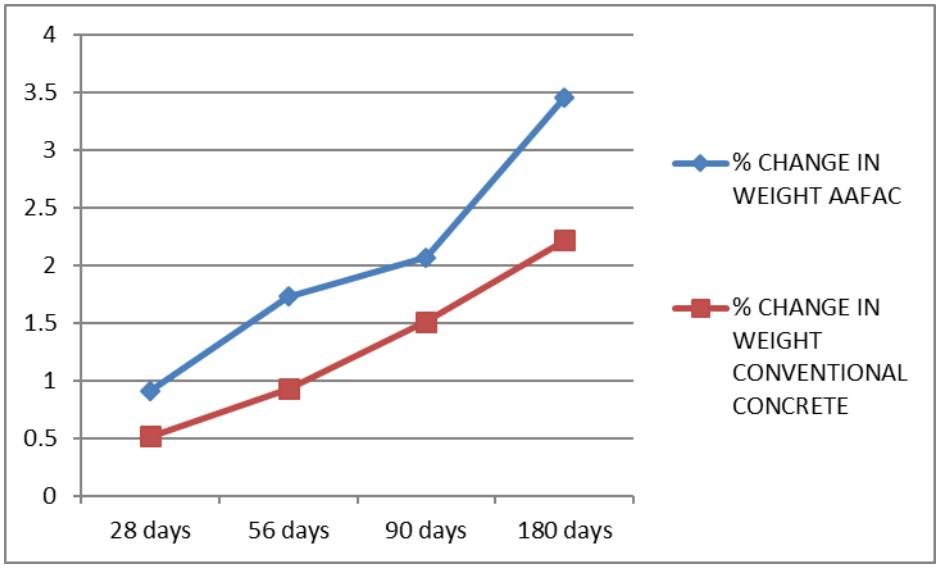

Fig 9 Sulphate attack % change in weight.

Sorptivity Test

The sorptivity test was the measure of the capillary force exerted by the concrete pore structure which causes the fluids to be drawn inside the body of the concrete. Concrete is sliced into 100mm dia x 50 mm thick samples using cutter. Specimens were waxed on all sides and the initial mass of the specimen was taken. The specimen was immersed in water at a depth of 2 to 5 mm. The quantity of water absorbed in time period of 30 minutes was measured by weighting the specimen on a top pan balance weighting up to 0.1 mg. surface water on the specimen was wiped off with a dampened tissue and each weighting operation was completed within 30 seconds.

Fig 10 water sorptivity samples.

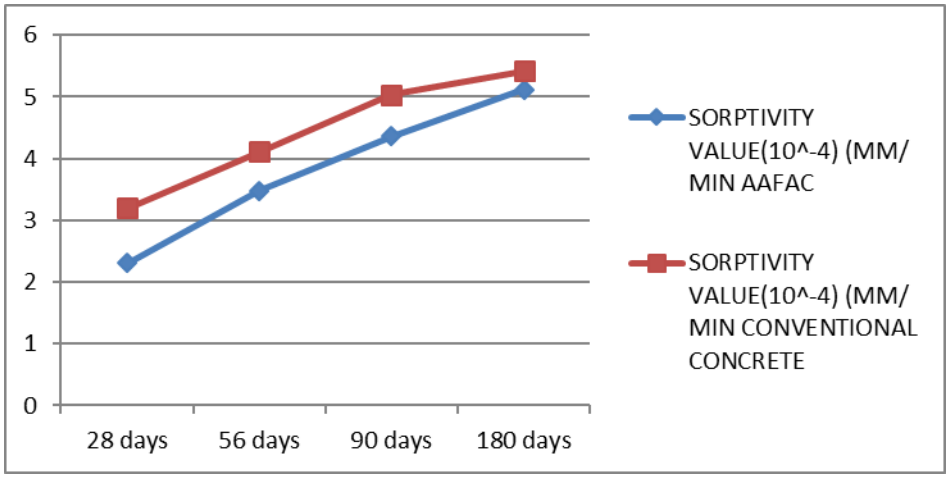

Fig 11 Water sorptivity test.

Rapid Chloride Penetration Test

In Rapid Chloride Penetration Test, the charge passed is a measure of the electrical conductance of the concrete during the period of the test, about 6 hr was recorded. In RCPT test, two cells will be there and one connected to the cathode terminal filled with 3% Nacl and the other is filled with 0.3N NaOH connected to the anode. The readings are recorded for 6 hours with 15min interval and a potential of 60V direct current is applied between the opposite sides of the concrete.

Fig 9 Rcpt apparatus.

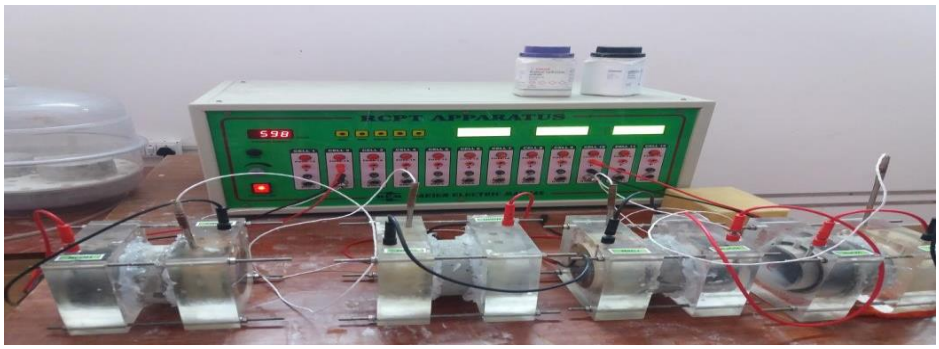

Table 5 Chloride ion penetrability based on charge passed.

CHARGE PASSED (COULOMBS)	CHLORIDE ION PENETRABILITY
>4000	High
2000–4000	Moderate
1000–2000	Low
100–1000	Very low
<100	Negligible

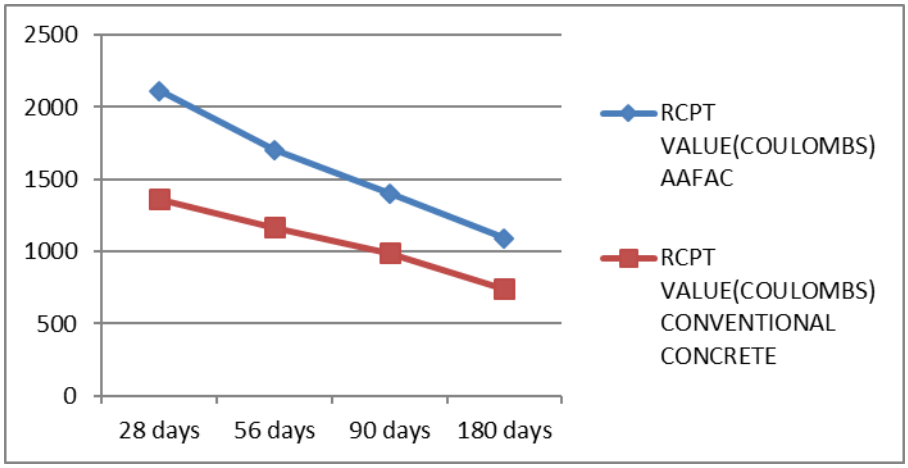

Fig 12 Rcpt Test

CONCLUDING REMARKS

Fly ash is mixed with alkaline activators at a ratio of 12% NaOH, 25% Na_2SiO_3, and 5% water is posse's high strength.

Specific gravity of alkali activated aggregates is 1.66, which is less than natural aggregates.

Weight of concrete was reduced by 13% which leads to decrease of dead load.

Concrete is exhibiting more resistance towards sulphate than other chemicals.

Rate of decrease of compressive strength of concrete is increasing with no of days when immersion in acid.

Concrete is offering nice resistance to chloride penetration Alkali activated fly ash aggregates concrete can also give good strength compared to conventional concrete.

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