Durability of Concrete with Binder by Partial Replacement of OPC with Fly Ash and Bentonite

P. L. K. Sowjanya, V. Ranga Rao

Abstract: ***Bentonite can also be used as low-cost construction material which can reduce energy consumption by blending with OPC up to certain percentage and can store natural resources and also can give solution for environmental problems which have cement production as well as which affects the durability and life cycle of the concrete structures. Fly ash contains very minute particles which can make the concrete highly dense, reduce the permeability of concrete, and also adds greater strength to structures and generates low heat of hydration. By partial replacement of OPC with bentonite and fly ash can reduce greenhouse effect and improves the durability of the concrete. In this paper, OPC is partial replaced with bentonite and fly ash with same proportions of 5%,10%'15%,20% and its compressive strength of concrete is studied by testing 81 cubes and the results were compared with that of controlled concrete. Durability of concrete with partial replacement of bentonite and fly ash with OPC were also studied by testing 108 specimens through RCPT equipment (rapid chloride penetration test) and the results were compared with that of OPC concrete.***

Index terms: Bentonite, Compression strength, Durability, fly ash

I. INTRODUCTION

The today's world is emerging lot of challenges to protect the environment because of release of the greenhouse gasses, sudden changes in the temperature due to the global warming and non the less is the construction field. Based on the following the construction field has the utmost importance to safeguard the entire world form the environmental damages. Because now-a-days the world is in the developing stage with lots of the infrastructure and new technology some of them are high rise buildings, bridges, dams, monuments, sky scrapers etc. with new innovative and technical ideas. In the present situation was literally going in the wrong direction by the high usage of the cement in the field of the construction.

Cement manufacturing process produces the lots of co2 and addition to that it will make the damage to the atmosphere and the surroundings. If the one ton of the cement is produced from the manufacturing plant it produces the one ton of the carbon dioxide [1].

This mainly takes the aspect of high usage of the cement in the field of the construction as the binding material. So, there is need to arrest the problem of high usage and effective usage of the natural binding materials which are eco-friendly in the aspect [2].

Revised Manuscript Received on April 09, 2019.

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These problems can be attained by using low-cost natural pozzolanic materials where it gives beneficial properties of concrete such as low heat of hydration, high ultimate strength, low permeability, high sulphate resistant and low alkali-silica activity [3].

This paper discusses the usage of the bentonite & fly ash which are natural pozzolanic materials and eco-friendly as the binders. These materials are partially replaced with the cement so that was minimizing the usage of the cement. Bentonite and fly ash exhibit same properties related to that of the cement not that in the damaging way. Bentonite is the earth material which is naturally obtained mineral in the form of the clay. The main reason for this is the presence of 85% clay mineral montmorillonite. Its presence and usage were first discovered by Fort Bento. This can be used as the binding material because it exhibits excellent plasticity and lubricity. The several researches have been going on these composite materials as the supplementary mineral admixtures and record the possible outcomes [4]. They are two types of bentonite named swelling and non-swelling. Sodium bentonite will absorb and swells in the presence of water calcium bentonite do not expand [4]. Bentonite is vastly used for many applications. sodium bentonite is used for drilling mud or for oil and gas Wells for sealing subsurface disposal systems and in preventing metal pollutant from entering groundwater. Calcium bentonite was used as an agent that cleans the intestinal tract, therefore, The motor and concrete properties will change according to type of bentonite used [5].

In addition to this fly ash is also used which is the industrial by product form the thermal power plant. It is obtained from the burning of the coal so it can also call as the pulverized fuel ash [6]. fly ash becomes denser, stronger and more durable in long term when compared it with to Portland cement concrete mixture. Particles of fly ash are spherical tiny glass boards & particles of Portland cement are solid angular particles [7]. It also improves the concrete workability and lowering the water content. fly ash has a lower heat of hydration, it is economical. Since the last century even though in mid of the 1900's there was a significant utilization of fly ash in concrete had started during the last 40 to 50 years, only in the United States the use of fly ash in concrete has significantly grown up with current utilization there around or more than 8 million tons per annum. This material will also become hazardous to the nature if it is not used properly [8-9]. So, these mineral

admixtures are replaced with some proportions in the place of the ordinary Portland cement, strength and durability tests were conducted and results are compared with conventional concrete.

II. OBJECTIVE

To determine the strength & durability of concrete by partial replacement of OPC with bentonite and bentonite + fly ash against chloride ion penetration.

III. METHODOLOGY

A. Materials

The material used in this work is cement, bentonite and Fly ash. Cement used is53 Grade, specific gravity of cement is 3.35, specific gravity of fine aggregate is 2.68, coarse aggregate is 2.58, Bentonite is 2.73 and fly ash is 2.13.The physical and chemical properties of bentonite and fly ash are given in Table I- IV and Figure 1 shows bentonite used for this study.

Figure 1: Bentonite used.

Table I: Physical properties of bentonite are mentioned

Color	Light yellow
Size	70 micron
Swell	60%
Nature	Pozzolanic

Table II: Chemical properties of bentonite are mentioned below

S. No	Chemicals Properties	Test Results
1	Al_2o_3	21.118
2	$Si0_2$	49.634
3	Fe_2o_3	3.235
4	TiO_2	0.498
5	Na_2o	0.449
6	Cao	0.65
7	MgO	3.591
8	K_2o	2.091

Figure 2: Fly ash used

Table III: Physical properties of fly ash are mentioned below

Specific Gravity	2.07
Fineness	290
Bulk Density, Kg/m^3	1100-1200
Color	Light Grey

Table IV: Chemical properties (%) of Fly ash are mentioned below

pH	10.27
Cao	12.34
SiO_2	72.08
Al_2O_3	5.15
Fe_2O_3	0.57
MgO	4.04
Loss of Ignition	0.76

B. Mix proportion

Mix proportion is calculated for obtaining cement, fine aggregate and coarse aggregate based on the code IS 10262: 2009 to achieve a compressive strength of M20 grade. The aggregate size is 10 mm and 20 mm, water content is 187 kg/m^3, water cement ratio 0.55.

C. Mix design details

With the help of standard procedure code IS 10262:2009 guidelines mix design is prepared. For 1m^3 the quantities are determined for all the mixes shown in below Table V.

Table V: Mix Design details

MIX	cement	Bentonite	Fly Ash	F.A	C.A		Water (lit)
					10mm	20mm	
CM	300	0	0	895.3	547.5	547.5	165
5BC	285	15	0	894.3	546.9	546.9	165
10BC	270	30	0	891.6	545.2	545.2	165
15BC	255	45	0	894	546.7	546.7	165
20BC	240	60	0	892.7	546.9	546.9	165
5FBC	270	15	15	893.9	545.6	545.6	165
10FBC	24	30	30	892.9	547	547	165
15FBC	210	45	45	892.1	545.5	545.5	165
20FBC	180	60	60	891.5	545.2	545.2	165

According to ASTM standard 150 mm by 150 mm cube were cast for the following mix proportions. For control mix water cement ratio (w/c) of 0.55 is considered, even for other remaining samples the water to Binder (Cement + Bentonite) & (Cement + bentonite + fly ash) water cement (w/c) is also kept constant as 0.55. For this research, 9 different mix proportions were calculated. These include control mix which is calculated without any replacement of Binder (Bentonite) & (bentonite + fly ash) and the remaining 8 mixes were calculated with different proportion of bentonite and fly ash as replacement of cement in concrete. Ordinary Portland cement (OPC) is partial replacement with bentonite of following proportions 0%, 5%, 10%, 15%, 20%& for fly ash of same proportions 0%, 5%, 10%, 15%, 20%, Each proportion has 9 Specimens the concrete cubes was tested for their compression test at the age of 7, 28 & 90 days according to ASTM C109. For 7- & 28-days curing H_2O solution is used and for 90 days NaCl solution is used after curing and its compressive strength of concrete was studied by testing 81 cubes and results were compared with that of controlled concrete.

Published By:
Blue Eyes Intelligence Engineering
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Durability of concrete with partially replaced of bentonite and fly ash with OPC same proportion 0%, 5%, 10%, 15% and 20% each proportion has 12 specimens, Total 108 specimens through RCPT (Rapid chloride preparation test) equipment and the results were compared with OPC concrete.

D. Rapid Chloride Penetration Test

The test equipment is shown in Figure 3. A test method involves obtaining a 100mm dia core and 50mm height of the cylinder sample is being tested. The sides of the cylindrical sample are coated with epoxy. The sample is dried and then dipped in a vacuum chamber for 180 min. The sample needs to be vacuum saturated for 60min and should be allowed to soak for 18 hours it is then inserted in the test device. The left-hand side has a negative (-ve) ion with 3% of NACL solution and the right-hand side has positive (+ve) ion with 0.3 NAOH solution &device is then connected, A 60-volt current is continuously applied for 6 hours. Readings should be noted for every half an hour. At the end the sample is removed from the cell and coulomb passed through the samples is calculated. Figure 3 shows Rapid chloride penetration test equipment.

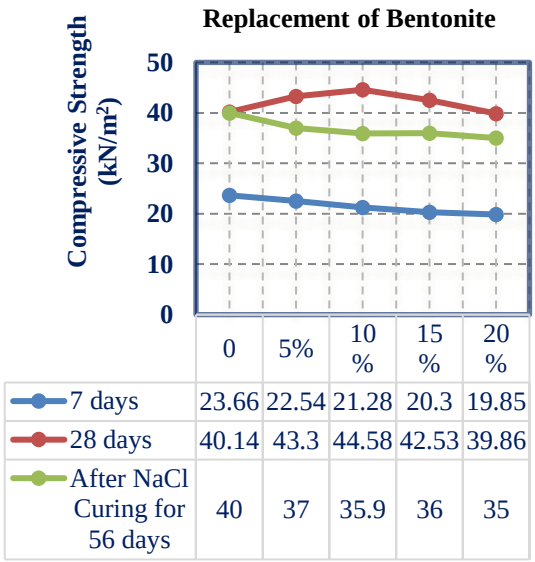
Figure 3: Rapid chloride penetration test equipment

According to AASHTO T277- Test method for rapid chloride permeability of concrete. ASTMC 1202- Test method for Electric ion indication of concrete which has ability to resist chloride Ion penetration. This test was developed in a Federal Highway administration FHWA research program. This is developed for non-destructive measure of chloride penetration of concrete was measured by a ponding test this test takes 90 days or longer and involve samples of the concrete at various depths to determine the chloride profile chloride ion penetration in concrete is also high in water cement ratio, where concrete is a slow process for a test method which accelerate chloride ion penetration when electric current was applied to specimen. It is then increased and accelerated the ratio, when the chloride ion penetration is induced into concrete.

IV. RESULTS AND DISCUSSIONS

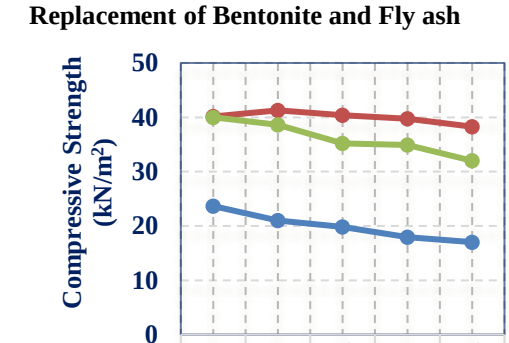
A. Compression Test

Compression test results show below Figures 4 & 5shows the results of Compression Test.



	0	5%	10 %	15 %	20 %
7 days	23.66	22.54	21.28	20.3	19.85
28 days	40.14	43.3	44.58	42.53	39.86
After NaCl Curing for 56 days	40	37	35.9	36	35

Fig. 4: Compression Test result for replacement of Bentonite for 7, 28 and 90 days



	0	5%	10 %	15 %	20 %
7 days	23.66	21.03	19.83	17.92	17.03
28 days	40.14	41.28	40.38	39.76	38.28
After NaCl Curing for 56 days	40	38.6	35.2	34.9	32

Fig. 5: Compression Test result for replacement of Bentonite and Fly ash 7, 28 and 90 days

B. Rapid Chloride Penetration Test

Below Figures 6 & 7 shows the results of RCPT.

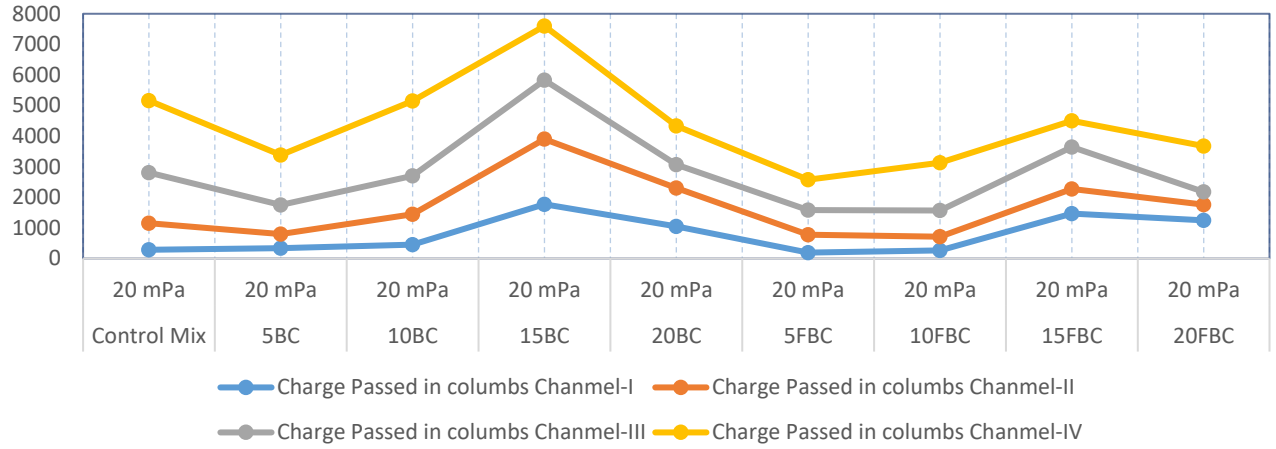


Fig. 6: Test result for replacement of Bentonite &Fly ash for 7 days

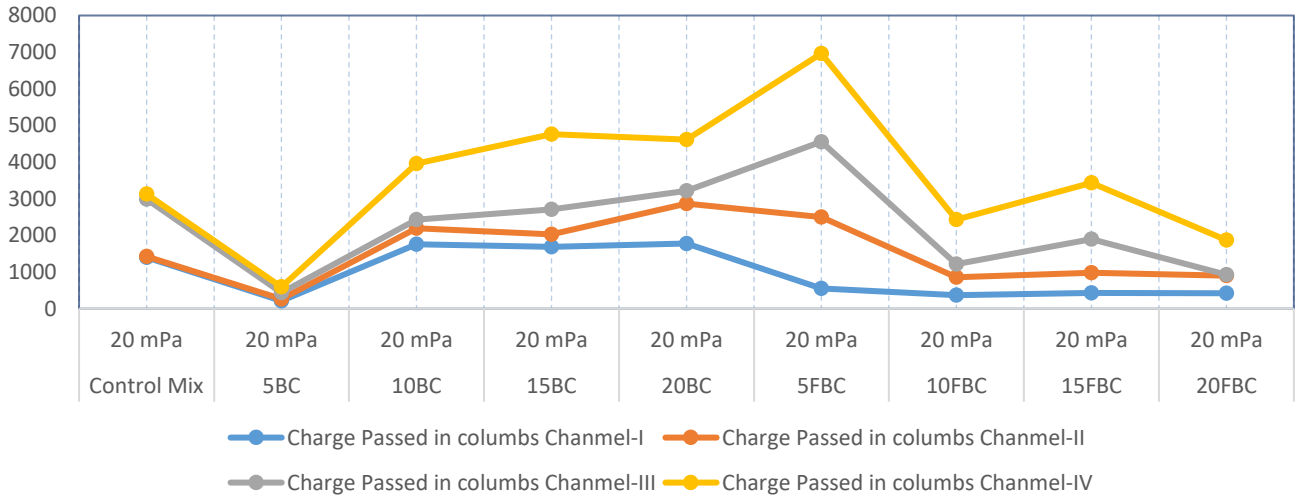


Fig. 7: Test result for replacement of Bentonite &Fly ash for 28 days

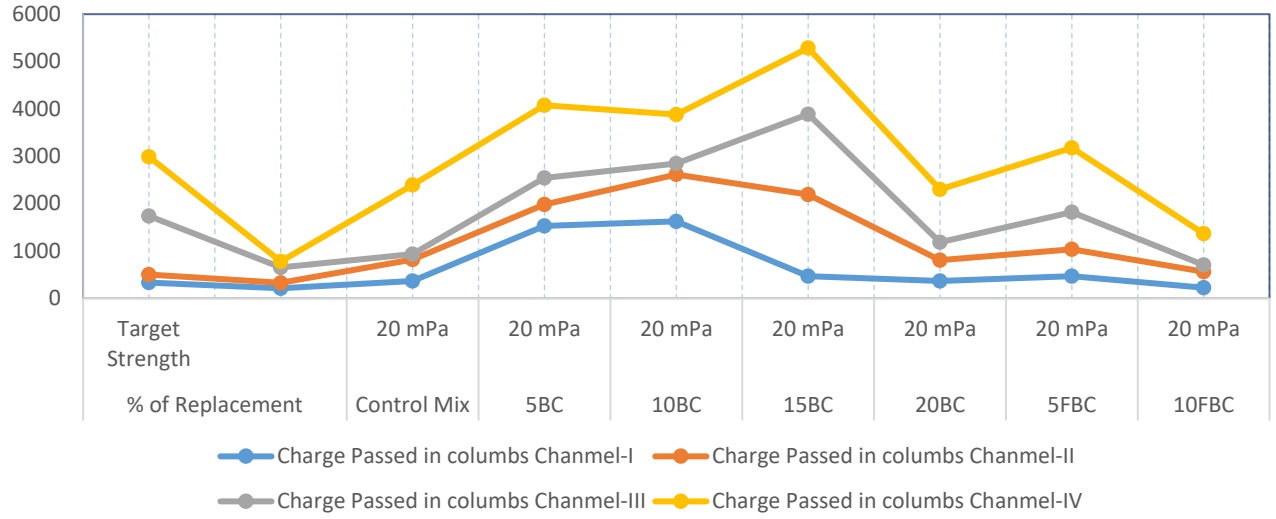


Fig. 8: Test result for replacement of Bentonite &Fly ash for 90 days

V. CONCLUSION

Since availability of fly ash and bentonite was cheaper than OPC research work is carried on these materials. However, these are ecofriendly.5BC and 10BC shows approximately compressive strength equal to control mix for 7, 28 and 90 days for bentonite replacement. 5FBC shows approximately compressive strength equal to control mix for 7, 28 and 90 days for bentonite and fly ash replacement.15BC and 5FBC shows high resistance to chloride attack when compared to OPC at 7 days,28 days and 90 days..

REFERENCES

1. S. A. Memon, R. Arsalan, S. Khan, and T. Y. Lo, "Utilization of Pakistani bentonite as partial replacement of cement in concrete," *Constr. Build. Mater.*, vol. 30, pp. 237–242, 2012.
2. M. Karthikeyan, P. Raja Ramachandran, A. Nandhini, and R. Vinodha, "Application on partial substitute of cement by bentonite in concrete," *Int. J. ChemTech Res.*, vol. 8, no. 11, pp. 384–388, 2015.
3. J. Mirza, M. Riaz, A. Naseer, F. Rehman, A. N. Khan, and Q. Ali, "Pakistani bentonite in mortars and concrete as low-cost construction material," *Appl. Clay Sci.*, vol. 45, no. 4, pp. 220–226, 2009.
4. I. Security, "Yearbook 2013," *Sipri*, vol. 2013, no. 0712, pp. 1–18, 2013.
5. Ahmad, Saeed &Barbhuiya, S.A. & Elahi, Ayub& Iqbal, J. (2011). Effect of Pakistani bentonite on properties of mortar and concrete. Clay Minerals. 46. 10.1180/claymin.2011.046.1.85.
6. Reddy G, V Ranga Rao, and M Achyutha Kumar Reddy, "Experimental investigation of strength parameters of cement and concrete by partial replacement of cement with Indian calcium bentonite," *Int. J. Civ. Eng. Technol.*, vol. 8, no. 1, 2017.
7. B. P. Kumar, V Ranga Rao, and M Achyutha Kumar Reddy, "Effect on strength properties of concrete by partial replacement of cement with calcium bentonite and fly ash," *Int. J. Civ. Eng. Technol.*, vol. 8, no. 4, 2017.
8. S. K Sreeniva, S. K. P Praneeth, K. R. M AchyuthA, and R. V Ranga, "A Study on Durability of Concrete by Partial Replacement of Cement with Bentonite A Study on Durability of Concrete by Partial Replacement of," *Int. Chem Tech Res.*, vol. 10, no. 6, pp. 898–904, 2017.
9. O. K. Swarup, P. V. R. Reddy, M. Achyutha, K. Reddy, and V. R. Rao, "A Study on Durability of Concrete by Partial Replacement of Cement with Bentonite and Fly Ash," *Int. Chemtech Res.*, vol. 10, no. 7, pp. 855–861, 2017.

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