IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

EFFECT ON STRENGTH PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH CALCIUM BENTONITE CLAY

[1]Somu S Krishna, [2]K Kalyan Kumar, [3] Bojja BK Sharath Kumar, [4] Prof. B. Jayarami Reddy

[1]Academic Consultant, [2]Academic Consultant, [3]Structural Engineer, [4]Professor

[1]Department of Civil Engineering,

[1]YSR Engineering College of Yogi Vemana University, Proddatur, Andhra Pradesh, India.

Abstract: The production of cement involves a lot of raw material and processing, which increases the cost of production. An enormous amount of wastage is produced from cement manufacturing industries which results in dwindling of natural resources. This leads to emission of greenhouse gases, majorly CO_2. To overcome this, the concept of partial replacement of cement with mineral admixtures in concrete is introduced. In this paper, bentonite clay is used as a partial replacement (5%,10%,15%) of Ordinary Portland Cement (OPC) in concrete and several tests were conducted like workability of concrete, compressive strength, split tensile strength and flexural strength and the results were discussed in this paper.

***Index Terms* – Bentonite Clay, Concrete, partial replacement, compressive strength, split tensile, flexural strength**

I. Introduction

In construction of buildings, concrete plays a major and important role which comprise cement, fine aggregate and coarse aggregate. Using water, cement acts as binding material and provides a strong bond between aggregates. These days, the demand as well as cost of cement escalates due to urban sprawl. To meet the demand, the production of cement is also increasing. With this, CO_2 produced form the industries which is about 7% of the total from industries causes desecration of environment. As a Civil engineer, to reduce the cost of construction as well as damage to environment, bentonite clay is partially replaced to cement. Cost of bentonite clay is less when contrasted with Ordinary Portland Cement and it is eco-friendly. Bentonite is traditionally used as lubricant while driving piles in footings.

In this project, as a partial replacement of cement, bentonite clay is introduced with different percentages like 5%, 10%, 15%. Basic tests for materials like, soundness, specific gravity, initial setting time, final setting time, normal consistency of cement, fineness modulus and water absorption tests were conducted for cement and aggregates. With the introduction of bentonite clay in different percentages (5%,10%,15%) as partial replacement of cement, tests like compressive strength, flexural strength and split tensile tests were conducted for cubes, cylinders and beams with M50 as mix design and 0.323 as water-cement ratio. After placing them in curing tank, the strength results were taken at 7, 14, 28 days.

II. Literature Review

V. Ranga Rao and M. Achyuth Kumar Reddy (2019) studied the effect of fly ash and bentonite as a partial replacement of OPC. It is proposed that the cement is replaced with Calcium bentonite and fly ash in equal proportions (5%, 7.5%, 10%, 12.5%, 15%) respectively and examine the impact of these materials. Various developing countries are changing the materials with the substances which can be recycled in order to reduce the environmental dangers and conserving natural sources. M30 grade cubes and cylinders have been casted and compressive strength and split tensile strength test results have been studied for 3, 7, 28 days and is compared with conventional concrete. The numerous strengths were diagnosed.

Shilpa P V and Mrs.Saritha Sasindran (2018) studied the need of alteration of cement by some natural minerals having pozzolanic properties to resist acid attacks. Calcium bentonite powder which is available abundant in nature having pozzolanic properties is used as replacement. Steel slag is used as a replacement of aggregate in concrete in order to reduce cost of industrial processing. They studied the physical properties and strength of concrete by partially replacing cement with Calcium bentonite in different percentages (0% to 20%) and fine aggregate with 40% of steel slag. Various tests were conducted for concrete like workability, tensile strength, compressive strength, flexural strength and non-destructive test like Ultra Sonic Pulse Velocity, acid attack test. The ideal percentage of replacement of bentonite clay and steel slag for better strength and workability of concrete was determined and results showed and an improvement in the properties of concrete.

M. Karthikeyan and P. Raja Ramchandran (2015) investigated bentonite as a partial replacement of OPC in concrete and compressive strength was determined. The compressive strength results showed that mixture of bentonite in concrete is poor in early stages and performed better in later stages when compared with conventional concrete. For a mix design of M25, variable proportion of bentonite (0, 25, 30 and 35% by weight of cement) is replaced with cement and compressive strength test, flexural strength test and split tensile tests were conducted at 28 days of curing.

O. Krishna Swaroop and P.V.Ravindra Reddy (2017) discussed about the effects of durability of concrete when the Ordinary Portland Cement (OPC) in it is partially supplanted with fly ash and bentonite in equal proportions. The supplanted percentages are 10%, 15%, 20%, 25% and 30 % for the weight of cement. For durability studies, Sulphuric acid (H_2SO_4) and Sodium Hydroxide (NaOH) of 10 molarity with 2% is used in this study. Compressive strength test is conducted after 28 days of curing. After 30 days of Sulphuric acid (H_2SO_4) and Sodium Hydroxide (NaOH) attacks, durability tests were carried out. Compressive strength results were found to be lower after 28 days of curing and higher after the durability attacks.

Amritha E.k and Neethu Paul (2016) investigated about the properties of concrete when it is partially replaced with bentonite and bentonite with steel fibre instead of Ordinary Portland Cement by weight for a mix design of M30 grade of concrete. After partial replacement of bentonite in different percentages with cement, tests like Workability, compressive strength test, flexural strength and split tensile strength were conducted. Further, same tests were conducted by adding hooked end steel fibre and bentonite in equal proportions which resulted in increase in the strength of concrete.

M. Aravindhraj and B.T. Sapna (2016) studies the usage of waste material in concrete. Quarry dust which is produced from waste rocks can be used as an alternative to river sand. Bentonite, which is produced from decomposition of volcanic ash has high proportions of montmorillonite which can be used in drilling, increases concrete strength and also acts as groundwater barrier. Bentonite having high plasticity, absorbs more water and has swelling characteristics. Durability tests were performed to determine the resistance offered by sulphate ions to concrete. Compressive strength test is performed by using ultrasonic pulse velocity.

R. Silvaraj and R. Priyanka (2015) discussed about the problems involved in manufacturing of cement like release of greenhouse gases which results in global warming. The concept of mixing of mineral admixtures is introduced in this paper. Bentonite which is cheaper compared to fly ash, silica fume etc., is replaced with varied percentages of Ordinary Portland cement (OPC) and Portland Pozzalano cement (PPC). The compressive strength tests were carried out and it is found that, at 15% replacement of OPC with bentonite and 12.5 % replacement of PPC with bentonite is found to be optimum

III. METHODOLOGY

All the materials were collected from the nearest available sources and various tests were conducted for the materials. Based on the results obtained, water-cement ratio and volume of concrete required for casting of cubes, cylinders and beams is derived for M50 mix design. Volume of Calcium bentonite to be replaced with cement is also calculated. After casting, they were cured with water in submerged condition. Cubes, Cylinders and Beams were tested at every 7 days, 14 days and 28 days and the results were recorded.

3.1 Properties of aggregate

3.1.1 Sieve analysis of fine aggregate:

Weight of fine aggregate =1000gm

Table 1: Sieve analysis of fine aggregate

S.No	IS sieve Size	Weight Retained (gm)	% Weight Retained (gm)	Cumulative % retained (gm)	% of Passing
1	4.75 mm	188	18.8	18.8	81.2
2	2.0 mm	491	49.1	67.9	32.1
3	1.0 mm	60	6.0	73.9	26.1
4	600µ	162	16.2	90.1	9.9
5	425µ	38	3.8	93.9	6.1
6	300µ	32	3.2	97.1	2.9
7	150µ	29	2.9	100	0
8	75µ	0	0	0	0
9	Pan	0	0	0	0
	Total	1000		463.8	

3.1.2 Specific gravity of fine aggregate:

Table 2: Results of Specific gravity of fine aggregate

S.No	Description	Weight(gm)
1	Weight of empty pycnometer (W_1)	628
2	Weight of pycnometer + sand (W_2)	1178
3	Weight of pycnometer + sand + water (W_3)	1834
4	Weight of pycnometer + Water (W_4)	1491
5	Specific gravity of fine aggregate $= \frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$	2.65

3.1.3 Specific gravity of Coarse aggregate:

Table 3: Results of Specific gravity of coarse aggregate

S.No	Description	Weight(kg)
1	Weight in water (A)	1.99
2	Empty weight of basket in water (B)	0.70
3	Surface dried aggregate weight (C)	2.02
4	Oven dry aggregate weight (D)	2.014
5	Specific gravity $= \frac{D}{C-(A-B)}$	2.758

3.1.4 Aggregate crushing test

Empty weight of cylinder = 923gm

Empty weight of cylinder + Aggregate weight =3850gm

Weight of aggregate (A) = 3850 – 923

= 2927gm

Weight of crushed aggregate passed through 2.36mm sieve (B) = 360gm

Aggregate crushing value = $\frac{B}{A} \times 100$

$= \frac{360}{2927} \times 100$

= 12.29%

3.1.5 Aggregate impact test

Weight of fraction passing the 2.36mm sieve (A) = 631 gm

Weight of oven dried sample (B) = 45gm

Aggregate impact value = $\frac{B}{A} \times 100$

$= \frac{45}{360} \times 100$

= 7.13%

3.2 Properties of Cement

3.2.1 Normal consistency of cement:

Table 4: Results of Normal consistency of cement

S.No	Amount of Water	Initial reading	Final reading	Depth of Penetration
1	26	44	29	15
2	28	44	39	5
3	30	44	41	3

3.2.2 Specific gravity of cement:

Weight of cement = 60kg

Initial reading in lechartelier flask = 0

Final reading in lechartelier flask = 19.2

Specific gravity $= \frac{0.60}{19.2-0} \times 100$

= 3.125

3.2.3 Fineness of cement

Weight of cement (W_1) = 100g

Weight retained on 90 microns sieve (W_2) =5g

Fineness $= \frac{W_2}{W_1} \times 100$

$$= \frac{5}{100} \times 100$$

= 5%

3.2.4 Initial setting time:

Table 5: Results of Initial setting time

S.No	Replacement of cement with Calcium Bentonite Clay	Initial setting time
1	0%	40
2	5%	38
3	10%	35
4	15%	32

3.3 Properties of Calcium Bentonite Clay

3.3.1 Specific gravity of calcium bentonite clay:

Weight of calcium bentonite clay = 60gm

Initial reading in lechatlier flask = 0

Final reading in lechatlier flask = 23.4

Specific gravity $= \frac{0.60}{23.4} \times 100$

= 2.56

3.3.2 Soundness test:

Table 6: Soundness values

S.No	Replacement of cement with Calcium Bentonite Clay	Initial Reading	Final Reading	Differences
1	0%	13	11	2
2	5%	13	12	1
3	10%	14	15	1
4	15%	19	18	1

IV. DISCUSSION ON TEST RESULTS

Tests like Slump cone, compaction factor and Vee-bee consistometer are conducted on fresh concrete with varying percentages of calcium bentonite, with a water-cement ratio of 0.328.

4.1 Test results of Concrete

Table 7: Workability of concrete

S.No	Mix	Slump	Compaction factor	Vee-bee
1	0%	50	0.93	8sec
2	5%	30	0.90	13sec
3	10%	23	0.92	15sec
4	15%	15	0.90	18sec

4.1.1 Slump cone Test:

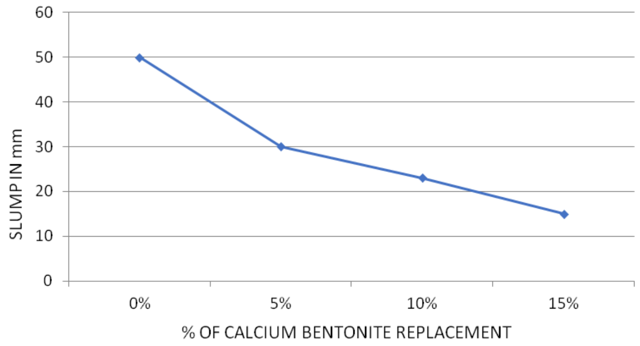

Figure 1: Slump value of concrete for different percentages of calcium bentonite clay

The above graph demonstrates the reduction of slump values with increase in % of calcium bentonite clay. The concrete with 0% calcium bentonite gives the maximum slump value.

4.1.2 Compaction Factor Test:

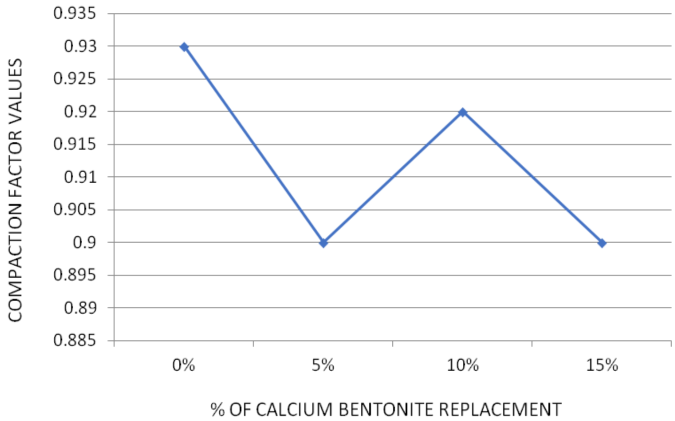

Figure 2: Compaction factor value of concrete for different percentages of calcium bentonite clay

The decrease in the compaction factor value is been observed from the above graph with an increase in percentage of calcium bentonite clay in cement.

4.1.3 Vee-Bee Consistometer Test:

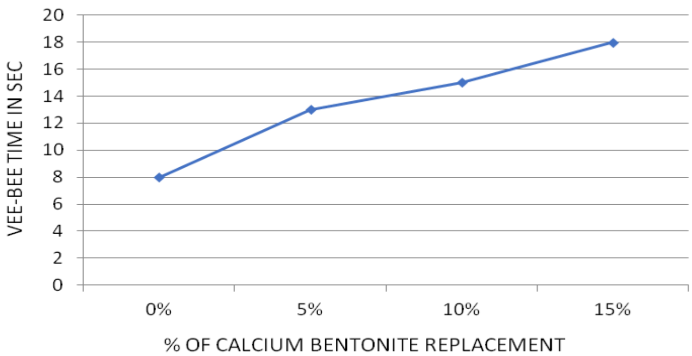

Figure 3: Vee-Bee time value of concrete for different percentages of calcium bentonite clay

The Vee-Bee time rises with increase in calcium bentonite clay in cement which shows low workability of concrete with calcium bentonite clay.

4.2 Compressive Strength test on concrete cubes:

Table 8: Results of compressive Strength test on concrete cubes

S.No	% of calcium bentonite replacement in cement	Compressive strength of cubes(N/mm^2)		
		7days	14days	28days
1	0%	36	39.2	52
2	5%	36.8	48	56
3	10%	25.9	36.4	40.1
4	15%	24.8	36.1	39.5

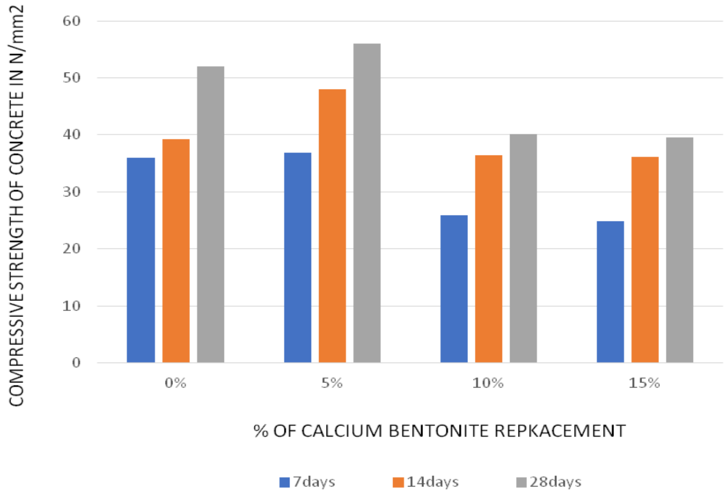

Figure 4: compressive Strength of concrete for different percentages of calcium bentonite clay

The above graph indicates an increase in compressive strength in all 7 days, 14 days and 28 days at 5% replacement of cement with calcium bentonite clay. The maximum compressive strength of concrete observed at 5% of calcium bentonite clay. And further addition of it decreases the compressive strength of concrete.

4.3 Split tensile strength test on concrete cylinder:

Table 8: Results of Split tensile strength test on concrete cylinder

S.No	% of calcium bentonite replacement in cement	Split tensile strength of cylinders (N/mm^2)		
		7days	14days	28days
1	0%	3.7	3.85	3.91
2	5%	3.8	3.96	3.97
3	10%	2.95	3.4	3.6
4	15%	2.13	2.77	2.85

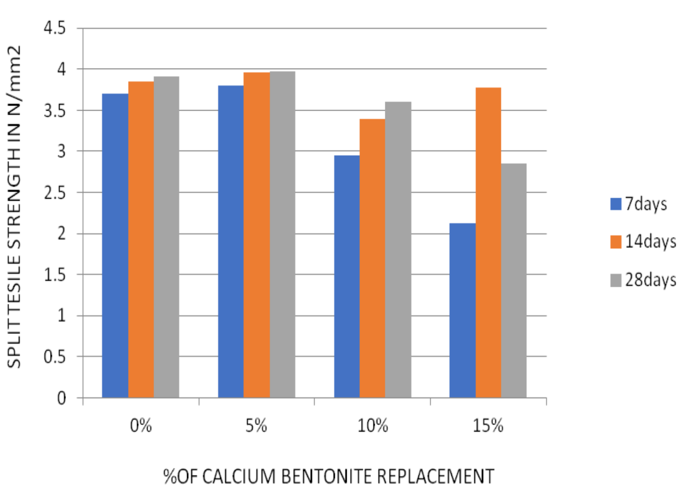

Figure 5: Split tensile strength of concrete for different percentages of calcium bentonite clay

The above graph indicates a slight increase in split tensile strength strength in all 7 days, 14 days and 28 days at 5% replacement of cement with calcium bentonite clay. And further replacement of calcium bentonite decreases the split tensile strength of concrete.

4.4 Flexural Strength test on concrete beam:

Table 9: Results of flexural strength test on concrete cylinder

S.No	% of Calcium Bentonite replacement with cement	Flexural strength in N/mm^2	
		14days	28 days
1	0%	5.6	6.2
2	5%	6.6	7.6
3	10%	5.8	6.0
4	15%	5.6	5.7

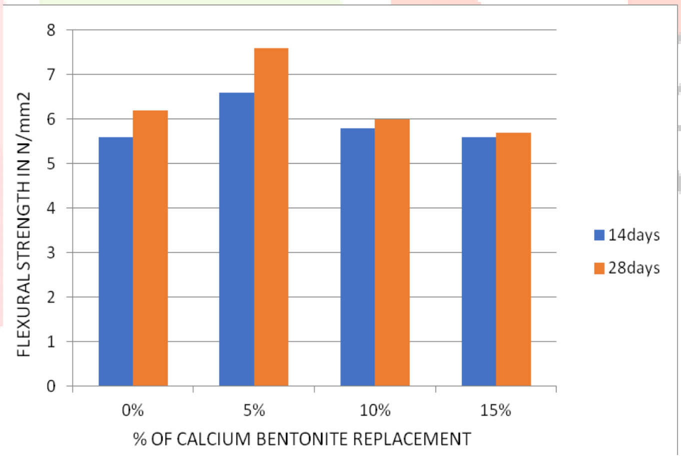

Figure 5: Flexural strength of concrete for different percentages of calcium bentonite clay

Similarly, from the above graph it is seen an increase in Flexural strength of concrete beam at 5% replacement. Further addition of calcium bentonite reduces the flexuaral strength.

From all the above tests, it is seen an increase in strength of concrete with partial replacement of cement with calcium bentonite clay at lower percentages. With this replacement, there will be a reduction in cost of project as bentonite is cheaper than cement as it is abundantly available. Due to this replacement, simultaneously the cement consumption is also reduced slightly compared to present scenario, which helps in reduction of wastage from manufacturing industries. Subsequently, the gases which are responsible for the degradation of environment released from cement manufacturing industries is also reduced.

V. CONCLUSION

- Reduces the cost of concrete when partially replaced cement with calcium bentonite.
- As the specific gravity of calcium bentonite clay is less when contrasted with cement, it helps in reduction of self-weight of concrete.
- As the water absorption capacity of calcium bentonite is more, the initial setting time as well as the workability of concrete decreased with increase in percentage of calcium bentonite in cement.
- The compressive strength of concrete when partially replaced with calcium bentonite increases upto a certain limit. Beyond which results in reduction of its strength.
- The bonding capacity with coarse aggregate increases with addition of small amount of calcium bentonite clay.
- Split tensile and flexural strength tests were carried out and found to be higher at small percentage of 5% replacement only.
- Experiential that, the calcium bentonite replacement is more effective than conventional concrete.
- With increase in water content in the concrete mixer, satisfactory results can be seen in workability with no effect on strength of concrete.

REFERENCES

[1]. Amritha E.K and Neethu Paul, "Evaluation of the Properties of Bentonite Concrete with and without Steel Fiber", International Journal of Scientific & Engineering Research, ISSN 2229-5518, Volume 7, Issue 10, October-2016.

[2]. M. Achyutha Kumar Reddy, V.Ranga Rao, "Utilization of Bentonite in Concrete: A Review", International Journal of Recent Technology and Engineering (IJRTE), ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019.

[3]. M. Karthikeyan, P. Raja Ramachandran, A. Nandhini, R. Vinodha, "Application on Partial Substitute of Cement by Bentonite in Concrete", International Journal of ChemTech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, Vol.8, No.11 pp 384-388, 2015.

[4]. M.Aravindhraj, B.T.Sapna, "Influence of Bentonite in Strength and Durability of High Performance Concrete, International Research Journal of Engineering and Technology (IRJET), e-ISSN: 2395 -0056, Volume: 03, Issue: 05, May-2016.

[5]. O.Krishna Swarup, P. V. Ravindra Reddy, M. Achyutha Kumar Reddy and V. Ranga Rao, "A Study on Durability of Concrete by Partial Replacement of Cement with Bentonite and Fly Ash", International Journal of ChemTech Research CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555, Vol.10 No.7, pp 855-861, 2017.

[6]. R.Selvaraj and R.Priyanka, "Characterisitics Study Of Bentonite Mortar With Replacement Of Cement", International Journal of Engineering Science Invention Research & Development; e-ISSN: 2349-6185, Vol. II Issue III, September 2015.

[7]. Shilpa P V, Mrs. Saritha Sasindran, "Experimental Study on Concrete by Partially Replacing Cement with Calcium BentoniteandFine Aggregate with Steel Slag", IOSR Journal of Engineering (IOSRJEN), ISSN (e): 2250-3021, ISSN (p): 2278-8719, Vol. 08, Issue 5 (May. 2018).

[8]. Sultan Tarawneh, EmhaidyGharaibeh and Falah, M., Saraireh, "Effect of using Steel Slag Aggregate on Mechanical Properties of Concrete", American Journal of Applied Sciences, Vol.11, Issue 5, 2013, pp. 700- 706.

[9]. SiowChunLim, Chandima Gomes, and MohdZainal, "Characterizing of Bentonite with Chemical, Physical and Electrical Perspectives for Improvement of Electrical Grounding Systems", International Journal of Electrochem, Vol.8, 2013, pp. 11429 – 11447.

[10]. Junaid Akbar, Bashir Alam, Muhammad Ashraf, Salman Afzal, Asfandyar Ahmad, and Khan Shahzada, "Evaluating the Effect of Bentonite on Strength and Durability of High Performance Concrete", International Journal of Advanced Structures and Geotechnical Engineering ISSN 2319-5347, Vol.02, No.01, January 2013.

[11]. XiaoluGuo, and Huisheng Shi, "Utilization of Steel Slag Powder as a Combined Admixture with Ground Granulated Blast-Furnace Slag in Cement Based Materials", ASCE Journal of Materials in Civil Engineering, Vol.25, Issue 12, December 2013.

[12]. Subathra Devia, V., and Gnanavel, B.K., "Properties of Concrete Manufactured using Steel Slag", ScienceDirect; Procedia Engineering, Vol.97, 2014, pp. 95 – 104.