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INCORPORATING BENTONITE PARTIALLY IN PLACE OF CEMENT-AN ASSESSMENT OF STRENGTH AND DURABILITY PROPERTIES

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ABSTRACT

The Production of cement exposes 7% of CO2 in the atmosphere, which is one of the reasons of Global Warming. Bentonite, a product of volcanic ash is a rich source of silica which substitutes cement which has homogeneous properties. Two types of concrete is prepared with different water-binder ratio of 0.45 and 0.50 designed for M25 with 10%, 20%, 30% replacement. The compressive strength and tensile strength are determined at 7, 28 days and carbonation test are carried out with exposure condition of 6 days. The results obtained from Bentonite replacement are i) Compressive Strength and Tensile strength is achieved on long term basis. ii) Carbonation penetration depth is about 20% less when compared to ordinary PCC.

Key words: Bentonite, Strength, Durability, Carbonation

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1. INTRODUCTION

Concrete is one of the most widely used construction material in the world. It can be cast in diverse shapes. Concrete is a composite material formed by the combination of cement, sand, coarse aggregate and water in a particular proportion in such a way that the concrete produced meets the needs as regards its workability, strength, durability and economy. It is found to be versatile and hence gained importance in building materials.

The concrete has high compressive strength, stiffness low thermal conductivity and low combustibility, but it has very low resistance tensile strength, limited ductility and little resistance to cracking.

In the context of increased awareness regarding the ill effects of global warming, eco-friendly technologies are to be developed for the effective management of resources. The cost effectiveness in construction will be achieved only if we thinking from every corner of construction materials.

In this project, an attempt has made to overcome this problem by the limited use of Bentonite powder in place of Cement.

2. OBJECTIVE

1. To determine the compressive strength and tensile strength of concrete replaced with Bentonite.

2. To determine the carbonation depth of PCC and Bentonite replaced concrete.

3. To establish the relationship between carbonation depth and compressive strength.

3. RESEARCH SIGNIFICANCE

This paper presents a methodology to estimate the long-term effect made with Bentonite based on the results obtained at a early stage of concrete specimen.

This enables the construction industry to replace Bentonite material in place of cement, which leads to overcome the financial constraint, in which Bentonite is the natural material, cost is very low in market.

4. LITERATURE REVIEW

1. A.Honda said that there is a concern that the coexistence of cementitious material and bentonite cause the alteration of smectite due to this interaction function of hydraulics barrier.

2. Fiona Neall gave from his study that Shear strength (the ability to resist failure by a shear motion stress field) is independent of sodium replacement calcium in montmorillonite.

3. A summary was given by Y. Sakamoto, The evolution of porosity in bentonite is important.

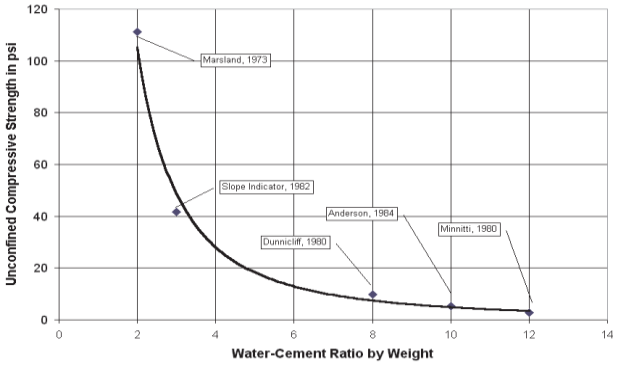
a. The initial porosity is very high.

b. If cement-bentonite alteration results in porosity reduction that causes a permeability decrease there could be an adverse effect on safety since potential for gas pressures to rise, leading to eventual cracking of the barrier, might be enhanced.

4. Ian Mckinley make his confident predictions that it will be very difficult to make a safety case which depends on the longevity of bentonite which can be degraded by interaction with cementitious materials. Rather than expend effort to better understand this degradation process, it may be better to avoid it by design.

5. Teplitskiy summary that to increase the capabilities for generating electricity at an existing plant, it was necessary to construct a hydro accumulation power station.As reinforced concrete alone does not perform to work good in the areas of hydro power station.In such cases due to the density of bentonite slurry being higher that that of water, bentonite slurry protects a trench from water inflow from outside sources.

6. P. Erik Mikkelsen gives the general view on strength and durability characteristic when cement is mixed with Bentonite This Graph gives the Compressive strength on 28 days of Cement Bentonite mixture.



7. Jefferis gives the basic reaction of Cement added with bentonite .And he also adds the properties change while they both mixed together.

$$CaB + NaCO3 = Na2B + CaCO3$$

8. D.J.Morgan gives from his project that Bentonite are produced by dry processing methods, modest quantities of high value white bentonite, in both the calcium and sodium form, are wet-refined using centrifuges to remove coarser impurities and to improve rheological properties.

5. MATERIALS AND METHODOLOGY

Concrete is an artificial material which is made up of cement, fine aggregate, coarse aggregate and water. In this project, an attempt has been made to replace cement by Bentonite. Hence the properties of material have been arrived by conducting laboratory tests and the results.

5.1. Materials Used

5.1.1. Cement

Cement is a binding material in concrete, which binds the other materials to form a compact mass. Generally OPC is used for all Engineering Construction works. OPC is available in three grades of 33, 43, 53. In this project, 53 grade cement is used for the experimental study.

Table 1 Properties of Cement

PROPERTIES	VALUE
Compressive Strength	53 Mpa
Specific Gravity	3.15
Initial Setting Time	30 min
Final Setting time	600 min

5.1.2. Fine Aggregate

A concrete with better quality can be made with sand consisting of rounded grains rather than angular grains. River or pit Sand must be used and not Sea Sand as it contains salt and other impurities. In this Project study, River sand is used as fine aggregate. By conducting Sieve Analysis, and compared with Grading table from IS 383-1970, Table 3.2, it was found that the sand used belongs to the Zone 3.

Table 2 Properties of Fine Aggregate

PROPERTIES	VALUE
Fineness modulus	3.24
Specific Gravity	2.41
Size	Passing through 4.75mm sieve
Water absorption ratio	1%

5.1.3. Coarse Aggregate

Aggregate must be clean and free from impurities. The coarse aggregate used in this project is of the size 20mm.

Table 3 Properties of Coarse Aggregate

PROPERTIES	VALUE
Fineness modulus	4
Specific Gravity	2.73
Size	Passing through 20 mm and retaining in 10mm sieve
Water absorption ratio	0.50%

5.1.4. Bentonite

Bentonite is available in powder and solution form,which can replaces cement upto 40% of cement used in the concerte. Bentonite presents strong colloidal properties and its volume increases several times when coming into contact with water, creating a gelatinous and viscous fluid. The ionic surface of bentonite has the useful property in making a sticky coating on sand grains.

Table 4 Properties of Bentonite

Properties	Value
Fineness Modulus	2.54
Specific Gravity	2.2

6. METHODOLOGY

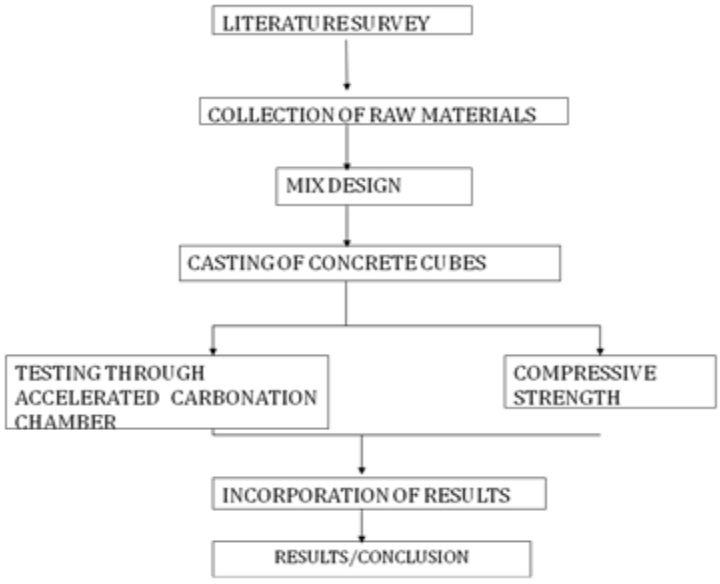


Table 5 Mix Proportion

Water	Cement	Fine Aggregate	Coarse Aggregate
174.84 kg	349.68 kg	560.42 kg	1260.19 kg
0.5	1	1.602	2.24

The mix proportion are 1:1.6:2.24, designed for M25. The experiment was conducted to find the difference in increased compressive strength and split tensile strength; when bentonite powder is added to OPC. The tests were conducted at 3th, 7th , 14th and 28th days. For that we followed all the procedures as per IS code specifications and tested in our college strength of material lab.

6.1. Process

The whole program can be separate into two divisions

- Casting
- Testing

Casting

The properties of the material, which are used for investigation, are presented in this section. All the experiments that are adopted to determine characteristics of the material are carried out as per Indian standards. This section also includes mix design for concrete as per Indian standards.

The casting procedure was explained under five categories:

- Material used
- Mould details
- Preparation of mould
- Preparation of concrete
- Preparing the specimen for testing

Mould details

The internal dimensions of the mould are

Cube size =150mm x 150mm x 150mm

Cylinder size =300mm length, 150mm diameter

6.2. Testing

6.2.1. Test Specimen

The experimental program was designed to study the mechanical properties of concrete with partial replacement of coarse cement by Bentonite for M25 grade of concrete. The compressive strength of the cubes after replacing the cement by 10%, 20%, 30% with Bentonite is studied after 28 days.

For the test specimens, 53 grade pozzolonic portland cement, natural river sand and coarse aggregate, Bentonite are being utilised. The maximum size of the coarse aggregate was limited to 20mm. A sieve analysis conforming to IS 383 – 1970 was carried out for both fine and coarse aggregates. The concrete mix proportions of M20 with the water cement ratio of 0.5 was used.

Figure 1 Replacing the cement with Bentonite in cube.

The concrete mix design was proposed to achieve the compressive strength of 25MPa after 28 days curing, in case of cubes. The split tensile strength of the specimens were also tested. The concrete cubes (150mmx150mmx150mm), Concrete beams (100mmx100mmx500mm) and Concrete Cylinders (150mmx300mm) for conventional as well as other mixes were casted. Each layer was compacted with 25 blows using 16mm dia rod.

Figure 2 Replacing the cement with Bentonite in cylinder.

6.2.2. Compression Test

The procedure is executed considering IS 516 – 1959. The specimens are tested to find out the mechanical properties. The concrete cube specimens were placed over the Compression Testing Machine and the load was gradually applied till the failure of the specimen. The ultimate load was noted down as collapse load and compressive strength was calculated. The Split Tensile Strength test was carried out with concrete cylinders in Compression Testing Machine for each type of concrete specimens.

Figure 3 Compressive strength of bentonite powder in 28 days

6.2.3. Split Tensile Test

Cylinder splitting tension test: This is also sometimes referred as ‘’Brazilian test’. This test was developed in Brazil in 1943. At about the same time this was also independently developed in Japan.

The test is carried out by placing a cylindrical specimen horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of the cylinder along the vertical diameter.

The splitting test is simple to perform and gives more uniform results than other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete, than the modulus of rupture. Splitting strength gives about 5 to 12% higher value than the direct tensile strength. In our investigation we used 300mm length and150mm diameter cylinder.

Figure 4 Tensile strength of bentonite powder in 28 days

7. RESULTS

Table 6 Compressive Strength for 3 days

S.no	Percentage of bentonite	Maximum load kn	3 days average compressive strength (mpa)
1.	0%	460	20.44
2.	10%	470	20.88
3.	20%	450	20.00
4.	30%	430	19.11

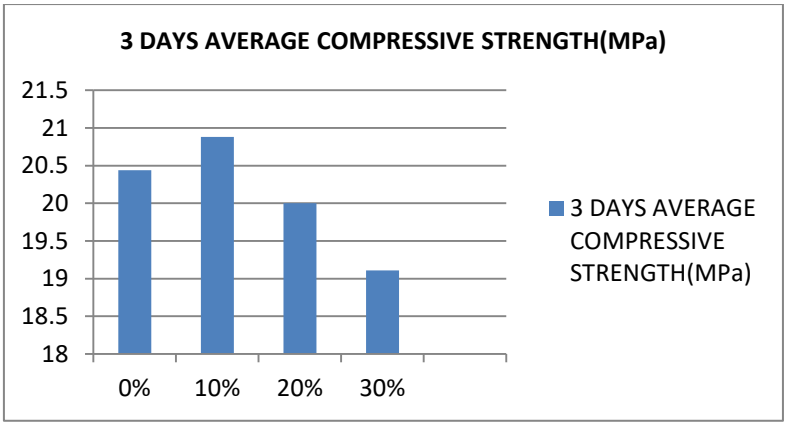


Figure 5 3 Days Average Compressive Strength (Mpa)

Table 7 Compressive Strength for 7 days

S.No	Percentage Of Bentonite	Maximum Load Kn	7 Days Average Compressive Strength (Mpa)
1.	0%	520	23.11
2.	10%	530	23.55
3.	20%	510	22.66
4.	30%	470	20.88

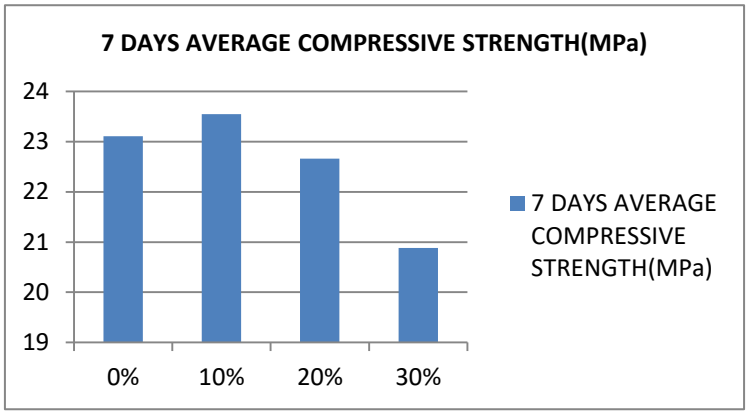


Figure 6 7 Days Average Compressive Strength (Mpa)

Table 8 Compressive Strength for 14 days

S.No	% Of Bentonite	Maximum Load Kn	14 Days Average Compressive Strength (Mpa)
1.	0%	570	25.33
2.	10%	580	25.77
3.	20%	560	24.88
4.	30%	510	22.66

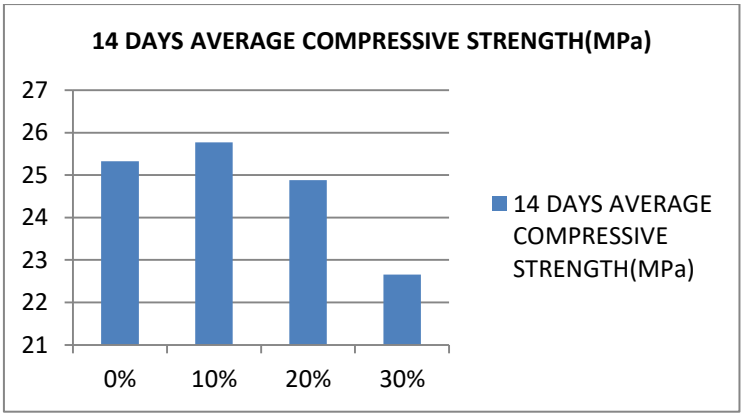


Figure 7 14 Days Average Compressive Strength (Mpa)

Table 9 Compressive Strength for 28 days

S.No	Percentage Of Bentonite	Maximum Load Kn	28 Days Average Compressive Strength (Mpa)
1.	0%	620	27.55
2.	10%	630	28.00
3.	20%	610	27.11
4.	30%	540	24.00

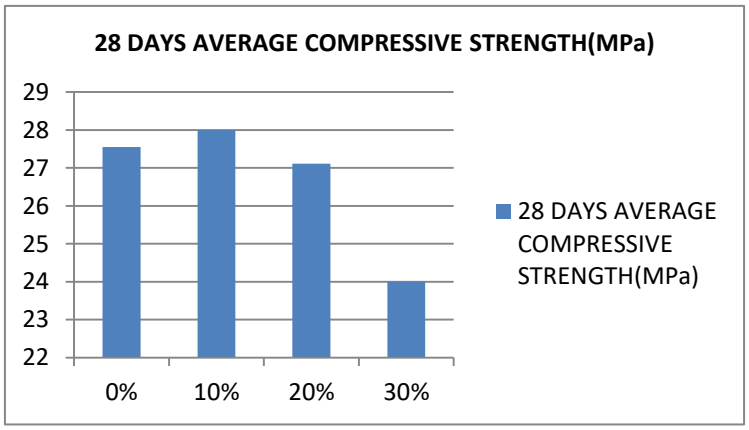


Figure 8 28 Days Average Compressive Strength (Mpa)

Table 10 Split Tensile Strength for 3 days

S.No	Percentage Of Bentonite	Maximum Load Kn	3 Days Average Tensile Strength (Mpa)
1.	0%	90	1.27
2.	10%	120	1.69
3.	20%	110	1.55
4.	30%	80	1.13

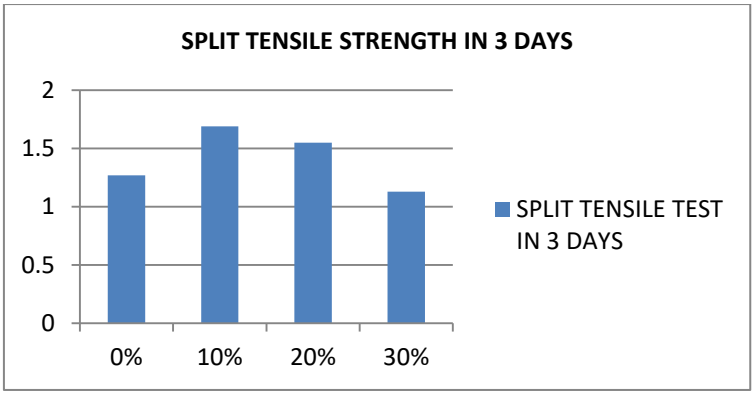


Figure 9 Split Tensile Strength In 3 Days

Table 11 Split Tensile Strength for 7 days

S.No	Percentage Of Bentonite	Maximum Load Kn	7 Days Average Tensile Strength (Mpa)
1.	0%	120	1.69
2.	10%	140	1.98
3.	20%	130	1.84
4.	30%	100	1.41

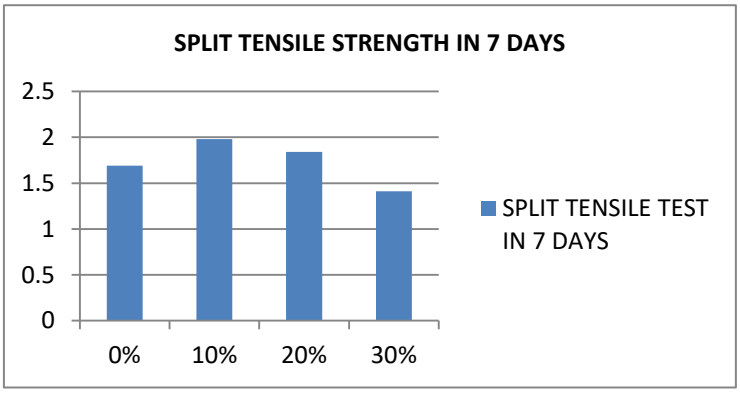


Figure 10 Split Tensile Strength In 7 Days

Table 12 Split Tensile Strength for 14 days

S.No	Percentage Of Bentonite	Maximum Load Kn	14 Days Average Tensile Strength (Mpa)
1.	0%	160	2.26
2.	10%	180	2.54
3.	20%	190	2.68
4.	30%	130	1.84

Table 13 Split Tensile Strength for 28 days

S.No	Percentage Of Bentonite	Maximum Load Kn	28 Days Average Tensile Strength (Mpa)
1.	0%	190	2.68
2.	10%	200	2.83
3.	20%	210	2.97
4.	30%	170	2.40

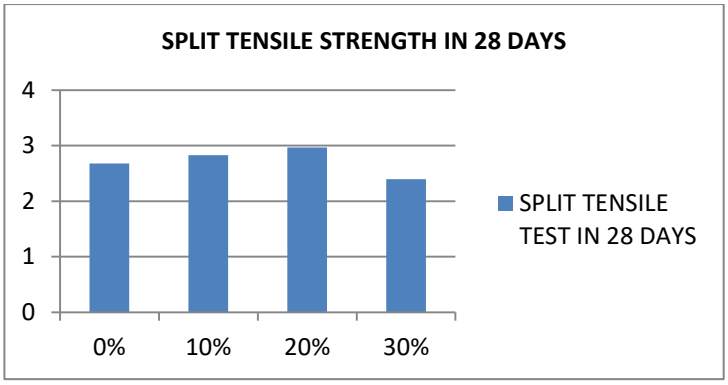


Figure 11 Split Tensile Strength In 28 Days

8. CONCLUSIONS

8.1. General

After conducting all the tests on the specimen, it has been observed that upto 20% replacement of cement with bentonite proved to be good in Compression, as well as in Tension, whereas the concrete properties with equal proportion of Bentonite and conventional cement confirmed to be inefficient.

8.2. Conclusions

- Based on the Compression Strength, 10% replacement Bentonite shows 28.00Mpa strength as the average strength on 28 days of curing.
- Based on the Compression Strength, 20% replacement Bentonite shows 27.11Mpa strength as the average strength on 28 days of curing.
- Based on the Compression Strength, 30% replacement Bentonite shows 24.00Mpa strength as the average strength on 28 days of curing.
- Based on the Tensile Strength, 10% replacement Bentonite shows 2.83 strength as the average strength on 28 days of curing.
- Based on the Tensile Strength,20% replacement Bentonite shows 2.97 strength as the average strength on 28 days of curing.
- Based on the Tensile Strength,30% replacement Bentonite shows 2.40 strength as the average strength on 28days of curing.

9. SUMMARY

"CONSTRUCTION MUST BE SUSTAINABLE"

The building industry have been living for long decades enjoying the various natural resources as raw materials directly and now, we are suffering a depletion of ozone layer due to the production of cement. Therefore, to cope up with this situation we can further employ other materials as resources for construction. It will enhances the safety of environment as well as efficient usage of landscape.

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