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An Investigation on the Characteristic Properties of Concrete Containing Bentonite

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ABSTRACT: Pozzolanic reaction in concrete is gaining importance these days because of the extra development of the strength in the later ages of concrete. Some of the important pozzolanas that are commonly used in concrete are flyash, silica fume, blast furnace slag, micro silica 600 etc. the addition of these pozzolanas to concrete not only increase the strength characteristics of concrete but also other properties of concrete too.

Bentonite is another pozzolana that can be used in concrete. On an average the silica content of Bentonite varies from 50% to 60%.

In this an attempt is made to study the various properties of concrete containing Bentonite in different percentages. The properties of concrete like compressive strength, tensile strength, flexural strength, impact strength, and workability properties etc. are found for different percentage addition of Bentonite like 0%, 2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%.

KEY WORDS: Bentonite, Pozzolana, pozzolanic reaction,

I. INTRODUCTION

Today's construction industry is utilizing maximum amount of concrete as a building material. Now-a-days the concrete has undergone many modifications. To suit a particular job the concrete can be designed and produced with the help of many available admixtures and other additions. As the industries are growing, the wastes cause the pollution and occupy the space for storage. Recently the concrete technologists have successfully utilized these industrial wastes in concrete to produce a concrete which can behave in a better way. The most commonly used industrial wastes include flyash, blast furnace slag, silica fume etc. All these industrial wastes act as pozzolana.

The pozzolanic reaction imparts a better strength and durability to the concrete. There are various pozzolanic materials available. These pozzolanic materials may be a waste product obtained from industries or naturally available. Some of the pozzolanas which have industry as their origin are flyash, blast furnace slag, silica fume. The pozzolanas which are available in nature are metakaolin, microsilica-600, Rice-husk-ash, clay and shale's, diatomaceous earth, volcanic tuffs and pumicites etc. A pozzolana is essentially a silicious material which while in itself possesses no cementitious properties, but in its finely divided form and in the presence of water react with calcium hydroxide at ordinary temperature to form compounds of cementitious properties.

Materials

Bentonite is another pozzolana that can be used in concrete because it contains 50% to 60% silica. Bentonite is a volcanic ash found in the black hills of South Dakota and is an inert material. During the cretaceous age, volcanoes in the yellowiest area of Wyoming (America) were subjected to long periods of eruptions. Ash falling from these eruptions dropped into sea, which cover much of Wyoming, forming sediment as much as 50 feet deep. These sediments were slowly altered into the clay, which is known today as 'Bentonite'. In India Bentonite is available in large quantities in Kutch (Gujarat) region. On an average the silica content of Bentonite varies from 50% to 60%. Bentonite has several uses in the production of various products. That is why Bentonite is called "The clay of thousand uses". Bentonite is used in various applications

Such as fertilizers, pesticides, clay liners, barriers, foundries, face creams, paints, polymers, water purification, sewage treatment plants, water coagulants, detergents etc.

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Properties of Bentonite

PHYSICAL PROPERTIES		CHEMICAL ROPERTIES	
Moisture content (%)	11.10%	SIo2	50-60%
pH	9	Al2O3	15-20%
Gelling time	60 seconds	Fe2O3	09-13%
Gelling Index	71	Tio2	01-1.5%
Swelling Capacity	27ml	CaO	02-03%
Fineness % passing through 200 mesh	90%	MgO	03-04%
GCS	13.2	K2O	0.2-0.5%
M. B. value	411	Na2O	01-1.5%
Liquid Limit	360%	LOI	08-10%

Objective of The Study

The main objective of this experimentation is to ascertain whether the Bentonite can act as pozzolana or not. In this dissertation an attempt is made to study the characteristic properties of concrete containing Bentonite in different percentages. The different percentages of Bentonite used in the experimentation are 0%, 2%, 4%, 6%, 8%, 10%, 12%, 14%, and 16%. The strength properties of concrete like compressive strength, tensile strength, flexural strength and impact strength are found for different percentage addition of Bentonite.

Scope of The Study

Bentonite is considered as the product of 1000 uses. It has several applications in different fields like medical, pharmaceuticals, foundry, automobile, construction etc. Since it is plentily available in U. S. and in India and in many parts of the world, Bentonite can be effectively used in construction field also. Since it contains 50% to 60% of Sio_2 it can be used in concrete also. Its other properties should be studied thoroughly for its addition into the concrete. Certainly Bentonite has a good prospective in future. That is why an indepth study of Bentonite is required.

Methodology

To study the different properties of concrete containing Bentonite in different percentages, several experimental works will have to be carried out. Thus the whole study is laboratory experimentation oriented.

II. TEST RESULTS

Overall Results of Compressive Strength of Concrete With Bentoite

The following Table no. 1 gives the overall results of Compressive Strength of concrete containing Bentonite in different percentages. Also the table shows percentage increase or decrease of compressive strength with respect to the variation of Bentonite.

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Table 1: Overall Compressive Strength of Concrete with Bentonite

Percentage of Bentonite	Average compressive strength (MPa)	Percentage increase or decrease in compressive strength
0	31.40	0%
2	31.55	+0.45%
4	32.00	+1.89%
6	32.74	+4.24%
8	**34.07**	**+8.49%**
10	31.85	+1.42%
12	26.07	-16.98%
14	25.15	-19.90%
16	24.88	-20.77%

The variation in the Compressive strength can be drawn in the form of graph as shown in fig.1.

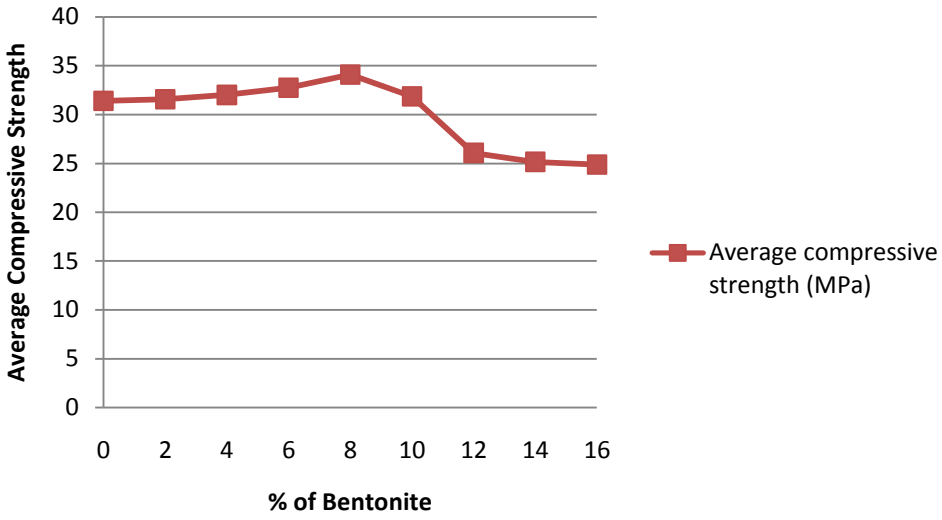

Fig.1-Graph Showing variation of Compressive strengths (28 days)

Overall Results of Tensile Strength of Concrete with Bentonite

The following Table no. 2 gives the overall results of Tensile Strength of concrete containing Bentonite in different percentages. Also the table shows percentage increase or decrease of Tensile strength with respect to the variation of Bentonite.

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Table 2: Overall Tensile Strength of Concrete with Bentonite

Percentage of Bentonite	Average Tensile strength (MPa)	Percentage increase or decrease in Tensile strength
0	3.73	0%
2	3.26	-12.5%
4	3.24	-13.14%
6	3.19	-14.14%
8	3.12	-16.41%
10	3.08	-17.43%
12	2.99	-19.7%
14	2.98	-19.97%
16	2.81	-24.76%

The variation in the Tensile strength can be drawn in the form of graph as shown in fig.2.

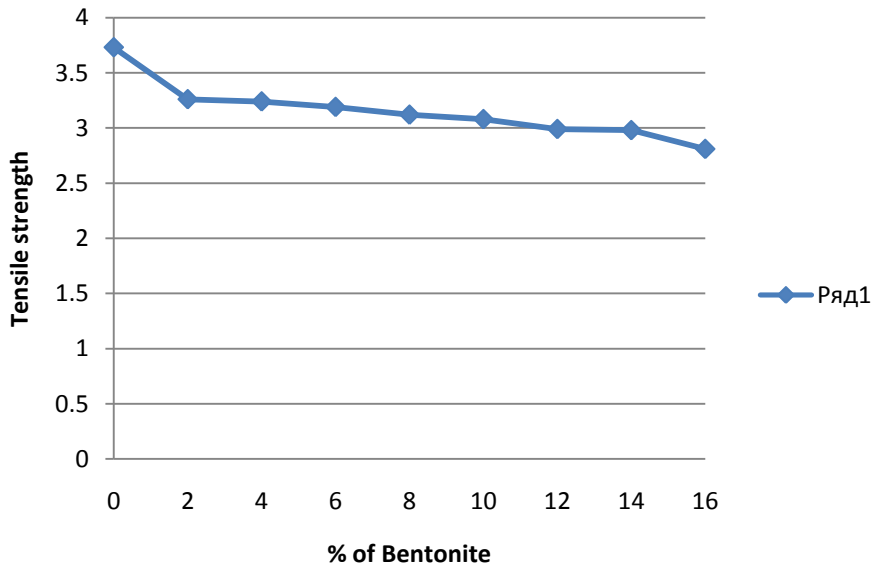

Fig.2-Graph Showing variation of Tensile strengths (28 days)

Overall Results of Flexural Strength of Concrete with Bentoite

The following Table no. 3 gives the overall results of Flexural Strength of concrete containing Bentonite in different percentages. Also the table shows percentage increase or decrease of Flexural strength with respect to the variation of Bentonite.

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Table 3: Overall Flexural Strength of Concrete with Bentoite

Percentage of Bentonite	Average Tensile strength (MPa)	Percentage increase or decrease in Flexural strength
0	3.52	0%
2	3.52	0%
4	3.71	+5.39%
6	3.78	+7.38%
8	**4.18**	**+18.75%**
10	4.16	+18.18%
12	3.57	+1.42%
14	3.49	-0.85%
16	3.28	-6.81%

The variation in the Flexural strength can be drawn in the form of graph as shown in fig.3.

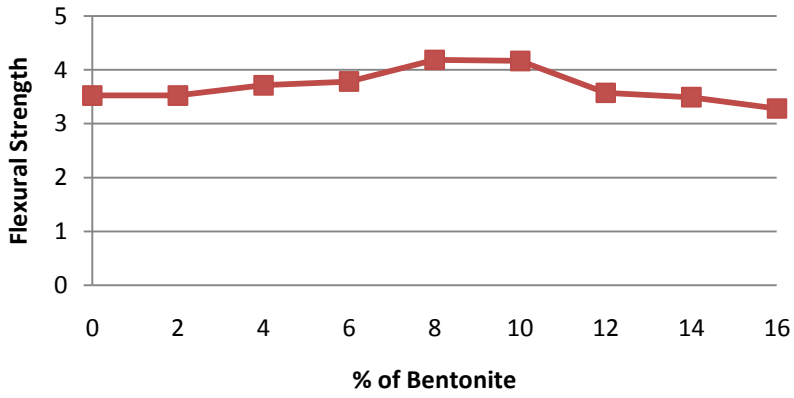

Fig.3-Graph Showing variation of Flexural strengths (28 days)

Overall Results of Impact Strength of Concrete with Bentonite

The following Table no. 4 gives the overall results of Impact Strength of concrete containing Bentonite in different percentages. Also the table shows percentage increase or decrease of Impact strength with respect to the variation of Bentonite.

Table 4: Overall Impact Strength of Concrete with Bentonite

Percentage of Bentonite	Average Impact Energy (N-M)		Percentage increase or decrease in Impact Energy	
	First Crack	Final Crack	First Crack	Final Crack
0	32.45	44.65	0%	0%
2	32.45	44.65	0%	0%
4	44.65	65.02	+37.5%	+45.62%
6	32.45	48.8	0%	+9.29%
8	28.42	40.62	-12.42%	-9.02%
10	20.25	32.45	-37.5%	-27.32%
12	16.22	28.42	-50.01%	-36.34%
14	12.2	24.4	-62.04%	-45.35%
16	8.05	16.22	-75.19%	-63.67%

The variation in the Impact strength can be drawn in the form of graph as shown in fig.4.
Series 1 shows variation of Impact energy for first crack and

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Series 2 shows variation of Impact energy for final failure.

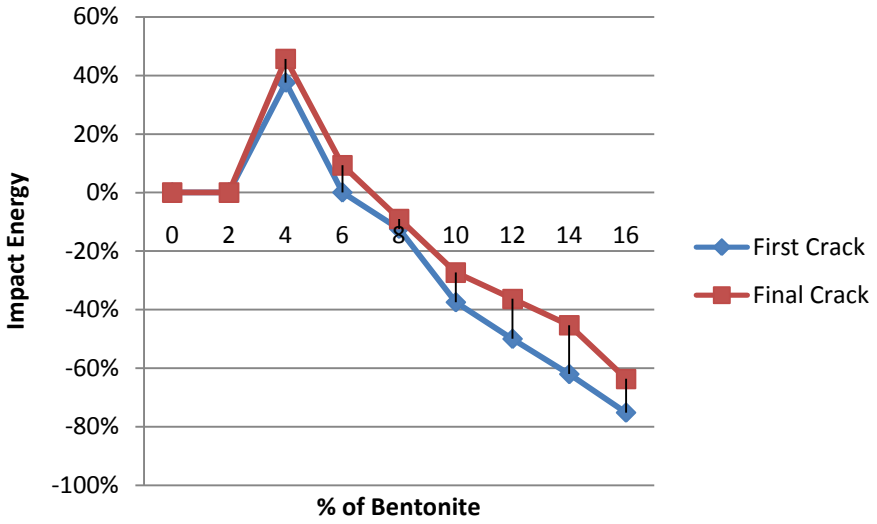

Fig.4-Graph Showing variation of Impact strengths (28 days)

Table 5: Test Results of Workability

Percentage of Bentonite	slump	Compaction factor
0	8	0.86
2	6	0.84
4	5	0.83
6	2	0.83
8	2	0.82
10	0	0.81
12	0	0.81
14	0	0.80
16	0	0.80

The variation in the Slump can be drawn in the form of graph as shown in fig.5.

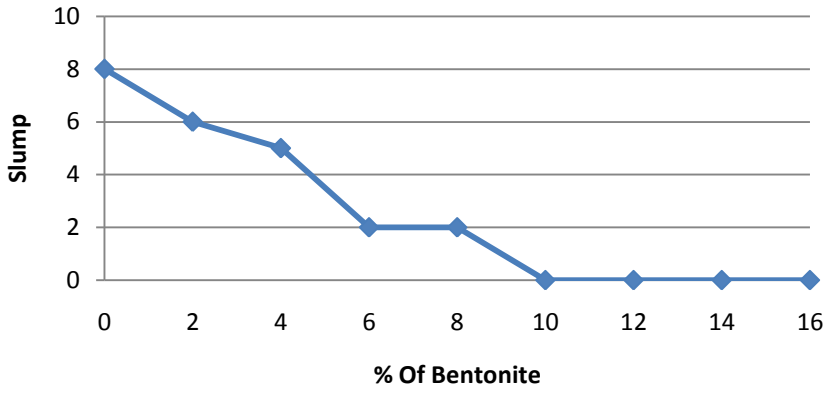

Fig.5-Graph Showing variation of Slump

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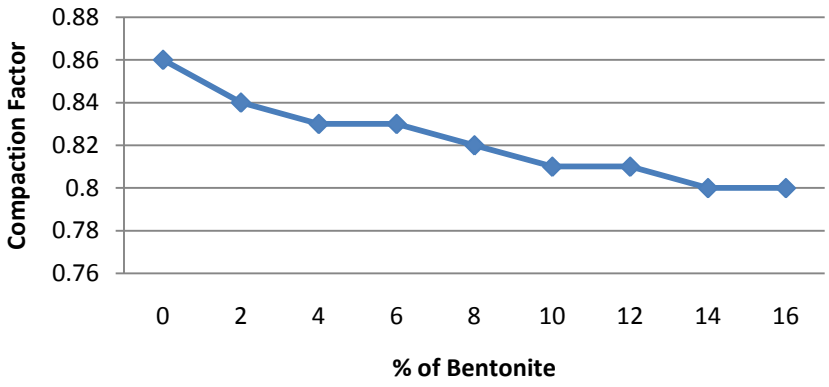

Fig.6-Graph Showing variation of Compaction Factor

III. OBSERVATIONS, DISCUSSIONS AND CONCLUSIONS

Based on the experimentation conducted on the effect of addition of Bentonite into the concrete, the following observations were made & hence some conclusions-

1. The concrete containing Bentonite shows an increasing trend in the compressive strength from 0% to 8%. The addition of 8% Bentonite into concrete yields the maxi mum compressive strength. More percentage addition of Bentonite than 8% will decrease the compressive strength. The percentage increase in the compressive strength is found to be 8.49% when 8% Bentonite is added to the concrete.

Since Bentonite contains silica (50-60%) it acts as a pozzolanic reaction, may be the reason for increase in the compressive strength. During hardening process the reaction takes places between cement & water to produce CSH gel along with $Ca(OH)_2$ which is called the primary hydration. The $Ca(OH)_2$ that is liberated is now reacts with the silica present in the Bentonite to produce CSH gel, which is called pozzolanic reaction or secondary hydration. The reactions explained above can be represented as follows.

$$2C_3S + 6H \longrightarrow C_3S_2H_3 + 3CH$$
$$2C_2S + 4H \longrightarrow C_3S_2H_3 + CH \text{ (Portland cement reaction)}$$
$$3CH + 2S \longrightarrow C_3S_2H_3 \text{ (Pozzolanic reaction)}$$

The CSH gel produced from the hydration of cement indicates the strength of concrete. The $Ca(OH)_2$ liberated along with CSH gel induces porosity to the concrete on leaching. The silica present in the Bentonite will now react with $Ca(OH)_2$ to produce CSH gel. This increases the strength of concrete.

Probably 8% addition of Bentonite into concrete will match with the amount of silica required for the complete pozzolanic reaction with $Ca(OH)_2$ to form CSH gel. The extra percentage addition of Bentonite will simply serve as a filler material. Probably this is reason why the greater percentage addition of Bentonite will decreases the compressive strength of concrete.

Another reason for increase in the compressive strength when Bentonite is added to concrete may be that the Bentonite acts as a micro filler to reduce the void contents of concrete.
Another reason that can be attributed for increase in the compressive strength when Bentonite is added to concrete is the high specific surface area of Bentonite. (250 – 500 m^2/gm).

Thus it can be concluded that 8% addition of Bentonite to concrete yields the maximum strength.

2. The concrete containing Bentonite shows a decreasing trend in the tensile strength from 0% to 16%. The percentage decrease in the tensile strength is 24.76% when 16% Bentonite is added.

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3. The concrete containing Bentonite shows an increasing trend in the flexural strength from 0% to 8%. The addition of 8% Bentonite into concrete yields the maxi mum flexural strength. More percentage addition of Bentonite than 8% will decrease the flexural strength. The percentage increase in the flexural strength is found to be 18.75% when 8% Bentonite is added to the concrete.
   The reason behind the increase in the strength is same as discussed in conclusion 1.

4. The concrete containing Bentonite shows an increasing trend in the impact strength from 0% to 4%. The addition of 4% Bentonite into concrete yields the maxi mum impact strength. More percentage addition of Bentonite than 4% will decrease the impact strength. The percentage increase in the impact strength is found to be 37.5% for causing the first crack and 45.62% for causing final failure.
   The reason behind the increase in the strength is same as discussed in conclusion 1.

5. The concrete containing Bentonite shows a decreasing trend in the compressive strength from 0% to 16% when subjected to alternate wetting and drying cycles.

Probably this may be due to the fact that the unreacted Bentonite when comes in contact with water repeatedly may swell and create pressure inside which may cause micro cracks. This will bring down the strength of concrete.
Thus it can be concluded that the addition of Bentonite into concrete is not preferred when subjected to alternate wetting and drying.

6. The concrete containing Bentonite shows a decreasing trend in the workability (as measured from slump & compaction factor) from 0% to 16%.

This may be due to the fact that the added Bentonite into the concrete will absorb water from the concrete system, thus reducing the flow ability of concrete.
Thus it can be concluded that the addition of Bentonite will result into lesser workability, thus demanding the use of super plasticizers.

7. Thus, in a nut shell it can be concluded that, the Bentonite will act as a pozzolana and hence can be used in concrete to improve the strength and other properties of concrete.

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BIOGRAPHY

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Anagha R Gargatti done B. E. in Civil Engineerig from Govt. College of Engineering Pune in 2000 and masters in Structural Engineering in 2003 from VTU. Presently working as Assistant Professor in the Department of Architecture in KLS's Gogte Institute of Technology, Belgaum.