International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

Assessment of the Effect of the Bentonite and Steel fibre on the compressive strength of concrete

Farheena Firdousi Islam , Angshuman Sarma , Bhaskarjyoti Deka ,
Dhanjit Deka, Dhrubajyoti Das , Harshit kumar Bez
Royal School of Engineering & Technology

ABSTRACT

With the increasing population and recent developments, there is a need of many civil engineering structures for various purposes like residents, commercial, industrial, transportation, etc. For all these civil engineering structures, the most important component is concrete and thus in order to make the structure economical, the major material of concrete i.e. cement can be replaced by various materials. In our project we have carried out an experimental investigation of replacing cement by certain percentages of Bentonite, Steel fibers and Coconut shells and later comparing their compressive strength with normal concrete without any replacement. In our project we also carried out the various preliminary tests on the various constituents of concrete i.e. cement, coarse aggregates and fine aggregates (sand). Accordingly, based on the observed results, the mix design was carried out in accordance with the Indian Standard codes. In our project, we replaced certain percentages of bentonite, steel fiber and coconut shells by weight of cement and the compressive strength of the cubes are tested in the compression testing machine. Thus in our project we aimed in increasing the compressive strength of concrete resulting in an economical concrete structure.

INTRODUCTION

Concrete is a compulsory man-made material which is widely used as building material in the construction industry. Regular concrete is a brittle material with which possesses a high compressive strength but on the other side has low tensile strength. The combine use of regular concrete and steel reinforcing bars was able to overcome that disadvantage leading to a material with good compressive and tensile strength but also with a long post-crack deformation. Reinforced concrete is made by embedding steel rods in concrete that improve its tensile strength.

Bentonite is an absorbent aluminium phyllosilicate clay consisting mostly of montmorillonite. The different types of bentonite are each named after the respective dominant element, such as potassium (K), sodium (Na), calcium (Ca), and aluminium (Al). Bentonite usually forms from weathering of volcanic ash, most often in the presence of water. However, the term bentonite, as well as similar clay called tonstein, has been used to describe clay beds of uncertain origin. For industrial purposes, two main classes of bentonite exist: sodium and calcium bentonite. The chemical formula of Sodium Bentonite is $Al_2H_2Na_2O_{13}Si_4$.

Steel Fiber is the leading low carbon, cold drawn steel fiber for concrete reinforcement. It is evenly distributed in concrete mixtures to provide “improved mechanical bonding capacity” exceeding most performance specifications for enhancing concrete’s flexural and shear strength, fatigue endurance, impact resistance and ductility. It is a reliable, cost efficient concrete reinforcement that is designed to be easy to mix, place and finish.

METHODOLOGY

1. Fineness of cement:

Table 1. Observation table for Fineness of Cement

Sample no.	Weight of cement (gms.)	I.S sieve size	Sieving time	Weight retained on sieve	% weight retained on sieve	Mean %
1	100	90 µ	15 mins	8 gms.	8%	
2	100	90 µ	15 mins	5gms.	5%	6.67%
3	100	90 µ	15 mins	7gms.	7%	

Result:-

Fineness of Cement= (100-6.67) %
= 93.33%

2. Standard consistency test:

Standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from top of the mould.

Table 2. observation table for standard consistency test

Sl No.	Weight of cement (gms.)	% of water	Quantity of water	Penetration from bottom of mould
1.	400	25%	100ml	38 mm
2.	400	28%	120ml	20 mm
3.	400	30%	112ml	24 mm
4.	400	32%	128ml	12 mm
5.	400	33%	132ml	10 mm
6.	400	34%	136ml	7 mm

Result:-

$P=\frac{1}{4}*100=34\%$

Therefore, standard consistency=34%.

3. Setting Test:

Initial setting time is that time period between the time water is added to cement and time at which 1 mm square section needle fails to penetrate the cement paste, placed in the Vicat's mould 5 mm to 7 mm from the bottom of the mould.

Final setting time is that time period between the time water is added to cement and the time at which 1 mm needle makes an impression on the paste in the mould but 5 mm attachment does not make any impression.

Result:-

Initial setting time= 45 mins.
Final setting time= 7hour 20 mins.

4. Slump Test:

Result:-

Slump obtained=75mm.

International Journal of Engineering Technology Science and Research
IJETSR
www.ijetsr.com
ISSN 2394 – 3386
Volume 4, Issue 11
November 2017

5. Fineness of sand:

Fineness modulus of fine aggregate varies from 2.0 to 3.5mm. Fine aggregate having fineness modulus more than 3.2 should not considered as fine aggregate. Various values of fineness modulus for different sands are detailed below.

Table 3. Limits of Fineness Modulus for Fine Aggregate

Sieve size	Zone-1	Zone-2	Zone-3	Zone-4
10mm	100	100	100	100
4.75mm	90-100	90-100	90-100	95-100
2.36mm	60-95	75-100	85-100	95-100
1.18mm	30-70	55-90	75-100	90-100
0.6mm	15-34	35-59	60-79	80-100
0.3mm	5-20	8-30	12-40	15-50
0.15mm	0-10	0-10	0-10	0-15
Fineness modulus	4.0-2.71	3.37-2.1	2.78-1.71	2.25-1.35

Type of sand	Fineness Modulus range
Fine sand	2.2-2.6
Medium sand	2.6-2.9
Coarse sand	2.9-3.2

Table 4. Observation table for fineness of sand

Sieve size	Weight retained (gms.)	Percentage weight retained	Cumulative percentage weight retained	Percentage finer
4.75 mm	14	14%	2.8%	97.2%
2.36 mm	48	62%	12.4%	87.6%
1.18 mm	53.5	115.5%	23.1%	76.9%
600µ	112	227.5%	45.5%	54.5%
300µ	172	399.5%	79.9%	20.1%
150µ	97.3	496.8%	99.3%	0.7%
pan	3	499.8%	99.7%	0.3%

Result:-

$$F.M. = \frac{\text{su} \quad \text{o cu} \quad \text{p} \quad \text{w} \quad \text{r} \quad \text{o s}}{1}$$

$$= \frac{2}{1}$$

=2.63

The sand conforms to zone II.

6. Specific Gravity of Coarse Aggregate:

Observations:-

Weight of empty jar= 655.5 gms.

Weight of water+jar = 1532.5 gms. (w_2)
Weight of water+aggregate+jar = 2166.0 gms. (w_1)
Weight of aggregate after 24 hours air dry= 1001 gms. (w_3)
Weight of aggregate after oven dry= 996 gms. (w_4)

(1) Specific gravity = $\frac{w4}{w3-(w1-w2)}$=2.71

(2) Apparent specific gravity =$\frac{w4}{w4-(w1-w2)}$=2.74

(3) Water Absorption = $\frac{w3-w4}{w4}$=0.50

Result:-

1. Specific gravity =2.71
2. Apparent specific gravity =2.74
3. Water Absorption = 0.50

Recommended Value:-

The size of the aggregate and whether it has been artificially heated should be indicated. ISI specifies three methods of testing for the determination of the specific gravity of aggregates, according to the size of the aggregates. The three size ranges used are aggregates larger than 10 mm, 40 mm and smaller than 10 mm. The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68. Though high specific gravity is considered as an indication of high strength, it is not possible to judge the suitability of a sample road aggregate without finding the mechanical properties such as aggregate crushing, impact and abrasion values. Water absorption shall not be more than 0.6 per unit by weight.

MIX DESIGN

Table 5. M-30 Concrete Mix Design

M-30 Concrete Mix Design	
As per IS-10262:2009 and IS-456:2000 Stipulations for proportioning	
1. Grade Designation	M30
2. Type of Cement	PPC
3. Maximum Nominal Aggregate Size	20mm
4. Maximum Cement Content (IS-456:2000)	320 kg/m^3
5. Maximum Water Cement Ratio (IS-456:2000)	0.40
6. Workability	75mm (slump)
7. Exposure Condition	Normal
8. Degree of Supervision	Good
9. Type of Aggregate	Crushed Angular Aggregate
10. Maximum Cement Content	480 kg/m^3

Test Data for Materials	
1. Cement Used	PPC
2. Specific Gravity of cement	3.1
3. Specific Gravity of water	1
4. Specific Gravity of 20mm aggregates	2.74
5. Specific Gravity of 10mm aggregates	2.74
6. Specific Gravity of sand	2.69
7. Water Absorption of 20mm aggregate	0.50%
8. Water Absorption of 10mm aggregate	0.50%
9. Water Absorption of sand	1.67%
10. Free (Surface) Moisture of 20mm Aggregate	Nil
11. Free (Surface) Moisture of 10mm Aggregate	Nil
12. Free (Surface) Moisture of sand	Nil
13. Sieve Analysis of Individual Coarse Aggregates	Separate Analysis Done
14. Sieve Analysis of Combined Coarse Aggregates	Separate Analysis Done
15. Sieve Analysis of Combined Fine Aggregates	Separate Analysis Done

Target Strength for Mix Proportioning	
1. Target Mean Strength	38.25 N/mm^2
2. Characteristics Strength	30 N/mm^2

Selection of Water Cement ratio	
1. Maximum Water Cement Ratio (IS-456:2000)	0.45
2. Adopted Water Cement Ratio	0.40

Selection of Water Content	
1. Maximum Water Content (IS-10262 table 2)	186 Lit.
2. Estimated Water Content for 75mm slump	192 Lit.

Calculation of Cement Content	
1. Water Cement Ratio	0.4
2. Cement Content (192/0.4)	480 kg/m^3

Proportion of volume of coarse aggregate and fine aggregate content	
1. Volume of C.A. as per table 3 of IS 10262	62.00%
2. Adopted volume of coarse aggregates (After adjustment)	64.00%
3. Adopted volume of fine aggregate (1-0.64)	36.00%

Mix Calculations

1. Volume of concrete in m^3	1
2. Volume of cement in m^3 (Mass of cement)/(Sp. Gravity of cement) × 1000	0.154
3. Volume of water in m^3 (Mass of water)/(Sp. Gravity of water) × 1000	0.192
4. Volume of All in aggregate in m^3 Sr. no. 1-(Sr. no. 2+3+4)	0.654
5. Volume of Coarse aggregate in kg	1146.85
6. Volume of Fine aggregate in kg	623.65

Mix Proportions for One Cum of Concrete	
1. Mass of Cement in kg/m^3	480
2. Mass of Water in kg	192
3. Mass of Fine Aggregate in kg	623.65
4. Mass of Coarse Aggregate in kg	1146.85
Mass of 20mm in kg	802.79
Mass of 10mm in kg	344.05
5. Water Cement Ratio	0.4

Table 6. Mix Proportion

Water Cement Ratio	Cement	Water	Coarse Aggregate	Fine Aggregate
0.4	480	192	1146.85 (802.79+344.05)	623.65
	1		2.39	1.3

EXPERIMENTATION AND RESULTS

The ability of a material to resist forces that attempt to squeeze or compress the material together is called compressive strength. The compression test is to be conducted using compressive test machine at the material lab of RGI. An increasing compressive load is applied to the specimen until failure occurs to obtain the maximum compressive load. The specimen dimension is taken before the testing. Concrete cubes of 150mm in length, width and height are used to determine the compressive strength. We have tested 36 numbers of cubes. Out of those 4 cubes were made using normal concrete, 16 cubes were made using bentonite, 16 cubes using steel fibers. The compressive strengths of concretes are determined at the ages of 7 and 28 days. Figure shows the compression testing machine used to conduct this study.

Compression strength = P/A

Where, P = ultimate compressive load of concrete (KN)

A = surface area in contact with the plates (mm^2)

Fig1. Cube testing by compression testing machine

Table 7. Percentage of Bentonite, Steel Fiber and Coconut Shells added in concrete in percentage of replacement to cement

Sl. No.	% of Bentonite added	% of Steel fiber added
1	5%	5%
2	10%	10%
3	15%	15%
4	20%	20%

Table 8. Compressive Strength of Various Cubes in 7 days and 28 days

	% added	No of cube test		Compressive Strength (N/mm^2)					
				For 7 days			For 28 days		
		For 7 days	For 28 days	Cube 1	Cube 2	Avg.	Cube 1	Cube 2	Avg.
Design mix	-	2	2	21.33	21.78	21.55	33.33	32.89	33.11
Bentonite	5%	2	2	21.78	22.67	22.22	33.78	34.67	34.22
	10%	2	2	24.00	23.11	23.56	36.00	35.55	35.78
	15%	2	2	24.89	25.33	25.11	36.89	37.78	37.33
	20%	2	2	18.67	19.56	19.11	32.89	32.44	32.67
Steel Fibers	5%	2	2	22.67	24.44	23.56	34.22	35.56	34.89
	10%	2	2	24.89	25.78	25.33	36.00	36.44	36.22
	15%	2	2	26.67	27.11	26.89	38.22	37.78	38.00
	20%	2	2	28.00	28.89	28.44	38.67	39.11	38.89

Results:-

From the experiment we find that

1. The strength of the conventional concrete cube of area (150mm×150mm) in 7 days is 21.55 N/mm^2 and in 28 days is 33.11 N/mm^2 respectively.

2. The strength of the concrete cube having a 5%, 10%, 15% and 20% replacement of cement by its weight by bentonite in 7 days is 22.22, 23.56, 25.11 and 19.11 N/mm^2 and 28 days is 34.22, 35.78, 37.33 and 32.67 N/mm^2 respectively.

3. The strength of the concrete cube having a 5%, 10%, 15% and 20% replacement of cement by its weight by steel fibers in 7 days is 23.56, 25.33, 27.11 and 28.44 N/mm^2 and 28 days is 34.89, 36.22, 38.00 and 38.89 N/mm^2 respectively.

4.

GRAPHICAL REPRESENTATION OF VARIOUS RESULTS OBSERVED FROM THE EXPERIMENTAL INVESTIGATION

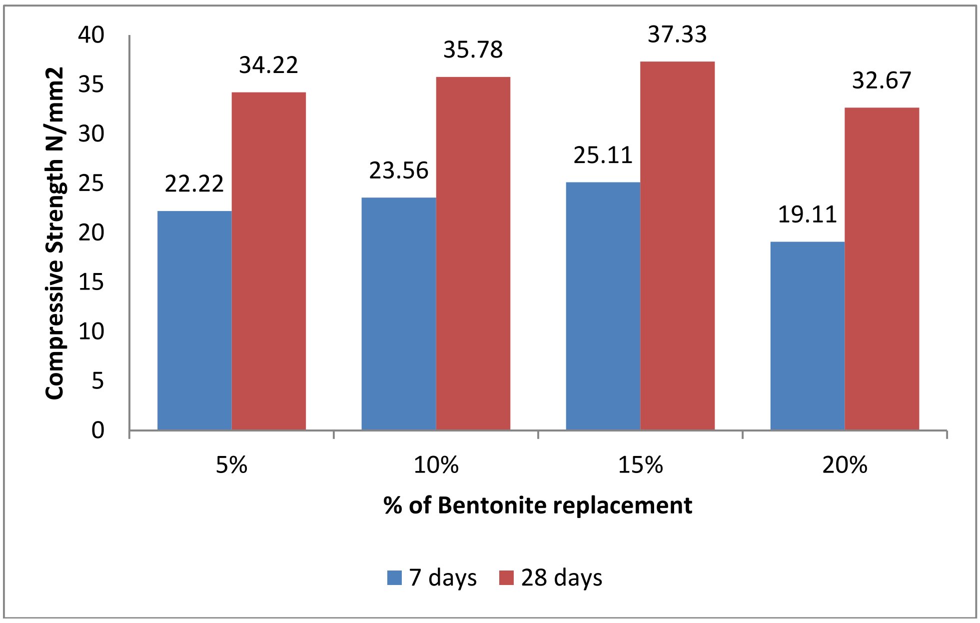

Fig 2. A graphical representation of % of bentonite replacement of cement by its weight in 7days and 28 days and Compressive Strength (N/mm2).

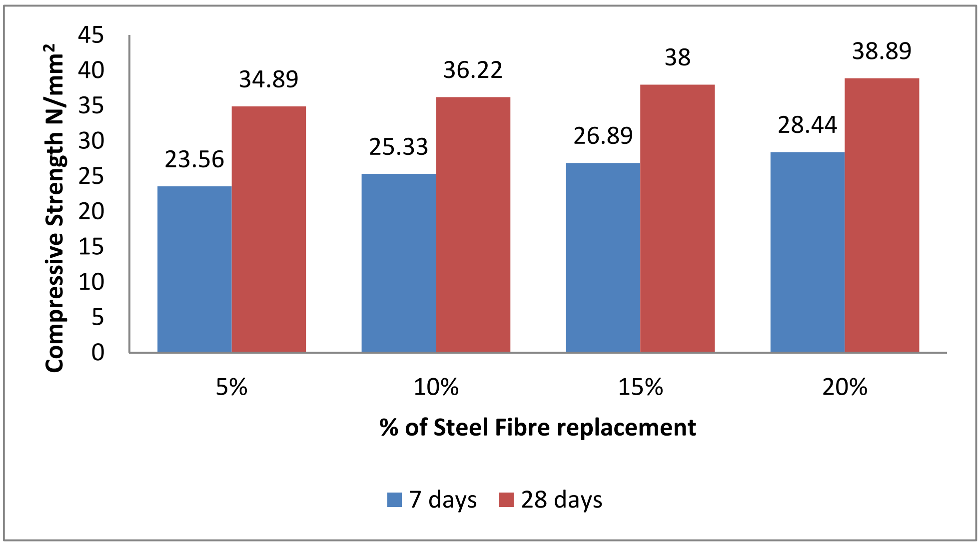

Fig 3. A graphical representation of % of steel fiber replacement of cement by its weight and Compressive Strength (N/mm2).

Farheena Firdousi Islam , Angshuman Sarma , Bhaskarjyoti Deka , Dhanjit Deka, Dhrubajyoti Das , Harshit kumar Bez

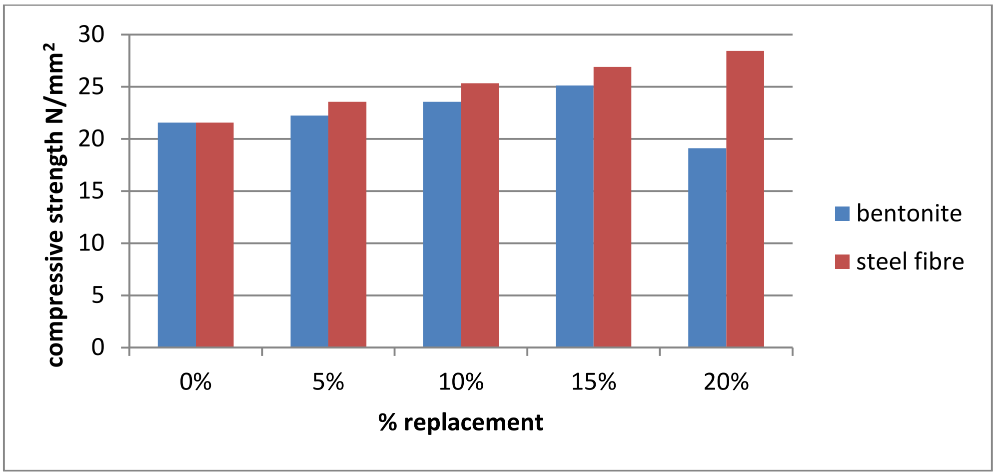

Fig 4. Graphical comparison of % replacement of bentonite and steel fiber by weight of cement with compressive strength N/mm2 for 7 days.

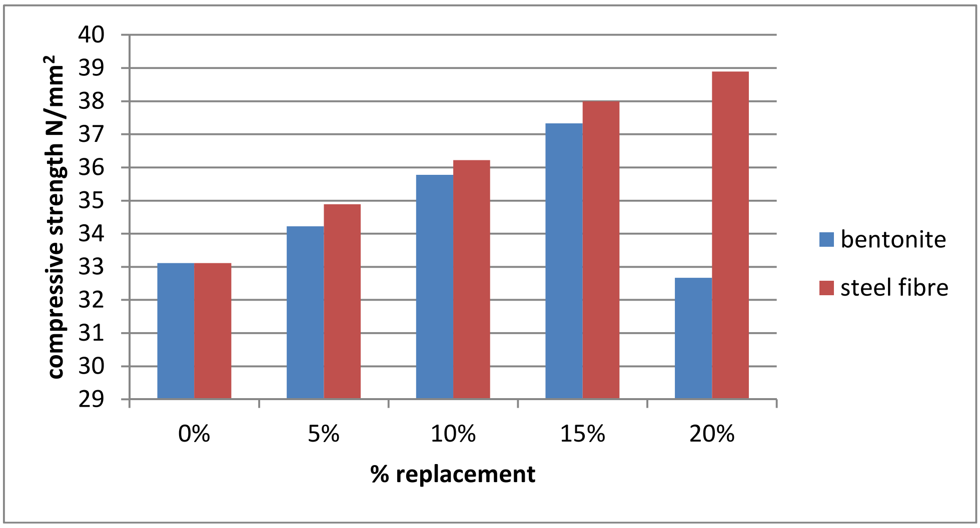

Fig 5. Graphical comparison of % replacement of bentonite and steel fiber by weight of cement with compressive strength N/mm2 for 28 days.

CONCLUSION

In this project named "Assesment of the Effect of the Bentonite and Steel fibre on the compressive strength of concrete", we have made an attempt to study the various types of materials that may increase the compressive strength of the structure when all other materials usually used for making the structure. A study is also carried out on the concrete mix proportioning as per the requirements using the routine materials which are used for concrete. The proportioning is carried out to achieve specified characteristics at specified age, workability of fresh concrete and durability requirements.

In our experiment we have considered 5%, 10%, 15% and 20% of bentonite and steel fiber replacement of cement by its weight of the cement. Based on our limited experimental investigation we can conclude that steel fiber shows gradual increase in compressive strength up to 20% whereas bentonite shows an increase in compressive strength till 15% but the compressive strength shows a decrease at 20% replacement. Hence we can conclude that for better compressive strength, steel fibers can be recommended as a replacement and in case of less load taking structures, we can recommend bentonite replacement upto 15% as per the results obtained.

SCOPE OF FUTURE STUDY

In our project, due to limited time and equipments we only carried out compressive strength test. We can recommend some experiments that can be taken up in future

- Flexural strength test and Split tensile test for reinforced beams in advance laboratories.
- For better strength bentonite and super plasticizer can be mixed and checked for compressive strength test.
- Both Bentonite and Steel Fibers can also be mixed together to check for compressive strength test.
- For farther investigations, the percentage replacement interval of the materials with cement by weight can be reduced.
- Light weight construction units can be made by using these wastes like panels & block production, internal wall casting, outdoor furniture etc.
- Combination with fly ash can also be an option for future experimentation. Other wastes like Sugarcane bagasse, blast furnace slag & Plastic can be an option for waste utilization in construction practices.

BIBLIOGRAPHY

- **Chakraborty Arunav** “Concrete Technology”, K.M publishing.
- **Gambhir M.L.** “Concrete Technology”, Tata McGraw-Hill publishing Company Ltd.
- **IS-456-2000** “Plain and Reinforced Concrete” published by BUREAU OF INDIAN STANDARDS.
- **IS-10262-2009** “Concrete Mix Proportioning” published by BUREAU OF INDIAN STANDARDS.
- **Gunasekaran K, Kumar PS**, (2008) “Developing lightweight concrete using Agricultural and Industrial Solid Wastes”, Proceedings of Innovative World of Concrete’08, 4th International Conference & Exhibition + ICI Silver Jubilee Celebration.
- **Junaid A.et.al** “Evaluating the Effect of Bentonite on Strength and Durability of High Perfomance Concrete” International Journal of Advance Science and Geotechnical Engineering ISSN 2319-5347, Vol. 02, No. 01, January 2013
- **Milind V. Mohod** “Performance of Steel Fiber Reinforced Concrete.” IJCS ISSN: 2278-4721, Vol. 1, Issue 12 (December2012), PP 01-04
- **Shetty M.S.** “Concrete Technology” published by S.Chand, Revised Edition.