Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 5, Issue 4; April-June, 2018, pp. 249-254

http://www.krishisanskriti.org/Publication.html

A Comparative Study on Performance of Concrete using Conventional and Nonconventional Additives

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Abstract—*In the present era of growth and development, progress is taking place in all over the world. But in the light of progress, nature has been ignored and destroyed in the form of using the virgin materials which is finally leading to the threat of global warming. The challenge in front of civil engineering community is to provide aesthetic, economical and comfortable infrastructure without causing any hardship for environment. In recent years, many researchers have established that the use of supplementary materials which can not only improve the various properties of concrete - both in its fresh and hardened states, but also can contribute to economy in construction costs. Efforts are being made in the field of concrete technology to develop such concretes with special characteristics. The aim of this study is to find out such supplementary materials which can considerably minimize the use of cements and reduce the cost of construction. Attempt has been made to partially replace OPC cement by Alccofine at 5%, 7.5%,10%, 12.5% and 15%; Fly-ash at 20% to 40%, Bentonite and Micro silica at 10% to 35 % in steps of 5%; Bamboo fibre at 2%, 4%, 6% and compared with 0% replacement. The Mix design has been performed as per IS 10262:2009 for M25 grade of concrete. Slump test, compaction factor test, bulk density, compression test and split tensile test are carried out to check the quality and strength of the specimen. Compression tests were performed for 7days, 28 days and 56 days of curing and split test were carried out for 28 days of curing. It was observed that replacement of cement by Alccofine at 12.5%, Fly-ash at 20%; Bentonite, Micro-silica at 15% and Bamboo fibre at 4% replacement of cement by weight showed maximum improvement factor.*

Keywords*: Compressive strength; Split tensile strength; Improvement factors.*

1. INTRODUCTION AND LITERATURE REVIEW

Concrete is an extraordinary and key structural material in the construction industry. It is no doubt that with the development of human civilization, concrete be a prevalent construction material. The necessity of high performance concrete is increasing day by day to reduce the cost as well as size of structural elements. Efforts for improving the performance of concrete over the past few years suggest that cement replacement materials along with Mineral & chemical admixtures can improve the strength and durability characteristics of concrete. The aim of this study is to reduce the cost of construction, to make high performance of concrete. This paper reports the results of an experimental investigation on concrete in which ordinary Portland cement (OPC) cement were partially replaced by Alccofine at 5%, 7.5%, 10%, 12.5% and 15%; Bamboo at 2%, 4%, 6%. Wood powder and Bamboo powder at 3%, 6% and 9%. More variation was tried with Bentonite and Micro-silica at 10% to 35%; Fly-ash at 20% to 40% in steps of 5% for making M-25 grade of concrete and compared with 0% replacement.

M.S Pawar et al. (2013) From their experimental investigations the filling ability, passing ability and resistance to segregation are the self-compatibility characteristic are increased by adding alccofine in SCC mixes and they found the fresh and harden properties of SCCs with adding of 10% alccofine is superior that of 5% and 15% of alccofine.**Dr. Shakeel Ahmad et al (2014)** tested that concrete cubes reinforced with 1% bamboo fibrein compression testing machine and stress -strain curve has been plotted. The results have been compared with plain concrete cubes. They had found that the strength of concrete cubes with fibres doesn't show much improvement up to 28 days but surprisingly strength become double in 50 days testing. Bamboo fibres can be used as replacement with concrete which can save the expensive concrete.**Md Athar Kazmi1 et al. (2015)** performed a series of tests to investigate the possibility of utilizing a broad range of materials as partial replacement of cement in the production of concrete. In their experiment they partially replace cement with Silica fume or micro silica by adding 0%, 5%, 7.5%, 10%, 12.5% by weight of cement in concrete and comparing the compressive strength of normal concrete. This study has shown that between 5 to 10% replacement level of cement by silica fume in concrete will develop strength sufficient for construction purposes. **M.VMohod et al. (2016)** Tested and Concrete mixtures were produced in the range of 0%, 10%, 15%, & 20% replacement by fly ash by weight for M-30 grade concrete and compared in terms of compressive strength, flexural strength and split tensile strength as an alternative to traditional concrete. The results shown that Concrete with 15% replacement of cement with fly ash shows good compressivestrength and split tensile

strength for 28 days of curing as compared to 10% and 20% of replacement.**R Suresh et al. (Nov. 2017)** performed tests with different water-binder ratio of 0.45 and 0.50 designed for M25 with 10%, 20%, 30% replacement by bentonite. The compressive strength and tensile strength are determined at 7, 28 days. The results shown at 10% replacement of cement by bentonite gives maximum compressive strength as well as tensile strength, with increasing in percentage of bentonite strength will decreases.

2. METHODOLOGY AND MATERIALS

The materials used for this study are OPC – 43 grade of cement (Dalmia), coarse sand from Kanaighat (Kalioni River), locally available coarse aggregates (Bihubor), CCB treated Bamboo fibres From Rain Forest Research Institute, Jorhat and Alccofine, Bentonite, Micro silica from the markets. Another admixture Fly ash is taken from Rajasthan NTPC with the help of TOPCEM INDIA Plant's Quality Control Department. The Mix design has been performed as per IS 10262:2009 and other physical properties of cement, FA, CA and admixtures are tested as per IS 383-1970, IS 460-1965, IS 5513-1959, IS 2720 (P-3), IS 1199-1959, IS 516-1959 and IS 5816-1999.

2.1 Materials

2.1.1 Alccofine is mineral admixture produce by Ambuja Cement Ltd. It's a one type of super-pozolanic micro fine concrete material, it reduces the permeability in concrete and create dense packing in concrete and ultimately reduces the water content and increases the compressive strength of concrete. It has unique characteristics to enhance "performance of concrete" in fresh and hardened stages due to its optimized particle size distribution. It is easy to use and can be added directly with cement, ultrafine particle of alccofine provide better and smooth surface finish. For high strength concrete the cost of the concrete mix prepared with alccofine is lesser than the concrete without alccofine. It also lowers the water/binder ratio. If the percentage level of alccofine is increased beyond that level it acts as a filler material and yields good workability to the concrete. There are two types of Alccofine, **Alccofine1203** is essential in terms of reducing heat of hydration and strength at all stages whereas Alccofine 1101 can be used as a grouting purpose. Alccofine 1203 is an alccofine with low calcium silicate. Alccofine 1200 series is of 1201, 1202, 1203 which represents fine, micro fine, ultrafine particle size respectively. Alccofine 1203 is a slag based SCM having ultra-fineness with optimized particle size distribution. Alccofine 1203 provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance

2.1.2 Bamboo is one of the commercially cultivated crops in India. According to the India State of Forest Report 2011, the total bamboo bearing area in the country is 13.96 million hectares. On a conservative estimate, it constitutes about 12.8% of the total area under forests is under bamboo in India. India is a second largest producer of bamboo next to China in the world. The annual production of bamboo in India is about 4.6 million tonnes. It is a natural renewable resource that grows twice as fast as a tree and matures within an average span of 3 years. The tensile strength of steel is 2.5-3.0 times higher than bamboo and the specific gravity 6-8 times that of bamboo; but by counting their tensile strength/unit weight (bamboo vs steel), the tensile strength of bamboo is 3- 4 times that of steel. It is based on this fact that the study sets out to compare the tensile strength of bamboo to steel as structural engineering material.

2.1.3 Bentonite is a fine clay material mined from the earth, formed by the decomposition of volcanic ash. It is an absorbent aluminium phyllosilicate, impure clay consisting mostly of montmorillonite. It contains variety of accessory minerals in addition to montmorillonite, these minerals may include quartz, calcite, feldspar and gypsum. Bentonite presents strong colloidal properties and its volume increases several times when coming into contact with water, creating a gelatinous and viscous fluid. Bentonite acts as natural pozzolan in ordinary Portland cement. A pozzolan is siliceous or aluminous material which itself possesses equivalent to zero percent cementing properties, but in the presence of moisture it chemically reacts with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties. When water is added in a mixture of OPC and pozzolan, its silica component reacts with liberated calcium hydroxide in hydrated cement paste. It is widely used as a drilling mud for oil and natural gas wells.

2.1.4 Fly ash: Global Coal reserves are expected to last another 200 years. India is the third largest producer of coal and coal based thermal power plant installations in India contribute about 70% of the total installed capacity for power generation. At present, 120-150 million tons of coal fly ash is generated in India. Among this 40 % to 50% ash is used in different sectors, coal this presents an inherent problem of ash disposal.This would require about 40000 hectares of land for the construction of ash ponds. In the utilization of **fly ash incement concrete** minimizes the Carbon dioxide emission problem to the extent of its proportion in cement.

2.1.5 Micro silica is the one of the waste materials that is being produced in tones of industrial waste per year in India. The term micro silica is the one normally used to describe the very fine powder which is an artificial pozzolanic material, produced by the reduction of high quality quartz with coal in an electric arc furnace in the manufacture of silicon or ferro silicon alloy and utilized in concrete to improve the properties of the concrete. Micro silica is also known as silicafume. It is usually a grey coloured powder, somewhat similar to Portland cement or fly ash. It can exhibit both pozzolanic and cementations properties. When pozzolanic materials are incorporated to concrete, the silica present in these materials react with the calcium hydroxide released during the hydration

of cement and forms additional calcium silicate hydrate (C–S–H), which improve durability and the mechanical properties of concrete. It can be used in concrete and refractory materials. Micro silica, when mixed in certain proportions it enhances the properties of both fresh and hard concrete such as compressive strength, bond strength, abrasion resistance and reduces the permeability of the concrete providing a more durable product.

The various physical properties of cement, FA, CA, and others admixtures are given in Table – 1, 2, 3& 4

Table 1: Physical properties of OPC – 43 Grade Cement

Tests	Value
Consistency of cement	31.50%
Initial Setting Time	2.05 hours
Final Setting Time	9.10 hours
Fineness	92%
Avg. Specific gravity	3.14
Colour	Grey

Table 2: Physical properties of FA and CA

Sample	Avg. Water absorption	Avg. Specific gravity	Size in mm
Fine Aggregates	1.181	2.77	4.75 down
Coarse Aggregates	0.523	2.525	20 down

Table 3:Physical properties of various admixtures

Sample	Fineness	Avg. Specific gravity	Colour
Alccofine	96.5%	2.875	White
Bentonite	74%	2.195	Brown
Fly Ash	85%	2.24	Light Grey
Micro Silica	94%	2.27	Grey
Bamboo fibre (Bambusabalcooa)	3mm Square in size with 1.5 inch long	0.534	Light brown

Table 4: Slump and Compaction factor

Sample	Slump	Compaction factor
Normal Concrete	48	0.931
Alccofine (12.5%)	60	0.953
Bamboo fibre (4%)	40	0.823
Bentonite (15%)	41	0.933
Fly Ash (20%)	65	0.963
Micro Silica (15%)	43	0.910

3. RESULT AND DISCUSSION

3.1 The cubes with various proportion, with different amounts admixtures are tested for Compressive strength at 7, 28, 56 days of curing are given in the Table 5, 6, 7, 8 and 9 having w/c 0.45

Table 5: Compressive strength of specimen with Alccofine as an admixture

% of Admixture used	Average Compressive strength in N/mm^2			Improvement factor at 28 days
	7 days	28 days	56 days	
0%	28.297	39.26	42.92	1.0
5%	24.885	34.28	41.0	0.893
7.5%	24.445	36.78	42.33	0.937
10%	24.445	40.78	43.45	1.039
12.5%	25.34	42.67	44.11	1.087
15%	24.11	35.56	40.33	0.906

Table 6: Compressive strength of specimen with Bamboo fibre as an admixture

% of Admixture used	Average Compressive strength in N/mm^2			Improvement factor at 28 days
	7 days	28 days	56 days	
0%	28.297	39.26	42.92	1.0
2%	25.67	39.0	44.44+	0.993
4%	23.775	39.89	44.44+	1.016
6%	19.22	35.44	39.335	0.903

Table 7: Compressive strength of specimen with Bentonite as an admixture

% of Admixture used	Average Compressive strength in N/mm^2			Improvement factor at 28 days
	7 days	28 days	56 days	
0%	28.297	39.26	42.92	1.0
10%	22.35	32.0	34.22	0.815
15%	24.82	34.0	35.77	0.866
20%	19.33	24.44	27.33	0.623
25%	17.21	21.78	25.11	0.555
30%	12.31	18.22	22.88	0.464
35%	9.07	12.89	17.56	0.328

Table 8: Compressive strength of specimen with Fly ash as an admixture

% of Admixture used	Average Compressive strength in N/mm^2			Improvement factor at 28 days
	7 days	28 days	56 days	
0%	28.297	39.26	42.92	1.0
20%	26.15	40.45	43.92	1.030
25%	22.885	35.56	42.0	0.906
30%	13.335	28.67	35.0	0.730
35%	13.0	26.335	33.89	0.671
40%	11.11	25.33	25.33	0.645

Table 9: Compressive strength of specimen with Micro Silica as an admixture

% of Admixture used	Average Compressive strength in N/mm²			Improvement factor at 28 days
	7 days	28 days	56 days	
0%	28.297	39.26	42.92	1.0
10%	22	31.11	34.22	0.792
15%	22.44	31.56	35.11	0.804
20%	18.22	22.67	28.66	0.577
25%	15.77	18.44	24.67	0.470
30%	12.67	15.44	22.44	0.393
35%	10.44	14.67	19.33	0.374

3.2 The comparison on compressive Strength at 7, 28 days and 56 days of curing of different admixtures in various proportions with 0% admixture are given in the fig. 1, 2, 3, 4 and 5

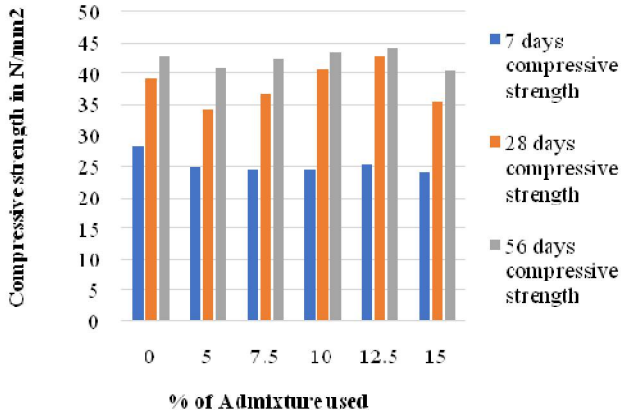

Fig. 1: Alccofine used as a admixture

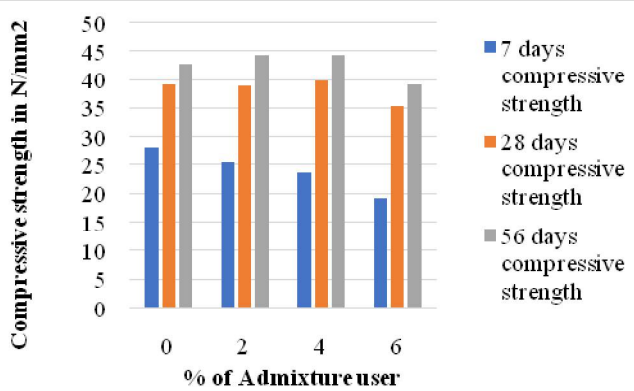

Fig. 2: Bamboo fibre used as a admixture

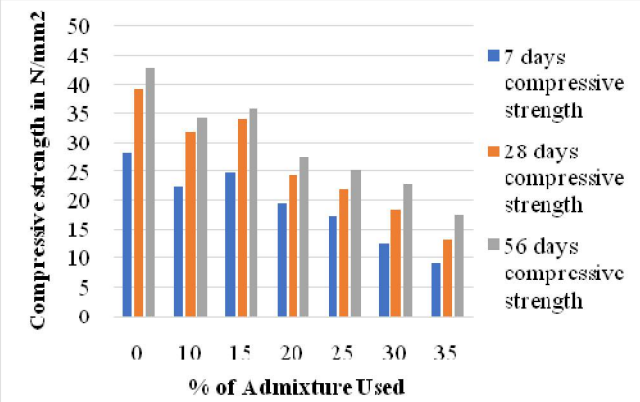

Fig. 3: Bentonite used as a admixture

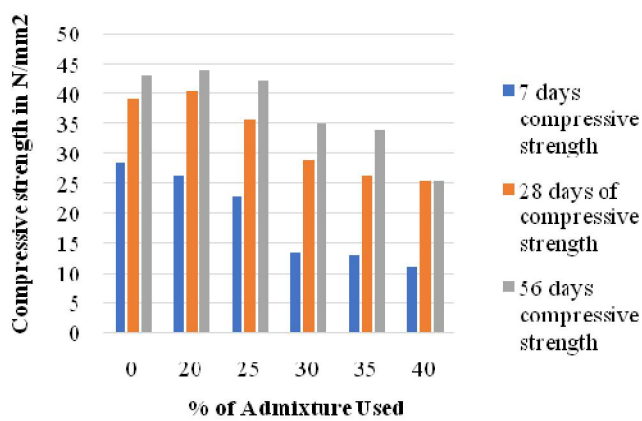

Fig. 4: Fly ash used as admixture

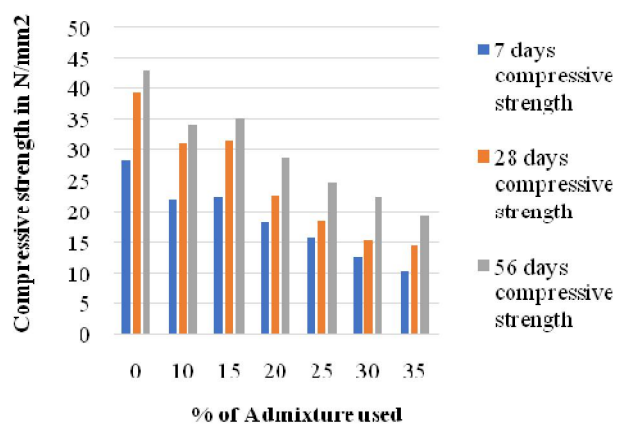

Fig. 5: Micro Silica used as admixture

3.3 The comparison on Split Tensile Strengthat 28 days of curing of different admixtures in various proportions with 0% admixture are given in the fig. 6

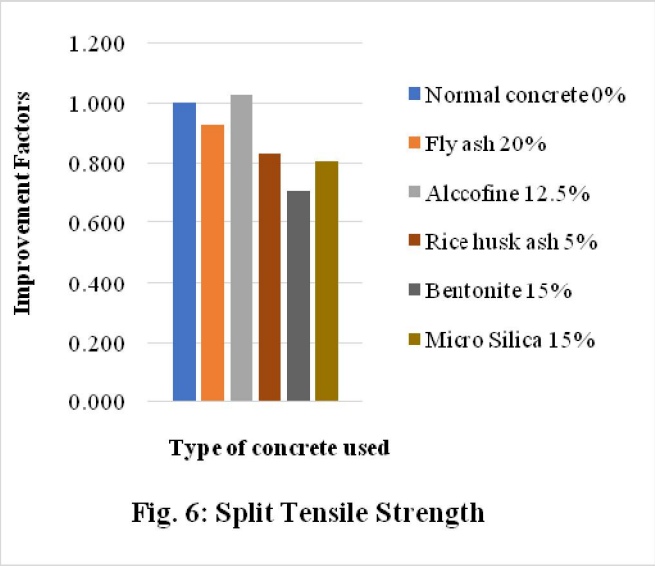

Fig. 6: Split Tensile Strength

3.4 The Split Tensile Strength and Bulk density of various admixtures with 0% admixture are given in the Table 10 and 11

Table 10: Split Tensile Strength Test

Admixture used	Split tensile strength at 28 days	Improvement Factor
Normal concrete 0%	2.900	1.000
Alccofine (12.5%)	2.971	1.024
Bamboo fibre (4%)	3.254	1.122
Bentonite (15%)	2.051	0.707
Fly ash 20%	2.688	0.927
Micro Silica (15%)	2.334	0.805

Table 11: Bulk Density Test

Sample	Avg. Bulk Density	Ratio
Normal Concrete	2320.000	1.000
Alccofine (12.5%)	2213.333	0.954
Bamboo Fibre (4%)	2232.000	0.962
Bentonite (15%)	2234.667	0.963
Fly Ash (20%)	2306.667	0.994
Micro Silica (15%)	2154.667	0.929

4. ESTIMATION OF THE DIFFERENT MIX DESIGNS

The market price of different materials, labours and cost analysis of concrete work are given in the Table 11 &12.

Table 12: Rate of different Items and labours as per Market price

Materials	Quantity	Rate	
Coarse aggregate	7.630 cu.m	Rs. 2100/cu.m	
Sand	4.687 cu.m	Rs. 1000/cu.m	
Cement	2.883 cu.m	Rs. 440/bag	
Admixture	Alccofine	Rs. 27/kg	
	Bamboo fibre	0	
	Bentonite	Rs. 5/kg	
	Fly ash	Rs. 0.5/kg	
	Micro Silica	Rs. 64/kg	
Labour:			
Head mason	1/3	Rs. 450	Rs. 116.67
Mason	2	Rs. 400	Rs. 660
Labour (male)	12	Rs. 300	Rs. 3600
(female)	20	Rs. 250	Rs. 5000
Water boy	6	Rs. 250	Rs. 1500
Total Labours Costper cu.m of concrete work Rs. 10876.67			

Table 14: Cost Analysis of per cu.m of concrete work as per Market price

Mixed Proportion	Sundries (T & P)	Avg. Labours Cost	Amounts (Rs.)	Water charges	Contractors Profits	Total	Rate per cu.m
0%	150.00	10876.67	69787.80	1046.82	6978.78	77813	7781.34
Alccofine 12.5%	150.00	10876.67	65324.75	979.87	6532.47	72837	7283.71
Bamboo fibre 4%	150.00	10876.67	68261.74	1023.93	6826.17	76112	7611.18
Bentonite 15%	150.00	10876.67	64148.99	962.23	6414.90	71526	7152.61
Fly Ash 20%	150.00	10876.67	62188.36	932.83	6218.84	69340	6934.00

5. ACKNOWLEDGEMENT

I would like to express my special thanks of gratitude to Dr. NayanmoniChetia, Assistant Professor, Civil Engineering Department, Jorhat Engineering College, Jorhat, Assam for her excellent guidance and encouragement and support during the course of my work that *I came to know about so many new things.* I am very thankful to all the Scientists of RFRI, Jorhat for their constant support. I would also like to thank all the members of TOPCEM INDIA Plant's Quality Control Department for helping in the collection of sample. Finally, thanks again to those who have given their undivided support will not be forgotten.

6. CONCLUSION

From the experimental investigation, the various admixtures exhibit different of improvement in compressive strength as well as in split tensile strength while used in different proportion. The partial replacement of cement was carried out for M25 grade of concrete.

- When the partial replacement of Fly ash is considered it shows maximum improvement at 20%.
- At 12.5% partial replacement of Alccofine, it shows maximum improvement.
- When the partial replacement of Bentonite and Micro silica is considered it shows maximum improvement at 15%.
- Another admixture Bamboo fibre is considered as partial replacement of cement, it shows maximum improvement at 4%.

This paper immensely highlights the admixtures which can be used for high performance light weight concrete in economic way.

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