As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 7(12): 321-326, 2021

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0712062
Available online at: http://www.ijmtst.com/vol7issue12.html

Mechanical Properties Of Fiber Reinforced Concrete With Nano Silica and Micro Silica

Palla Krishnaveni, Ch.Sai Kiran

Department of Civil Engineering, Visakha Technical Campus, Andhra Pradesh, India.

To Cite this Article

Palla Krishnaveni, Ch.Sai Kiran. Mechanical Properties Of Fiber Reinforced Concrete With Nano Silica and Micro Silica. *International Journal for Modern Trends in Science and Technology* 2021, *7* pp. 321-326. https://doi.org/10.46501/IJMTST0712062

Article Info

Received: 15 November 2021; Accepted: 12 December 2021; Published: 21 December 2021

ABSTRACT

The Earth is getting rapidly heated up mostly due to the carbon dioxide emissions. It is believed that one ton of cement produces one ton of carbon dioxide. We can reduce cement content by partial replacement of cement with by-products like micro silica and nano silica. Adding basalt fibre to concrete improves its characteristics like high tensile strength, extended operating temperatures, better chemical resistance and environmental friendliness. The present study is concentrated on strength characteristics of basalt fibre reinforced concrete with micro silica (8.0% of cement) and nano silica (2.0% of cement). From the experimental study it is found out that the concrete specimens of superior properties can be produced using micro silica (8.0% of cement) and nano silica (2.0% of cement) combination. This combination in the concrete causes shrinkage and decreases the tensile strength. To overcome this, varying percentages of basalt fibre (0.1%, 0.2%, 0.3% and 0.4%) is added.

It is also found out that, generally addition of basalt fibre in concrete reduces the compressive strength and increases the split tensile strength. So the combination of basalt fibre reinforced concrete with micro silica and nano silica is considered ideal. Specimens containing micro silica (8.0% of cement), nano silica (2.0% of cement) and basalt fibre (0.1%, 0.2%, 0.3% and 0.4%) are casted and are tested for compressive and split tensile strength. It is observed that the strength values are improved compared to cement concrete. The tensile strength values increased comparatively whereas compressive strength decreased with increase of basalt fibres content.

Keywords:- fly ash, GGBS, Cement, silica fume, compressive strength.

I.INTRODUCTION

Concrete is a very strong and versatile mouldable construction material. It consists of cement, sand and aggregate (e.g., gravel or crushed rock) mixed with water. The cement and water form a paste or gel which coats the sand and aggregate. When the cement has chemically reacted with the water (hydrated), it hardens and binds the whole mix together. The initial hardening reaction usually occurs within a few hours. It takes some weeks for concrete to reach full hardness and strength. Concrete can continue to harden and gain strength over many years.

The United States uses about 230 million cubic meters (300 million cubic yards) of ready mixed concrete each year. It is used in highways, streets, parking lots, parking garages, bridges, high-rise buildings, dams, homes, floors, sidewalks, driveways, and numerous other applications.

The performance of concrete is related to workmanship, mix proportions, material characteristics, and adequacy

of curing. The production of quality concrete involves a variety of materials and a number of different processes including: the production and testing of raw materials; determining the desired properties of concrete; proportioning of concrete constituents to meet the design requirements; batching, mixing, and handling to achieve consistency; proper placement, finishing, and adequate consolidation to ensure uniformity; proper maintenance of moisture and temperature conditions to promote strength gain and durability; and finally, testing for quality control and evaluation.

Many people with different skills come into contact with concrete throughout its production. Ultimately, the quality of the final product depends on their workmanship. It is essential that the workforce be adequately trained for this purpose. When these factors are not carefully controlled, they may adversely affect the performance of the fresh and hardened properties.

Micro Silica is also called as condensed silica fume. It is a by product of the industrial manufacture of ferrosilicon and metallic silicon in high-temperature electric arc furnaces. Micro silica is an amorphous type of silica dust mostly collected in bag house filters as by-product of the silicon and Ferro-silicon production. The ferrosilicon or silicon product is drawn off as a liquid from the bottom of the furnace. Vapour rising from the 2000°C furnace bed is oxidized, and as it cools condenses into particles which are trapped in huge cloth bags. Processing the condensed fume to remove impurities and control particle size yields micro silica. Added to concrete it reacts with the cement hydration products and helps in improving the concrete strengths, durability and impermeability, allowing concrete to be used in ways never before possible.

Nano technology is an emerging field and has many applications and it is getting good amount of interest from civil engineering field. There are many nano materials that can be used in concrete, but among them nano-silica possess more Pozzolanic nature. The high strength, impermeability and durability to concrete with nano silica is due to its capability to react with the free lime during the cement hydration and forming a additional C-S-H gel. The usage of nano silica is quite less due to high cost. Nowadays, the two most important commercial processes in the production of nano-silica are the neutralization of sodium silicate solutions with acid and the flame hydrolysis. Both processes are expensive because of the price of the raw materials and the energy requirements. Nanosilica could be applied even more widely if a new industrial, low cost, production process could be developed.

REVIEW OF LITERATURE

M.Nili and et.al, [1] have studied about the mixing of different content of micro silica and colloidal nano silica as partial replacement of cement in the concrete mixture. Silica fume was used at 0%,3%,4.5%,6%,7.5% and colloidal nano silica was used at 0%,1.5%,3%,4.5% as partial replacement of cement. The testing ages were 3, 7, 28, 91 days. The results show that increasing in nano silica content, 1.5% to 4.5% leads to an increase in compressive strength at all stages. And containing both nano and micro silica have higher compressive strength than reference ones. And it is concluded that 6% micro silica and 1.5% nano silica results in improved compressive strength and electrical resistance.

Dr. D. V. Prasada Rao and et.al, [2] researched the influence of Micro-Silica and Nano-Silica used as partial replacement of cement for the preparation of concrete. The main objective of the study is to obtain the influence of the combined application of micro-silica and nano-silica on various strength properties of M40 and M50 grades of concrete. 5% and 10% of Micro-Silica and 1.5% and 3% of Nano-Silica by weight of cement replacement is adopted. Compressive strength, split tensile strength and flexural strength of the two grades of concrete prepared using different proportions nano-silica and micro-silica are to be obtained and the results are to be compared with that of controlled concrete. It is observed that the increase in 7 days and 28 days cube compressive strength concrete with 1.5% nano-silica and 10% micro-silica combination is 20.2% and 19.6% respectively for M40 grade concrete and for M50 grade increase in 7 days and 28 days cube compressive strength concrete with 1.5% nano-silica and 10% micro-silica combination is 14% and 19.7% respectively. The increase in the split tensile strength of M40 and M50 grades of concrete with 1.5% nano-silica and 10% micro-silica combination is 14% and 15.2% respectively. The increase in the flexural strength of M40 and M50 grade of concrete with 1.5% nano-silica and 10% micro-silica combination is 19.1% and 17.3% respectively. So, the concrete prepared with a combination of 10% Micro-Silica and 1.5% Nano-Silica

possesses improved strength properties compared to the controlled concrete and the increase in the various strength characteristics of concrete can be attributed to the effective particle packing and the availability of additional binder during hydration in the presence of Micro-Silica and Nano-Silica.

Fatha Irine I.A [3] investigated on strength aspects of basalt fibre reinforced concrete. The authors have studied and compared the compressive, flexural, split tensile strength with M30 grade concrete. The cube, beam and cylindrical specimens have been designed with basalt fibre reinforced concrete containing 1Kg/m3, 2kg/m3, 4kg/m3 basalt fibres at 3,7,28 days. From the experiment it is observed that for addition of 4kg/m3 fibre gives maximum compressive strength, split tensile strength and flexural strength at 28 days.

Dr.K.B.Prakash and et.al, [4] studied the different strength characteristics of compressive strength, tensile strength, flexural strength, shear strength and impact strength. The main objective is to study the behavior of basalt fiber (chopped strand) reinforced concrete in which the fibers are added from 0% to 2.5% with 0.50% increments. The design mix of M30 is adopted for all the testing specimens with or without basalt fiber. The higher compressive strength, tensile strength, flexural strength, shear strength and impact strength of basalt fiber reinforced concrete is obtained by adding 2% basalt fibers and the percentage increase in compressive strength is 17.57%, tensile strength is 65.93%, flexure strength is 78.94%, shear strength is 94.55%, impact strength is 2296.53% for M30 grade basalt fiber reinforced concrete when compared to same grade of concrete without fiber. The workability of basalt fiber reinforced concrete decreases as the percentage of fibers in it increases. So, it is recommended that 2% of basalt fibers can be added to the concrete for effective strength. So the usage of 2% basalt fibers in concrete shows significant increase in strength of the concrete especially in flexural and impact strength.

Parvez Imraan Amari and et.al, [5] researched on the compressive strength and split tensile strength of concrete cubes and cylinders with and without basalt fibre. They made using each grade of concrete as normal concrete and basalt concrete (M20&M30) and basalt fibre is mixed in the proportions of 0.5%,1%,1.5%. The test was carried out at 28, 56, 90 days. According to the test results specimens having 1% basalt fibre show maximum value of compressive and split tensile strength when compared with plane concrete mix proportion.

EXPERIMENTAL WORK

TESTS ON CEMENT

The cement used is ordinary Portland cement (OPC 53) confirming to IS: 12269-1987. The KCP OPC 53 grade is used in experimental work. The physical properties of the cement are tested in accordance with IS: 4031-1988.

S.No	Description of test	Test result	Permissible limits
1.	Specific Gravity	3.09	3.15
2.	Fineness	7.8%	Should not exceed 10% residue on 90 micron sieve(max)
3.	Standard consistency	33%	Minimum 23 % till obtaining viscous paste
4.	Initial Setting time	30 min	Should not be less than 30 minutes
5.	Final setting time	275 min	Maximum 600 minutes

TESTS ON FINE AGGREGATE

Fine aggregate should pass through I.S. sieve 4.75 mm. Standard coarse sand is to be from river origin. According to IS 383-1970, fine aggregate used in this present study confirms to zone – II classification.

S. No	Property	Test Results	Standard Limits	IS Standard Testing Code
1	S Specific gravity (Fine aggregate) Zone II Sand	2.5019	> 2.5	IS 2386-1963] Part III
2	Fineness modulus of Fine aggregates	2.58	2.6-3.2 (Coarse Sand)	IS 2386-1963 Part III
3	Bulk Densityin Fineaggregates	1.49	1.5 ~ 1.7	IS 2386-1963 Part III
4	Water absorption	0.47	(0.5- 1) %	IS 2386-1963 Part III
Type ofFineaggregates - Natural riversand Result – The properties of the fine aggregates tested lie within the Indian standard limits and are considered to be suitable for production of concrete since the properties come under ZONE II category				

NATURAL COARSE AGGREGATES

Aggregate which retained on 4.75 mm sieve and the broken stone is generally used as a Coarse aggregates. The nature of work decides the maximum size of the coarse aggregates. Locally available coarse aggregates having the maximum size 20 mm and minimum size 10 mm was used in the present work.

Several laboratory testing will be carried out and compared to the standard requirements as per IS: 2386-1963 has grouped the test methods for aggregates into different parts

S.No	Property	Test Results	Permissible Limit	IS Standard Testing Code
1	Specific gravity	For 20mm-2.80 For 10mm-2.68	2.5 to 3.0	IS 2383-1986
2	Water Absorption	For 20 mm-0.3 For 10 mm-0.60	Not more than 0.6 %	IS 2383-1986
3	Bulk density (kg/m^3)	1738	1520 to 1680 kg/m^3	IS 2383-1986
4	Flakiness Index %	11.3%	Not more than 15 %	IS 2383-1963 Part 1
5	El Elongation Index	18.9%	Not more than 15 %	IS 2383-1963 Part 1
6	Aggregate Impact Value	28.6%	Not more than 30%	IS 2383-1963 Part 1
7	Aggregate Crushing Value	26.459%	Not more than 30%	IS 2383-1963 Part 1
8	Fineness modulus	6.27	-	IS 2383-1963 Part 1

Mix design for M30 grade concrete with basalt fibre, NS &MS

Components for concrete mix (Kg/m^3)	BF CONTENT				
	0%	0.1%	0.2%	0.3%	0.4%
Cement(C) (Kg/m^3)	315	315	315	315	315
MS(8%C) (Kg/m^3)	28	28	28	28	28
NS(2%C) (Kg/m^3)	7	7	7	7	7
Fine aggregate (Kg/m^3)	715.01	715.01	715.01	715.01	715.01
Coarse aggregates (Kg/m^3)	1235.90	1235.90	1235.90	1235.90	1235.90
w/c	0.45	0.45	0.45	0.45	0.45
Water content (Kg/m^3)	157.5	157.5	157.5	157.5	157.5
BF (Kg/m^3)	0	2.45	4.91	7.37	9.83

Total number of cubes to be casted

Number of days	% volume of basalt					Total
	0%	0.1%	0.2%	0.3%	0.4%	
7days	3	3	3	3	3	15
28days	3	3	3	3	3	15
Grand total						30

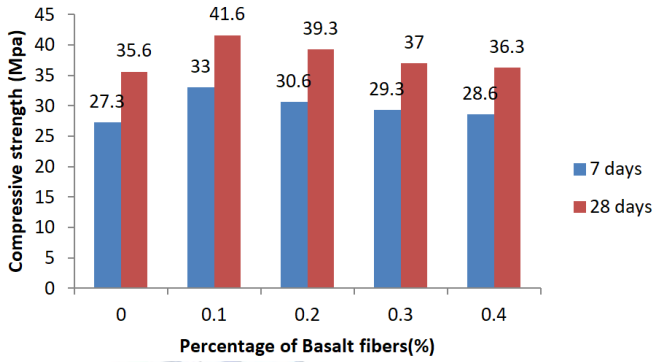
Total number of cylinders to be casted

Number of days	% volume of basalt					Total
	0%	0.1%	0.2%	0.3%	0.4%	
7days	3	3	3	3	3	15
28days	3	3	3	3	3	15
Grand total						30

RESULTS AND DISCUSSIONS

Compressive strength of M30 grade concrete with basalt fibre

S.NO	% replacement of basalt fibers	Compressive strength (MPa)	
		7 days	28 days
1	0	27.3	35.6
2	0.1	33	41.6
3	0.2	30.6	39.3
4	0.3	29.3	37
5	0.4	28.6	36.3



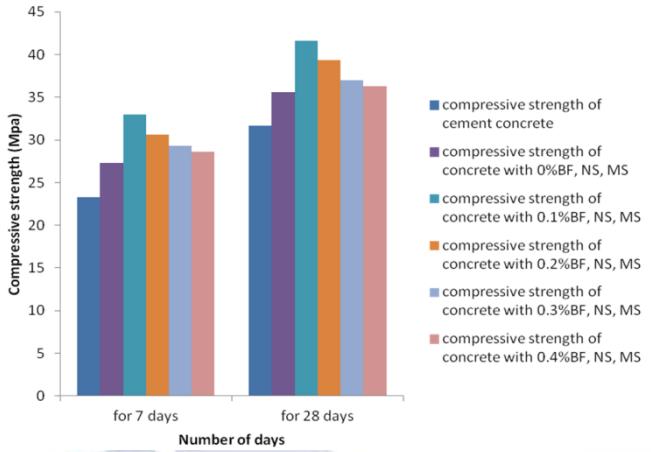
Graph representing compressive strength vs. percentage of Basalt fibers

From the above figure 16, we can observe that with the increase in basalt fiber content the compressive strength goes on decreasing. The maximum compressive strength value is obtained when the specimen is made of 0.1% basalt fibers and containing nano silica (2% cement), micro silica (8%cement)

Comparison of compressive strength values between cement concrete and Basalt fiber reinforced concrete with nano and micro silica

comparison of compressive strength values

Cement concrete		*Concrete with BF, NS, MS*	
7 days	*28 days*	*7 days*	*28 days*
23.33	*31.67*	27.3(0%BF)	35.6(0%BF)
23.33	*31.67*	33(0.1%BF)	41.6(0.1%BF)
23.33	*31.67*	30.6(0.2%BF)	39.3(0.2%BF)
23.33	*31.67*	29.3(0.3%BF)	37(0.3%BF)
23.33	*31.67*	28.6(0.4%BF)	36.3(0.4%BF)

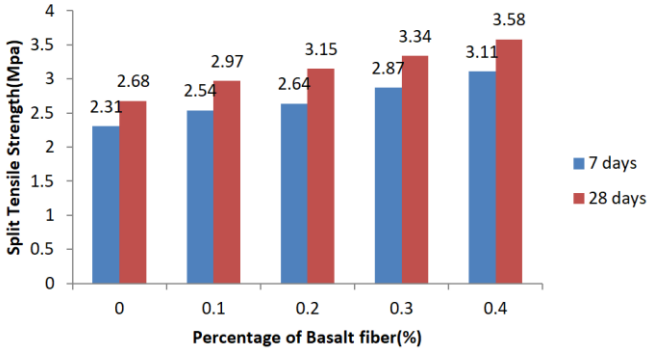


Graph showing comparison between cement concrete and basalt fibre (varying percentages) reinforced concrete containing NS and MS in terms of compressive strength

From the above figure 17, we can observe that the compressive strength for basalt fiber reinforced concrete containing nano and micro silica is higher when compared with cement concrete.

Split tensile strength of M30 grade concrete with basalt fibre

S.NO	% replacement of basalt fibers	Split Tensile strength (MPa)	
		7 days	28 days
1	0	2.31	2.68
2	0.1	2.54	2.97
3	0.2	2.64	3.15
4	0.3	2.87	3.34
5	0.4	3.11	3.58



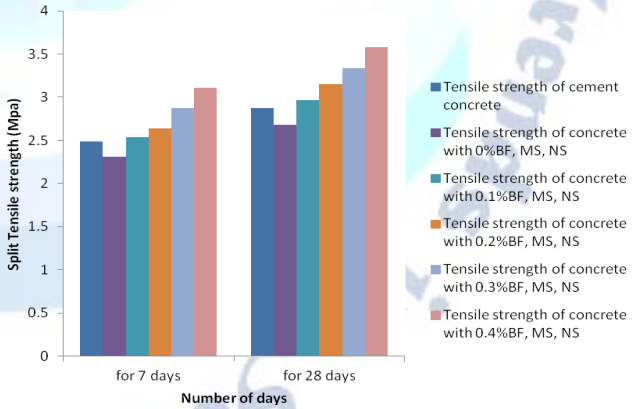
Graph representing split tensile strength vs. Percentage of basalt fibres.

From the above figure 18, we can say that the tensile strength increases with increase in basalt fibres.

Comparison of split tensile strength values between cement concrete and Basalt fiber reinforced concrete with nano and micro silica

Comparison of tensile strength values

Cement concrete		*Concrete with BF, NS, MS*	
7 days	*28 days*	*7 days*	*28 days*
2.49	*2.87*	2.31 (0%BF)	2.68(0%BF)
2.49	*2.87*	2.54(0.1%BF)	2.97(0.1%BF)
2.49	*2.87*	2.64(0.2%BF)	3.15(0.2%BF)
2.49	*2.87*	2.87(0.3%BF)	3.34(0.3%BF)
2.49	*2.87*	3.11(0.4%BF)	3.58(0.4%BF)



Graph showing comparison between cement concrete and basalt fibre (varying percentages) reinforced concrete containing NS and MS in terms of split tensile strength

From figure 19, we can observe that adding basalt fibres to concrete improves the tensile strength significantly.

CONCLUSIONS

From the research following conclusions were obtained:

1. Compressive strength of basalt fibre reinforced concrete containing micro silica and nano silica specimens were higher than cement concrete specimens at all the ages.
2. Split tensile strength for concrete specimens containing 2% nano silica and 8% micro silica with 0% basalt fibres it is observed that there is decrease in split tensile strength when compared to control concrete specimen.
3. With the increase in basalt fibre proportions of (0.1%, 0.2%, 0.3%, 0.4%) it is observed that split tensile strength goes on increasing and compression strength goes on decreasing at all ages.
4. The compressive strength difference between basalt fibre reinforced concrete containing nano and micro silica specimens and cement concrete specimens became high distinct in the beginning age of curing itself.
5. Compressive strength increases by 11% in the specimens containing 0% basalt fibres with micro silica (8%cement) and nano silica (2%cement) when compared to cement concrete.
6. Compressive strength increases by 24% and tensile strength increases by 3% in of specimens containing 0.1 % basalt fibres with micro silica (8%cement) and nano silica (2%cement) when compared to cement concrete.
7. There is 20% increase in the tensile strength and 12% increase in compressive strength of specimens containing 0.4% basalt fibres with micro silica (8%cement) and nano silica (2%cement) when compared to cement concrete.
8. When specimens containing only micro silica (8%cement) and nano silica (2%cement) there is 11% increase in compressive strength and 7% decrease in tensile strength when compared to cement concrete.

REFERENCES

[1] 1. M. Nili, A. Ehsani and K. Shabani, "Influence of Nano-SiO2 and Micro silica on Concrete Performance", Second International Conference on Sustainable Construction materials and Technologies , 2010.

[2] Dr. D. V. Prasada Rao, U. Anil Kumar "An experimental investigation on strength properties of concrete containing micro-silica and nano- silica", IJCIET, Volume 5, Issue 8, pp. 89-97 , August 2014.

[3] Fathima Irine I .A, "Strength Aspects of Basalt Fiber Reinforced Concrete", International Journal of Innovative Research in Advanced Engineering (IJIRAE), Volume 1, Issue 8, September 2014 .

[4] Sangamesh upasi, Sunil kumar .H.S, Manjunatha. H, Dr.K.B.Prakash, "An Investigation on Strength characteristics of basalt fibre reinforced concrete", International journal of Engineering Research-Online, Vol.2., Issue.5, 2014.

[5] Parvez Imraan Ansari, Rajiv Chandak, "Strength of Concrete Containing Basalt Fibre" , Parvez Imraan Ansari Int. Journal of Engineering Research and Applications, Vol. 5, Issue 4, (Part -6), pp.13-17, April 2015.

[6] Urkhanova Larisaa, Lkhasaranov Solbona, Buiantuev Sergeib, "Fiber-reinforced concrete with mineral fibers and nanosilica", 18th International Conference on Rehabilitation and Reconstruction of Buildings 2016, CRRB 2016,

[7] A.Ranjani, K.Keerthana, N.K.Amudhavalli, "Study on effect of micro silica and nano silica in polyester fibre reinforced concrete", IRJET volume 3, issue 4, April -2016.

[8] Maria Wlodarczyka, Igor Jedrzejewskia, "Concrete slabs strengthened with basalt fibres – experimental tests results", XXV Polish – Russian – Slovak Seminar on Theoretical Foundation of Civil Engineering, 2016.

[9] Mr.Gore ketan R, Prof. Suhasini M.Kulkarni, "The Performance of basalt fibre in high strength concrete", Journal of information, knowledge and research in civil engineering, Volume 2, Issue2, pp-117-124, 2013.

[10] Joshi A. A., Dr. Rangari S. M., and Shitole A. D, "The use of Basalt Fibers to improve the Flexural Strength of Concrete Beam", International Journal of Innovative Science, Engineering & Technology (IJISET), Vol. 1 Issue 10, pp-612-614, December 2014.

[11] Nayan Rathod, Mukund Gonbare, Mallikarjun Pujari, "Basalt Fiber Reinforced Concrete", International Journal of Science and Research (IJSR), Volume 4, Issue 5, pp-359-361, May 2015.

[12] S. Tanveer Hussain, K.V.S.Gopala Krishna Sastry, "Study of strength properties of concrete by using micro silica and nano silica", International Journal of Research in Engineering and Technology (IJRET), Volume: 03, Issue: 10, pp-103-108, Oct 2014.

[13] Panditi venkata , lakshnmi neeharika, bhuvanagari sreenu, "Experimental evaluation of nano composite concrete" , International Journal of Advanced Scientific Technologies in Engineering and Management Sciences (IJASTEMS),Volume.2, Issue.12, pp-25-31, December.2016.

[14] Mahdi koohdaragh, Hamed Hajkhan Mohamadi , "Comparison of Mechanical of the Concrete Samples Containing Micro-Silica and Nano-Silica", Australian Journal of Basic and Applied Sciences, Volume 5, pp-560-563, 2011.

[15] Arivalagan.S., "Study On the Compressive and Split Tensile Strength Properties of Basalt Fibre Concrete Members",Global Journal of Researches in Engineering Civil And Structural Engineering, Volume 12, pp-23-28, 2012.

[16] IS: 516-1959, Indian standard Methods of Tests for Strength of concrete, Bureau of Indian Standards, New Delhi, India.