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Studies On Behaviour Of Concrete Using Micro And Nano Materials In Compression Flexure Shear And Torsion

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ABSTRACT: Concrete ranks second in human consumption after water. Every building uses it. Cement manufacture uses a lot of energy and emits a lot of CO_2. As a consequence, many researchers have studied several material combinations to limit carbon dioxide emissions and energy dissipation, which pollute the environment and destroy the ecosystem. Microsilica, GGBS (slag), and nanosilica were employed as mineral admixtures to partly replace cement by weight in this investigation. This research examined concrete behaviour with varying particle sizes and percentage replacements. Steel and iron industry waste like microsilica and GGBS harms the environment. Microsilica and GGBS promote concrete reinforcement via pozzolanic reactions due to their cementitious characteristics. These reactions reinforce concrete with lime and silica. When cement is mixed with water, C-S-H gel and $Ca(OH)_2$ develop, which reinforces concrete when combined with silica. This process reduces concrete's calcium concentration. Experimental mechanical property investigation comprises compressive, flexural, shear, and torsional strength. The above experiments identify micro silica, GGBS, and nanosilica particle sizes for various percentage replacements. Tables and graphs show system behaviour with varying percentage replacements.

Keywords: Microsilica, GGBS (slag), Nanosilica, C-S-H gel, Compressive, Flexural, Shear, And Torsional Strength.

1. INTRODUCTIONS

Concrete and steel have greatly impacted civilization's development and progress as building materials for infrastructure. This practice has had a tremendous impact on the progression of civilisation throughout the course of history. Additionally, the consumption of concrete on a worldwide scale is second only to that of water; hence, concrete has the distinguished position of being the building material that is used for construction purposes the most often after water. The amount of concrete produced annually worldwide is believed to be around one cubic metre for each and every human being is believed to be around one cubic metre for each and every human being that is now living on the planet [01].

One of the most well-known authorities in the field of cement and concrete, Brunauer and Copeland, wrote an article for Scientific American in 1964 that included the following statement: "The most widely used construction material is concrete, which is commonly made by mixing Portland cement with sand, crushed rock, and water. " Brunauer and Copeland are two of the most well-known experts in the field of cement and concrete. "Brunauer and Copeland are two of the most well-known and respected professionals in the area of concrete and cement. Inside the boundaries of the United States of America, 63 million tonnes of Portland cement were converted into 500 million tonnes of concrete in the year 2005. This transformation took place. When expressed in terms of weight, the transformation is equivalent to five times the amount of steel that was used in the project. More than ten to one is the ratio of concrete consumption to steel consumption in the majority of nations. Concrete consumption is higher than steel consumption. By 2005, global concrete

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use had reached about three billion tonnes. This number equates to approximately one tonne for every living human on Earth. Humans only consume water in such large quantities; they don't consume anything else. Compared to forty years ago, the current amount of concrete used is significantly greater than it was at that time. It is estimated that the quantity of concrete that is now being used all over the globe is somewhere in the neighbourhood of 11 billion metric tonnes on a yearly basis [01]. In order to determine whether or not it is feasible to make use of industrial byproducts, namely GGBS, microsilica, and nanosilica, the objective of this research project is to carry out an experimental investigation into the situation. As part of the study that has been planned, this inquiry is now being carried out. In order to provide experimental data for the manufacturing of cement concrete, it is advised to make use of a broad variety of combinations of GGBS, microsilica, and nanosilica. This is because these three types of silica are all components of cement concrete. These combinations will be used in order to create data for a broad variety of factors and characteristics that have an effect on the manufacture of cement concrete. These elements and qualities include cubes and prisms of this material. A number of the mechanical characteristics of concrete, such as its compressive strength, flexural strength, shear strength, and torsional strength, are now being explored via the use of analytical methods. All of these qualities are being examined. In order to greatly increase the utilisation of GGBS, microsilica, and nanosilica among workers in the construction sector, this study was carried out with the primary purpose of achieving this goal. In the process of putting into action the experimental programme that is now being created, there are a number of particular goals that are expected to be accomplished, including the following:

2. MATERIAL AND METHODOLOGY

Researchers must incorporate the literature review as an essential component in every research effort they undertake today. The purpose of the literature review is to facilitate the identification of themes and the scope for more research in the subject matter that is being addressed, as well as to arrive at a conclusion on the aims of the current study.

It is going to be the results of the literature review that will be utilised to choose the topic matter of this inquiry, as well as the subsequent method that will be followed to select the materials that will be employed in the study that will come after that. Consequently, it is of the highest significance to have a firm grasp of the essential technical qualities of the materials to identify whether or not the materials meet the acceptance requirements for the purpose that they are developed for. This chapter's study assigns characteristics to the materials used in the inquiry. The research that is detailed in this chapter is concerned with the assignment of characteristics.

- Ground Granulated Blast Furnace Slag (GGBS)
- Microsilica (MS/ms)
- Nanosilica (NS/ns)
- Ordinary Portland Cement (OPC)
- Fine Aggregates- Natural River Sand
- Coarse Aggregate-Crushed Stone
- Water

Table 1: Physical Properties of GGBS

Specific gravity	Bulk density(kg/m$^{3)}$	Surface area m^2/kg	Insoluble residue (%)	Loss on ignition (%)	Moisture content (%)
2.90	1220	416	0.14	0.19	0.14

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Table 2: Physical Properties of Microsilica

Particulars	Microsilica
Specific gravity	2.27
Surface area m^2/kg	20000
Particle size micrometer	<1
Bulk density kg/m^3	187.91
Loss on ignition (%)	1.92
PH	7.90

Table 3: Physical Properties of Nanosilica

Particulars	Nanosilica
Specific gravity	2.2-2.5
Surface area m^2/gm	210
Particle size in nm	5-14
Bulk density kg/m^3	-
Loss on ignition (%)	0.67
PH	4.1

Table 4: Analysis of Particle Size of Cement

Particle size in micrometer			
<25	25-45	45-90	90-150
81.60	15.98	2.42	0.00

Specific gravity	Trail 1	Trail 2	Trail 3	Average
Cement	3.12	3.00	3.15	3.09

Table 5: Physical Properties of River Sand

Sl no	Description	River sand
1	Specific gravity	2.57
2	Bulk density(loose)kg/m^3	1480
3	Bulk density(compacted)kg/m^3	1695
4	Fineness modulus	2.45
5	Grading zone	II

3. RESULTS AND DISCUSSIONS

The study of concrete's strength under compression is becoming increasingly popular. The ability of a material to withstand stress refers to the amount of stress that must be applied for it to fail. One of the organisations that came up with the concept of strength was the American Society of Mechanical Engineers. In addition, the concrete has a wide range of other characteristics, each of which includes flexure, shear, and torsion, among others. In addition to the fundamental features, these properties are also present. Because the compressive strength of concrete is used as the basis

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for establishing the other strengths of the material, the precise measurement of compressive strength becomes the most essential difficulty [01]. This difficulty is because the compressive strength of concrete is utilised as the foundation.

3.1 Compressive Strength For Control Mix

In order to ascertain the quality of concrete of the M 20 grade, cubes were cast and examined after 7, 14, 21, and 28 days without any admixtures being added to the mixture. The testing was done in order to determine the quality of the concrete.

Table 6: Compressive Strength for Control Mix

Sl. No.	PARTICULARS	7 DAYS	14 DAYS	21 DAYS	28 DAYS
01	COMPRESSIVE STRENGTH IN MPa	14.65	18.40	21.75	25.90

Effect on Compressive Strength at Microsilica

This means that the compressive strength of a material is about 22.2 megapascals at 14, 21 megapascals at 21, and 34.5 megapascals after 28 days when the thickness of the material is less than 20 micrometres. The compressive strength of a material is significantly increased when the particle size is less than 20 micrometres, in comparison to the compressive strength of other particle sizes. In contrast, this is not the case with particles of various sizes. During the course of the research, it was found that particles with a size range of 125-250 µm demonstrated the lowest value, which ranged from 17.7 to 26.9 MPa. This value was found out as the particles were being measured, which is when it was taken into consideration. When compared to particles with a size range of 125 to 250 µm, particles with a size of less than 20 µm display a 28-day improvement in compressive strength that is 28% more than the previously described particles. When the two distinct types of particles are compared to one another, it is feasible to identify this. Based on the compressive strength values that were acquired for different percentages of the mixes, it has been observed that the strength values for particles with a size that is smaller than 20 µm have been found to be larger. This was discovered during the process of analysing the compressive strength values. As a result of this discovery, the results that were acquired were taken into consideration. When compared to the control mix, it has been shown that the percentage improvement in strength is 33% greater when the particle size is found to be less than 20µm. According to the comparison, this is the case.

Table 7: Compressive Strength on Microsilica

Sl.No	Particle Size(µm) of microsilica in the range	Compressive Strength(MPa)			
		7 days	14 days	21 days	28 days
Compressive strength for control mix		14.65	18.40	21.75	25.90
1	<20	17.80	22.20	31.20	34.50
2	20-45	16.50	20.40	28.70	32.50
3	45-90	15.60	19.20	27.10	30.60
4	90-125	15.10	18.60	25.90	29.30
5	125-250	14.70	17.70	23.80	26.90

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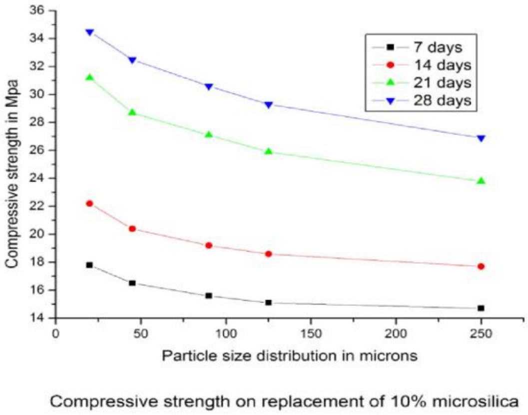

Figure 1: Compressive Strength on Microsilica

Effect on Flexural Strength at Microsilica

The graph is something that can be seen. It has been discovered that the flexural strength of particles with a size range of 125-250 µm is 1.72 MPa after seven days have passed. With regard to particles with a size range of less than 20 µm, it is worth noting that the highest value of 3.10 MPa is recorded for these particles. When particles with a size that is less than 20µm are compared to particles with a size that spans from 125 to 250µm, there is a 44% rise in the improvement in flexural strength from the former to the latter. The flexural strength of particles with a size that is less than twenty micrometres is 3.82 megapascals on the fourteenth day, 4.67 megapascals on the twenty-first day, and 5.31 megapascals on the twenty-eighth day. The values that were recorded for particles with a size range from 125 to 250 µm were determined to be the lowest, with 1.96, 2.05, and 2.18 MPa, respectively.

Table 8: Flexural strength on replacement of 10% Microsilica

Sl.No	Particle Size(µm) of microsilica in the range	Flexural Strength(MPa)			
		7 days	14 days	21 days	28 days
Control mix		1.63	1.74	1.81	1.89
1	<20	3.1	3.82	4.67	5.31
2	20-45	2.71	3.1	3.7	4.35
3	45-90	2.12	2.56	3.1	3.59
4	90-125	1.93	2.21	2.79	3.12
5	125-250	1.72	1.96	2.05	2.18

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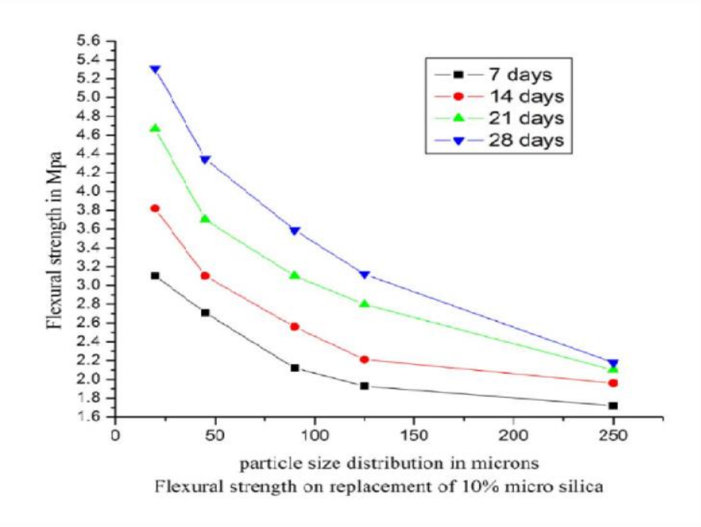

Figure 2: Flexural Strength on Microsilica

Effect on Shear Strength Microsilica

The shear strength value for 125-250 µm is found to be 0.68 MPa over the course of seven days, whereas the shear strength value for less than 20 µm is found to be 1.5 MPa across the same period of time. The proportion has increased by a factor of 55% from the last occurrence. The graph demonstrates that there is a consistent rise in the strength throughout the remaining days of the testing, as can be observed in the analysis. It is anticipated that this pattern will continue. When the 28-day mark arrives, the strength range for individuals with 125-250 µm is 1.12 MPa, but the strength range for those with less than 20 µm is 2.6 MPa, to be precise. The shear strength values that were acquired for a certain range of particles are significantly different from the values that were obtained for the control mix.

Table 9: Shear strength on Microsilica

Sl.No	Particle Size(µm) of microsilica in the range	Shear Strength(MPa)			
		7 days	14 days	21 days	28 days
Control mix		0.61	0.73	0.93	1.08
1	<20	1.50	1.92	2.14	2.60
2	20-45	1.27	1.64	1.86	2.17
3	45-90	1.05	1.28	1.57	1.81
4	90-125	0.92	1.12	1.41	1.60
5	125-250	0.68	0.84	1.01	1.12

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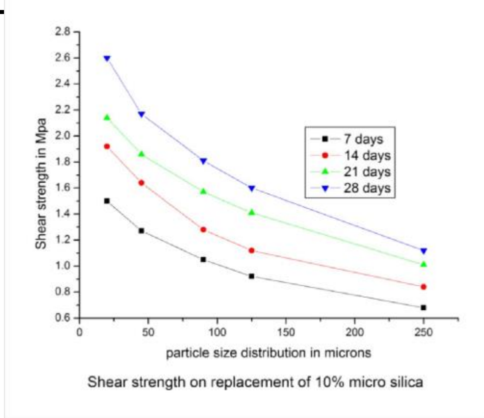

Figure 3: Shear strength on Microsilica

Effect on Torsional Strength of Microsilica

Furthermore, it is evident from both the table and the graph that the maximum torsional strength is recorded at a replacement level of thirty percent. This is the case. It is possible to see that this is the highest possible value. According to the findings, the following values were obtained for the different particle sizes: 1.88, 1.98, 2.02, 2.11, and 2.19 kilonewtons per metre. The range of these values is from 125 to 250 micrometres, with a minimum of 20 micrometres. A comparison is made between the control mix and the particles with a size smaller than 20µm, and it is shown that the percentage increase in torsional strength after 28 days is 22% for the particles with the smaller size. For particles with a size that falls between 125 and 250µm, on the other hand, the increase tends to be practically identical to that of the control mix. This is because particles with this size range tend to have a smaller size.

Table 10: Torsional Strength on replacement of Microsilica

Sl no	Particle Size(µm) of microsilica in the range	Torsional Strength in KN-m at 28 days			
Torsional strength for Control mix		1.80 KN-m			
Percentage replacement		10%	20%	30%	40%
1	<20	2.1	2.17	2.19	1.90
2	20-45	2.03	2.09	2.11	1.85
3	45-90	1.96	1.99	2.02	1.77
4	90-125	1.92	1.94	1.98	1.76
5	125-250	1.83	1.85	1.88	1.72

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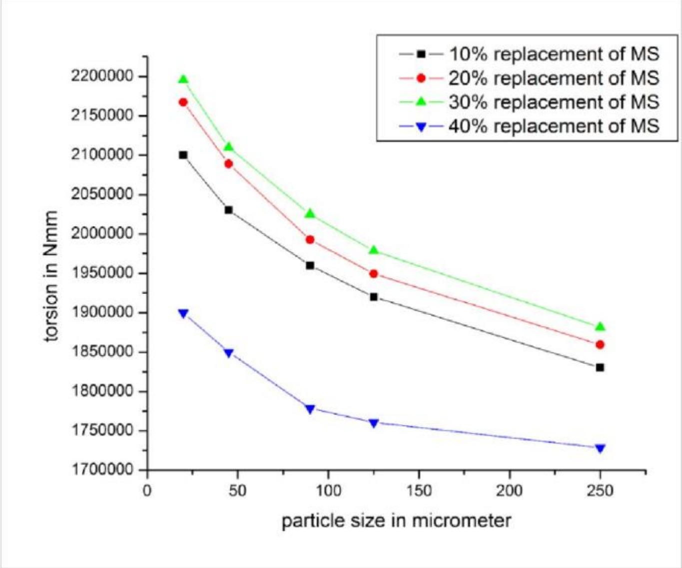

Figure 4: Torsional Strength on replacement of Microsilica

4. CONCLUSIONS

- Compressive strength is best with 20% microsilica cement. Maximum strength occurs at particle sizes < 20 µm due to increased pozzolanic reaction surface area. Compared to the control mix, compressive strength increases by 43% for <20 µm particles to 36.9 MPa but only 10% for 125-250 µm particles.
- The ideal compressive strength is 43.3 MPa at a <20 µm particle size with 4% NS + 20% MS substitutions. The percentage increase above the control mix is 67% for <20 µm and 21% for 125-250 µm. If dispersed properly, nanosilica in concrete mixes plugs cement capillary pores and has a high specific surface area, boosting pozzolanic reactivity in cement hydration and making the concrete more firm and compact.
- Insufficient pozzolanic reaction surface area, particle size, and concrete matrix nanoparticle dispersion weaken other replacement levels.
- Samples with varied doses and particle sizes showed lower strength after 28 days compared to 20% microsilica replacement with < 20 µm particles. Using bigger particle sizes (125-250 µm to 90-45 µm) for reactions may reduce surface area and increase matrix voids.
- In concrete, analytical microsilica replaces 20% of flexure and shear (4% NS + 20% MS) and 30% of torsional strength.
- Torsional strength is maximum at 30% MS, whereas flexure and shear strength are best with 4% NS and 20% MS replacements (Analytical).

REFERENCES

[1] P.Kumar Mehta, Paulo J.M and Monteiro “Concrete – Microstructure, Properties and Materials” 2006, McGraw Hill Publications.

[2] Terence .C.Holland “Silica fume users Manual” Federal Highway Administration ,2005.

[3] R.Siddique and M. Iqbal Khan “Silica fume” supplementary cementing materials, Engineering materials, 2011, Springer PP 67-119.

[4] R. Siddique “Ground granulated blast furnace slag” waste Materials and by-products in concrete, Springer, 2008.

[5] V.S. Ramachandran and James ,J. Beaudoin “Hand book of Analytical Techniques in concrete Science and Technology” 2000, National Research Council ,Ottawa,Canada.

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AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
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ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

[6] Santanu Bhanja and Bratish Sengupta "optimum silica fume Content and its mode of action on concrete" ACI material journal V100 NO 5, 2003, PP 407-412.

[7] Byung-Wan jo, Chang-Hyun Kim and Jae-HoonLim "Characteristics of Cement mortar with nano-Sio_2 particles" ACI materials journal, 2007, 104, PP 404-407

[8] BLP Swami, P. SrinivasRao, PSS Narayana "Studies on cement Replacement in concretes by microsilica 920-D" our world in Concrete and structures 2005.

[9] Verma Ajay, Chandak Rajeev and Yadav R.K "effect of microsilica On the strength of concrete with ordinary Portland cement". Research journal of engineering sciences 2012.

[10] K.Permmal, R.Sundarajan "Effect of partial replacement of cement with silicafume on the strength and durability characteristics of high performance concrete" 29^{th} conference on one world in concrete and structures 2004.

[11] G. AppaRao "Role of water-binder ratio on the strength Development in mortars incorporated with silicafume". Cement and concrete research, 2001, 31, PP 443-447.

[12] Davoud Tavakoli, Ali Heidari "Properties of concrete incorporating Silica fume and nano-Sio_2" Indian journal of science and Technology" 2013, vol 6, pp 108-112.

[13] R.Duval and E.H. Kadri "influence of silica fume on the workability and the compressive strength of high performance concretes" Cement and concrete research 1998, 28, PP 533-547.

[14] SayedAbdel-Baky, Sameh Yehia and Ibrahim S Khalil "influence of Nano-silica addition on properties of fresh and hardened cement Mortar", NANOCON, 2013, Czeh republic.

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