

An Experimental Investigation on Concrete with Nano Silica and Partial Replacement of Cement with Flyash

S. Reshma¹, Dr.S.Siddirajulu²

¹ PG student, Department of Civil Engineering, Siddharth Institute of Engineering & Technology

²Professor, Department of Civil Engineering, Siddharth Institute of Engineering & Technology

Abstract: The main aim of this study is that in order to improve the performance of the concrete in construction site different technologies are adopted. Therefore the combination of partial replacement of fly ash and Nano Silica are used in the present project in order to determine the compressive strength, split tensile strength, flexural strength and young's modulus of elasticity and that should be compared to controlled concrete. To improve the performance of further, Nano materials are also now being introduced as supplementary materials. Hence concrete fly ash and Nano silica is used as partial replacement with controlled concrete of M20 grade. In the present study, the cement is replaced by 20% and 30% of fly ash and Nano silica 1.5%, 3% and 4.5% by weight is determined with M20 grade. Similarly different tests are conducted which are stated above. Hence the results are compared with both the materials. Therefore from the tests conducted it has been concluded that the concrete prepared with 20% Fly ash and 3% Nano silica combination possess improved properties compared to controlled concrete.

Keywords: Concrete, Nano silica, Fly ash class F

1. Introduction

Concrete plays the vital role in the construction process. By using the partial replacement of cement with different admixtures the unit cost of the concrete is decreased. But the production of cement consumes large amount of energy and emits carbon dioxide which cause environmental pollution. Hence in order to improve the performance of concrete Nano silica is used as supplementary material which is a highly reactive amorphous material. The performance of Nano silica is more effective due to its small size and high surface area when compared to the other pozzolona materials.

2. Experimental Investigation

Materials Used:

Cement: For this project opc 43 grade cement was used.

Cement Properties

S.NO	Cement properties	Readings
1	Specific Gravity	3.15
2	Normal Consistency	34 %
3	Setting Time	
	i) Initial Setting time	42mins
	ii) Final setting time	6hrs 30min

FLYASH:

In the present project Class fly ash was used and properties were obtained as follows.

Fly Ash Properties

S.No.	Ingredient	Value
1	Silica	56.88 %
2	Aluminium trioxide	27.65 %
3	Ferric oxide	6.28 %
4	Titanium dioxide	0.31 %
5	Calcium oxide	3.6 %
6	Magnesium oxide	0.34 %
7	Sulphate	0.27 %
8	Loss of ignition	4.46 %
9	Specific gravity of Fly Ash	2.12

NANO SILICA

Nano silica is a fine amorphous material which is better than the pozzolanic materials. It is generally available in the form of emulsion of colloidal silica. By using Nano silica the cement content may be reduced and also it prevents in early cracking of concrete in the pavement structure. Nano silica improves the micro structure and makes concrete more impermeable and more durable. As it produces a dense concrete, compressive strength is increased. In addition, it reduces segregation and bleeding.

WATER

Generally water is used for mixing the concrete. In most of the cases the water which is free from impurities is used in construction site otherwise it adversely influences the strength of the concrete. The potable water which is used for drinking may also be used in site in some cases.

Mix Design for M20 Grade Concrete

Mix Proportions for M20 Grade Concrete

S.No	Cement (%)	Fly Ash (%)	Nano-Silica (%)	Water (lit)	Cement (kg)	Fly Ash (kg)	Colloidal Nano-Silica (kg)	Fine Aggregate (kg)	Coarse Aggregate (kg)
1	100	0	0	165	300	0	0	734	1243
2	80	20	0	165	240	60	0	734	1243
3	78.5	20	1.5	158.25	235.5	60	11.25	734	1243
4	77	20	3	151.50	231	60	22.5	734	1243
5	75.5	20	4.5	144.75	226.5	60	33.75	734	1243
6	70	30	0	165	210	90	0	734	1243
7	68.5	30	1.5	158.25	205.5	90	11.25	734	1243
8	67	30	3	151.50	201	90	22.5	734	1243
9	65.5	30	4.5	144.75	196.5	90	33.75	734	1243

Concrete cube of size 150X150X150mm³ were tested at different stages in order to get the compressive strength, split tensile strength, flexural strength and modulus of elasticity

For M20 grade concrete the compressive strength of cube is calculated with various proportional of fly ash and nano silica at different ages such as 3, 7, 28, 56 days. From the graph we can conclude that at 3% nano silica the compressive strength is increases at both 20 and 30% of fly ash. Later on addition of high quantity, the strength decreases gradually.

3. Tests and Results

Compressive strength of concrete

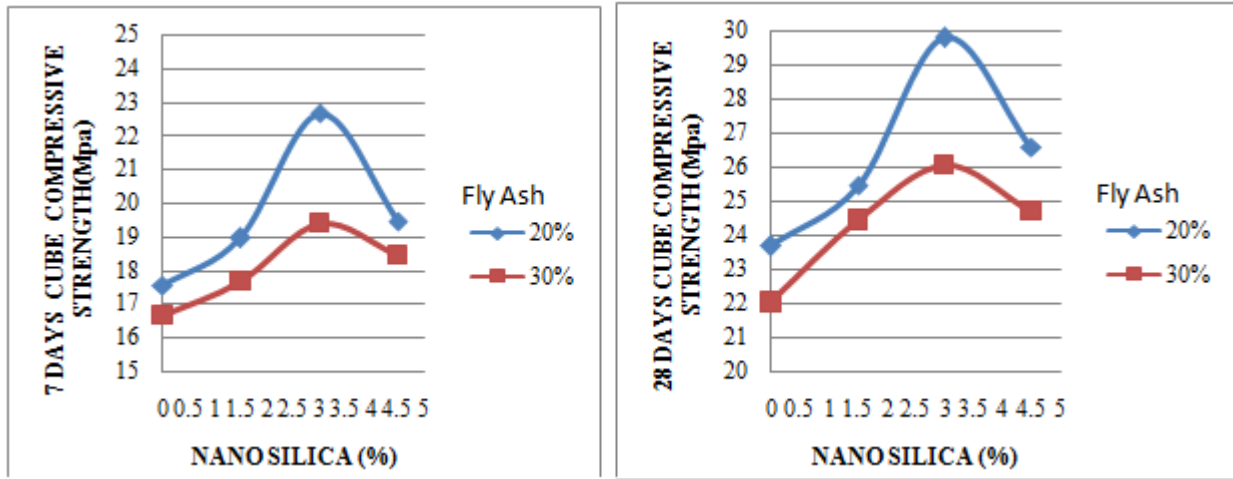


Figure: Compressive strength of M20 grade concrete with NS along with various percentages of fly ash

4. Split Tensile Strength

The test results of split tensile strength of M20 grade concrete with various proportions of fly ash and Nano-silica is shown in below Table. The split tensile strength of control concrete is 3.30 MPa. The split tensile strength of concrete initially increased up to 3% of Nano silica for the given percentage of fly ash and beyond which the split tensile strength decreases with increase in the nano-silica. It can also be observed that at a combination of 3% of nano-silica and 20% fly ash combination maximum split tensile strength can be obtained. The increase in split tensile strength of concrete with 3% nano-silica and 20% fly ash content is 3%.

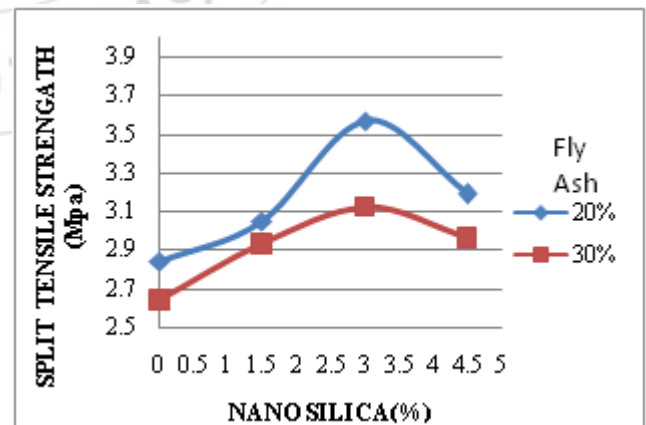


Figure: A graph between split tensile strength and percentage of nano silica and fly ash

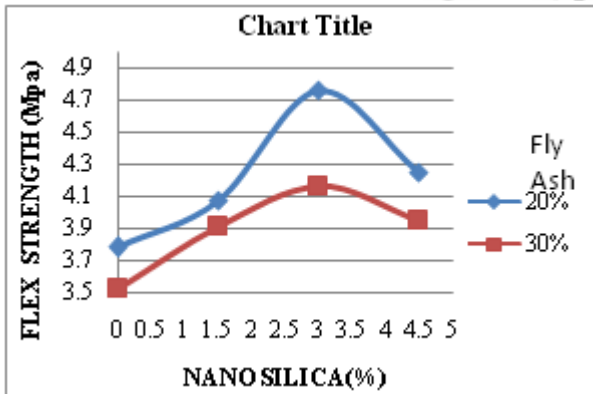
5. Flexural Strength

The test results of flexural strength of M20 grade concrete with various proportions of fly ash and nano-silica is shown in below table. The flexural strength of control concrete is

4.45 MPa. The variation of flexural strength of concrete initially increases up to 3% percentage of nano-silica for different percentage of fly ash and then with further increase in the nano-silica the flexural strength decreases. The increase in the flexural strength concrete with 3% nano-silica and 20% fly ash content compared to control concrete is 4.76%.

Flexural Strengths of M20 Grade of Concrete

Concrete Mix	FA (%)	Colloidal Nano Silica (%)	Flexural Strength (MPa)
			for 28 Days
Control Concrete	0	0	4.45
FA 20 % + NS 0 %	20	0	3.78
FA 20 % + NS 1.5 %	20	1.5	4.07
FA 20 % + NS 3 %	20	3	4.76
FA 20 % + NS 4.5 %	20	4.5	4.25
FA 30% + NS 0 %	30	0	3.52
FA 30 % + NS 1.5 %	30	1.5	3.91
FA 30% + NS 3%	30	3	4.16
FA 30% + NS 4.5 %	30	4.5	3.95



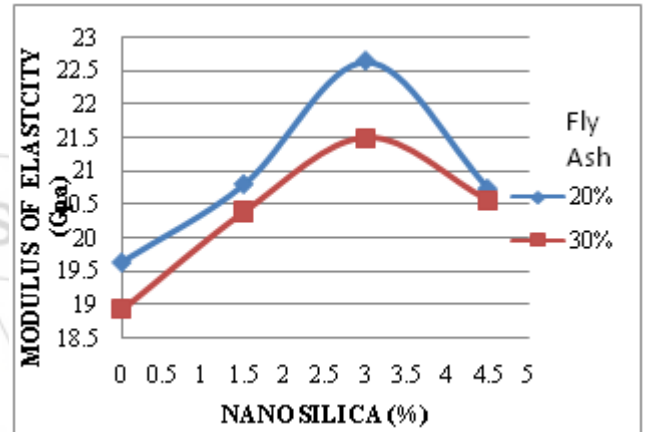
A graph between flexural strength and proportions of fly ash and nano silica

6. Modulus of Elasticity

The test results of modulus of elasticity of M20 grade concrete with various proportions of fly ash and nano-silica is shown in below table. . It can be observed that the modulus of elasticity of concrete increases with nano-silica for the given content of fly ash. The maximum value is obtained at 3% nano-silica for the given content fly ash. The M20 grade control concrete has modulus of elasticity of 21.42 GPa. The presence of 20% fly ash the modulus of elasticity is decreased to 19.64 GPa and with 30% fly ash the value is further decreased to 18.94 GPa. The modulus of elasticity of fly ash concrete increases in presence of nano-silica. The modulus of elasticity of M20 grade concrete attains maximum value at a combination of 3% nano-silica and 20% fly ash by weight of cement. The increase in the modulus of elasticity of concrete with 3% nano-silica and 20% fly ash content is 3.3%.

Modulus of Elasticity of M20 Grade of Concrete

Concrete Mix	FA (%)	Colloidal Nano Silica (%)	Modulus of Elasticity (GPa)
			for 28 Days
Control Concrete	0	0	21.42
FA 20 % + NS 0 %	20	0	19.64
FA 20 % + NS 1.5 %	20	1.5	20.81
FA 20 % + NS 3 %	20	3	22.65
FA 20 % + NS 4.5 %	20	4.5	20.74
FA 30% + NS 0 %	30	0	18.94
FA 30 % + NS 1.5 %	30	1.5	20.4
FA 30% + NS 3%	30	3	21.5
FA 30% + NS 4.5 %	30	4.5	20.56



7. Conclusions

From the results it can be conclude that by increasing the percentage of nano silica the different strength properties are increased up to 3%, more over beyond 3% the properties of concrete are decreased gradually

- By conducting the different tests it has been noted that M20 grade fly ash concrete with various percentages of nano-silica indicates the similar trend.
- Due to the high presence of nano silica and fly ash the characteristics strength of concrete is decreased by using more than 3% of content
- By the combination of 3% nano silica and 20% fly ash content in the concrete leads to the increase in different characteristics strength , from which we can conclude that the cement content can be reduced

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