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A Study on the Mechanical Properties of Concrete with Flyash and Nano-Silica

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Abstract

Concrete is the most common used material for construction and their design consumes almost the total cement production in the world. The use of large quantities of cement produces increasing CO_2 emissions and as a consequence the greenhouse effect. A method to reduce the cement content in concrete mixes is the use of Flyash and silica fines. One of the silica fines with high potential as cement replacement and as concrete additive is nano-silica (NS). This would save not only the natural resources and energy but also protect the environment with the reduction of waste material.

The present work deals with addition of Flyash and Nano-silica to concrete as partial replacement to cement in 10%, 20% & 30% and dosages of 1%, 1.5% and 2% respectively by weight of cement. Based on early research M20 grade concrete has been chosen for this work. The mix design was prepared using IS: 10262-2009 Guidelines for concrete mix design proportioning. In the present work 117 numbers of specimens were casted (78 numbers of cube moulds and 39 numbers of cylinder moulds) with addition of Flyash and Nano-silica in different proportions which are tested for compressive strength and split tensile strength. Addition of Nano-silica to normal cement concrete show increase in compressive strength and decrease in splitting tensile strength. SEM (Scanning Electron Microscope) analysis evidence the direct involvement of Flyash and Nano-silica in region of specimen.

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Keywords: *Nano-silica, Compressive strength, Split tensile strength, SEM (Scanning Electron Microscope)*

Objective of the Present Work

The objective of the present work is to find the influence of the application of Flyash and NanoSilica on various strength properties of M20 grade of concrete. 10%, 20% and 30% of Flyash and 1%, 1.5% and 2% of Nano-Silica gel are adopted as cement replacement by weight. Specific objectives are To find the workability aspect of the Nano-Silica for M20 grade concrete using Flyash. To know the strength characteristics of the concrete using Flyash and Nano-Silica.

- To conduct SEM (Scanning
- Electron Micrograph) investigation
- On both normal concrete and concrete with Flyash and Nano-Silica.

Procurement of Materials

The Materials used for the study are:

- Cement
- Fine Aggregate
- Coarse Aggregate
- Flyash
- Nano-Silica Gel
- Water

Property of Cement

S. No	Property	Value
1	Specific Gravity	3.15
2	Normal Consistency	27%
3	Setting Time 1. Initial Setting Time 2. Final Setting Time	36 Min 390 Min

AGGREGATES

Properties of Fine Aggregate

S.No	Property	Result
1	Specific Gravity	2.6
2	Fineness Modulus	2.8
3	Bulk Density (Loose)	15.75 kN/m3
4	Grading of Sand	ZONE-II

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Properties of Coarse Aggregate

S.No	Property	Result
1	Specific Gravity	2.60
2	Bulk Density (Loose)	14.15 kN/m3
3	Water Absorption	0.5%
4	Fineness Modulus	7.2

Properties of Flyash

S.No	Ingredient	Value
1	Silica (SiO2)	56.88 %
2	Aluminum trioxide (Al2O3)	27.65 %
3	Ferric oxide (Fe2O3 + Fe3O4)	6.28 %
4	Titanium dioxide (TiO2)	0.31 %
5	Calcium oxide (Cao)	3.6 %
6	Magnesium oxide (MgO)	0.34 %
7	Sulphate (SO4)	0.27 %
8	Loss of ignition (LOI)	4.46 %
9	Specific gravity of Fly Ash	2.12

Properties of Nano-Silica Gel

S.No	Property	Actual Analysis
1	Active nano Silica Content	35-40%
2	PH	9.3 -9.6
3	Specific Gravity	1.08-1.11
4	Texture	Milky White Liquid
5	Dispersion	Water

Number of Specimens Casted

S.No	Description	Number of Cubes	Number of Cylinders
1	Control Concrete	6	3
2	10% Flyash replaced with Cement		

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	0% Nano Silica Gel	6	3
	1% Nano Silica Gel	6	3
	1.5% Nano Silica Gel	6	3
	2% Nano Silica Gel	6	3
3	20% Flyash replaced with Cement		
	0% Nano Silica Gel	6	3
	1% Nano Silica Gel	6	3
	1.5% Nano Silica	6	3
	Gel 2% Nano Silica	6	3
	Gel		
4	30% Flyash replaced with Cement		
	0% Nano Silica Gel 1% Nano Silica Gel	6	3
	1.5% Nano Silica Gel	6	3
	2% Nano Silica Gel	6	3
		6	3
	TOTAL	78	39

RESULTS AND DISCUSSIONS

Slump Values

S.No	Description	Slump Value
1	Control Concrete	75mm
2	CF 10%	83mm
3	CF 10% + 1% NS	81mm
4	CF 10% + 1.5% NS	80mm
5	CF 10% + 2% NS	78mm
6	CF 20%	88mm
7	CF 20% + 1% NS	85mm
8	CF 20% + 1.5% NS	82mm
9	CF 20% + 2% NS	79mm
10	CF 30%	96mm

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11	CF 30% + 1% NS	93mm
12	CF 30% + 1.5% NS	90mm
13	CF 30% + 2% NS	87mm

Compressive Strength Results

S.No	Specimen Description	Compressive Strength (N/mm^2)	
		7 Days	28 Days
1	Control Concrete	17.51	34.32
2	Flyash 10%	14.98	26.96
3	10% Flyash + 1% NS	15.92	28.59
4	10% Flyash + 1.5% NS	16.78	30.12
5	10% Flyash + 2% NS	17.33	32.45
6	Flyash 20%	14.42	25.13
7	20% Flyash + 1% NS	15.42	26.64
8	20% Flyash + 1.5% NS	16.31	28.85
9	20% Flyash + 2% NS	16.98	31.26
10	Flyash 30%	13.67	24.06
11	30% Flyash + 1% NS	14.96	25.77
12	30% Flyash + 1.5% NS	15.86	28.93
13	30% Flyash + 2% NS	16.45	30.42

Tensile Strength Results

S. No	Specimen Description		Tensile Strength (28 Days)
1	C C	NS 0%	3.145
2	CF 10%	NS 0%	3.004
		NS 1%	2.981
		NS1.5%	2.788
		NS 2%	2.652
3	CF 20%	NS 0%	2.916
		NS 1%	2.862
		NS 1.5%	2.611

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		NS 2%	2.643
4	CF 30%	NS 0%	2.841
		NS 1%	2.826
		NS 1.5%	2.584
		NS 2%	2.451

CONCLUSIONS

1. We observed that when Flyash is added to Concrete, the Workability has increased and when Nano-Silica Gel is added to Flyash Concrete, the Workability has decreased.

2. When compared with Control Concrete, Concrete partially replaced with 10% Flyash has a decrease in 7 daysCompressive Strength by 14.48%. When Nano- Silica gel is added to CF10 in dosages of 1%, 1.5% and 2% the Compressive Strength is increased by 6.27%, 12.01% and 15.68% respectively.

3. When compared with Control Concrete, Concrete partially replaced with 20% Flyash has a decrease in 7 days Compressive Strength by 17.64%. When Nano- Silica gel is added to CF20 in dosages of 1%, 1.5% and 2% the Compressive Strength is increased by 6.93%, 13.1% and 17.75% respectively.

4. When compared with Control Concrete, Concrete partially replaced with 30% Flyash has a decrease in 7 days Compressive Strength by 21.93%. When Nano- Silica gel is added to CF30 in dosages of 1%, 1.5% and 2% the Compressive Strength is increased by 9.43%, 16.02% and 20.33% respectively.

5. When compared with Control Concrete, Concrete partially replaced with 10% Flyash has a decrease in 28days Compressive Strength by 21.44%. When Nano- Silica gel is added to CF10 in dosages of 1%, 1.5% and 2% the Compressive Strength is increased by 6.04%, 12.05% and 20.36% respectively.

6. When compared with Control Concrete, Concrete partially replaced with 20% Flyash has a decrease in 28days Compressive Strength by 26.77%. When Nano- Silica gel is added to CF20 in dosages of 1%, 1.5% and 2% the Compressive Strength is

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increased by 6.0%, 14.8% and 24.39% respectively.

7. When compared with Control Concrete, Concrete partially replaced with 30% Flyash has a decrease in 28days Compressive Strength by 29.89%. When Nano- Silica gel is added to CF30 in dosages of 1%, 1.5% and 2% the Compressive Strength is increased by 7.1%, 20.24% and 26.4% respectively.

8. Due to decrease in the quantity of cement, the concrete becomes economical and eco-friendly.

9. By adding Flyash CO2 emission is decreased and in presence of NS the compressivestrength has been increased.

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