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An Experimental Investigation on Strength Properties of Concrete with Nano Silica Using Manufactured Sand

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Abstract

Concrete is the most widely used material of construction all over the world. In India, the conventional concrete is mostly produced by using natural sand which is obtained from the riverbeds. One of the important ingredients of conventional concrete is natural sand or river sand. This sand plays a vital role as fine aggregate. However, due to the increased use of concrete in almost all types of construction works, the demand of natural or river sand has been increased. Thus, to meet these increased demands of construction industry, excessive quarrying of sand from river beds is taking place causing the shortage of natural sand. This scarcity of natural sand due to such heavy demands in growing construction activities have forced engineers to find a suitable substitute. One of the cheapest and the easiest ways of getting substitute for natural sand is by crushing natural stone to get artificial sand of desired size and grade .The use of artificial sand will conserve the natural resources for sustainable development of the concrete in construction industry .Hence the practice of replacing river sand with M-Sand is taking a tremendous growth.

In the present investigation the ordinary portland cement is partially replaced with nano silica by 2% and natural sand is replaced with manufactured sand in different proportions of 0%,25%,50%,75%,100%.Here the workability and strength parameters were considered. The workability parameters includes slump cone method and compaction factor method. The strength parameters deals with compressive, split tensile, flexural strengths which comes under destructive tests.

Keywords: manufactured sand,nano silica,workability, compressive strength,flexural strength,split tensile strength.

I. INTRODUCTION

Sand is one of the principle ingredients of construction aggregates used for purposes ranging from masonry and plastering to concreting and finishing works. Its composition is highly variable depending on the local sources and conditions. Historically sand has been sourced from alluvial deposits like river beds, sea shores and deep earth pits. Its physical composition emerges in different types like the fine, medium and coarse varieties, based on granular size and shape. River sand is a product of natural weathering of rocks over a period of millions of years. It is mined from the river bed. Sand mining has disastrous environmental consequences. River sand is becoming a scarce commodity and hence exploring alternatives to it has become imminent. However environmental pressures, high costs and shortage of natural sources has necessitated manufacturing of sand from quarried material. Rock crushed to the required grain size distribution is termed as manufactured sand (M-sand). Manufactured sand is defined as a purpose-made crushed fine aggregate produced from a suitable source material.

Recently Nano Technology has been introduced in Civil Engineering applications. One of the most used nano material is Nano Silica (NS). This is the first nano product that has replaced the micro silica. The advancement made by the study of concrete at nano scale has proved that nano silica is much better than silica fume used in conventional concrete. Nano silica possess more pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and durability to concrete.

II. RESEARCH SIGNIFICANCE

This study is an attempt to evaluate the characteristics of concrete using M-sand as fine aggregate. For the purpose of comparison characteristics of concrete with river sand has also been explored.

To study the properties of manufactured sand and its comparison with natural sand.

To evaluate the workability characteristics in terms of compaction factor and slump cone test for M20 grade of concrete with different proportions of manufactured sand without and with addition of 2 % of nano silica.

To study the effect of percentage replacement of natural sand by manufactured sand as 0%, 25%,50%, 75% and 100% respectively on the strength properties of concrete along with percentage replacement with addition of 2 % of nano silica by weight of cement.

III. MATERIALS AND PROPERTIES

1) **Cement:** JAYPEE Ordinary Portland Cement of 43 Grade confirming to IS 8112-1989 of specific gravity 3.12.

2) **Fine Aggregate:** River sand and Manufactured sand confirming to Zone-II of IS 383.

3) **Coarse Aggregate:** Crushed granite metal with 60% passing 20 mm and retained on 10 mm sieve and 40% passing 10mm and retained on 4.75 sieve was used.

4) **Water:** Potable water confirming to IS: 456-2000.

Table 1 a). Physical Properties of Aggregates (IS 383, IS 2386 Part III)

S.No.	Property	Natural Sand	Manufactured Sand	Coarse Aggregate
1	Specific Gravity	2.61	2.61	2.78
2	Fineness Modulus	2.38	2.84	6.62
3	Silt Content	2%	8%	-
4	Bulk Density (kg/m^3) Loose state Compacted state	 1530 1690	 1540 1730	 1505 1684

5) **Nano Silica:**Nano Silica CEM SYN XTX type is used.

Table 1 b).Properties of nano silica

Notation of Nano Silica Gel	CEM SYN XTX
Active nano content (%wt/wt)	30.0-32.0
pH	9.0-10.0
Specific Gravity	1.20-1.22

IV. METHODOLOGY AND EXPERIMENTAL INVESTIGATION

Experimental investigation was planned to provide sufficient information about the strength characteristics of manufactured sand concrete and natural sand concrete with and without using nano silica and comparing the performances of both types of concrete. Tests were conducted on materials to know their physical properties. Also different tests were performed on manufactured sand concrete to study its workability. Results were analyzed to derive useful conclusions regarding the strength characteristics of manufactured sand concrete with and without using nano silica.M20 concrete has been used as a reference mix.

V. TEST RESULTS

Table 2. Workability characteristics of M20 grade concrete (is 1199-1959)

S.No	Mix	without nano silica		with 2% nano silica	
		Slump (mm)	Compaction factor	Slump (mm)	Compaction factor
1.	M20 + 0% M-Sand	60	0.910	55	0.895
2.	M20 + 25% M-Sand	51	0.907	30	0.890
3.	M20 + 50% M-Sand	45	0.903	20	0.880
4.	M20 + 75% M-Sand	30	0.900	5	0.868
5.	M20 + 100% M-Sand	28	0.861	0	0.837

Table-3 a). Variation of Compressive Strength of M20 Grade Concrete with different proportions of Manufacture Sand without nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	23.4	25.1	26.81	25.77	26.77
7 Days	27.11	29.3	32.6	32.1	34.37
28 Days	39.4	40.2	42.07	41.11	43.11

Table-3 b). Variation of Compressive Strength of M20 Grade Concrete with different proportions of Manufacture Sand with 2% nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	25.33	25.105	24.88	27.4	26.8
7 Days	33.7	32.47	31.25	35.85	27.7
28 Days	43.56	41.18	38.8	41.11	31.77

Table-4 a). Variation of Split Tensile Strength of M20 Grade Concrete with different proportions of Manufacture Sand without nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	2.33	2.41	2.59	2.38	2.14
7 Days	2.52	2.60	2.68	2.64	2.45
28 Days	3.18	3.38	3.54	3.89	3.74

Table-4 b). Variation of Split Tensile Strength of M20 Grade Concrete with different proportions of Manufacture Sand without nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	2.02	2.28	2.45	2.405	2.26
7 Days	2.78	2.81	2.829	2.78	2.71
28 Days	3.04	3.26	3.324	3.25	3.6

Table-5 a). Variation of Flexural Strength of M20 Grade Concrete with different proportions of Manufacture Sand without nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	4.97	4.85	5.01	5.08	4.68
7 Days	5.44	5.53	5.62	5.36	5.88
28 Days	7.11	6.93	6.88	6.958	7.2

Table-5 b). Variation of Flexural Strength of M20 Grade Concrete with different proportions of Manufacture Sand with 2% nano silica.

Description	M20 + 0% M-Sand	M20 + 25% M-Sand	M20 + 50% M-Sand	M20 + 75% M-Sand	M20 + 100% M-Sand
3 Days	4.60	4.75	4.89	4.839	6.46
7 Days	5.886	5.781	5.676	6.22	6.566
28 Days	6.59	6.493	6.396	7.377	7.848

VI. DISCUSSIONS

- The values of slump and compaction factor are found to be decreasing as the percentage of replacement of natural sand with manufactured sand is increasing.
- The round shape and smooth surface texture of natural sand reduces the inter particle friction in the fine aggregate component, so that the workability is high in natural sand. Manufactured sand is angular in shape and the rough surface texture improves the internal friction in the mix, which reduces the workability of the concrete.
- It is observed that the compressive ,split tensile and flexural strengths are increased with the increase in percentage of replacement of natural sand with manufactured sand at all the ages.

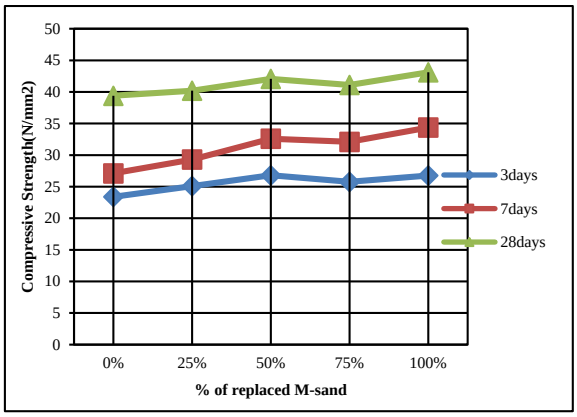

Fig. 1.1 Variation of Compressive Strength of M20 Grade Concrete with different proportions of % M-sand at 3,7 and 28 days

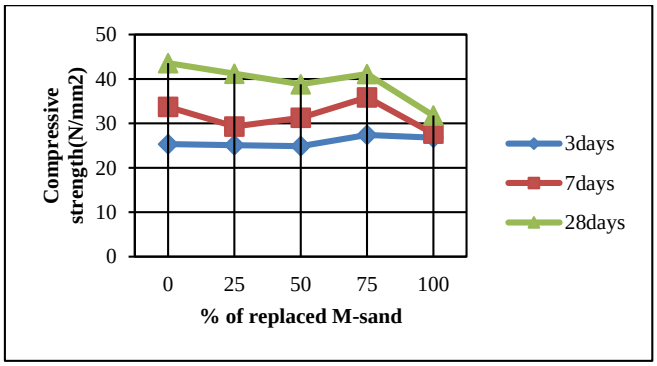

Fig. 1.2 Variation of Compressive Strength of M20 Grade Concrete with different proportions of % M-sand with 2% nano silica at 3,7 and 28 days

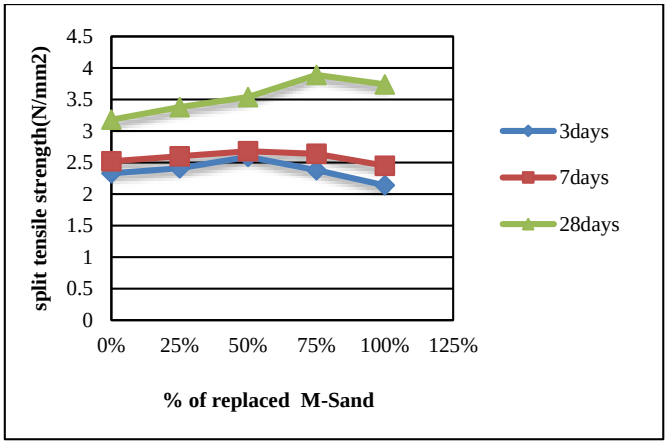

Fig. 1.3 Variation of Split Tensile Strength of M20 Grade Concrete with different proportions of % M-sand at 3,7 and 28 days

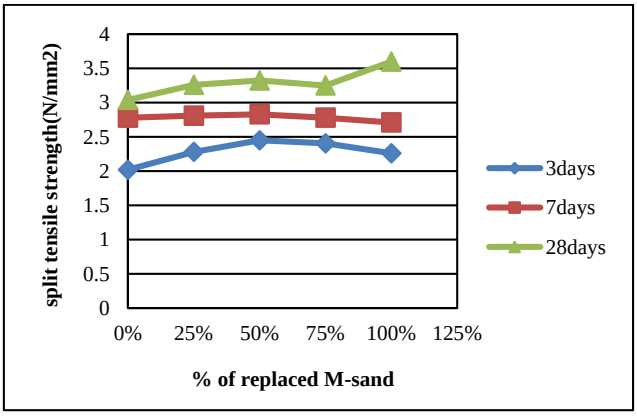

Fig.1.4 Variation of Split Tensile Strength of M20 Grade Concrete with different proportions of %M-sand with 2% nano silica at 3,7 and 28 days

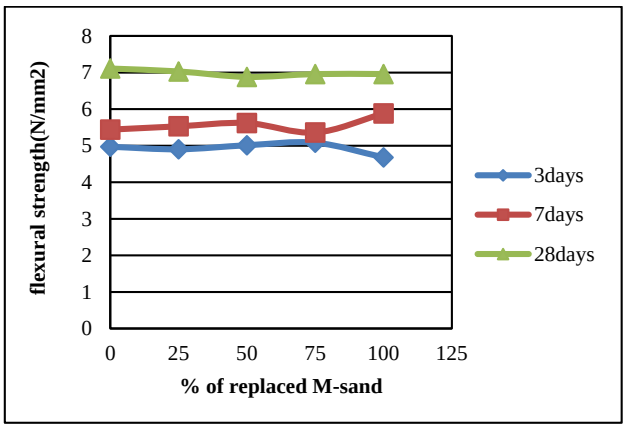

Fig.1.5 Variation of Flexural Strength of M20 Grade Concrete with different proportions of % M-sand at 3,7 and 28 days

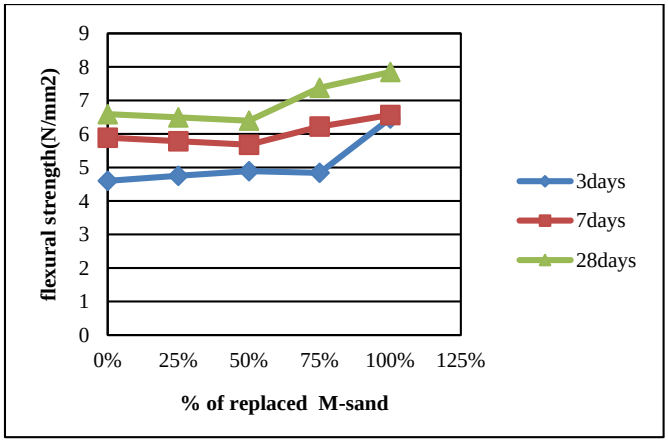

Fig. 1.6 Variation of Flexural Strength of M20 Grade Concrete with different proportions of % M-sand with 2 % nano silica at 3,7 and 28 days

VII. CONCLUSIONS

The following conclusions were drawn from the results considering the workability, strength characteristics of concrete made with replacement of natural sand with manufactured sand in different proportions for M20 grade.

- Manufactured sand is a good alternative for natural sand as fine aggregate and gives more strength depending upon the percentage replacement.
- The presence of nano silica improves the strength of concrete with manufactured sand at early ages when compared to normal concrete.
- The compressive strength of concrete with 100 % replacement of natural sand by manufactured sand is maximum by about 9.41% when compared to normal aggregate concrete.Where as for concrete with addition of 2% of nano silica, compressive strength is decreased at all % replacements which is not favorable.
- Split tensile strength acquires higher value at 75% replacement of natural sand by manufactured sand by about 22.32% when compared to normal aggregate concrete .On addition of 2% nano silica, it is higher by 18.42% at 100% replacement when compared to normal aggregate concrete.
- The flexural strength of concrete with 100% replacement of natural sand by manufactured sand shown greater strength by 1.26% when compared to normal aggregate concrete and by 19.08 % in the case of 2% addition of nano silica.

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