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AN EXPERIMENTAL STUDY ON EFFECT OF NANO MATERIALS AS CEMENT REPLACEMENT IN CONCRETE AND MARBLE WASTE AGGREGATE AS COARSE AGGREGATE REPLACEMENT

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ABSTRACT

Concrete, as a constructive material, has been used in construction industry for about two centuries. Approximately, the whole bulk of the concrete is used in one year is more than one ton apiece. Therefore, doing research about using modern technologies in production concrete is of great importance. Furthermore, one of the most critical problems of the world has been related to remove the wastage and reusing of it. Reducing the necessary amount of Portland cement without reducing the performance of concrete is significant for big projects that require a large amount of cement. Waste material recycling through using in concrete manufacturing not only provides a promising resource to produce a high quality concrete, but also helps to properly encounter the problem of waste disposal.

The present experimental study deal with the investigation of possibility of using Marble Waste Aggregate in concrete as coarse aggregate replacement upto 50% with 10% fixed proportion along with nano silica as cement replacement of 0, 4 and 8% respectively of M20 & M30 grade of concrete Besides, all other parameters are constant. Finally the slump value, compressive strength of the concrete for the samples were calculated. The findings revealed that generally using Marble Waste Aggregate lead to enhancing the properties of concrete.

I. INTRODUCTION

Concrete is the most commonly used construction material; its usage by the communities across the globe is second only to water. Customarily, concrete is produced by using the Ordinary Portland Cement (OPC) as the binder. The usage of OPC is on the increase to meet infrastructure developments. The world-wide demand for OPC would increase further in the future. It is well-known that cement production depletes significant amount of natural resources and releases large volumes of carbon-dioxide. Cement production is also highly energy-intensive, after steel and aluminium. On the other hand, coal burning power generation plants produce huge quantities of GGBS and some of the materials which are byproducts. The volume of fly ash would increase as the demand for power increases. Most of the fly ash is considered as waste and dumped in landfills. In order to address the issues mentioned above, it is essential that other forms of binders must be developed to make concrete.

NANOMATERIALS- USE IN CONCRETE

Nanomaterials are very small sized materials with particle size in nanometres. These materials are very effective in changing the properties of concrete at the ultrafine level by the virtue of their very small size. The small size of the particles also means a greater surface area (Alireza Naji Givi, 2010). Since the rate of a pozzolanic reaction is proportional to the surface area available, a faster reaction can be achieved. Only a small percentage of cement can be replaced to achieve the desired results. These nanomaterials improve the strength and permeability of concrete by filling up the minute voids and pores in the microstructure. The use of nanosilica in concrete mix has shown results of increase in the compressive, tensile and flexural strength of concrete. It sets early and hence generally requires admixtures during mix design. Nano-silica mixed cement can generate nano-crystals of C-S-H gel after hydration. These nano-crystals accommodate in the micro pores of the cement concrete, hence improving the permeability and strength of concrete.

OBJECTIVES

This investigation focuses on the following pattern of work

- Nano-Silica is used as partial replacement of cement and Marble Waste as coarse aggregate replacement.
- In the present experimental investigation, the cement is partially replaced by Nano Silica 0, 4, 8% respectively of M20 & M30 grade of concrete
- Curing was done at the ages of 7,14,28 and 56 days were tested i.e. compression, split tensile strength and flexural strength along with durability test.

II. LITERATURE REVIEW

- Aalok D. Sakalkale, G. D. Dhawale gave replacement of fine aggregate (Natural sand).The use of sand in Construction activities result in increase in scour depth and sometime flood possibility. Disposal of the marble powder material from the marble industry is one of the environmental problems worldwide today. The aim of this study is utilizing Waste marble powder construction industry itself as fine aggregate in Concrete, replacing natural sand. The replacement is done partially and fully in the proportion 0%, 25%, 50% and 100% and its effect on properties of concrete were investigated. They studied the effect of use of waste marble dust on the mechanical properties of concrete, compared the compressive, flexural and tensile strength using WMD with the given design mix and established alternative for sand with partial use of WMD in concrete.

- Raminder Singh, Manish Bhutani gave the feasibility of the substitution of waste marble powder for cement and waste tile aggregates for coarse aggregates to achieve economy and environment saving.There is an increase in the Compressive strength of the concrete produced from waste marble powder as partial replacement of cement up to 10% and crushed tile aggregate as partial replacement of natural coarse aggregate up to 30%.The presentation on workability of concrete in this paper. They conducted ten mixes with different combinations of waste marble powder and waste tiles aggregates prepared. Study on partial replacement level of waste marble powder with cement in concrete. They conducted compressive strength for different proportional mixes of concrete 7 days and 28 days. Also check the workability of concrete with using of marble dust and tiles aggregate.
- Muhammad Junaid Munir, Syed Minhaj Saleem Kazmi, Yu-Fei Wu gave the efficiency of waste marble powder (WMP) in controlling alkali silica reactivity of concrete. To initiate the ASR phenomena, reactive aggregate was used in the study. Mortar bar specimens prepared with WMP as cement replacement material at 10%, 20%, 30% and 40% replacement levels (by cement weight) were evaluated. Mechanical properties as well as durability properties are greatly affected as a result of ASR in concrete. Chemical properties of raw materials (cement and WMP) were analysed through X-ray fluorescence (XRF) and X-ray diffraction (XRD) Gerry Lee, Chi Sun Poon, Yuk Lung Wong (2013) [5] , gave the mixtures were proportioned with a fixed total aggregate/cement ratio of 4% and 50% of the total aggregate was fine aggregate.
- Sara de Castro, Jorge de Brito, gave the mechanical properties of concrete made with glass, this one focuses on their durability performance. Mixes containing 0%, 5%, 10% and 20% of glass aggregates (GA) as replacement of natural aggregates (NA) were prepared. Also analysed is the influence of the size of the replaced aggregates (fine and coarse, separately or simultaneously), in a total of 10 concrete mixes. They was found that the particle size strongly affects the workability of concrete. Due to the lower density of the glass aggregates, the mixes made with glass had a lighter fresh density than the reference concrete. They also studied on the fresh properties such as workability and density of concrete and the hardened properties such as compressive strength, water absorption by capillarity, water absorption by immersion, carbonation resistance, chloride penetration resistance and shrinkage

III. MATERIALS AND PROPERTIES

The following materials are being used and are listed below.

- Cement
- Fine aggregate (sand)
- Coarse aggregate
- Water
- Nano silica
- Marble waste aggregate (MWA)

CEMENT

The most widely recognized bond utilized is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 review (OPC) Ultratech Cement fitting in with IS: 8112-1989 is utilized. A bond is a fastener, a substance utilized as a part of development that sets, solidifies and clings to different materials, restricting them together. Bond is only sometimes utilized exclusively, however is utilized to tie sand and rock (total) together.

Table: 1 Physical properties of cement

S.No.	CHARACTERISTICS	VALUE
1	SPECIFIC GRAVITY	3.15
2	NORMAL CONSISTENCY	31%
3	INITIAL SETTING TIME	60 minutes
4	FINAL SETTING TIME	600minutes

AGGREGATES

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own right. They are also the raw materials that are an essential ingredient in concrete.

Depending upon the size the aggregates are classified into two types

1) Fine Aggregate
2) Coarse Aggregate

Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment.

Table: 2 Properties of fine aggregate

S.No.	CHARACTERISTICS	VALUE
1	ZONE	II
2	SPECIFIC GRAVITY	2.64
3	DENSITY	14KN/m^3
4	WATER ABSORPTION	2.1%

Coarse Aggregates

Coarse aggregates are particles greater than 4.75mm, but generally range between 9.5mm to 37.5mm in diameter. They can either be from Primary, Secondary or Recycled sources. Primary, or 'virgin', aggregates are either Land- or Marine-Won. Gravel is a coarse marine-won aggregate; land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder.

Table: 3 Coarse Aggregate Physical Properties

S.No.	CHARACTERISTICS	VALUE
1	NOMINAL SIZE	10mm
2	SPECIFIC GRAVITY	2.84
3	DENSITY	1625.83Kg/m^3
4	WATER ABSORPTION	2.4%

Marble waste aggregate (MWA):

In the present experimental work we used marble waste aggregate as coarse aggregate. The nominal maximum size of marble aggregate used was 10 mm and 20 mm

Marble is a metamorphic rock types derived from the exposed limestone and Metamorphose regional contact. In community / entrepreneur building materials / trade term is shiny marble, limestone rock can form, granite, marble and other types of basalt. Marble stone obtained from a mountain located in the region Campurdarat Tulungagung. The marble stones processed into a variety of crafts, including sculpture and so on. During the milling process to craft marble waste is obtained. Floured marble waste reddish white, marble waste when mixed with water it will harden, because floured then can serve as a binder.

Table: 4 Marble waste aggregate (MWA) @Coarse aggregate

S.No.	Characteristics	Value Coarse Aggregate	Value Ceramic Tile
1	Nominal size	10mm	10mm
2	Specific gravity	2.84	2.33
3	Density	1625.83Kg/m^3	1635.83Kg/m^3
4	Water absorption	2.4%	2.8%

NANO SILICA:

Silicon dioxide nanoparticles, also known as silica nanoparticles or nanosilica, are the basis for a great deal of biomedical research due to their stability, low toxicity and ability to be functionalized with a range of molecules and polymers. The properties of silica include both chemical and physical properties such as hardness, color, melting and boiling point, and reactivity. Silica under normal conditions of temperature and pressure is a solid, crystallized mineral.

WATER:

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

Table: 5 Mix Proportion @ M20

MIX	NS %	MWA%		C	FA	CA	W
CC	0%	0%	0	360	584	1323.4	180.42
		10%	132.34	360	584	1191.06	180.42
		20%	264.68	360	584	1058.72	180.42
		30%	397.02	360	584	926.38	180.42
		40%	529.36	360	584	794.04	180.42
		50%	661.7	360	584	661.7	180.42
Mix-1	4%	0%	0	345.6	584	1323.4	180.42
		10%	132.34	345.6	584	1191.06	180.42
		20%	264.68	345.6	584	1058.72	180.42
		30%	397.02	345.6	584	926.38	180.42
		40%	529.36	345.6	584	794.04	180.42
		50%	661.7	345.6	584	661.7	180.42
Mix-2	8%	0%	0	331.2	584	1323.4	180.42
		10%	132.34	331.2	584	1191.06	180.42
		20%	264.68	331.2	584	1058.72	180.42
		30%	397.02	331.2	584	926.38	180.42
		40%	529.36	331.2	584	794.04	180.42
		50%	661.7	331.2	584	661.7	180.42

Table Mix Proportion @ M30

Mix	NS	MWA		C	FA	CA	WT
CC	0%	0%	0	394	716	1155.312	197
		10%	115.53	394	716	1040.082	197
		20%	231.06	394	716	924.252	197
		30%	346.59	394	716	808.722	197
		40%	462.12	394	716	693.192	197
		50%	577.65	394	716	577.662	197

Mix-1	**4%**	**0%**	**0**	378.24	716	1155.312	197
		10%	**115.53**	378.24	716	1040.082	197
		20%	**231.06**	378.24	716	924.252	197
		30%	**346.59**	378.24	716	808.722	197
		40%	**462.12**	378.24	716	693.192	197
		50%	**577.65**	378.24	716	577.662	197
Mix-2	**8%**	**0%**	**0**	362.48	716	1155.312	197
		10%	**115.53**	362.48	716	1040.082	197
		20%	**231.06**	362.48	716	924.252	197
		30%	**346.59**	362.48	716	808.722	197
		40%	**462.12**	362.48	716	693.192	197
		50%	**577.65**	362.48	716	577.662	197

IV EXPERIMENTAL INVESTIGATION

Workability of Concrete

- Slump Test
- Compaction factor test

Strength Test

- COMPRESSIVE STRENGTH TEST
- SPLIT TENSILE STRENGTH TEST
- FLEXURAL STRENGTH TEST

COMPRESSIVE STRENGTH TEST

Concrete cubes of sizes 150mm×150mm×150mm were tested for crushing strength. Compressive strength depends on loads of factor such as w/c ratio, cement strength, excellence of concrete material and excellence control during manufacture of concrete.

These cubes are tested by compression testing machine after 7 days, 14 days or 28 days and 56 days curing. The sample is placed centrally on the base plate of machine and the load have to be apply gradually at the rate of 140 kg/cm2 per minute till the specimen fails. Load at the failure separated by area of sample gives the compressive strength of concrete. The sample to increased load breaks down and no greater load greater load can be constant. The maximum load applied to specimen shall then be recorded and any unusual value noted at the time of failure brought out in the report.

The cube compressive strength, then $f_c = P/A$ N/mm^2

Where P is an ultimate load in N, A is a cross sectional area of cube in mm^2

Fig. 1 Compressive Strength Test

V EXPERIMENTAL RESULTS

SLUMP TEST

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and Tamping rod.

The internal surface

of the mould is thoroughly cleaned and applied with a light coat of oil. The mould is placed on a smooth, horizontal, rigid and non-absorbent surface. The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould. Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section). After the top layer is rodded, the concrete is struck off the level with a trowel

Table: 7 Slump test @ M20 Grade of Concrete

Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Slump (mm)
CC	0%	0%	65
		10%	80
		20%	98
		30%	115
		40%	131
		50%	120
Mix-1	4%	0%	70
		10%	84
		20%	102
		30%	119
		40%	142
		50%	124
Mix-2	8%	0%	72
		10%	86
		20%	100
		30%	109
		40%	114
		50%	100

Table: 8 Slump test @ M30 Grade of Concrete

Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Slump (mm)
CC	0%	0%	68
		10%	75
		20%	85
		30%	94
		40%	124
		50%	112
Mix-1	4%	0%	72
		10%	84
		20%	105
		30%	112
		40%	128
		50%	105
Mix-2	8%	0%	74
		10%	86
		20%	98
		30%	108
		40%	115
		50%	103

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Compaction Factor

Table: 9 Compaction Factor @ M20 Grade of Concrete

Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Factor
CC	0%	0%	0.781
		10%	0.795
		20%	0.801
		30%	0.805
		40%	0.816
		50%	0.800
Mix-1	4%	0%	0.8021
		10%	0.8124
		20%	0.834
		30%	0.856
		40%	0.901
		50%	0.869
Mix-2	8%	0%	0.801
		10%	0.8019
		20%	0.824
		30%	0.832
		40%	0.845
		50%	0.817

Table: 10 Compaction Factor @ M30 Grade of Concrete

Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Factor
CC	0%	0%	0.852
		10%	0.879
		20%	0.892
		30%	0.912
		40%	0.932
		50%	0.902
Mix-1	4%	0%	0.880
		10%	0.898
		20%	0.903
		30%	0.923
		40%	0.942
		50%	0.925
Mix-2	8%	0%	0.875
		10%	0.889
		20%	0.900
		30%	.0.912
		40%	0.923
		50%	0.9124

RESULTS & DISCUSSION

COMPRESSIVE STRENGTH

Table Compressive strength @ M20 Grade of Concrete

M	NS	MWA	STRENGTH N/MM²			
			7 DAYS	14 DAYS	28DAYS	56 DAYS
CC	0%	0%	10.78	18.65	28.64	32.14
		10%	12.64	20.21	30.12	33.21
		20%	14.84	22.12	34.12	39.81
		30%	16.89	24.35	36.19	40.21
		40%	18.91	26.87	39.21	42.18
		50%	17.12	25.12	35.34	39.84
Mix-1	4%	0%	11.24	19.02	29.50	33.21
		10%	13.05	21.32	32.02	35.98
		20%	15.08	23.01	35.02	40.02
		30%	17.02	25.21	37.25	45.28
		40%	19.12	27.50	40.21	43.64
		50%	18.13	26.21	36.35	41.20
Mix-2	8%	0%	12.05	21.02	30.12	34.56
		10%	14.85	22.36	33.02	34.98
		20%	15.82	23.45	35.02	39.02
		30%	18.32	26.12	36.90	40.28
		40%	20.12	28.23	40.21	42.64
		50%	19.13	25.24	35.35	41.20

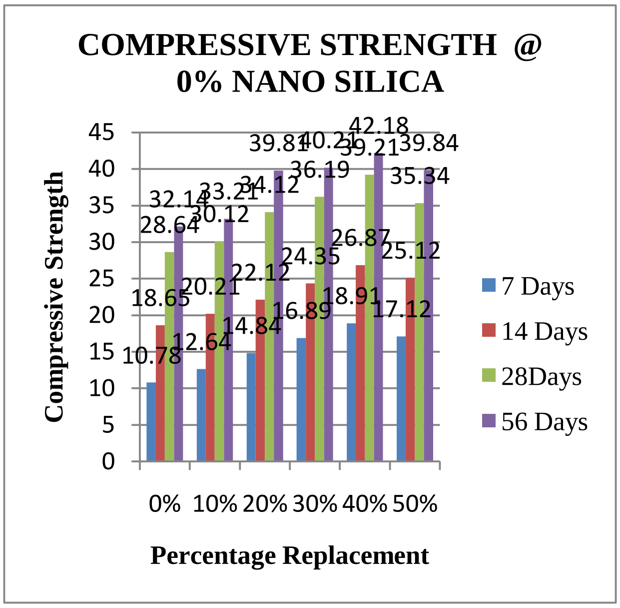

Fig.: 6.1. COMPRESSIVE STRENGTH @ M20 0% NANO SILICA

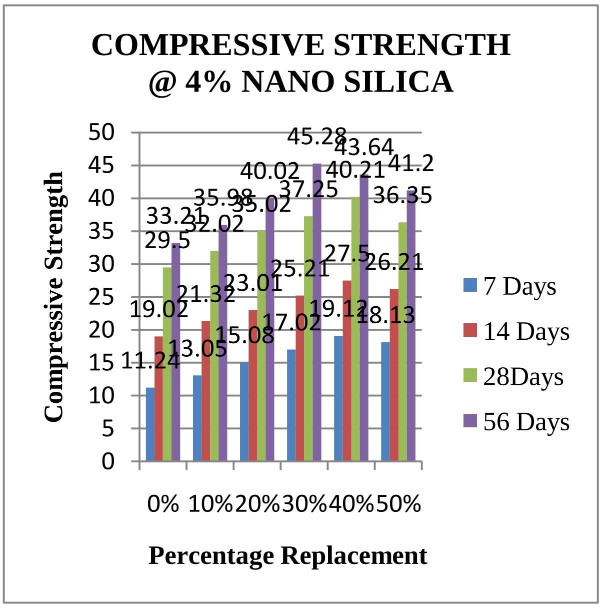

Fig.: 6.2. COMPRESSIVE STRENGTH @ M20 4% NANO SILICA

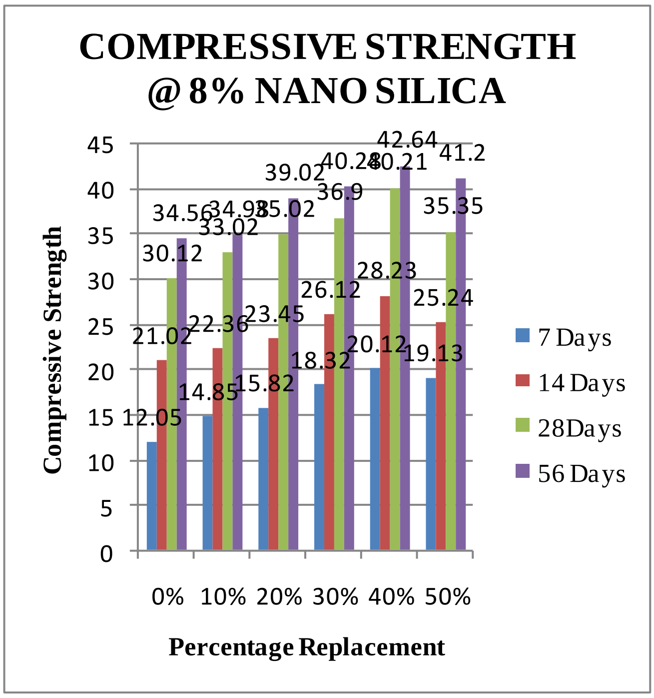

Fig.: 6.3. COMPRESSIVE STRENGTH @ M20 8% NANO SILICA

Table: 12 Compressive strength @ M30 Grade of Concrete

M	NS	MWA	STRENGTH N/MM²			
			7 DAYS	14 DAYS	28DAYS	56 DAYS
CC	**0%**	**0%**	11.28	20.65	37.64	39.12
		10%	14.02	23.65	40.02	40.12
		20%	15.02	25.12	42.35	39.81
		30%	18.12	28.94	45.12	40.21
		40%	20.12	30.12	48.01	42.18
		50%	19.85	29.86	43.02	39.84
Mix-1	**4%**	**0%**	12.82	21.78	38.98	40.01
		10%	15.24	24.75	41.28	42.20
		20%	17.06	26.49	43.24	44.08
		30%	19.85	27.96	46.74	48.28
		40%	22.24	31.28	50.02	52.18
		50%	20.15	30.01	48.02	49.84
Mix-2	**8%**	**0%**	13.02	22.08	39.81	41.01
		10%	16.24	25.05	42.12	43.02
		20%	17.96	27.09	43.04	45.18
		30%	20.85	28.96	45.74	46.28
		40%	21.24	34.28	49.02	50.19
		50%	19.15	29.01	47.02	48.24

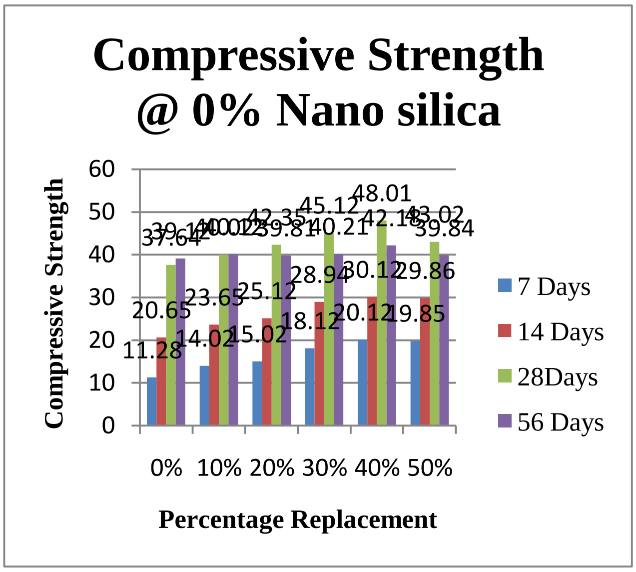

Fig.: 6.4. COMPRESSIVE STRENGTH @ M30 0% NANO SILICA

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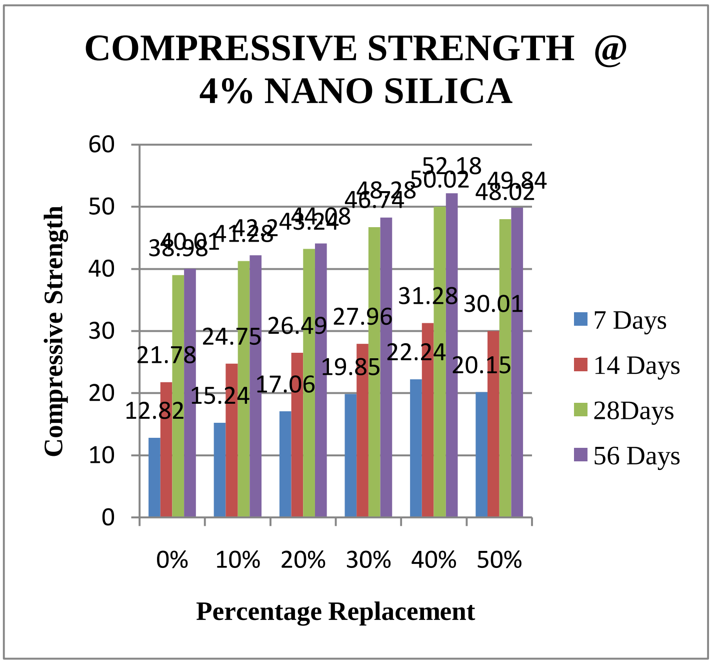

Fig.: 6.5. COMPRESSIVE STRENGTH @ M30 4% NANO SILICA

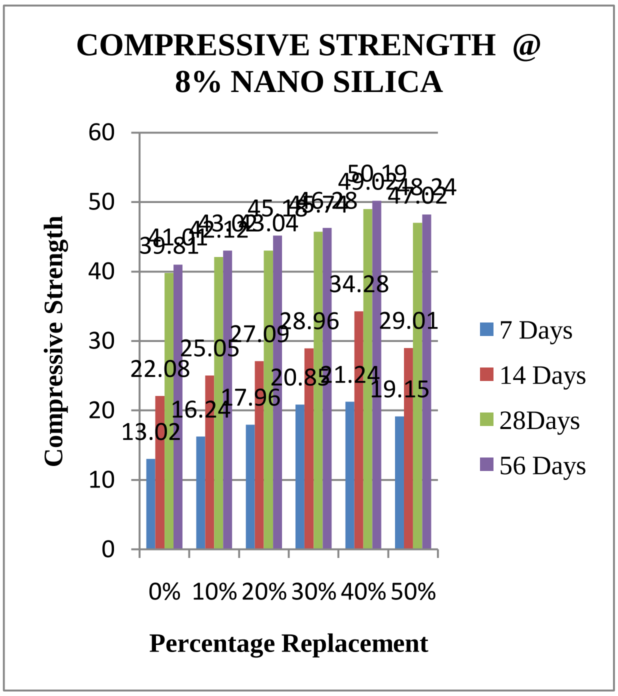

Fig.: 6.6. COMPRESSIVE STRENGTH @ M30 8% NANO SILICA

TABLE: 6.3 SPLIT TENSILE STRENGTH M20 GRADE OF CONCRETE NA(0%,4%,8%)&MWR(0%,10%,20%,30%,40%,50%)

M	NS	MWA	STRENGTH N/MM^2			
			7 DAYS	14 DAYS	28DAYS	56 DAYS
CC	**0%**	**0%**	3.02	3.85	4.20	4.8
		10%	3.26	4.25	4.39	5.48
		20%	3.32	4.68	4.63	5.92
		30%	3.58	4.98	5.01	6.82
		40%	3.72	5.65	5.89	7.2
		50%	3.68	5.42	5.6	5.92
Mix-1	**4%**	**0%**	3.02	3.85	4.20	4.8
		10%	3.62	4.01	4.25	4.86
		20%	3.35	4.32	4.52	5.98
		30%	3.45	4.98	4.72	6.81
		40%	4.32	5.8	6.23	7.38
		50%	4.12	5.01	6.12	7.12
Mix-2	**8%**	**0%**	3.02	3.85	4.20	4.8
		10%	3.82	4.21	4.68	4.98
		20%	3.856	4.32	4.69	5.986
		30%	3.93	5.12	5.23	6.023
		40%	4.43	5.23	5.32	7.012
		50%	3.92	4.89	5.02	6.5

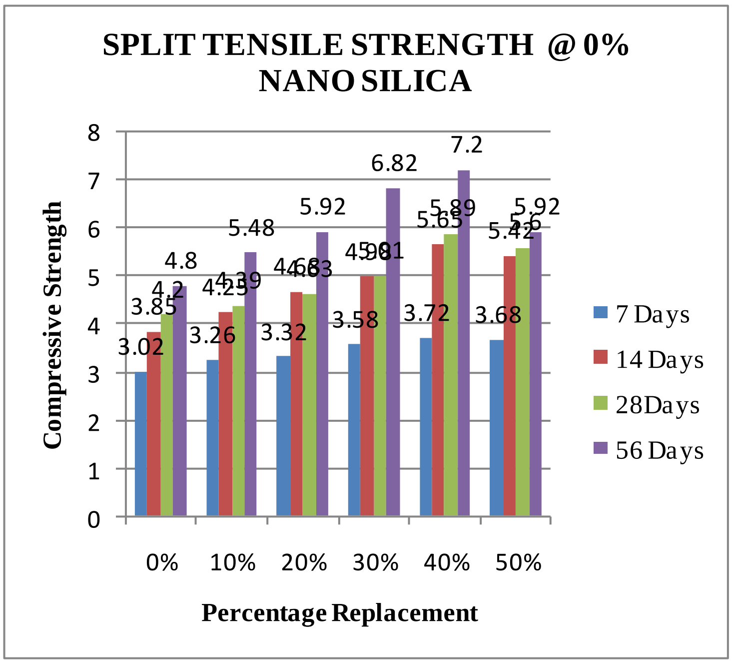

Fig.: 6.1. SPLIT TENSILE STRENGTH @M20 0% NANO SILICA

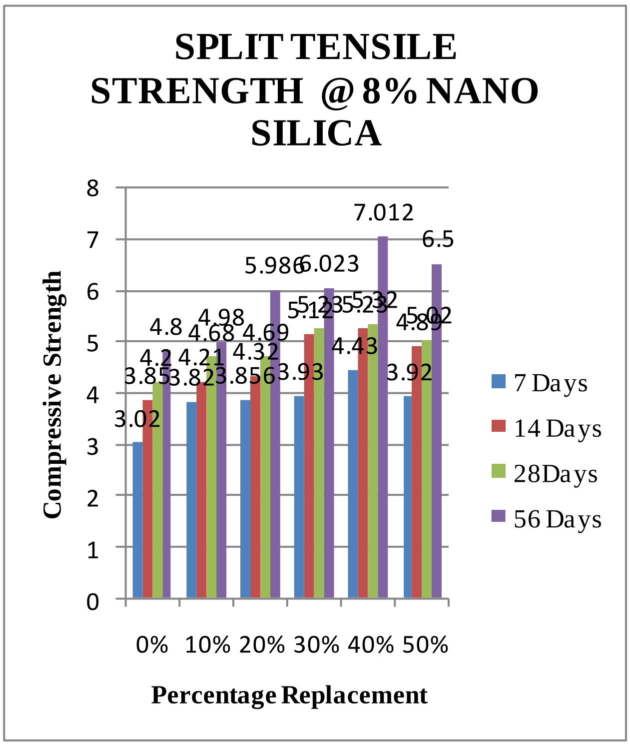

Fig.: 6.3. SPLIT TENSILE STRENGTH @ M20 8% NANO SILICA

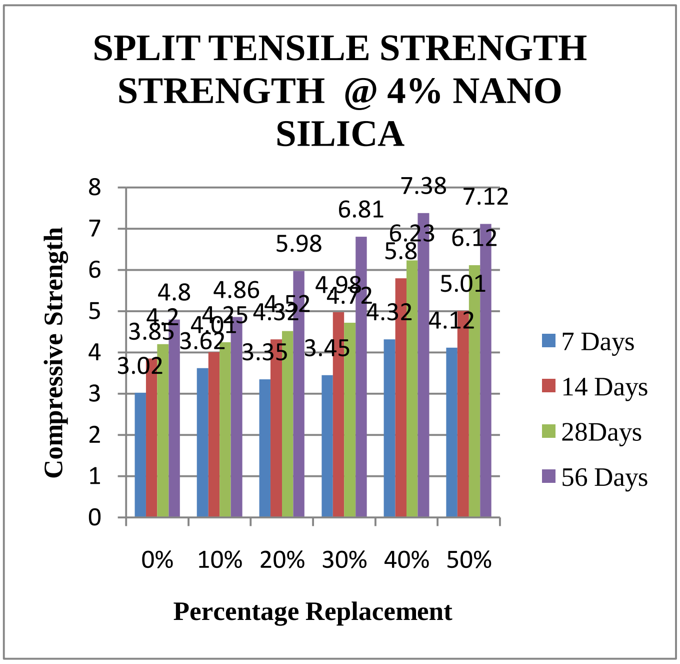

Fig.: 6.2. SPLIT TENSILE STRENGTH @M20 4% NANO SILICA

TABLE: 6.4. SPLIT TENSILE STRENGTH M30 GRADE OF CONCRETE NA(0%,4%,8%)&MWR(0%,10%,20%,30%,40%,50%)

M	NS	MWA	STRENGTH N/MM²			
			7 DAYS	14 DAYS	28DAYS	56 DAYS
CC	**0%**	**0%**	2.2	3.18	3.7	4.2
		10%	2.62	3.28	3.96	4.45
		20%	2.89	3.77	4.01	4.65
		30%	3.15	3.98	4.5	4.8
		40%	3.25	4.21	4.74	4.98
		50%	3.12	4.10	4.65	4.65
Mix-1	**4%**	**0%**	2.2	3.18	3.7	4.2
		10%	2.7	3.32	4.01	4.8
		20%	2.92	3.92	4.23	5.21
		30%	3.18	4.02	4.68	5.6
		40%	3.32	4.65	4.89	5.01

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		50%	3.21	3.78	3.87	4.85
Mix-2	**8%**	**0%**	2.2	3.18	3.7	4.2
		10%	2.9	3.52	4.21	4.9
		20%	3.2	4.12	4.32	5.41
		30%	3.32	4.32	4.98	5.82
		40%	3.52	4.65	5.32	6.2
		50%	3.21	3.81	5.24	5.6

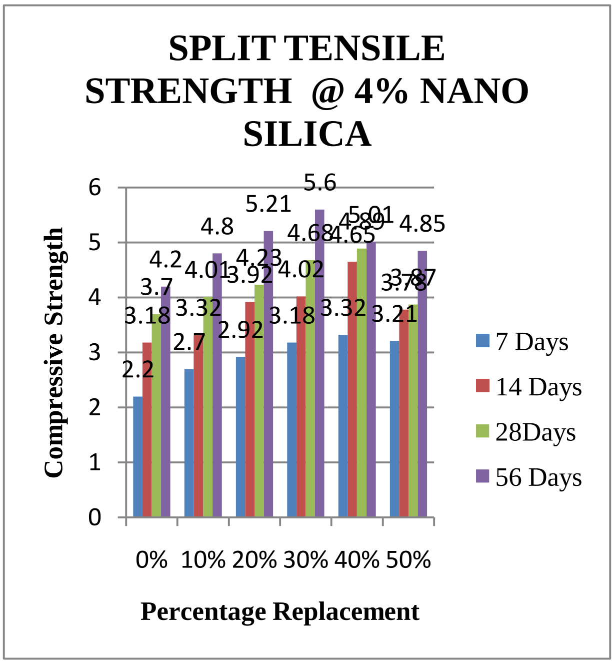

Fig.: 6.5. SPLIT TENSILE STRENGTH @ M30 4% NANO SILICA

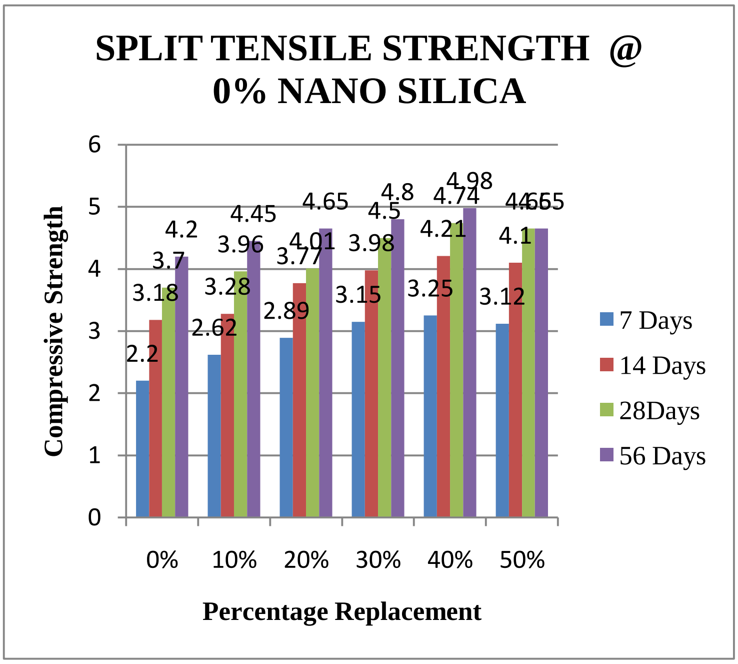

Fig.: 6.4. SPLIT TENSILE STRENGTH @ M30 0% NANO SILICA

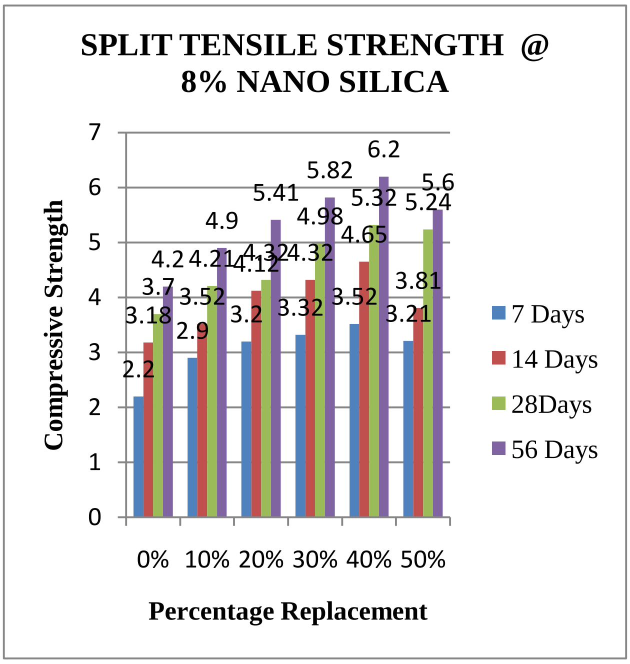

Fig.: 6.6. SPLIT TENSILE STRENGTH @ M30 8% NANO SILICA

FLEXURE STRENGTH

TABLE: 6.5. FLEXURAL STRENGTH M20 GRADE OF CONCRETE NA(0%,4%,8%)&MWR(0%,10%,20%,30%,40%,50%)

M	NS	MWA	STRENGTH N/MM²			
			7 DAYS	14 DAYS	28DAYS	56 DAYS
CC	**0%**	**0%**	2.2	2.45	2.98	3.52
		10%	2.42	2.96	3.01	3.92
		20%	2.65	3.01	3.45	4.05
		30%	2.88	3.65	3.86	4.56
		40%	2.98	3.98	4.21	4.98
		50%	3.32	3.85	4.01	4.88
Mix-1	**4%**	**0%**	2.2	2.45	2.98	3.52
		10%	2.45	3.25	3.68	4.68
		20%	2.92	3.68	3.92	4.99
		30%	3.21	3.42	3.89	5.1
		40%	3.5	3.89	4.12	5.32
		50%	3.42	3.58	4.01	5.22
Mix-2	**8%**	**0%**	2.2	2.45	2.98	3.52
		10%	2.55	3.65	3.98	4.98
		20%	2.92	3.78	3.92	5.1
		30%	3.21	3.95	3.89	5.25
		40%	3.64	4.12	4.32	5.48
		50%	3.52	3.87	4.11	5.32

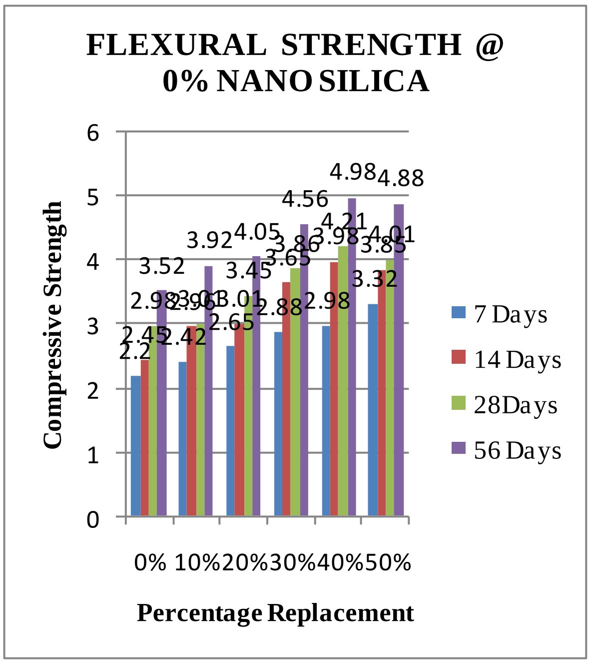

Fig.: 6.1. FLEXURAL STRENGTH @ M20 0% NANO SILICA

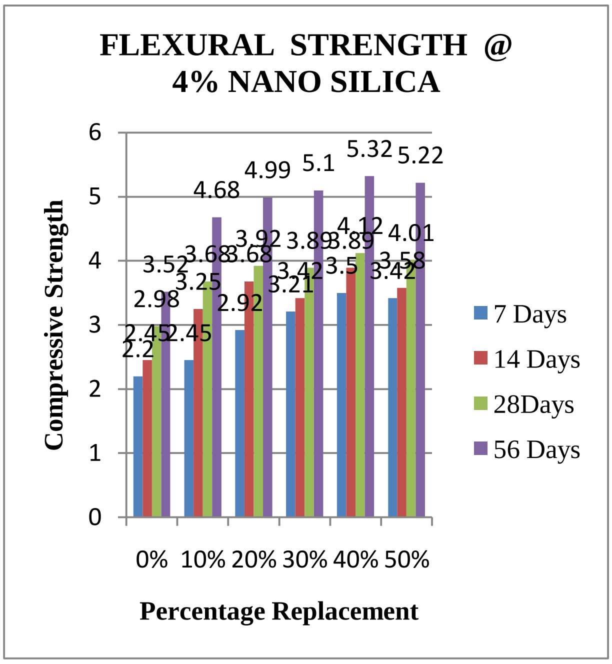

Fig.: 6.2. FLEXURAL STRENGTH @ M20 4% NANO SILICA

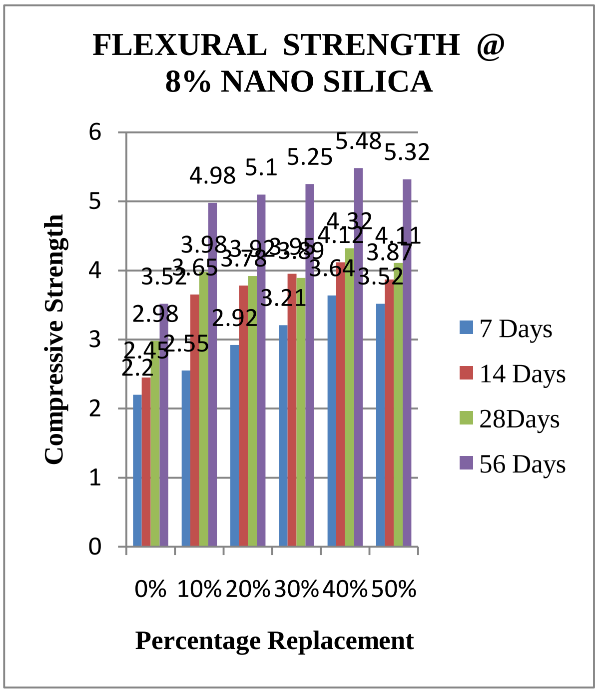

Fig.: 6.3. FLEXURAL STRENGTH @ M20 8% NANO SILICA

TABLE: 6.5. FLEXURAL STRENGTH M30 GRADE OF CONCRETE NA(0%,4%,8%)&MWR(0%,10%,20%,30%,40%,50%)

M	NS	MWA	STRENGTH N/MM²			
			7 DAYS	**14 DAYS**	**28DAYS**	**56 DAYS**
CC	**0%**	**0%**	2.8	3.2	3.9	4.2
		10%	2.98	3.42	4.02	5.02
		20%	3.01	3.54	4.8	5.42
		30%	3.28	3.98	4.92	5.68
		40%	3.35	4.01	5.1	5.98
		50%	3.12	3.95	4.85	5.62
Mix-1	**4%**	**0%**	2.8	3.2	3.9	4.2
		10%	3.08	3.8	4.32	4.92
		20%	3.57	4.02	4.69	5.06
		30%	3.98	4.32	4.97	5.98
		40%	4.12	4.548	5.18	6.01
		50%	3.98	4.32	5.01	5.68
Mix-2	**8%**	**0%**	2.8	3.2	3.9	4.2
		10%	3.18	3.92	4.42	5.01
		20%	3.68	4.12	4.9	5.56
		30%	4.1	4.32	5.12	6.1
		40%	4.2	4.6	5.48	6.21
		50%	3.98	4.32	5.11	5.78

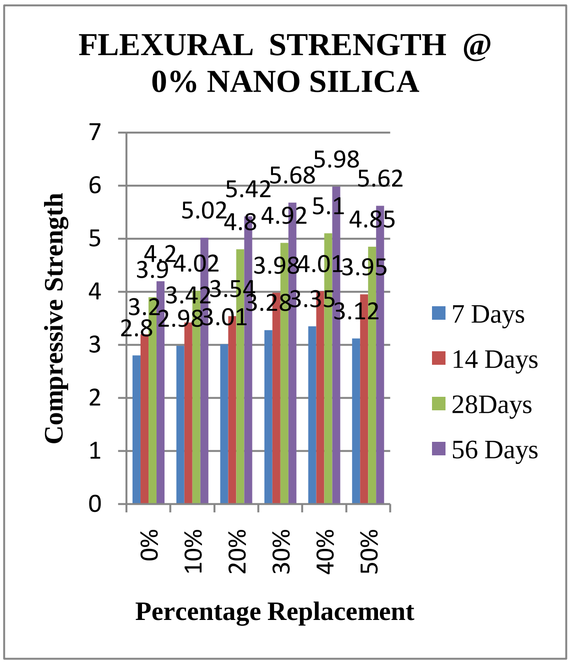

Fig.: 6.4. FLEXURAL STRENGTH @ M30 0% NANO SILICA

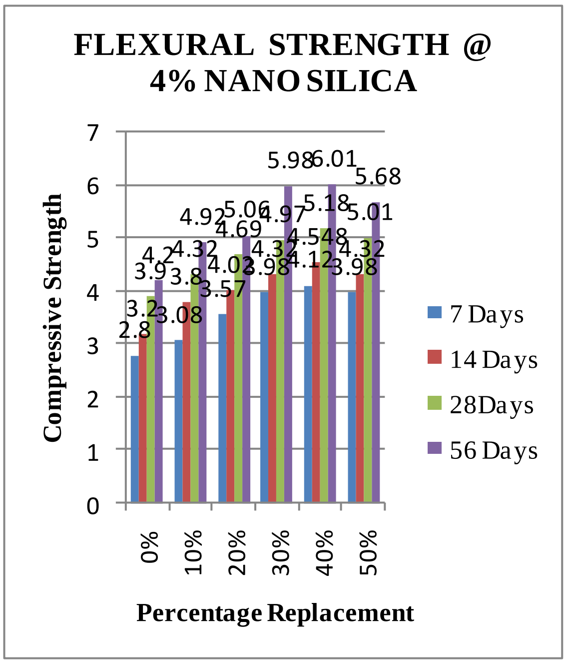

Fig.: 6.5. FLEXURAL STRENGTH @ M30 4% NANO SILICA

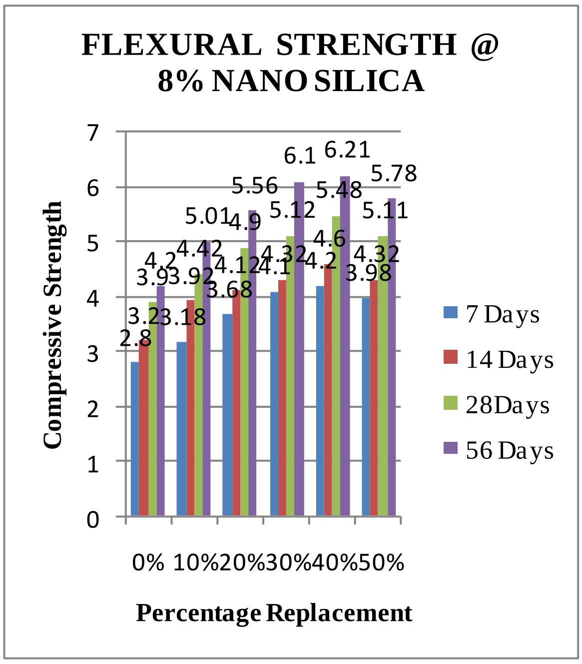

Fig.: 6.6. FLEXURAL STRENGTH @ M30 8% NANO SILICA

VI. CONCLUSIONS

Waste aggregate are the main problem of tile industries. The aim of this investigation was the utilization of tiles collected from industries in concrete as coarse aggregate and the strength characteristics of tile waste as replacement of coarse aggregate in concrete by adding 4% and 8% Nano silica of weight of the cement. The agent Nano silica is added to improve the bonding between cement and tiles in concrete to get increase in concrete strength. The following are the conclusions obtained

1. Replacement of coarse aggregate with Marble waste aggregate has much effect on the workability of concrete.
2. Compressive strength of concrete mixes up to 40% replacement of Marble waste aggregate is greater than conventional concrete mix.
3. For 7, 14, 28 and 56 days of curing, compressive strength of 40% replacement of Marble waste aggregate is greater than conventional concrete.
4. Adding 4% Nano Silica of weight of the cement by various percentage Marble waste aggregate as replacement of coarse aggregate increases the compressive strength of it up to 40% compared to the normal concrete.
5. Optimum results upto Marble waste aggregate 40% replacement of coarse aggregate along with 4% nano silica recommendable.

FUTURE SCOPE

Further testing and experiment can be done on Marble waste aggregate concrete, as it is highly recommended to indicate strength characteristics of this type of material for application in normal or low rise structural concrete. Some recommendations made for further studies:

1) Experiment can be done by varying water/cement ratio, to know the varying strength parameters while addition of sodium silicate, in order to get better grip on workability.
2) More investigations and research can be done on the strength characteristics of Marble waste aggregate powder as cementitous material which is also a pozzolanic material.
3) Non-destructive testing like Rapid Chloride Penetration Test (RCPT) can be done to support its suitability for structural concrete.
4) Use of waste can sustain environment and eco-system the whole; therefore there is an active research on Marble waste aggregate.

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