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,asaconstructivematerial,hasbeenused in construction industry for about two centuries.
Approximately,thewholebulkoftheconcreteis 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 reducingtheperformanceofconcreteissignificant 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 concreteBesides,allotherparametersareconstant. 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 PortlandCement(OPC)asthebinder.Theusageof 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 generationplantsproducehugequantitiesofGGBS and some of the materials which are byproducts.

The volume of fly ash would increase as the demandforpowerincreases.Mostoftheflyashis 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-USEINCONCRETE

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 useofnanosilicainconcretemixhasshownresults 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 cementconcrete,henceimprovingthepermeability and strength of concrete.

OBJECTIVES

Thisinvestigationfocusesonthefollowingpattern of work

- Nano-Silicaisusedaspartialreplacementof cementandMarbleWasteascoarseaggregate replacement.
- In the present experimental investigation, the cementispartiallyreplacedbyNanoSilica0,2,4 6, 8% respectively of M20 & M30 grade of concrete
- Curingwasdoneattheagesof7,28and56days weretestedi.e.compression,splittensilestrength and flexural strength along with durability test.

II. LITERATUREREVIEW

- 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.Disposalofthemarblepowdermaterial from the marble industry is one of the environmentalproblemsworldwidetoday.Theaim 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% and100% anditseffectonpropertiesof 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 replacementof cement up to 10% and crushed tile aggregate as partial replacement of natural coarse aggregate up to30%.Thepresentationonworkabilityofconcrete in this paper. They conducted ten mixes with differentcombinationsofwastemarblepowderand 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 ofconcrete 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 ascementreplacementmaterialat10%,20%,30% and 40% replacement levels (by cement weight) were evaluated. Mechanical properties as well as durabilitypropertiesaregreatlyaffectedasaresult 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 totalaggregate/cementratioof4%and50%of the total aggregate was fine aggregate.
- Sara de Castro, Jorge de Brito, gave the mechanicalpropertiesofconcretemadewithglass, 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 (fineandcoarse,separatelyorsimultaneously),ina totalof10concretemixes.Theywasfoundthatthe particle size strongly affects the workability of concrete. Due to the lower density of the glass aggregates,themixesmadewithglasshadalighter freshdensitythanthereferenceconcrete.Theyalso studied on the fresh properties such as workability anddensityofconcreteandthehardenedproperties such as compressive strength, water absorption by capillarity, water absorption by immersion, carbonation resistance, chloride penetration resistance and shrinkage

III. MATERIALSANDPROPERTIES

Thefollowingmaterialsarebeingusedandare listed below.

- Cement
- Fineaggregate(sand)
- Coarseaggregate
- Water

- Nanosilica
- Marblewasteaggregate(MWA)

CEMENT

The most widely recognized bond utilized is an Ordinary Portland Cement (OPC). The Ordinary Portland Cement of 53 review (OPC) Ultratech CementfittinginwithIS:8112-1989isutilized.A bond is a fastener, a substance utilized as a part of development that sets, solidifies and clings to differentmaterials,restrictingthemtogether.Bond is only sometimes utilized exclusively, however is utilized to tie sand and rock (total) together.

Table:1Physicalpropertiesofcement

S.No.	CHARACTERISTICS	VALUE
1	SPECIFICGRAVITY	3.15
2	NORMAL CONSISTENCY	31%
3	INITIALSETTINGTIME	60 minutes
4	FINALSETTING TIME	210 minutes

AGGREGATES

Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end productintheirownright.Theyarealsotheraw materials that are an essential ingredient in concrete.

Dependinguponthesizetheaggregatesare classified into two types

1) FineAggregate
2) CoarseAggregate

FineAggregate

Fineaggregatearebasicallysandswonfromthe land or the marine environment.

Table:2Propertiesoffineaggregate

S.No.	CHARACTERISTICS	VALUE
1	ZONE	II
2	SPECIFICGRAVITY	2.64
3	DENSITY	$14KN/m^3$
4	WATERABSORPTION	2.1%

CoarseAggregates

Coarseaggregatesareparticlesgreaterthan 4.75mm,butgenerallyrangebetween9.5mmto 37.5mm in diameter. They can either be from Primary,SecondaryorRecycledsources.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:3CoarseAggregatePhysicalProperties

S.No.	CHARACTERISTICS	VALUE
1	ZONE	II
2	SPECIFICGRAVITY	2.64

3	DENSITY	$14KN/m^3$
4	WATERABSORPTION	2.1%

Marblewasteaggregate(MWA):

In the present experimental work we used marble wasteaggregateascoarseaggregate.Thenominal maximum size of marble aggregate used was 10 mm and 20 mm

Marble is a metamorphic rock types derived from theexposedlimestoneandMetamorphoseregional 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. Flouredmarblewastereddishwhite,marblewaste when mixed with water it will harden, because floured then can serve as a binder.

Table:4Marblewasteaggregate(MWA)

S.No.	**Characteristics**	**Value Coarse Aggregate**	**Value Ceramic Tile**
1	Nominalsize	10mm	10mm
2	Specific gravity	2.84	2.33
3	Density	$1625.83Kg/m3$	$1635.83Kg/m3$
4	Water absorption	2.4%	2.8%

NANOSILICA:

Silicondioxide

as silica nanoparticles or nanosilica, are the basis foragreatdealofbiomedicalresearchduetotheir stability, low toxicity and ability to be functionalized with a range of molecules and polymers.

WATER:

Water is an important ingredient of concrete as it actuallyparticipatesinthechemicalreactionwith cement.Sinceithelpsto from thestrength giving cement gel, the quantity and quality of water is required to be looked into very carefully.

Table:5MixProportion@ M20

Mix	Nano Silica % of cement	Marble waste aggregate Replacement		Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (lit/m^3)
CC	0%	0%	0	360	584	1223.8	180.42
		10%	122.38	360	584	1101.42	180.42
		20%	244.76	360	584	979.04	180.42
		30%	367.14	360	584	856.66	180.42
		40%	489.52	360	584	734.28	180.42
		50%	611.9	360	584	611.90	180.42
Min-1	4%	0%	0	360	584	1223.8	180.42
		10%	122.38	360	584	1101.42	180.42
		20%	244.76	360	584	979.04	180.42
		30%	367.14	360	584	856.66	180.42
		40%	489.52	360	584	734.28	180.42
		50%	611.9	360	584	611.90	180.42
Min-2	8%	0%	0	360	584	1223.8	180.42
		10%	122.38	360	584	1101.42	180.42
		20%	244.76	360	584	979.04	180.42
		30%	367.14	360	584	856.66	180.42
		40%	489.52	360	584	734.28	180.42
		50%	611.9	360	584	611.90	180.42

Table:6MixProportion@M30

Mix	Nano Silica % of cement	Marble waste aggregate Replacement		Cement (Kg/m^3)	Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Water (lit/m^3)
CC	0%	0%	0	394	732	1139	197
		10%	113.9	394	732	1025.1	197
		20%	227.8	394	732	911.2	197
		30%	341.7	394	732	797.3	197
		40%	455.6	394	732	683.4	197
		50%	569.5	394	732	569.5	197
Mix-1	4%	0%	0	394	732	1139	197
		10%	122.38	394	732	1025.1	197
		20%	244.76	394	732	911.2	197
		30%	367.14	394	732	797.3	197
		40%	489.52	394	732	683.4	197
		50%	611.9	394	732	569.5	197
Mix-2	8%	0%	0	394	732	1139	197
		10%	122.38	394	732	1025.1	197
		20%	244.76	394	732	911.2	197
		30%	367.14	394	732	797.3	197
		40%	489.52	394	732	683.4	197
		50%	611.9	394	732	569.5	197

IVEXPERIMENTALINVESTIGATION

WorkabilityofConcrete

- SlumpTest
- Compactionfactortest

StrengthTest

- COMPRESSIVESTRENGTHTEST

COMPRESSIVESTRENGTHTEST

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 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 ofsample 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 recordedandanyunusualvaluenotedatthetimeof failure brought out in the report.

Thecubecompressivestrength,thenf$_C$=P/AN/mm^{2}Where P is an ultimate load in N, A is a cross sectional area of cube in mm^2

Fig.1CompressiveStrength Test

V EXPERIMENTALRESULTS

SLUMPTEST

Slump test is used to determine the workability of freshconcrete.SlumptestasperIS:1199–1959is 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:7Slumptest@M20GradeofConcrete

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:8Slumptest@M30GradeofConcrete

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

CompactionFactor

Table:9CompactionFactor@M20Gradeof 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:10CompactionFactor@M30Grade 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

-
- **COMPRESSIVESTRENGTH**

Table:11Compressivestrength@M20 Grade of Concrete

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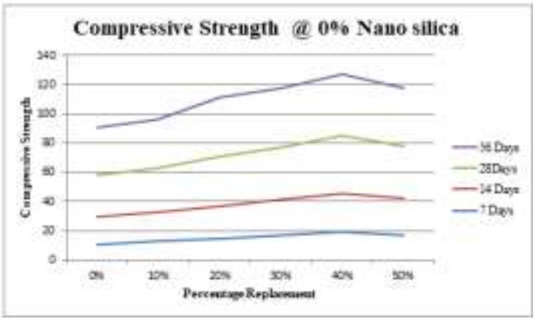
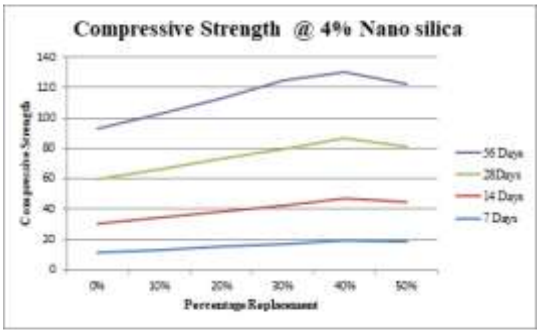
Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Compressive strength N/mm²			
			7 Days	14 Days	28Days	56 Days
CC	0%	0%	10.78	18.65	28.64	32.14
		10%	12.64	20.21	30.12	33.21
		20%	14.84	22.12	34.12	39.81
		30%	16.89	24.35	36.19	40.21
		40%	18.91	26.87	39.21	42.18
		50%	17.12	25.12	35.34	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



Graph1



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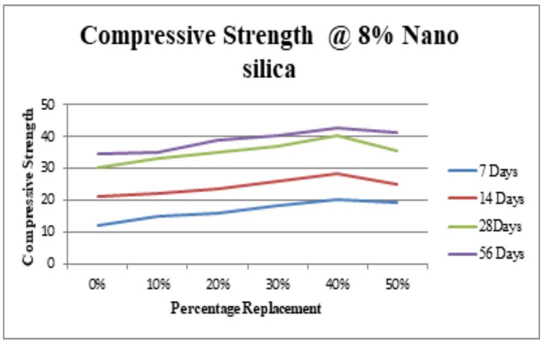
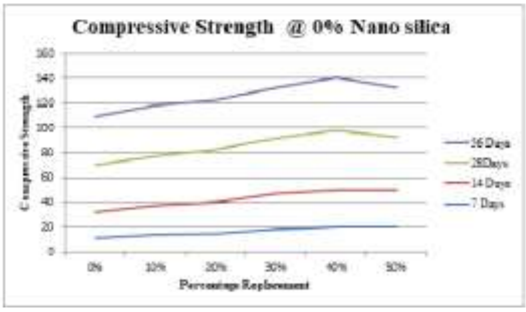


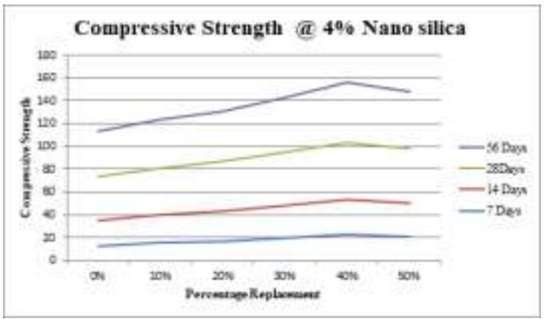
Graph3

Table:12Compressivestrength@M30 Grade of Concrete

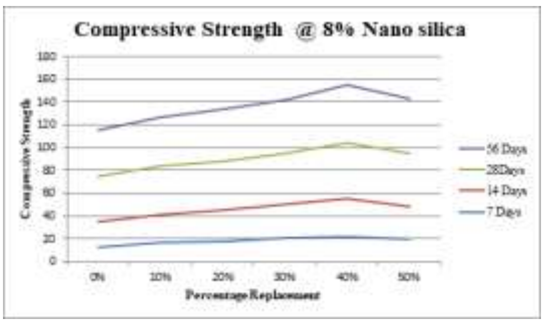
Mix	Nano Silica % of cement	Marble waste aggregate Replacement	Compressive strength N/mm²			
			7 Days	14 Days	28Days	56 Days
CC	0%	0%	11.28	20.65	37.64	39.12
		10%	14.02	23.65	40.02	40.12
		20%	15.02	25.12	42.35	39.81
		30%	18.12	28.94	45.12	40.21
		40%	20.12	30.12	48.01	42.18
		50%	19.85	29.86	43.02	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%	20.13	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



Graph4



Graph5



Graph6

VI. CONCLUSIONS

Waste aggregate are the main problem of tileindustries.Theaim ofthisinvestigationwasthe utilization of tiles collected from industries in concrete as coarse aggregate and the strength

characteristics of tile waste as replacement ofcoarse 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 betweencementandtilesinconcretetogetincrease 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.

FUTURESCOPE

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 orlow rise structural concrete. Somerecommendations 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.

REFERENCES

- 1. Krishan Kumar, Sumesh Jain, 2017, Combined Effect of Marble Dust and Steel Fibre on the Mechanical Properties of High Strength Concretes, International Journal of TrendinScientificResearchandDevelopment, Vol. 1(4), pp 384-388.
- M. Devi, 2014, Significance of Fibres in Enhancing Strength and Corrosion Resistance of Fly Ash Blended Quarry Dust Concrete, International conference on Biological,Civil

and Environmental Engineering (BCEE- 2014), pp 57-61.
- Susanto Teng, Tze Yang Darren Lim, Bahador Sabet Divsholi. 2013, Mechanical and durability properties of high strength concrete incorporating ultra fine Ground Granulated Blast-furnace Slag, Construction and Building Materials, 40, 875–881.
- Tamimi A.K., Abdalla J.A., Sakka Z.I. 2008, Prediction of long term chloride diffusion of concrete in raspy environment, Construction and Building.