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Partially Replacement of Coarse and Fine Aggregate with Ceramic Tile Waste and Nano Silica

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ABSTRACT:Larger percentage of industries wastes com in form of ceramic wastes as leading industries waste obtained in various forms like ceramic powder, broken tiles and slurry waste, the disposal of which creates environment pollution. These waste materials sometimes can be used to replace cement, fine aggregate, coarse aggregate and also acts as a supplementary addition in concrete. This study focused on the partially inclusion on ceramic tile waste as coarse aggregate and Nano silica as fine aggregate in the concrete production. The experimental work is mainly concern with the study of making concrete and to investigate the mechanical properties like compressive strength, split tensile strength by partial replacement of coarse aggregate and fine aggregate by ceramic tile waste and Nano silica Tests over carried out on cubes, cylinders to study the mechanical properties of concrete ceramic tile waste and Nano silica and compare with conventional concrete with coarse aggregate. Ceramic tile waste and Nano silica are replacing with 10%,20%,30%,40%, of coarse aggregate and fine aggregate by weight using grade M30. Compression test, splitting tensile strength and water absorption test were carries out to evaluate the strength properties of concrete at the age of 7,14,28 days. Nano materials have been widely used in the past few decades due to their proven capacity to enhance the mechanical properties of materials. The project aims to investigate the mechanical properties of cement concrete incorporating Nano-silica. It has been given that the compressive strength of mortar is increased when adding Nano silica. But in this project, we check the performance of Nano silica when it is added in reinforcement beam. To determine the dosage of Nano silica for the beam by adding it in concrete cube at different percentage. So, in this project we add nominal percentage of Nano silica at which the strength increased in concrete cubes.

KEYWORDS: Ceramic tiles, Nano silica, mechanical properties, compression test, split tensile test.

I. INTRODUCTION

Ceramic tiles are important construction materials used in almost all buildings. The production of these tiles normally starts from raw materials, girding, and mixing, and granulating by spray drying, pressing, firing and polishing and glazing. Waste mud, which is the sediment of washed down particles from these manufacturing processes is approximately 2% wt of the final product[1]. This mud which contains both coarse particles (feldspar quartz, and ground fixed tiles) and fine particles (clay minerals such as kaolinite and mica) is far too impure to be re-used in tile production, so it is normally disposed of as waste in landfills. Elimination of this waste mud has become more and more problematic due to the huge amount of this waste production each year and the increasing cost of disposal. One way forward to solve this problem is by utilizing this waste for other purposes. The amount of ceramic tile waste on earth is enough for use a coarse and fine aggregate in concrete. Ceramic tile is produced from natural materials interested at high temperatures. There are no harmful chemicals in tile. Waste tiles cause only the hazard of pollution. Some parts of tiles are used in as flooring and in different types of structures used differently like tennis courts, walkways,

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cycling paths and gardens as a ground material. Due to such reasons waste tiles are stored in factory fields because of their economic value[2]. Nevertheless, ever year approximately 250,000 tons of tiles are washed out, while 100 million tiles are used for repairs. Ceramic waste can be transformed into useful Fine and Coarse aggregate. The use of supplementary cementitious materials (SCM) reduces the embodied energy in concrete considerably. Furthermore, it significantly improves the durability of concrete and increases its life cycle thus leading to a more sustainable design. Researches have examined the effects of using Nano silica in mortars and concrete. The majority of these studies found that using small dosages of Nano silica improves the early age and the 28-day strength, however, inadequate dispersion of Nano silica can lead to agglomeration, which can drastically reduce the benefits of using Nano silica especially at early age. Identifying relationships between design variables and inspection ratings is insufficient to determine causation[17]. In the construction industry, extensive research is going on to improve the performance of building materials and development of durable and sustainable concrete. These members offer flexibility in design and construction and are an ideal choice for projects that require long uninterrupted spans with high load-carrying capability and quick erection times[16]. Among all the materials Nano silica is the most widely used materials in the cement and concrete to improve the performance, because of its pozzolanic reactivity besides the pore-filling effect. The concrete strength is influenced by lots of factors like concrete ingredients, age and water cement ratio. Sustainability is assessed in three domains: economic, environmental, and social[18].

Objectives:

1. To determine the adding percentage of Nano silica and ceramic tile waste in concrete cube at different percentage.
2. To increase the flexural strength of concrete by incorporating Nano silica and ceramic tile waste.
3. To improve the structural strength.
4. To increase the compressive strength of the concrete.

II. MATERIAL

Cement:

A cement is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together. Cement is seldom used on its own, but rather to bind sand and gravel (aggregate) together[3]. Cement mixed with fine aggregate produces mortar for masonry, or with sand and gravel, produces concrete. Concrete is the most widely used material in existence and is only behind water as the planet's most- consumed resource.

Grade of cement

1. 33 grade of cement
2. 43 grade of cement
3. 53 grade of cement

Figure2.1: Cement

Coarse Aggregate

Coarse aggregates will not pass through a sieve with 4.75 mm openings (No. 4). Those particles that are predominantly retained on the 4.75 mm (No. 4) sieve and will pass through 3-inch screen, are called Coarse aggregate[4]. The coarse the aggregate, the more economical the mix. Larger pieces offer less surface area of the particles than an equivalent volume of small pieces. Use of the largest permissible maximum size of coarse aggregate permits a reduction in cement and water requirements. Using aggregates larger than the maximum size of coarse aggregates permitted can result in interlock and form arches or obstructions within a concrete form. That allows the area below to become a void, or at best, to become filled with finer particles of sand and cement only and results in a weakened area.

Fine Aggregate

The other type of aggregates are those particles passing the 9.5 mm (3/8 in.) sieve, almost entirely passing the 4.75 mm (No. 4) sieve, and predominantly retained on the 75 µm (No. 200) sieve are called fine aggregate. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The purpose of the fine aggregate is

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to fill the voids in the coarse aggregate and to act as a workability agent[5].

Figure2.2: Aggregates

Admixtures are materials in the form of powder or fluids that are added to the concrete to give it certain characteristics not obtainable with plain concrete mixes. Admixtures are defined as additions "made as the concrete mix is being prepared". The most common admixtures are retarders and accelerators. In normal use, admixture dosages are less than 5% by mass of cement and are added to the concrete at the time of batching/mixing. In recent constructions, the consumption of ceramic materials is increasing day by day in the form of tiles, sanitary fittings, electrical insulators etc. But a large quantity of ceramic materials changes into wastage during processing, transporting and fixing due to its brittle nature[6]. Therefore, using these wastes in concrete production could be an effective measure in maintaining the environment and improving the properties of concrete. Hence, the crushed waste ceramic tiles were used in concrete as a replacement for natural coarse aggregates with 0%, 5%, 10%, 15% 20% and 25% of substitution. After analyzing results, the optimum value of waste ceramic tile to be used within the concrete mix with a water/cement ratio of 0.5 was determined as about 20%. The findings revealed that using waste ceramic tile lead to enhancing the properties of concrete.

Fig2.3: Ceramic tilewaste

Nano Silica

1. Nano-silica up to 3% can enhance mechanical and durability properties of concrete.
2. Concrete compressive strength increases as the content of Nano-silica increases.
3. Nano-silica has a very high pozzolanic activity.
4. Filling effect of Nano-silica notably influences the refinement of pore structure.
5. Incorporating a small amount of Nano particles in concrete can modify the Nano-structure of cementitious materials, and thus procure high durability.
6. Recently Nano-silica has gained particular attention compared to conventional mineral addition due to its better performance in concrete.

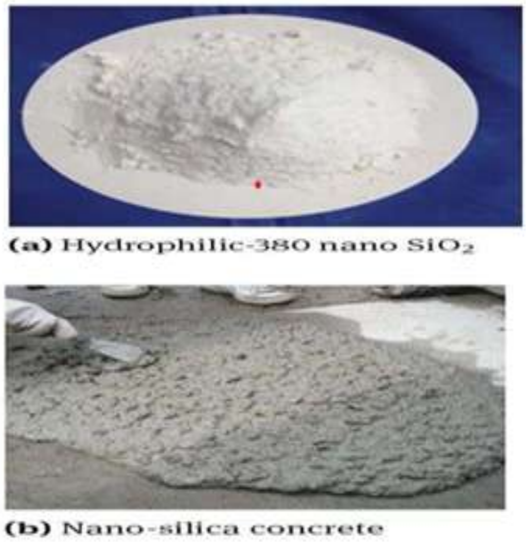

Fig2.4: Nano silica

III. MATERIAL TESTING

Specific gravity of cement

The flask shall be filled with kerosine to a point on the stem between the zero and 1ml of mark. The first reading shall be recorded after the flask has been filled with kerosene[7].

1. Take 64 grams of cement sample and pour the sample into the bottle using glass stick.
2. Remove the sticked cement with glass stick and observe the final reading of kerosene after complete immersion of cement into the bottle.
3. Type and company cement= OPC 53 GRADE (BIRLA).
4. Liquid used in experiment=Kerosene.
5. Density of liquid=780kg/m3.
6. Weight of the cement taken(w)=64 grams.

$$\text{Specific gravity (G)} = \frac{\text{weight of cement}}{\text{volume of cement}} = \frac{64}{20.4} = 3.137$$

Table3.1Specific gravity of cement

S.No	Initial reading	Final reading	Volume of cement	Sp. gravity of cement
1	0	20.4	20.4	3.137

Fineness of cement

1. Weight 100 grams of cement sample in electronic weight balance and shift it continuously for 15 min on IS sieve no-9.
2. Air set lumps will be broken down with fingers but should not rubbed on the sieve[9].
3. Find the weight of residue on the sieve after sifting is over and report the value as percent of the original.

Table3.2Specific gravity of cement

Trail number	1	2	3
Weight of cement in grams	100	100	100
Weight of the residue on sieve in grams	6	6.5	6.5
Amount of retained (%)	6%	6.50%	6.50%

Normal consistency of cement

1. The standard consistency of a cement is defined as that consistency which will permit the vicat plunge to penetrate to a point 5 to 7mm from the bottom of the vicat mould[10].
2. Initially a cement of sample about 400 grams is taken in a tray and is mixed with a known percentage of water by weight of cement say starting from 26% and them it is increased by every 2% until the normal consistency achieved.
3. Prepare a paste of 400g of cement with a weighted quantity of portable water and mix it thoroughly proper care can be taken during the mixing and it shall not be more than 3 to 5 min[8].
4. Fill the vicat mould with this plate the mould resting upon a non-porous plate. After completely filing the mould trim the surface of the plate making it level on the top of the mould. The mould may be slightly shaken to expel the air.
5. Place the test block in the mould together with the non-porous resting plate under the rod beaning the plunger lower the plunger gently to touch the surface of the test block and quickly release allowing it to sink into the paste this operation shall be varies out immediately after filing the mould and note down the reading.
6. Preparation trial pastes with varying percentages of water and test as described above until the amount of water necessary for making up the standard consistency.

Table3.3Normalconsistencyofcement

% of water	Initial reading	Final reading	Height not penetrated (mm)
26	50	33	17
28	50	24	26
30	50	12	38
32	50	5	45

Initial setting time and final setting time of cement

1. Prepare a near cement paste with 0.85 times the water required to give standard consistency.
2. Start the stop watch at the instant addition of water. Fill the vicat mould with paste and trim the surface of the mould and rests on the non-porous plate.
3. Place the test block under the rod bearing the needle, lower the needle gently in contact with surface of the test block and quickly release and allowing it into penetrate[11].
4. Repeat the procedure until the needle when brought into contact with the test block fails to pierce the block for 5 to 7mm from the bottom of the mould.
5. The period elapsed since adding water is the initial time of the given cement sample weight of the cement is 400 grams.
6. Weight of water= 0.85 X P X 400=0.85 X 0.32 X 300=108.8ml.

Table3.4 Initial and final setting of cement

Time(min)	0	20	40	60	80	100	120
Initial reading (mm)	50	50	50	50	50	50	50
Final reading (mm)	0	1	2	3	4	5	6
Height not penetrate d(mm)	0	49	48	47	45	44	43

Fig3.1: Initial setting time

Fig3.2: Specific gravity of cement

Fig3.3: Fineness of cement

Fig3.4: Consistency of cement

Specific Gravity and Water Absorption Tests

1. Take about 2kg of dry sample of coarse aggregate is places in wire basket &immersed in water foe 24 hrs. The sample is weighted in water &the buoyant weight is found.
2. The aggregates ate then taken out, surface dries well with absorbent cloth and weighted.
3. The aggregates are turn dries in an oven at a temperature 110C for 24hrs &then the oven dry weight is determined.
4. Then the specific gravity is calculated by dividing the dry weight of aggregate by weight of equal volume of water.
5. The water absorption is expressed as the percent water absorbed in terms of oven dried weight of the aggregates[12].

Table3.5Specificgravity and water absorption of coarse aggregates

S.No	Description	Aggregate
1	Weight Of Saturated Aggregate &Basket in Water(w1gms)	2050
2	Weight Of Basket in Water(w2gms)	820
3	Weight Of Saturated Surface Dry Aggregate in Air(w3gms)	1955
4	Weight Of Oven Dried Aggregate in Air (W4gms)	1950
5	Specific Gravity of Aggregates	2.89
6	Water Absorption of Aggregates	0.16%

Fig3.5: Specific gravity aggregates

Table 3.6 Specific gravity and water absorption

S.No	Description	tiles
1	Weight of saturated ceramic tiles(w1gms)	2000
2	Weight of basket in water(w2gms)	820
3	Weight of saturated surface dry ceramic tiles in air(w3gms)	1900
4	Weight of oven dried ceramic tiles in air(w4gms)	1850
5	Specific gravity of ceramic tiles	2.57
6	Water absorption of ceramic tiles	2.7

Fig3.6: Water absorption test on coarse

Aggregate Impact Test: -

The test sample consists of aggregates passing 12.5mm test sieve and retain on 1omm sieve and dried in oven for 4 hours at a temperature 100-110ºc and cooled the aggregates are filled with upto one third full in the measuring cylinder and tampered 25 times with rounded end of the tamping rod[14]. Future quality of aggregates is then added upto about 2/3 full in the cylinder and 25 stokes of the tamping rod given.

- The hammer is raised until its lower race is 380mm above the surface of the aggregate is the cup and allowed to fall freely on the aggregates.
- The sample is subjected to a total of 15 blows of the hammer, each internal being delivered at an interval less the one second[13].
- The crushed aggregate is then removed from the cup and whole of it is sieved on 2.36 mm sieve until o further significant amount passes.
- The fraction retained on sieve is also weighted and if the total weight of factions weighted and retained Weight of the empty container (w1)=922
- Weight of container and aggregate(w2)=1279.2.

Table3.7aggregate impacttest

S.no	**Details**	**aggregates**
1	Total weight of aggregate sampling filling in the cuylinderr measure(w3)gms	286
2	Weight of aggregate retained on 2.36mm(w4)	45.5
3	Different in weight (w5)	240.5
4	Aggregate impact value w4 ×100	15.90%

Aggregate Crushing Test: -

- The cylinder of the test appratus shall be put in position on the base plate and the test sample added in thirds, each third being subjected to 25 times from the tamping rod.
- The surface of the aggregate shall be carefully levelled and the plunger is inserted.
- So that is rests horizontally on this surface core being taken to ensure that the plunget does not aim in the cylinder.
- The apparatus with the test sample and the plunger in the position shall be placed between this plates of the resting machine and loaded at uniform as ossible shall be 40 tonnes.
- The load shall be released and the whole of the material removed from the cylinder and sieved on a 2.36mm.

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- The fraction passing through the sieve shall be weighted as B. then by using the formuls crushing value has to be determine[15].

Fig3.7aggregateimpacttest

Table3.8Aggegatecrushingtest

S.no	**Details**	**Aggregates**
1	Total weight of dry sample taken(w3)gms	2675
2	Weight of portion passing 2.36mm seive(w4)gms	670.5
3	Aggregate crushing value w4×100 / W3	25.06%

Bulking of Sand

1. Put sufficient quality of sand 1000gms into a container level off the top of the sand and pushing a steel rule vertically down through the sand at the middle to the bottom, measure the height, suppose this in h1 cm.
2. Empty the sand out of the container into another where none of it will be lost. half fill the first container with water. Put back about half the sand and stir it with a steel rod, about 6mm in diameter. So that it volume is reduced to a minimum. Them add the reminder of the sand and rod it in the same way.
3. Repeat the above procedure and noted down the percentage of moisture content of the sample.
4. The percentage of bulking of the sand due to moisture shall be calculated from the formula.
5. Height of the dry sand(h)=17.5cm

Table3.9 Bulkingofsand

S.no	Percentage of (h) water added by the weight of sand	Height of moist sand(h')in cm	Percentage of bulking of sand
1	1%	19.2	9.71
2	2%	20	14.28
3	3%	20.6	17.71
4	4%	21.2	21.14
5	5%	22.1	26.28
6	6%	21.6	23.42
7	7%	20.8	18.85

IV. MIX DESIGN

IS 10262 -2009 code is used to design the control mix

DESIGN OF CONCRETE MIX-M30

a. Grade Designation: M30
b. Type of Cement: OPC53 grade (BIRLA)
c. Maximum Nominal Size of Aggregate: 20mm angular
d. Minimum Cement Content:320kg/m3
e. Maximum Water Cement ratio: 0.55
f. Workability: 50-75 mm(slump)

Table4.1 Mix Design Proportion

Cement	Fine aggregate	Coarse aggregate	water
456 kg/m3	666.91 kg/m3	1130.35 kg/m3	191.5 kg/m3
1	1.462	2.478	0.42

- The standard size of cube for compression test is 150mm×150mm×150mm.
- The standard size of cylinder for split tensile test is 150mm×300mm.

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Table4.2 Quantity of material

S.No	% of Nano silica added to fine aggregate	Nano silica(kg)	% off ceramic tile waste added to coarse aggregate	Ceramic tile waste(kg)	Fine aggregate (kg)	Coarse Aggregate (kg)	Cement (kg)
1	0%	0	0%	0	2.39	3.96	1.65
2	10%	0.23	10%	0.39	2.06	3.57	1.65
3	20%	0.47	20%	0.79	1.91	3.16	1.65
4	30%	0.71	30%	1.18	1.67	2.77	1.65
5	40%	0.95	40%	1.58	1.43	2.37	1.65

Table 4.2 compressive strength7 days test results

S.no	**Sample results**	**7 days (N/mm2)**
1	0% of ceramic tiles and Nano silica	26.22
2	10% of ceramic tiles and Nano silica	27.7
3	20% of ceramic tiles and Nano silica	28.6
4	30% of ceramic tiles and Nano silica	29.4
5	40% of ceramic tiles and Nano Silica	31.6

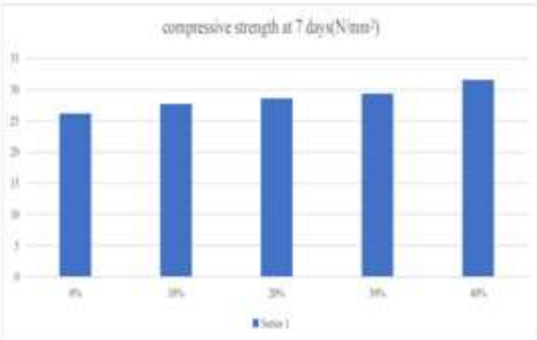

Fig 4.1: Compressive strength (7days)

Table4.3 Compressive strength14 days test results

S.no	**Sample results**	**14 days (N/mm2)**
1	0% of ceramic tiles and Nano silica	35.1
2	10% of ceramic tiles and Nano silica	37.4
3	20% of ceramic tiles and Nano silica	38.4

4	30% of ceramic tiles and Nano silica	39.6
5	40% of ceramic tiles and Nano silica	36.6

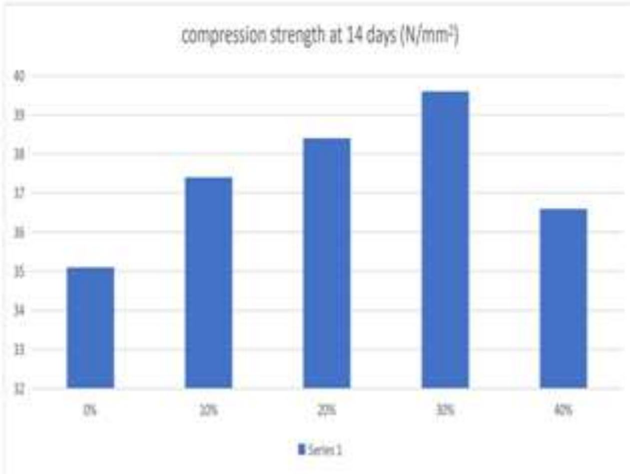

Fig 4.2: Compressive strength (14days)

Table4.4compressivestrength28 days testresults

S.no	**Sample results**	**28 days (N/mm2)**
1	0% of ceramic tiles and Nano silica	41.8
2	10% of ceramic tiles and Nano silica	43.5
3	20% of ceramic tiles and Nano silica	44.8
4	30% of ceramic tiles and Nano silica	46.3
5	40% of ceramic tiles and Nano silica	42.4

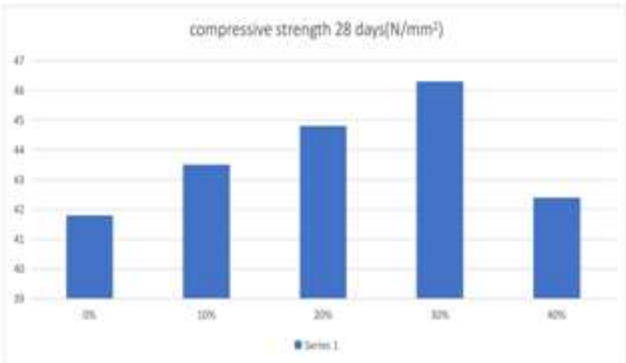

Fig 4.3: Compressivestrength (28days)

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Table4.5 Splittensilestrengthtestresults (28 days)

S.no	Sample results	28 days (N/mm2)
1	0% of ceramic tiles and Nano silica	3.67
2	10% of ceramic tiles and Nano silica	3.79
3	20% of ceramic tiles and Nano silica	3.88
4	30% of ceramic tiles and Nano silica	3.92
5	40% of ceramic tiles and Nano silica	4.21

V.CONCLUSIONS

- The workability of concrete increases with the increase in tile aggregate replacement.
- The workability is further increased with the addition of ceramic tiles with the concrete by replacing the coarse aggregate.
- It is observed that these is a strength increased with addition of ceramic of 30% and beyond which there appears to be no specific enhancement in strength.
- The properties of concrete increased linearly with the increase in ceramic aggregates up to 40% replacement later it is decreased linearly.
- M30 mix(30% of ceramic tiles) of concrete produced a better concrete in terms of compressive strength, split tensile strength, than the other mixes.
- Thus, it concluded that the replacement of coarse aggregate with ceramic waste up to 30% replacement reaches optimum level.
- Based on the above experimental procedure and test, we conclude as :
- The use of Nano silica can increase the strength of concrete not only in compression test but also in split tensile test.
- The use of Nano silica incorporated concrete can be more economical in terms of strength when compared to other type of concrete.
- In this project we also saw that the waster absorption capacity of concrete with Nano silica is lesser than conventional concrete.
- We strongly recommend 1.5% dosage of Nano silica in reinforced structure because it can withstand high load along with deflection and has better workability when compared to other ratios.
- On addition of Nano silica there is a substantial increase In the early-age strength of concrete compared to the 28 days increase in strength.

SCOPE OF FUTURE WORK

Further this porject can be done by adding admixtures to increase the various properties of the concrete.

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