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Flexural Study on Slab specimens of Modified Concrete using Light weight Silica Fume Aggregate, Sintered Fly-ash Aggregate, LECA and Penta Blended Cement with Pozzolanic and Nano Materials

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ABSTRACT: ***Aim of the project is to examine the flexural properties of the modified M_{20} grade concrete by fully replacing the coarse aggregate by Silica fume aggregate, Sintered fly ash aggregate and LECA (Light expandable clay aggregate) in equal proportions. It is also proposed to replace 11% weight of cement with three numbers of pozzolanic materials like Silica Fume, Slag and Fly Ash along with varying percentages like 0, 0.5, 1 and 1.5% of nano materials on 11% of weight of cement. The Nano materials used are Nano Silicon oxide (SiO_2), Nano Aluminum Oxide (Al_2O_3) and Nano Titanium oxide (TiO_2) in equal proportions. With these variations the effect of replacements on cube strength and flexural strength on slab specimens is proposed to be studied.***

Keywords: Silica Fume aggregate, Sintered fly ash aggregate, LECA, Ultra tech 53grade Cement, Nano Silicon oxide (SiO_2), Nano Aluminum Oxide (Al_2O_3), Nano Titanium oxide (TiO_2), Cube Compressive Strength , flexural Strength of Slabs.

1. INTRODUCTION :

Cement Concrete is the most versatile and highly consumed building material which consists of hard inorganic materials like Crushed rock aggregates, fine aggregates (sand) bonded together using Portland cement and water. Due to the high consumption of these natural resources they may get depleted very fast. In metro cities besides scarce availability of these natural resources, transportation of these materials to the construction site is becoming expensive. Much research is going on to find the artificial aggregates using industrial wastes like fly ash and Silica fume which are otherwise being used as land fill etc causing environmental pollution. Effective utilization of these industrial wastes has become an alternate and viable solution for the ever increasing needs of the construction industry. Silica fume aggregate, sintered fly aggregate and LECA have emerged as replacement of natural crushed rock aggregates which are also light in weight and thereby there is reduction in the density of concrete.

Previous investigations revealed that the presence of Nano materials in cement concrete decreases the amount of cement content than that is needed for conventional concrete and there on an improvement in compressive and flexural strengths, It is because of the high surface to volume proportion of Nano materials. The Nano material densifies the cement lattice by expanding the C-S-H gel in addition to the pozzolanic properties of these materials. Also the Nano measured molecule fills the voids in interfacial zone of the cement paste and aggregate.

2. LITERATURE REVIEW:

Wasserman and Bentur [1] had shown that the strength of the concrete could not be accounted by the strength of the aggregates only and it was suggested that the absorption and pozzolanic activity of the aggregates could have an influence on the strength developed.

Alduaij et al. [2] In their investigation studied lightweight aggregate concrete with different unit weight aggregates such as light weight crushed bricks, lightweight expanded clay and normal weight gravel aggregates without the usage of natural fine aggregate (no-fines concrete). They obtained a lightweight concrete with 22 MPa cylinder compressive strength and 1520 kg/m^3 dry unit weight and maximum strength of 28 $N/mm^2$was attained at 8% replacement, while the minimum strength of 2.75 $N/mm^2$was attained at 20%replacement.

Nazari, et al [3], reported that Nano Al_2O_3 particle blended concrete had significant higher compressive strength compared to that of the concrete without that Nano Al_2O_3 particles. It was found that the cement could be advantageously replaced with Nano-Al2O3 particles up to maximum limit of 2% with average particle sizes of 15nm, although the optimum level of Nano Al_2O_3 Particles was achieved with 1.0% replacement. It was also found that partial replacement of cement by Nano-Al_2O_3 particles decreased workability of fresh concrete; therefore use of super plasticizer is a must.

Zhenhua Li &HuafengWang(2014),[4] studied about the effect of containing different amounts of Nano alumina. Cylindrical specimens were cast to study the compressive strength and elastic modulus of cement composite. Elastic modulus was increased by 143%, with the addition of 5% Nano alumina after 28 days of curing and compressive strength was increased by 30 %, with the addition of 7% Nano alumina after 7 days of curing. Thus Nano alumina has significant effect on both elastic modulus and compressive strength.

Arvind Kumar &DilipKumar.[5], reported that the maximum compressive strength of 36.25 N/mm^2 was attained at 12% replacement of Sintered fly ash aggregate in concrete while the minimum strength of 26.68 N/mm^2 was attained at 20% replacement. It is also reported that the maximum flexural strength of 4.95N/mm^2 was attained at 8% replacement, while the minimum strength of 2.75 N/mm2 was attained at 20% replacement.

V.Bhaskar Desai and A. Sathyam [6] studied about the effect of using different percentages of Silica fume pelletized aggregate replacing natural aggregate and their different properties and they compared with those of natural aggregates.

Mahdy (2016) [7] made a study on structural light weight concrete using cured LECA. In this research a new technology was developed to enhance the quality of light weight aggregate (LECA) by immersing it in the solution of silica fume in order that the silica fume particles get through the aggregates and try to pack some voids.

From the brief literature review conducted here it appears that much less attention has been paid earlier on the study of flexural properties of modified concrete slabs with partial to 100% replacement of natural aggregates with Cold bonded Silica Fume and Sintered fly ash aggregates and LECA along with the usage of Nano materials in combination with pozzolanic materials. Hence the present investigation has been under taken.

3. EXPERIMENTAL PROCEDURE:

The experimental program comprises of casting and testing of 15 numbers of reinforced concrete slabs and 15 numbers of cubes made up of modified concrete by replacing 100 % natural aggregate with sintered fly ash aggregate, silica fume aggregate and LECA in equal proportions along with replacement of cement with 11% of its weight by 3 no of pozzolanic materials i.e. fly ash, slag and silica fume in equal proportions. Varying percentages of three numbers of Nano materials i.e., Nano Silicon dioxide, Nano Aluminum oxide and Nano titanium oxide in equal proportions i.e., 0, 0.5, 1, and 1.5 on 11% of cement were used in the investigation. The two way slabs were tested with fixed end condition on all its four sides and under udl after 28 days of curing. All the slabs were of square in shape and are of size 600 × 600 × 50 mm. The slabs were white washed for easy identification of crack patterns and placed over the platform for testing. To simulate the fixed supported edge condition, plates were fixed on all the four sides of the slab through nuts and bolts in order to prevent any rotation and any differential settlement. The various mix proportions used are presented in Table 1.

3 numbers of cube specimens 150x150x150 mm were also cast for the corresponding proportions of cement concrete to find out the compressive strength simultaneously.

Table 1: Mix proportions:

Mix	% Volume replacement of Coarse aggregate by Silica fume Sintered fly ash aggregates & LECA	% of admixtures in equal proportions(fly ash, silica fume & slag)	% of Nano Materials on 11% of cement	% of cement	Number of cubes	Number of slab specimens
S-0	100	0	0	100	3	3
S-1	100	11	0	89.00	3	3
S-2	100	11	0.5	88.945	3	3
S-3	100	11	1	88.890	3	3
S-4	100	11	1.5	88.835	3	3

4. MATERIALS:

The following materials were used for preparing the concrete mix.

1. Ultra tech cement of 53grade
2. Fine aggregate i.e., sand
3. Coarse aggregate i.e. Silica fume aggregates, Sintered fly ash aggregates and LECA
4. Fly ash
5. Silica fume
6. Slag
7. Water
8. Nano materials i.e. aluminum oxide, silicon dioxide and titanium oxide
9. Steel of HYSD 415grade

4.1 Cement: Ordinary Portland cement Ultra tech 53 grade was used as binder. Some of the physical properties are presented in Table 2

Table 2: properties of cement

S. No.	Property	Value
1	Normal consistency	30%
2	Fineness	5%
3	Specific gravity	3.26
4	Initial setting time Final setting time	50 minutes 460 minutes

4.2. Fine Aggregate:
Natural river sand procured from Chitravathi River near Bathalapalli, AP, with specific gravity of 2.54 was used as a fine aggregate which is conforming to zone- II of IS: 383-1970

4.3. Coarse Aggregates:
4.3.1: Silica fume aggregates:

Silica fume is a byproduct in the form of smoke that results from electric furnaces of industries producing Silicon metal or ferrosilicon alloys. Silicon and ferrosilicon alloys are produced in electric furnaces and the raw materials are quartz, coal and wood chips. Before the mid 1970's nearly all Silica fume was discharged into atmosphere. After environmental concerns necessitated collection and land filling became economically justified to use Silica Fume in various applications. Because of it's chemical and physical properties it is found that it is a very reactive pozzolana.
One of the common techniques while producing the light weight aggregate is by agglomeration technique. In agglomeration technique the pellets are formed by agitation granulation and compaction. The agitation method does not take any external force rather than the rotational force. With the increasing dosage of water in the binder the cohesive force of the particles increases. Here attempts have been made to form pellets of Silica Fume with various proportions of lime and cement mixed with water. Pelletization of Silica Fume is done by using a rotating drum with fixed blades having adjustable inclination. The percentage of binder content is taken by weight of Silica fume. The percentage proportion adopted for formation of pellets is 47:47:6 i.e., Silica fume: lime: cement. The drum used for pelletization of Silica fume aggregates is as shown vide plate no: 1 and the view of manufactured Silica fume aggregates vide plate no: 2
Silica fume was procured from Ferro Silica Unit at Ahmadabad. The physical properties of Silica fume aggregate are shown below Table 3

plate 1: Manufacture process of Silica fume aggregate

plate 2: Silica fume aggregates

Table 3: Typical physical characteristics of Silica fume aggregates

S. No.	Property	Value
1	Bulk Density	854 Kg/ m3
2	Water Absorption	20%
3	Shape	Round
4	Specific Gravity	2.18
5	Fineness modulus	5.80

4.3.2: Sintered fly ash aggregate:

The usual procedure of preparation of Sintered fly ash aggregates is by mixing of fly ash with little amount of water and pellets are formed through the technique of agglomeration, pelletizing and then sintered at a temperature of 10000^{0}C to 12000^{0}C . These hard pellets can then be used as superior, consistent, lightweight aggregate which is up to 50% lighter than natural aggregate. These aggregates are generally black, brown or red In color depending on its chemical composition. Plate 3 shows the sintered fly ash aggregates used in this study. Sintered fly ash aggregates procured from Litagg Company Ahmedabad was used in this investigation. Some of the physical properties are presented in Table 4

Table 4: Physical properties of sintered fly ash aggregate (as supplied by the manufacturer)

S. No	Property	Value
1	Aggregate Size	8-12mm
2	Bulk Density	800kg/m3
3	Bulk Porosity	35-40%
4	Aggregate Strength	>4.0MPa
5	Water Absorption	< 16 %
6	Shape	Round pellets
7	Hardness	23.2%
8	Fineness modulus	6.57
9	Specific gravity	1.7
10	Impact	28%

Plate 3: Sintered fly ash aggregate

4.3.3: Light expandable clay aggregates (LECA):

LECA (Light Expandable Clay Aggregate) is an acronym term for which is produced in rotary kiln at about 1200 degree centigrade. The base material is plastic clay which is extensively preheated. Light Expandable Clay Aggregate was procured from Nexcus Buildcon Solution India. Typical physical properties of Light Expandable Clay aggregates are listed in table below. The industrial preparation method of LECA is shown in plate 4 below.

Plate 4: Flow chart of LECA Manufacturing process

Plate 5: Light Expandable Clay Aggregate

Table 5: Physical properties of LECA

S. No	Property	Value
1	Aggregate size	4-10mm
2	Specific gravity	1.18
3	Aggregate strength	>2.26mpa
4	Bulk density	645kg/m^3
5	Water absorption	18%
6	Bulk porosity	35-40%
7	Aggregate shape	Angular

4.4: Fly ash: The fly ash admixture was procured from Rayalaseema Thermal plant, Muddanur, AP. Some of the physical properties are presented in Table 6

Table 6: Physical properties of fly-ash

S. No	Property	Value
1	Specific gravity	2.7
2	Fineness (retained on 90 micron sieve)	0%
3	Bulk density loosest state	800 kg/m^3
4	Bulk density compacted state	960 kg/m

4.5 Silica Fume: The Silica fume admixture was procured ferro Silica unit at Ahmedabad. Some of the physical properties are presented in Table 7

Table 7: Physical properties of Silica fume

S.NO.	Property	Test results
1	Specific gravity	2.1
2	Fineness (retained on 90 micron sieve)	0%
3	Bulk density loosest state	420 kg/m^3
4	Bulk density compacted state	700 kg/m^3

4.6 Slag: The source of slag is from Jindhal steel industries, Bellary, Karnataka. Some physical properties are presented in table 8

Table 8: Physical properties of Slag

S.NO.	Property	Test results
1	Specific gravity	2.86
2	Bulk density loosest state	600 kg/m^3
3	Bulk density compacted state	980 kg/m^3

4.7: Water: water used for casting and curing of concrete specimens should be free from acids, impurities and suspended solids etc. The presence of above materials in water affects the strength and durability of the concrete. The local drinking water which was free from such impurities was used in this experimental investigation.

4.8 Nano materials:

4.8.1: Nano aluminum oxide:

Nano aluminum oxide was procured from AVANSA technologies, KHANPUR. Some of the physical properties are presented in Table 9

Table 9: Physical Properties of Aluminum Oxide (Al_2O_3) (As Given by the supplier).

S.NO	PROPERTY	VALUE
1	Purity	99.5%
2	Aps	<20nm
3	SSA	20-80m^2/g
4	(Al_2o_3)color	White
5	Bulk Density	0.18g/cm^3
6	True Density	2.9g/cm^3

4.8.2: Nano silicon oxide:

Nano Silicon Oxide was procured from AVANSA technologies, KHANPUR. Some of the physical properties are presented in Table 10

Table 10: Physical Properties of Silicon Dioxide (Sio_2) (As Given by the supplier).

S.NO.	PROPERTY	VALUE
1	Purity	98%
2	APS	60-80nm
3	SSA	160-600m^2/g
4	(Sio_2) Color	White
5	Bulk Density	<0.10 g/cm
6	True Density	2.4 g/cm^3

4.8.3: Nano titanium oxide:

Nano titanium oxide was procured from AVANSA technologies, KHANPUR. Some of the physical properties are presented in Table 11

Table 11: Physical Properties of Titanium Oxide (TIO_2) (As Given by the supplier).

S.NO	PROPERTY	VALUE
1	Purity	99.9%
2	SSA	289m^2/g
3	Color	White
4	Bulk Density	0.12-0.18g/cm^3

4.9: Reinforcement:

All the slabs are reinforced with 8 mm diameter with Fe_{415} grade steel reinforcement, placed at 130 mm spacing in both directions.

5. CASTING OF SPECIMENS:

The M20concrete mix is designed using IS code which gives a mix proportion of 1:1.49:2.88 with water cement ratio of 0.50. Four different mixes are used, which are designated as in Table no.1. Steel moulds were used to cast the slab specimens of required size. Two L-shaped frames with a depth of 50 mm were connected to a flat plate at the bottom using nuts and bolts. Cross-stiffeners were provided to the flat plate at the bottom to prevent any possible deflection while casting the specimens. The gaps were effectively sealed by using thin card-boards and wax to prevent any leakage of cement-sand slurry in slab specimens. The moulds are shown in plate 6 Initially, the steel mould was coated with waste oil so that the slab specimens can be removed easily from the moulds. Then the mat of 8 mm steel rods @ 130 mm c/c was kept, at the bottom of mould over 8 mm cover blocks. Then the remaining portion of entire mould was filled with freshly prepared concrete. The details of casting are shown in plate 7. Initially dry mixture of cement, pozzolanic materials and Nano materials and sand was spread over the heap of coarse aggregate i.e., mixture of Cold bonded Silica fume aggregates, sintered flyash aggregates and LECA. Hand mixing was done after adding required quantity of water to achieve uniform mix and to prevent the segregation or balling of aggregates and cement slurry. For all the specimens table vibration was adopted. The test specimens were demoulded after 24 hours and cured for 28 days in water ponds. After removing the slab specimens from the curing pond, they were allowed to dry under shade for a while and then they were white washed on both sides, to achieve clear visibility of cracks during testing. The loading position on the top and the dial gauge position at the bottom of the slab were marked with black paint.

plate 6: Slab mould with reinforcement

plate 7:Slab mould filled with concrete

6. APPLICATION OF LOAD:

The experiment consists of testing of square slabs, supported on all its four sides with fixed end supports, under uniformly distributed loading. The slab specimen was placed over a clear opening of 470mm x 470mm. Plates were fixed on all the four sides of the slab through nuts and bolts in order to prevent any rotation and any differential settlements. Load was applied to the top surface of the slabs by a hydraulic pump through 25 tons pre calibrated proving ring at regular intervals .This point load was transmitted to the entire slab specimen through a series of I- sections placed on a flat plate welded with a series of iron balls to transfer the load as uniformly distributed load.

This plate was placed over the slab specimen in inverted position with iron balls touching the surface as shown in plate 8 & plate 9. At the bottom face of slab specimen, a deflectometers with a least count of 0.01mm were placed at centre and 2nos each along the two diagonals to record the deflections. The load at the first crack and the corresponding deflection at the bottom centre and critical sections of the slab were recorded. The ultimate load and corresponding deflection at the centre and critical sections were also observed and recorded for all the slab specimens.

Plate 8: Slab testing frame with fixed ends

Plate 9: Testing of slab for flexural strength

7. TESTING OF SPECIMEN:

7.1 Compressive strength of cubes: Compressive strength of cubes was calculated by dividing load taken by the specimen by the cross sectional area. Values of compressive strength at different percentages of Nano materials are given in table 13 below

7.2 First crack load and ultimate load of slabs in fixed condition:

The load taken at which first crack formed on the bottom face of slab is called first crack load. The ultimate load was taken when the pointer in the proving ring goes in reverse direction. The values are presented in table 12.

7.3 Moment carrying capacity of slabs at first crack load and ultimate load based on IS code method:

According to IS code method of designing the moment carrying capacity calculated using the following formula

$$M=W*\alpha_x*L^2_x$$

Where M= Bending moment

For restrained supported condition

α_x**=0.056**(moment coefficient from IS code: 456:2000)

L_x=Effective length of slab

W=ultimate load carrying of slab

The values are presented in table 12.

7.4 Moment carrying capacity of slabs at first crack load and ultimate load based on Yield line theory:

According to yield line theory the moment carrying capacity of slabs can be calculated by following formula derived from combined process of Virtual work done and equilibrium method

Moment carrying capacity for fixed condition is

$$M_X= \frac{Wl_x^2}{48}$$

Where

W= collapse load

L= Total length of slab

The values are presented in Table 12.

7.5 Strain energy stored of slabs:

The energy absorption is defined as the area under the load-deflection curve. The values are determined from test results, and are listed in Table 12

Table 12: Moment carrying capacity of Fixed Slabs and strain energy stored in slabs.

Mix	At First Crack load			At Ultimate load			
	Load (KN)	Moments (KN-m)		Load (KN)	Moment(KN-m)		Strain Energy Stored (KN-mm)
		by IS Code method	By yield Line theory		IS Method	Yield Line Theory	
S-0	11.55	0.85	0.33	54.90	4.10	3.42	154.86
S-1	12.59	1.15	0.50	80.71	4.18	3.55	190.00
S-2	20.73	1.53	0.70	108.96	8.05	5.89	248.50
S-3	17.59	1.30	0.59	99.48	7.35	5.37	235.79
S-4	15.72	1.16	0.53	81.23	6.63	4.89	216.21

Table 13: Cube Compressive Strength

Mix proportions	Cube compressive strength in N/mm^2	Percentage increase of compressive strength w.r.t to S-0
S-0	12.12	0
S-1	15.44	8.53
S-2	19.86	39.46
S-3	17.64	28.36
S-4	16.24	18.64

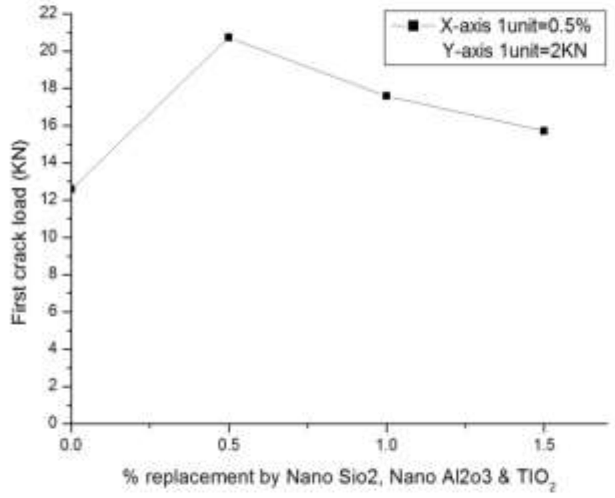

Figure 1: First crack load Vs % replacement by NanoSiO_2, Nano Al_2O_3 & TiO_2

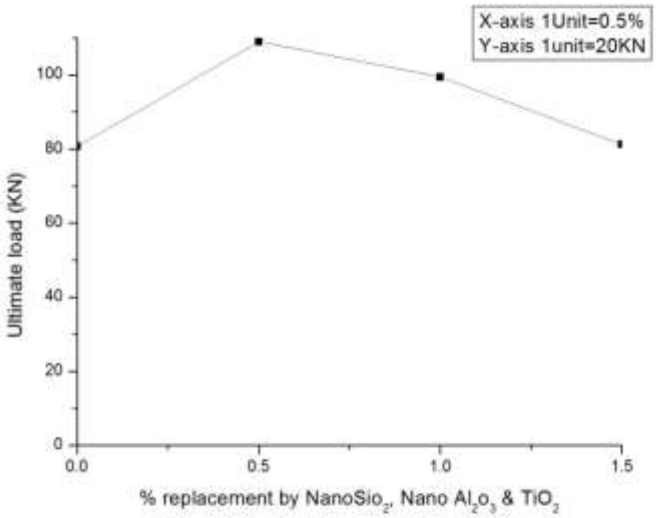

Figure 2: ultimate load Vs %replacement by NanoSiO_2, Nano Al_2O_3 & TiO_2

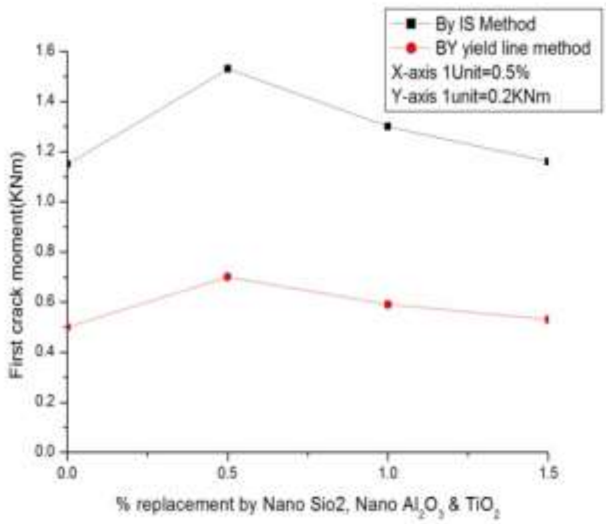

Figure 3: Comparison of First crack moments as per IS Code and Yield Line theory

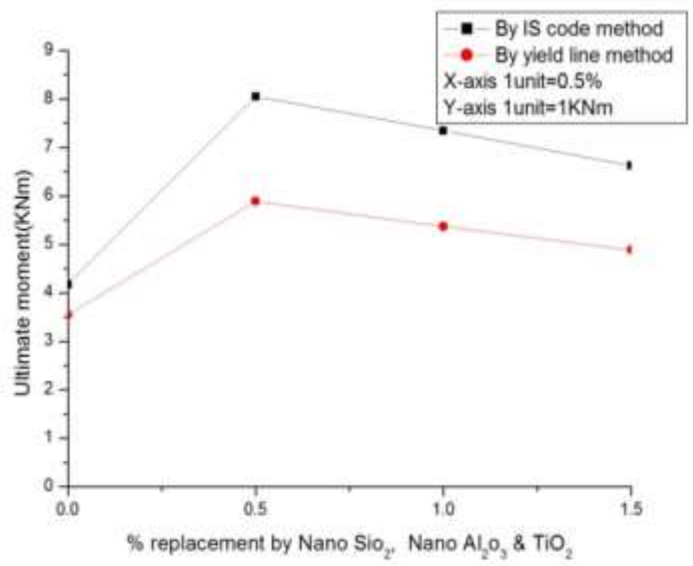

Figure 4: Comparison of ultimate moments as per IS code & Yield Line theory

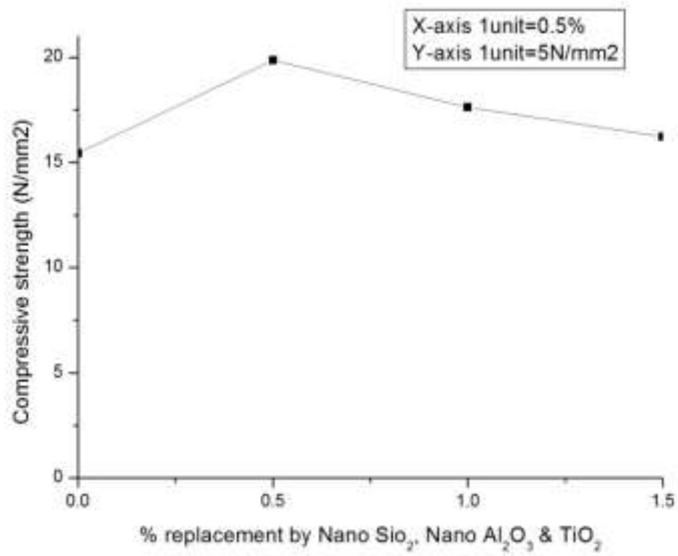

Figure 5: Compressive strength of cubes Vs% replacement by Nano SiO_2, Nano Al_2O_3 & TiO_2

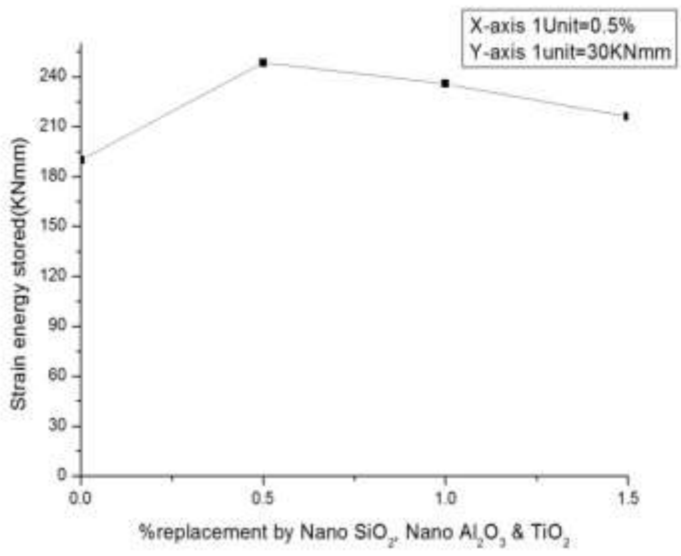

Figure 6: Strain energy stored Vs %replacement by Nano SiO_2, Nano Al_2O_3 and TIO_2

8. Discussion of test results

8.1 Influence of Nano SiO_2, Al_2O_3 and Nano TIO_2 on First crack and Ultimate load in two way slabs with fixed end condition:

In the present study natural aggregate has been fully replaced with Sintered fly ash aggregate, Silica fume Aggregate and LECA in equal proportions. The variation of first crack load and Ultimate load versus varying percentage addition of Nano Sio_2, $Al2O_3$ and TIO_2in equal proportions at 0%, 0.5%, 1% and 1.5% on 11% of cement along with pozzolanic materials at 28 days are presented graphically vide Figure 1 and Figure 2 From the figures it may be observed that with addition of silicon dioxide , aluminum oxide and titanium oxide, the first crack and ultimate loads are increased up to 0.5% replacement of nano materials and with more addition of Nano materials of SiO_2, Al2O3 and TiO_2 both these loads have decreased. The results are tabulated in table 13. Hence 0.5% addition of nano material combination is found to be optimum.

8.2 Influence of Nano SiO_2, $Al2O_3$ and TiO_2 on Moment carrying capacity of slabs at first crack load and Ultimate load in two way slabs with Fixed end condition based on IS code and Yield line theory:

In the present study natural aggregate is fully replaced with Sintered fly ash aggregate, Silica fume aggregate and LECA in equal proportions. The moment carrying capacity of slabs is increased continuously up to 0.5% addition of Nano materials of SiO_2, $Al2O_3$ and TiO_2 and with further addition it is decreased. The results are tabulated vide table13 and graphical representation is given vide Figure 3 and Figure 4. Also the moment carrying capacity calculated using IS code method is found to be higher than that calculated using yield line theory approach. Hence here also 0.5% addition of nano material combination is found to be optimum.

8.3 Influence of Nano Sio_2, Al_2O_3 and TiO_2 on cube compressive strength:

In the present study natural aggregate has been fully replaced with Sintered fly ash aggregates, Silica fume aggregate and LECA in equal proportions. The variation of compressive strength versus varying percentage addition of Nano SiO_2, $Al2O_3$ and TiO_2 in equal proportions at 0%, 0.5%, 1% and 1.5% on 11% of cement along with replacement of cement with constant 11% of its weight with three numbers of pozzolanic materials i.e., Silica fume, Slag and Fly ash in equal proportions is presented in Figure 5. From the above figures it may be observed that with the addition of silicon dioxide, aluminum oxide& titanium dioxide the cube compressive strength increases with addition up to 0.5% and with more addition of Nano SiO_2, Al2O3 and TiO_2 the strength is decreased. The results are tabulated vide table no 13 and represented graphically vide Figure 5. Hence the combination of nano material is optimum at 0.5%.

8.4 Influence of Nano Sio_2, Al2O3 and TiO_2 on strain energy stored in slabs:

In the present study natural aggregate is fully replaced with Sintered fly ash aggregate, Silica fume aggregate and LECA in equal proportions. The strain energy stored in the slabs is increased continuously up to 0.5% addition of Nano materials and there after the strain energy is decreased. The results are tabulated vide table no 12 and represented graphically vide Figure 6. Here also 0.5% nano material combination is optimum.

9. CONCLUSIONS:

1) The target mean strength of M_{20} grade concrete is 26.60 N/mm^2. From the experimental study it is observed that the 28 days cube compressive strength of modified concrete with 100% replacement of natural aggregate by Sintered fly ash aggregates, Silica fume aggregates and LECA in equal proportions is 12.12 N/mm^2.With the replacement of cement by 11% of its weight with three numbers of pozzolanic materials i.e., Silica fume, fly ash and slag in equal proportions and with addition of three numbers of Nano materials i.e., Nano SiO_2, Nano Al2O3 and TiO_2 in equal proportions on 11% weight of cement, The cube compressive strength rises to 19.86 N/mm^2 from 12.12 N/mm^2. Hence 0.5% nano material combination is found to be optimum.
2) Moment carrying capacity of slabs calculated at first crack load and ultimate loads, as per Yield line theory method is less when compared with those calculated using IS code method.
3) Moment carrying capacity of slabs is found to be optimum at 0.5% replacement by Nano silicon oxide, Nano aluminum oxide and Nano titanium oxide combination.
4) The strain energy stored in slabs is found to be optimum at 0.5% replacement of Nano silicon oxide, Nano aluminum oxide and Nano titanium oxide i.e., 248.50KN-mm.
5) The light weight concrete prepared by combination of Sintered fly ash aggregates, Silica fume aggregates and LECA, can be used as concrete with reduction in density of concrete and reduced consumption of cement by 11% which is ecofriendly.

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