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Flexural Study on Slab Specimens with Partial to Fully Replacement of Natural Coarse aggregate by Sintered Fly Ash Aggregate

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Abstract: Light weight concrete has become more popular in recent days owing to the tremendous advantages it offers over the conventional concrete due to its lower density and superior thermal insulation properties with low thermal conductivity, compared with normal weight concrete. The new sources of artificial aggregate which are produced from industrial waste are used in this study. A mix design is done for M_{20} grade concrete by IS code method. It is proposed to replace natural aggregate with Sintered fly ash aggregate with varying percentages of 0,25,50,75 and 100 to cast RCC slab specimens. After 28 days of curing, tests are carried out on slab specimens to find the moment carrying capacity and strain energy stored due to bending under simply supported condition, corresponding cube compressive strength. Moment carrying capacity and strain energy stored in slab specimens under simply supported edge condition are reported and analysed.
Keywords: Sintered fly ash aggregate, two way slabs, natural coarse aggregate, and ACC 53 grade.

I. INTRODUCTION

The management of coal fly ash produced by thermal power stations is a major problem in many parts of the world. India produces about 120 million tonnes of fly ash annually. Although some fly ash is used in wide range of applications particularly as a substitute for cement in concrete, large amount of fly ash ie, about 75% of production remain unused and thus required more effective disposal. Due to continuous usage of naturally available aggregates, within short span of time these natural resources get depleted and it will be left nothing for future generations. The use fly ash for production of sintered fly ash light weight aggregate is an appropriate step to minimize the consumption of precious natural resources on one hand and showing an alternate mode for disposal of ever increasing production of fly ash year by year. The usual procedure for formation of pellets is mixing of flyash with limited amount of water and pellets are formed through the technique of agglomeration and pelletizing and then sintered at a temperature of 1000^0C to 1200^0C .The fly ash may contain some unburnt coal which may vary from 2 to 15 percent depending upon the efficiency of burning. The aim is always to make use of the fuel present in the fly ash and to avoid the use of extra fuel materials. The burning of carbon in the pellets and loss of moisture creates a cellular structural bonded together by the fusion of fine ash particles.

Use of such lightweight aggregate for production of Structural Lightweight Concrete (SLC) is next appropriate step. The use of light weight concrete permits greater design flexibility and substantial cost savings, reduced dead load, improved cyclic loading, better structural response, longer spans, better fire ratings, thinner sections, smaller size structural members etc., Artificial light Weight Aggregate is a relatively new material. For the same crushing strength, the density of concrete made with such an aggregate can be as much as 35 percent lower than that of the normal weight concrete.

Figure 1: Sintered flyash aggregates

II. REVIEW OF LITERATURE

Alduaij et.al.(1) studied light weight concrete using different unit weight aggregates including light weight crushed bricks, light weight expanded clay and normal weight gravel without the use of natural fine aggregate (no-fines concrete).

They obtained a light weight concrete with 22 MPa cylinder compressive strength and 1520 kg/m³ dry unit weight at 28 days.

V VArora, et.al. (2) investigated the suitability of sintered fly ash aggregate for strength properties with water cement ratios of 0.45 and 0.55. The various Mechanical properties such as Compressive strength, Flexural strength, Split tensile strength, Drying shrinkage, Modulus of Elasticity and Poisson's ratio were determined.

Arvindkumar, Dilipkumar et.al.,(3) in their experimental investigation used M_{25} mix design with OPC 43 grade cement. Natural aggregates were replaced with sintered fly ash aggregates. Compressive strength studies were made to attain optimum percentage of sintered fly ash aggregate content .

Owens, P.L. et.al.(4) stated that Light weight aggregate concrete has been used for structural purposes since the 20^{th} century. The Light weight aggregate concrete is a material with low unit weight and often made with spherical aggregates. The density of structural Light weight aggregate concrete typically ranges from 1400 to 2000 kg/m³ compared with that of about 2400 kg/m³for normal weight aggregate concrete.

Sidramappa and Archita (5) studied the flexural behavior of RCC slab and ferro cement slabs for cyclic loading. The first crack and collapse load along with their deflections were measured during testing. On comparison ferro cement slabs are found to be more ductile when compared to RCC slabs for same moment and flexure behavior of ferro cement slabs were found to be superior when compared to RCC slabs

SudarsanaRao et al., (6) studied the effect of various volume percentages of steel fiber in SIFCON slab specimens subjected to punching shear, deflection, failure load and crack patterns in punching shear. Plain concrete slab and fiber reinforced concrete specimens were used as control specimens.

The results showed that SIFCON slabs with 12% fiber volume possess higher performance than the other slab specimens in all respects. The experimental result was compared with IS and ACI codes and the need for separate provisions for SIFCON in punching shear was emphasized.

To predict the punching shear capacity of SIFCON slabs a regression model was developed.

Vasant and Kalurkar (7) investigated the punching shear behaviour of fibre reinforced concrete slabs with simply supported condition along all the four edges and loaded up to ultimate failure under a concentrated load at the centre over a square area.

The parameters were the volume fraction, slab thickness, concrete strength, span to depth ratio and size of load-bearing plate characterized by first crack and ultimate load, increasing of slab thickness and volume fraction and grade of concrete increases the punching shear strength and ductility of slab and concluded that the ultimate punching shear strength of slab specimens, compared with the predictions of equations available in literature and code provisions. The CP 110's equation of British standard was reasonably matched with the experimental values.

Curcio, et.al, (8) had shown that the as per the Norwegian design code, NS 3473 (1998), the reduction in tensile strength of Light weight aggregate concrete when compared with that of normal weight concrete of the same compressive strength is obtained by multiplying with a factor (0.3 + 0.7 D/2400) if the tensile strength is not determined by testing, where D is the density of the concrete in kg/m³. For the ratio between flexural and splitting tensile strength of high performance Light weight aggregate concrete, values of 1.5 to 1.6 have been found.

From the brief literature summary conducted here it appears that much less attention has been paid earlier on the study of concrete modified with artificial aggregate i.e., sintered Fly ash aggregate on the two way slab. Hence the present investigation has been under taken.

III. EXPERIMENTAL PROCEDURE

The experimental program comprises of casting and testing of 15 numbers of reinforced concrete slabs with various percentage replacements of natural coarse aggregate with sintered flyash aggregate and the slab specimens were tested with simply supported condition on all four edges.

The mix proportions of the various specimens cast are presented in Table 1. All the slabs are square in shape and are of size 600 × 600 × 50 mm. The slabs are white washed for easy identification of crack patterns and placed over the platform for testing.

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IV. MATERIALS USED

The following materials were used for preparing the concrete mix.

A. Cement

ACC 53 grade cement with specific gravity 3.26 isused as binder. Some physical properties are presented in the following table.

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

B. Fine Aggregate

Locally available river sand passing through 4.75 mm I.S. Sieve is used. The specific gravity of the sand is found to be 2.54 and it was conformed to zone II.

C. COARSE AGGREGATE

Crushed granite aggregate available from local sources has been used. The specific gravity of the coarse aggregate is 2.60.

D. Sintered Fly Ash Aggregate

Sintered fly ash aggregate procured from IndiaMart Company, Ahmedabad is used in this investigation. Typical physical characteristics of Sintered fly ash aggregates as shown in below

S.NO.	PROPERTY	VALUE
1	Aggregate Size	8-12mm
2	Bulk Density	800 kg/m3
3	Bulk Porosity	35%
4	Aggregate Strength	>4.0 MPa
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%

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E. Reinforcement

All the slabs are reinforced with 10 mm diameter Fe 415 grade steel rods, placed at 130 mm spacing in both directions.

F. Water

Water used for casting and curing of concrete specimens should be free from acids, impurities and suspended solids etc. if the above materials are present in water it effects the strength and durability of concrete. The local drinking water which was free from such impurities has been used in this experimental investigation.

V. MIXING, CASTING AND CURING

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 Fig. 1. 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 10 mm steel rods @ 130 mm c/c was kept, at the bottom of mould over 10 mm thick cover blocks. M20 mix design has been carried out with the mix proportions of 1: 1.58: 2.88 with constant water cement ratio 0.5 by using IS code 10262-2009 **(10)** .It means that 1 part of cement, 1.58 parts of fine aggregate and 2.88 parts coarse aggregate. It is proposed to replace natural aggregate by saturated and surface dry sintered fly ash aggregate with varying percentages of 0,25,50,75 and 100. All of these were mixed thoroughly by hand mixing. No super plasticizer was added in concrete. After mixing concrete was placed inside the moulds and vibrated for 6 to 10 seconds and allowed to set. The specimens were de moulded after 24 hours of casting and were kept immersed in a clean water tank for curing. After 28 days of curing the specimens were taken out of water and they were allowed to dry under shade for few hours and then they were white washed on both sides, to achieve clear visibility of cracks during testing. For each proportion, three cubes and three reinforced concrete slabs were cast following the usual procedure.

Figure 2: Slab mould with reinforcement

Figure 3: slab specimen placed on loading platform

A. Testing of Specimens

1) *Compressive strength of Cubes:* The cube specimens were removed from the water and allowed to become dry under shade for some time and tested under compression following the usual standard procedure.

The compression strength of cubes is tabulated in table1 and variation is presented graphically in figure 5.

2) *Moment Carrying Capacity Of Slabs*

a) *Structural Loading Frame and Platform :* Typical arrangement for testing, square slabs is as shown vide fig., 3. The loading platform consists of four welded steel beams of ISLB 150 in square shape with clear opening of 47cm X 47 cm to place the cast RCC slab and the platform is supported on columns of ISLB 150 placed at four corners. The loading platform and loading frame are stiff enough to support the loading without significant deformations. The loading frame and set up is as shown in fig no., 4

Figure 4: Load setup

b) Application Of Load And Loading Sequence : The experiment consists of testing of square slabs, simply supported on all four edges, under uniformly distributed loading. Application of load on the top surface of the slab is through pre-calibrated proving ring and hydraulic jack at a rate of 1 Kn/Sec as point load. The load was applied to the slab through a distribution system also called "loading tree" or "load spreaders". This loading system was designed to spread the load as uniformly distributed load throughout the slab with four edges of slab allowed for free rotation. Below the slab specimen, deflectometers with a least count of 0.01mm was placed at centre and 2nos each along the diagonals to record the deflections. The load at the first crack and the corresponding deflection at the bottom centre and at other points of the slab were recorded. The ultimate load and corresponding deflection at the centre and along the diagonals were observed and recorded for all the slab specimens.

B. First crack load and Ultimate Load of Slabs in Simply Supported Condition

The loads and deflections were recorded periodically. The load at the observation of first crack developed on the surface of slab specimen and failure load were used to calculate the moment carrying capacity of the slab specimens.

C. Moment carrying capacity of slabs at First crack Load And Ultimate Load Based on IS Code Method (9)

According to IS code the moment carrying capacity is calculated using the following formula

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

Where M= Bending moment

For simply supported condition

α_x=0.062(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 2, and graphical variations are presented in figure 8 to 9.

Moment carrying capacity under simply supported condition based on Yield line Theory is calculated using the formula

$$M_y=\frac{WL2}{24}$$

Where

W= collapse load

L= Total length of slab

The values are presented in table 2 and figure 8 to 9.

D. Strain Energy Stored In Slabs

WheZn an elastic body is loaded it undergoes deformation i.e., it's dimensions change and when it is relieved of the load it regains its original shape. For the time loaded energy stored in it, the same is given up or releases by the loading when the load is removed. This energy is called Strain energy. Strain energy stored in a member = work done results of strain energy stored in the slabs are calculated as the area under load–deflection diagram. They are tabulated in table 2 and typical load versus deflection graphs are presented in figure 10.

Table 1: Compressive strength of Cubes:

Mix	%Volume Replacement of coarse Aggregate with Sintered Fly ash Aggregate	Ultimate load (KN)	Cube compressive strength in N/mm^2	Percentage decrease of compressive strength
J1	0	867	38.50	0.0
J2	25	812	36.05	6.36
J3	50	720	32.50	15.58
J4	75	708	31.46	18.28
J5	100	641	28.84	25.09

Table 2: Moment carrying capacity and strain energy stored in slabs:

Mix	%Volume Replacement of coarse Aggregate with Sintered Fly ash Aggregate	First crack load(KN)	First crack moment as per IS code (KN-m)	First crack moment as per yield line theory (KN-m)	Ultimate load (KN)	Ultimate Moment as per IS code (KN-m)	Ultimate Moment as per Yield line theory (KN-m)	% Increase in ultimate moment w.r.t Yield line theory	Strain energy stored in slab (KN-mm)
J1	0	26.355	2.237	1.789	148.84	12.63	10.107	24.96	258.13
J2	25	22.605	1.919	1.535	121.36	10.303	8.24	25.04	215.0
J3	50	20.73	1.759	1.34	108.85	9.24	7.39	25.03	171.37
J4	75	17.0	1.44	1.154	93.85	7.968	6.37	25.08	141.27
J5	100	15.10	1.28	1.023	81.98	6.960	5.57	24.95	110.37

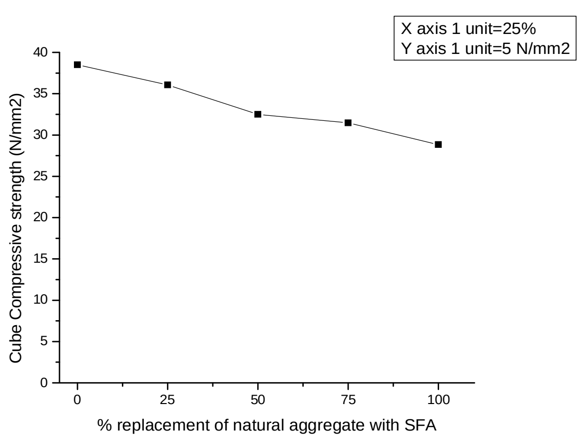

Figure 5: Variation of Cube compressive strength Vs. % replacement of natural aggregate by SFA

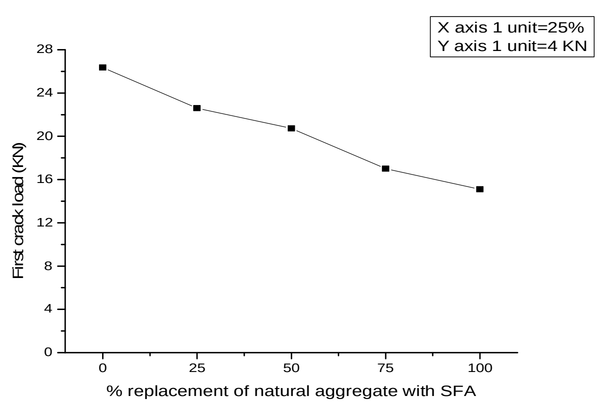

Figure 6: Variation of First crack load Vs. % replacement of natural aggregate by SFA

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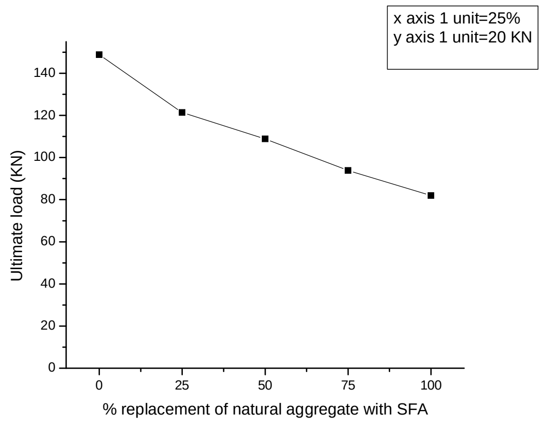


Figure7: Variation of Ultimate load vs. % replacement of natural aggregate by SFA

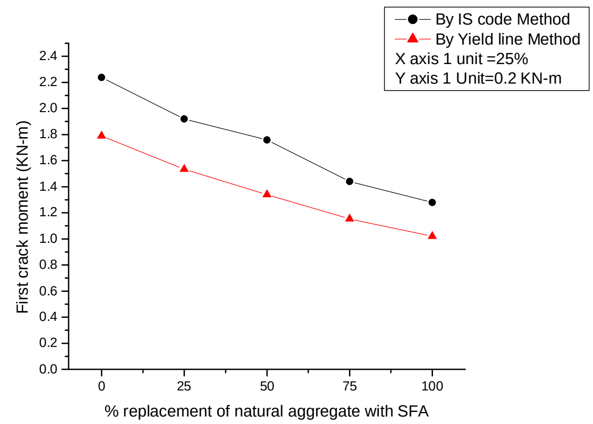


Figure 8: Super imposed variation of moments at first crack Vs. % replacement of natural aggregate by SFA

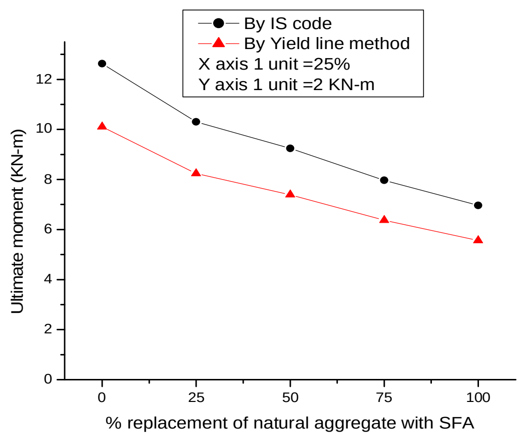


Figure 9: Super imposed variation of moments . Vs. % replacement of natural aggregate by SFA

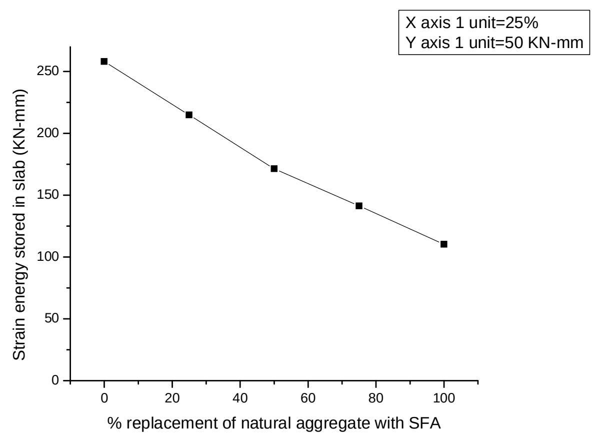


Figure 10: Strain energy stored in slab at ultimate load Vs. % replacement of natural aggregate by SFA

VI. DISCUSSION OF TEST RESULTS

A. Compressive Strength Of Cubes

In the present study natural aggregate has been replaced with sintered fly ash aggregates with varying percentages of 0, 25, 50, 75 and 100% of natural coarse aggregate. The cube compressive strength is presented vide table 1 and graphically presented in figure no 5. From them it is found that the cube compressive strength is reduced with the increase in percentage of replacement of sintered fly ash aggregate.

B. First crack load of Slab

In the present study natural aggregate has been partially and fully replaced with sintered fly ash aggregates. The variation of first crack load verses varying percentage replacements of 0, 25, 50, 75 and 100 are shown vide fig 6. From the above figure it may be observed that with the increase in addition of light weight sintered flyash aggregate the first crack load is decreased.

C. Ultimate Load of Slab

In the present study natural aggregate has been partially and fully replaced with sintered fly ash aggregates. The variation of ultimate load verses varying percentage replacements of 0, 25, 50, 75 and 100% are presented vide fig no 7. From the above figure it may be observed that with the increase in addition of light weight sintered fly ash aggregate the ultimate load is decreased.

D. Moment Carrying Capacity of Slabs at First Crack Load

In the present study natural aggregate has been partially and fully replaced with sintered fly ash aggregates. The moment carrying capacity has been calculated using two approaches. i.e., IS code method and yield line theory approach. The variation of moment carrying capacity of slab at first crack load verses varying percentage replacement at 0, 25, 50, 75 and 100% of natural coarse aggregate with sintered flyash aggregate is presented in figure 8. From the above figure it may be observed that with the increase in addition of light weight sintered flyash aggregate the moment carrying capacity of slab is decreased. Also the moment carrying capacity calculated using IS code method is found to be higher than that of using yield line theory approach.

E. Moment Carrying Capacity of Slabs at Ultimate Load

In the present study natural aggregate has been partially and fully replaced with sintered fly ash aggregates. The moment carrying capacity has been calculated using two approaches. i.e, IS code method and yield line theory approach. The variation of moment carrying capacity of slab at ultimate load verses varying percentage replacement at 0, 25, 50, 75 and 100% of natural coarse aggregate with sintered fly ash aggregate is presented in figure 9. From the above figure it may be observed that with the increase in addition of light weight sintered fly ash aggregate the moment carrying capacity of slab is decreased. Also the moment carrying capacity calculated using IS code method is found to higher than that calculated using yield line theory approach.

F. Strain Energy Stored in Slabs

The variation of strain energy stored in slab verses varying percentage replacements at 0, 25, 50, 75 and 100% of natural coarse aggregate with sintered flyash aggregate at 28 days is shown in figures 10. From the above figure it may be observed that with the increase in addition of light weight sintered flyash aggregate the strain energy stored in slab is decreased.

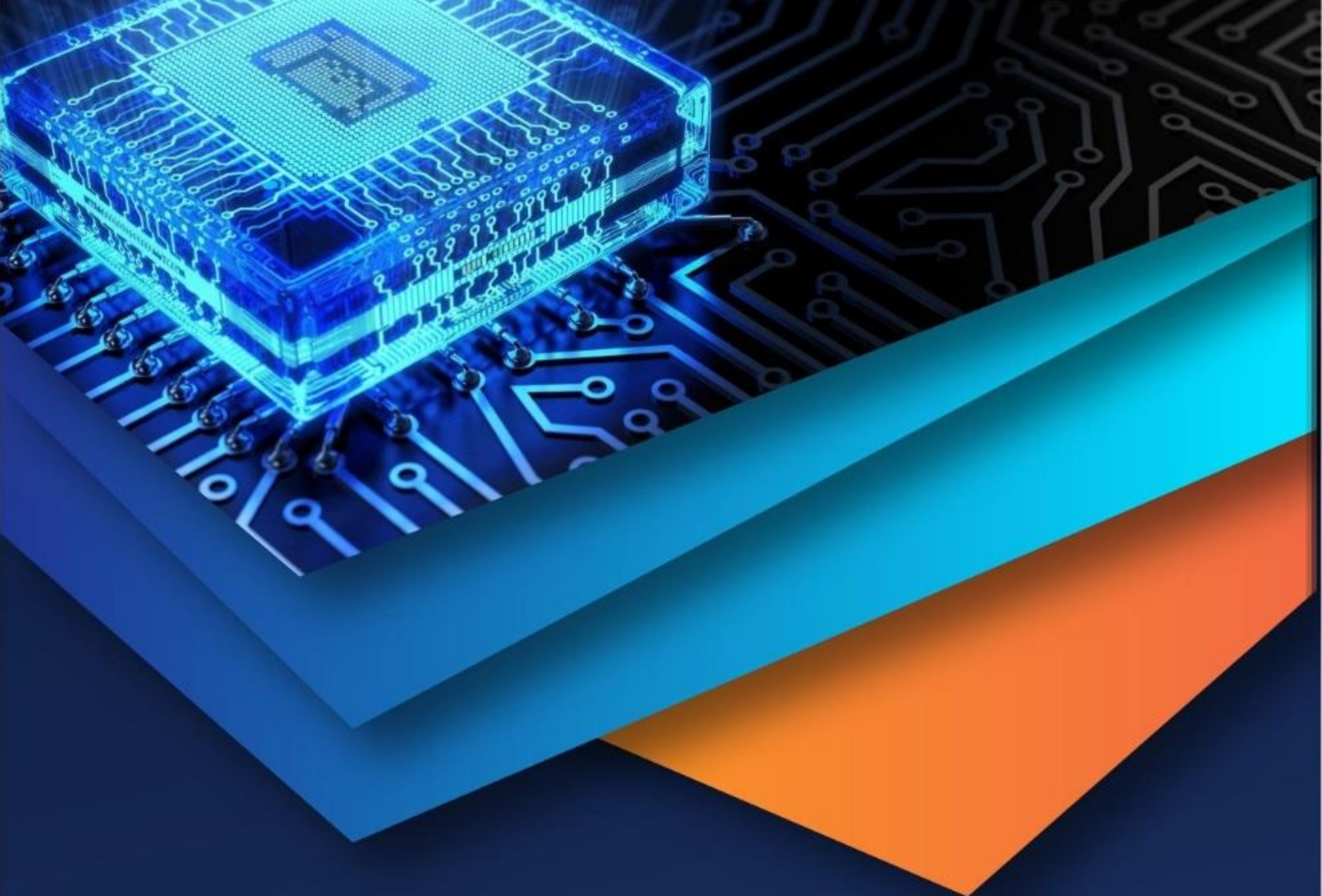
VII. CONCLUSIONS

A. The Following Conclusions are Drawn Based on The Experimental Results

1) From the study it is found that the cube compressive strength is decreased continuously with the increase in % replacement of natural aggregate by sintered fly ash aggregate form 0 to 100%. It varies from 38.5 to 28.84N/mm^2. The target mean strength of M_{20} concrete i.e., 26.60 N/mm^2 has been achieved even for 100% replacement of Sintered fly ash aggregate content.
2) The moment carrying capacity of slabs as per IS Code at first crack load is found to vary from 2.237KN-m to 1.28KN-m with the replacement of natural aggregate by sintered fly ash aggregate from 0 to 100 percent.
3) The moment carrying capacity of slabs as per IS Code at ultimate load is found to vary from 12.63KN-m to 6.960KN-m with the replacement of natural aggregate by sintered fly ash aggregate from 0 to 100 percent.
4) The moment carrying capacity of slabs as per yield line theory at first crack load is found to vary from 1.789KN-m to 1.023KN-m with the replacement of natural aggregate by sintered fly ash aggregate from 0 to 100 percent.
5) The moment carrying capacity of slabs as per yield line theory at ultimate load is found to vary from 10.1067KN-m to 5.567KN-m with the replacement of natural aggregate by sintered fly ash aggregate from 0 to 100 percent.
6) The moment carrying capacity of slab calculated from IS Code method is slightly higher than the value calculated based on yield line theory.
7) The strain energy values stored in slabs at ultimate load are observed to vary from 258.1326 KN-mm to 110.3733KN-mm with replacement of natural aggregate by sintered flyash aggregate from 0 to 100 percent.
8) Based on the experimental investigations it is concluded that sintered fly ash aggregate is no way inferior to other natural coarse aggregates.

REFERENCES

[1] J. Alduaij, K. Alshaleh, M.N. Hague, K. Ellaithy, Lightweight concrete in hot coastal areas, Cem. Concr. Compos. 21 (5– 6) (1999) 453–458.
[2] V VArora, P N Ojha& Mantu Gupta, Suitability of sintered fly ash aggregate in structural concrete, National council for cement and building materials , Indi
[3] Arvind Kumar and Dilip Kumar - "Strength Characteristics of Concrete with Sintered fly ash Aggregate" Journal of IJSRD Volume 2, Issue 7,Sept-2014
[4] Owens, P.L. (1993). "Light weight aggregates for structural concrete," Structural Light weight Aggregate Concrete, Chapman & Hall, London, pp.1-18
[5] Sidramappa Dharane and ArchitaMalge; International Journal of Civil Engineering and Technology, 5(3), 2014, 77-82
[6] Sudarsana Rao. H; Gnaneswar. K and N. V. Ramana; Indian Journal of Engineering and Materials Science, 15, 2008, 326-333
[7] Vasant. B. Jatale and L. G. Kalurkar; International Journal of Engineering Research and Application, 3(6), 2013, 269-275
[8] Curcio, F., Galeota, D., gallo, A., Giammatteo, M. High-performance Lightweight Concrete for the precast Prestressed Concrete Industry. Proc.4th. Int. CANMET/ACI/JCI Symposium, Japan, pp. 389-406,1998
[9] I.S.Code 456-2000 "Code of practice for plain and reinforced concrete" Bureau of Indian Standards, New Delhi
[10] IS 10262-2009 recommended guide lines for concrete design mix



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