IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 15, Issue 4 Ver. I (Jul. - Aug. 2018), PP 51-60
www.iosrjournals.org

Study of Concrete Modified With Artificial Cold Bonded Pelletized Light Weight Silica Fume Aggregates

K.Venkateswarlu[1], Dr.V.Bhaskar Desai[2]
[1]M.Tech, JNTUA College of Engineering, Ananthapuramu – 515002, A.P.
[2]*Professor, Dept. of Civil Engineering, JNTUA College of Engineering, Anantapuramu – 515002, A.P.*

Abstract: *The recent advancements in the construction industry necessitate the development of new materials which have high performance than the ordinary conventional concretes. In the present scenario light weight aggregate has been the subject of extensive research which affects the strength properties of cement concrete. Light weight aggregate concrete has become more popular in recent advancements owing to the tremendous advantages, it offers over the conventional concrete but at the same time light in weight and strong enough to be used for. Lightweight concrete has been successfully used since the ancient Roman times and it has gained its popularity due to its lower density and superior thermal insulation properties. Compared with normal concrete, light weight concrete can significantly reduce the dead load of structural elements, which makes it especially attractive in multi-storey buildings. The most important characteristic of light weight concrete is its low thermal conductivity as this property improves with decreasing density.*

In this present experimental investigation an attempt is planned to be made to study the strength properties and the behaviour at elevated temperature of light weight aggregate concrete, with Silica Fume pellets is considered. The Silica Fume pellets are prepared by mixing silica fume with lime and cement as binders by using Pelletization machine.

The variables considered are five percentages of silica fume aggregate replacing the conventional coarse aggregate i.e. 0%, 25%, 50%, 75% and 100% with 28 days curing period.

Key words: *Pelletization, cold bonding, light weight aggregate, silica fume aggregate.*

Date of Submission: 02-07-2018 Date of acceptance: 18-07-2018

I. Introduction

Concrete is a composite material composing mainly of cement, aggregates and water in suitable proportions. Construction industry is the single largest consumer of the natural resources available in the world. Due to continuous usage of naturally available aggregates within short length of time these natural resources get depleted and it will be left nothing for future generations. Hence there is a necessity for finding alternate for aggregate making use of waste materials from agricultural produce and industrial wastes. On the other hand, enormous quantity of by-product materials is generated from industries, domestic and agricultural wastes. These by-products are also called waste materials and possess lots of environmental problems. Large amount of by-products generated from industrial, agricultural and domestic sources are land filled due to non-availability of economically attractive use options.

From the earlier studies it appears that much less attention has been made towards study of using artificial coarse aggregate. An attempt has been made to use silica fume as the basic ingredient in preparing artificial coarse aggregate which is also light in nature.

II. Review Of Literature

A brief review of available studies related to the present study is discussed here. FIP, 1983 (1) stated that in general the effect of using super plasticizer in light weight aggregate concrete is similar to that of using them in normal weight concrete. It is possible that part of the fluid admixtures may be absorbed by light weight aggregate, thus reducing their action if the light weight aggregate is un-soaked. The absorption of a part of the free water with the dissolved additives will decrease the effectiveness of the latter.

The mechanical properties like strength, modulus of elasticity, colour etc., are affected by the high temperatures exposure. High Performance Concrete (HPC) made with the partial replacement of cement by additives such as fly ash, silica fume, metakaolin, finely grounded pumice(FGP), group granulated blast furnace slag(GGBS), polypropylene fibre(PP fibre), palm oil fuel ash(POSFA), Portland pozzolana cement(PPC), rice husk ash(RHA) provides higher fire resistance. These concretes playvery important role in the present day durable concrete construction utilizing the mineral and chemical admixtures with low water cement ratio and high strength aggregates (Bentz.D.P. et al., 1991) (3).

The researchers focused on the use of HPC subjected to elevated temperatures to know their fire resistance. It was investigated that the loss in structural quality of concrete due to a rise of temperature is influenced by its degradation through changes induced in basic processes of cement hydration and hardening of the binding system in the cement paste of concrete (Con. X et al, 1995 and Escalante – Garcia.J.I et al.,1998) (4,5).

Curcio, et.al, (6) 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 SFActor (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.

The extensive use of concrete as a structural material for the high-rise buildings, nuclear reactors, pressure vessels, storage tanks for hot crude oil & hot water and coal gasification &liqueSFAction vessels increases the risk of concrete being exposed to elevated temperatures. Concrete is most suitable to resist high temperatures because of its low thermal conductivity and high specific gravity (Arioz.o, 2007) (9).

V. Bhaskar Desai, D. Jagan Mohan, V. Vijay kumar (10) studied the mechanical properties like compressive, split tensile strength, modulus of elasticity and flexural behavior of concrete made with the partial replacement of normal coarse aggregate by Hematite aggregate.

Weigler, H. and Karl, S. Stahlleichtbeton (11) reported that Air entraining agents can be used with Light Weight Aggregate Concrete. It’s use reduces the density proportionally to the weight of the paste it replaces, enhances the workability and reduces the segregation and bleeding.

H.Bomhard (12) had reported that Structural light weight aggregate concretes are considered as alternatives to concretes made with dense natural aggregates because of the relatively high strength to unit weight ratio that can be achieved.

According to Abeles and Bardhan-Roy (13), concretes containing light - weight aggregate preserve their strength up to nearly 500^{o}C. It was stated that the residual strength of Light weight concrete after fire decreases linearly from 100% to 40% as a result of increasing the temperature from 500^{o}C to 800^{o}C.

F.W.Lydon (14) stated that for light weight aggregate concrete, it is more relevant for mix design purpose to relate strength to cement content.

As per the conference proceedings, Japan JASS (15) it was reported that, light weight concretes do not specify any density values, and properties are only provided for concrete made with light weight coarse and fine aggregates.

Neville (16) stated that Due to the rapid economic development and growth in the world population, there is a strong demand on natural aggregate usage. Such aggregates are available in many parts of the world and can be used in producing concrete in a wide range of unit weights and suitable strength values for different fields of applications. In Europe ENV 206 (17) it was published that, light weight concrete is classified according to density.

Clarke, J.L (18) stated that Tensile strength of concrete is important when considering cracking. Light weight aggregate concrete presents a flexural and tensile splitting strength slightly inferior to that of normal weight concrete of the same compressive strength.

Owens, P.L. (19) stated that Light weight aggregate concrete has been used for structural purposes since the 20th 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.

Thorenfeldt, E reported that (20) Light Weight Aggregate Concrete has a SFAster hardening SFActor in the initial setting phase than conventional concrete, normally reaching 80 % of the 28 day strength within 7 days. The strength growth from 28 to 90 days is generally low and decreases with increasing concrete strength level. This is assumed to be a consequence of the strength limiting effect of the light weight aggregate.

III. Silica Fume Aggregate

Silica Fume is also known as micro silica a byproduct of the reduction of high purity quartz with coal in electrical furnaces in the production of Silicon and ferrosilicon alloys. Silica Fume is collected as a byproduct of other silicon alloys such as ferromanganese, ferromagnesiam, and calcium silicon. Before the mid 1970s, nearly all the Silica Fume was discharged into the atmosphere. After environmental concerns necessitated the collection and land filling of Silica Fume, it became economically justified to use Silica Fume in various applications. The cold bonded pellets are hardened by normal water curing. The making use of pellets is produced from the civil engineering laboratory, college of engineering, JNTUA, Ananthapuramu.

Table 1. Physical Properties Of Silica Fume

1. Specific gravity of silica fume	2.23
2. Average particle size	99.4μm
3.Nitrogen adsorption	21,300 BET
4.Nitrogen adsorption	15,000-35,000 m^2/kg
5.Bulk density	1350-1510 kg/m^3

Table 2. Chemical Compositions Of Silica Fume

a) Silica as SiO_2	81.35%
b) Alumina as Al_2O_3	4.48%
c) Iron oxide as Fe_2O_3	1.42%
d) Calcium oxide as CaO	0.8%
e) Magnesium oxide as MgO	1.47%
f) Sulphur tri oxide as SO_3	1.34%

Table 3. Properties Of Silica Fume Aggregate

a)Specific gravity of Silica Fume pellets	928 kg/m^3
b)Bulk density of Silica Fume pellets (dry & loose state	1035 kg/m^3
c)Bulk density of Silica Fume pellets (dry & compacted state)	1027 g/m^3
d)Bulk density of Silica Fume pellets (Saturated and surface dry in loose state)	928 kg/m^3
e)Bulk density of Silica Fume pellets (Saturated and surface dry in compacted state)	1125 kg/m^3
f)Fineness modulus of coarse aggregate	4.36

MATERIALS USED FOR INVESTIGATION:

Cement: Ordinary Portland cement of 43 grade confirming to ISI standards IS:8112-1989 has been used. The specific gravity of cement is 3.07

Coarse aggregate: 20 mm and down sized crushed granite metal is used. The specific gravity of granite is 2.68, fineness modulus is 6.83.

Silica fume aggregate: properties are as shown in table 3

Fine aggregate: local river sand is used as fine aggregate and specific gravity is 2.60, and fineness modulus is 3.65.

Water: fresh potable water which is free from acids, organic substances etc. are used.

MIXING OF SILICA FUME AGGREGATE CONCRETE:

The mixing of silica fume light weight aggregate concrete was done in the same way as it was done for conventional concrete i.e. in two stages. In the first stage, cement, fine aggregate i.e. sand, and two-thirds of water were mixed and is called as mortar. In the second stage, coarse aggregate i.e. conventional coarse aggregate and silica fume aggregate which was pre soaked and in surSFAce dry condition were added with the rest of the water, and these ingredients were mixed thoroughly. The concrete mixture of uniform in colour and consistency was achieved which was then ready for casting. Before casting of specimens workability was measured by slump and compaction SFActor tests. For the M_{20} designed mix, proportion of ingredients is 1:1.55:3.04 with w/c ratio 0.50. The various percentage of replacements of natural aggregate by artificial aggregated adopted are 0%, 25%, 50%, 75% and 100%.

DETAILS OF SPECIMENS CAST:

Totally 60 numbers of specimens were cast for five percentage replacements with 28 days of curing. Out of 60 number of specimens, 30 numbers of cubes of size 150 x 150 x 150 mm were cast to find out compressive strength and 30 numbers of beams of size 100 x 100 x 500 mm were cast to find flexural strength.

On completion of workability tests on these samples, moulds were placed on vibrating table and concrete was filled into moulds in 3 layers, each layer was compacted thoroughly with tamping rods to avoid "honey combing". Finally all the samples were thoroughly vibrated on table vibrator for 6 to 7 seconds filling all the moulds to the brim. Vibration was maintained constant for 6 to 7 seconds for all samples and all the other castings throughout the study.

CURING PROCEDURE:

After casting the cube and beam specimens were kept 24 hours at room temperature for air curing after proper marking. However the specimens were de moulded after 24 hours of casting and allowed for 28 days of curing. After desired age of curing the specimens were taken out of water and were allowed to dry under shade for some time. The designation of different mixes is as follows. SSFA-0, SSFA-25, SSFA-50, SSFA-75 and SSFA-100. SSFA represents pelletized cold bonded silica fume light weight aggregate and 0, 25, 50, 75 and 100 represents percentage of silica fume aggregate replacing the natural aggregate. The details of different mixes adopted with designation are presented in table 4.

Table 4 Designations Of Different Mixes

Name of the Mix	Percentage of aggregate		Total no of specimens cast for 28 days curing	
	Conventional Aggregate	Silica fume Aggregate	Cubes of size 150x150x150mm	Beams of size 100x100x500mm
SFA0	100	0	6	6
SFA-25	75	25	6	6
SFA-50	50	50	6	6
SFA-75	25	75	6	6
SFA-100	0	100	6	6
		Total	30	30

COMPRESSION TEST ON PLAIN BEAMS:

Compression test is done as per IS: 516-1959. All the concrete specimens were tested in a 3000KN capacity automatic compression testing machine with 0.5KN/sec is the rate of loading until the specimens are crushed. Concrete cubes of size 150mm x150mm x 150mm is tested for crushing strength. The displacements were automatically recorded through 3000KN digital compression testing machine. The maximum load applied to the specimens has been recorded and dividing the failure load by the area of the specimen, the compressive strength has been calculated.

Compressive strength = $\frac{P}{A}$ in N/mm^2

Where P= Load in N

A= top loaded area of cube in mm^2

The obtained results from the tested specimens are presented in table 6 and the super imposed variation of cube compressive strength vs percentage of SSFA aggregate replacing natural aggregate is presented graphically in fig 2.

TESTING OF BEAMS FOR FLEXURAL STRENGTH

The loading arrangement to test the specimens for flexure is as follows. The element is simply supported over the span of 500mm. The specimen is checked for its alignment longitudinally and adjusted if necessary. Required packing is given using rubber packing. Care is taken to ensure that two loading points are at the same level. The loading is applied on the specimen using 15 tones pre-calibrated proving ring at regular intervals. The load is transmitted to the element through I - section and two 16mm diameter rods placed at 166.67mm from each support. For each increment of loading the deflection at the centre and at 1/3rd points of beam are recorded using dial gauge. Continuous observations were made. Before the ultimate stage the deflection meters are removed and the process of load application is continued. As the load is increased the cracks are widened and extended to top and finally the specimen collapsed in flexure. At this stage the load is recorded as the ultimate load. Making use of the above data flexural strength has been calculated.

The flexural strength of beam is calculated using the formula

f =M/Z in N/mm^2

Where M = Bending moment in N.mm

Z=I/y= Section modulus in mm^3

f = Flexural strength of beam in N/mm^2

= WL/bd^2

W=Ultimate load and L, b and d are section dimensions

Flexural strength is also calculated using IS code method

$f = 0.7\sqrt{f_{ck}}$

Where f = Flexural strength of beam in N/mm^2

f_{ck}= Compressive strength of cube in N/mm^2

The obtained results are presented in table 8 and the superimposed variation of flexural strength versus percentage replacing natural aggregate with pelletized silica fume aggregate is represented graphically in fig 4.

IV. Discussion Of Test Results

INFLUENCE OF SILICA FUME AGGREGATE ON DENSITY:

In the present study the influence of cold bonded SFA aggregate on density has been studied with percentage replacement of cold bonded silica fume aggregate by natural coarse aggregate in different percentages i.e. from 0% to 100% with an interval of 25%. All the cubes were initially weighed before subjecting them to temperature test. After exposing the cube specimens to sustained elevated temperature (100^oC) they were again weighed. Results of density of concrete were measured and variations are plotted. The density results at 28 days curing are presented in Table 5. And also density vs percentage of silica fume aggregate replacing natural aggregate is presented graphically in fig 1.

From the table and figure, it is observed that with increasing the percentage of silica fume aggregate replacing conventional aggregate, the density decreases continuously from 0% to 100% replacements both at room temperature and at 100^oC elevated temperature. And also the densities are found to decrease marginally at the elevated (100^0 c) temperature, when compared with these at room temperature.

INFLUENCE OF SILICA FUME AGGREGATE ON CUBE COMPRESSIVE STRENGTH:

In the present study the influence of silica fume aggregate has been studied by percentage replacement of silica fume aggregate by natural coarse aggregate in different percentages from 0% to 100% with an interval of 25%. The obtained tested results at 28 days are presented in Table 6 and the graphically represented vide fig 2.

From the results, it is observed that with the increase in replacement of silica fume aggregate the cube compressive strength decreases continuously from 0% to 100%. And also the compressive strengths are increased marginally at elevated (100^0 c) temperature, when compared to those at room temperature.

The residual strength at a particular temperature is defined as the ratio of the strength obtained at the elevated temperature to the
strength obtained at normal temperature.

The percentage of residual strength = $*100$

Where R_x = Strength at 100^oC elevated temperature

R_n = Strength at normal temperature

It is found that the residual strengths are increased with the temperature increase.

INFLUENCE OF SILICA FUME AGGREGATE ON FLEXURAL STRENGTH:

In the present study the influence of silica fume aggregate has been studied with the replacement of silica fume aggregate by natural coarse aggregate in different percentages of 0% to 100% with an interval of 25%. The flexural strength results at 28 days curing are presented in table 7 & 8 at room temperature and at elevated temperature respectively and also presented graphically in figures 3 & 4 at room temperature and elevated temperature respectively.

From the above results, it is observed that with the increase in replacement of silica fume aggregate the flexural strength decreases continuously from 0% to 100%. And also the flexural strengths are increased at elevated (100^0 c) temperature, when compared at room temperature.

INFLUENCE OF SILICA FUME AGGREGATE ON MODULUS OF ELASTICITY: APPROACH-I

From the results of cube compressive strength the youngs modulus results are also calculated using IS code method [10]

$E_1 = 5000\sqrt{f_{ck}}$

Where E_1 = youngs modulus in N/mm^2

f_{ck}= Compressive strength of cubes in N/mm^2

The modulus of elasticity results with various percentage replacements of natural aggregate by silica fume aggregate is presented in table 9. The graphical representation is presented in fig 5.

From the results, it is observed that the behaviour of theoretical modulus of elasticity varies more or less same as that of Compressive strength of concrete.

INFLUENCE OF SILICA FUME AGGREGATE ON MODULUS OF ELASTICITY: APPROACH-II

In the 2^{nd} approach of young"s modulus is calculated by Empherical formula suggested by Takafumi[(11)] for light weight
aggregate concrete is given by

$E_2 = k_1 * k_2 * (1.486*10^{-3}) * f_{ck}^{1/3} * \gamma^2$ N/mm².

Where k_1 = correction factor for coarse aggregate i.e. 0.95

k_2 = correction factor for mineral admixture i.e. 1.026

f_{ck}= compressive strength of concrete in MPa.

γ = Density of concrete in kg/m^3

The modulus of elasticity results with various percentage replacements of natural aggregate by silica fume aggregate is presented in table 10. The graphical variation is presented in fig 6.

From the results, it is observed that the behaviour of theoretical modulus of elasticity varies more or less same as that of Compressive strength of concrete.

V. Conclusions

From the study the following conclusions are arrived based on the experimental investigations carried out.

1).In general, workability of the concrete is increased with the increasing percentage replacement of silica fume aggregate due its rounded shape.

2).Modified concrete with silica fume aggregate has equal or slightly lower strength than the reference concrete for $M_{20.}$

3).There is a tremendous advantage from environmental and ecological considerations due to the usage of these silica fume aggregate, instead of conventional aggregate.

4).The investigations have shown that it is possible to produce structural grade concrete from pelletized silica fume aggregate and cold bond technique.

5).From the study it may be concluded that the cube compressive strength, Young's modulus have decreased continuously with the increase in percentage of Silica fume aggregate.

6).It is observed that the Density decreases with increase of silica fume aggregate.

7).From the study it is observed that the flexural strengths calculated based on experimental results and using I.S code decrease continuously with the increase in percentage of Silica fume aggregate i.e., from 0 to 100% replacement of natural aggregate.

8).The use of pelletized silica fume aggregate as replacement of natural aggregate caused the increase in the compressive strength, modulus of elasticity and colour change of the concretes at elevated temperatures.

9).The uses of pelletized silica fume aggregate exhibited reduction of mechanical properties of concrete at elevated temperatures. Different curing methods irrespective of types of concretes made with different admixtures also caused the reduction in the mechanical properties at elevated temperatures.

10).Silica fume is not a waste and it can be effectively used in concrete either as aggregate fillers, replacement for coarse aggregate with pelletization.

11).The overall studies conducted by various researchers have shown that the silica fume aggregate produced by pelletization can be an effective aggregate in concrete production. Also, the efficiency of pelletization depends on the speed of the pelletizer, angle of the pelletizer and the type of binder added along with the silica fume.

12).The cost effective and simplified production techniques for manufacturing silica fume aggregate can lead to mass production and can be an ideal substitute for the utilization in many infrastructural projects. In the near future the depletion of the nature resources for aggregate can be suitably compensated from the usage of silica fume aggregate.

Table 5. Density Results

Sl.No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		Density in Kg/Cum at normal temperature	Density in Kg/Cum at 100^0 c temperature	Percentage of increase or decrease in Density wrt normal temperature
		Natural aggregate	Pelletized SF aggregate			
1	SF-0	100	0	2464.79	3582.02	0.00
2	SF-25	75	25	2413.43	3483.26	-2.76
3	SF-50	50	50	2294.32	3339.06	-6.78
4	SF-75	25	75	2151.31	3119.60	-12.91
5	SF-100	0	100	2027.85	3063.11	-14.49

Table 6. Cube Compressive Strength Results

sl.No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		Cube Compressive strength in N/mm^2		Percentage of increase or decrease in compressive strength wrt normal temperature
		Natural aggregate	Silica Fume	normal cubes	after 100˚c temp	28 days
1	SF-0	100	0	32.62	36.62	12.26
2	SF-25	75	25	29.02	31.99	10.23
3	SF-50	50	50	20.95	26.03	24.25
4	SF-75	25	75	15.67	18.21	16.21
5	SF-100	0	100	11.16	15.61	39.87

Table 7. Flexural Strength Results

sl.No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		flexural strength N/mm2		Percentage of increase or decrease in flexural strength wrt normal temperature
		Natural aggregate	Pelletized SF aggregate	normal	after 100˚c temp	28 days
1	SF-0	100	0	3.58	3.4	-5.03
2	SF-25	75	25	3.58	2.87	-19.83
3	SF-50	50	50	3.40	2.87	-15.59
4	SF-75	25	75	3.23	2.51	-22.29
5	SF-100	0	100	2.69	2.51	-6.60

Table 8. Flexural Strength Results Based On The I.S.Code Method

Sl.No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		Flexural strength in N/mm² at normal temperature	Flexural strength N/mm^2 at 100^0 c temperature	Percentage of increase or decrease in flexural strength wrt normal temperature
		Natural aggregate	Pelletized SF aggregate			
1	SF-0	100	0	4.00	4.24	6.00
2	SF-25	75	25	3.77	3.96	5.04
3	SF-50	50	50	3.20	3.57	11.56
4	SF-75	25	75	2.77	2.99	7.94
5	SF-100	0	100	2.34	2.77	18.38

Table 9. Youngs Modulus Results Based On The I.S.Code Method

Sl.No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		Youngs modulus in *10^4 N/mm2		Percentage of increase or decrease in Youngs modulus wrt those at normal temperature
		Natural aggregate	Pelletized SF aggregate	Normal	after 100˚c temp	28 days
1	SF-0	100	0	2.86	3.03	5.94
2	SF-25	75	25	2.69	2.83	5.20
3	SF-50	50	50	2.29	2.55	11.35
4	SF-75	25	75	1.98	2.13	7.58
5	SF-100	0	100	1.67	1.98	18.56

Table 10. Youngs Modulus Results Based On Empherical Method Suggested By Takafumi

Sl. No	Name of the mix	Percentage of pelletized silica fume aggregate replacing natural aggregate		Youngs modulus in *10^4 N/mm2		Percentage of increase or decrease in Youngs modulus wrt normal temperature
		Natural aggregate	Pelletized SF aggregate	normal	after 100˚c temp	28 days
1	SF-0	100	0	2.81	2.87	2.14
2	SF-25	75	25	2.68	2.54	-5.22
3	SF-50	50	50	2.10	2.19	4.29
4	SF-75	25	75	1.68	1.7	1.19
5	SF-100	0	100	1.33	1.25	-6.02

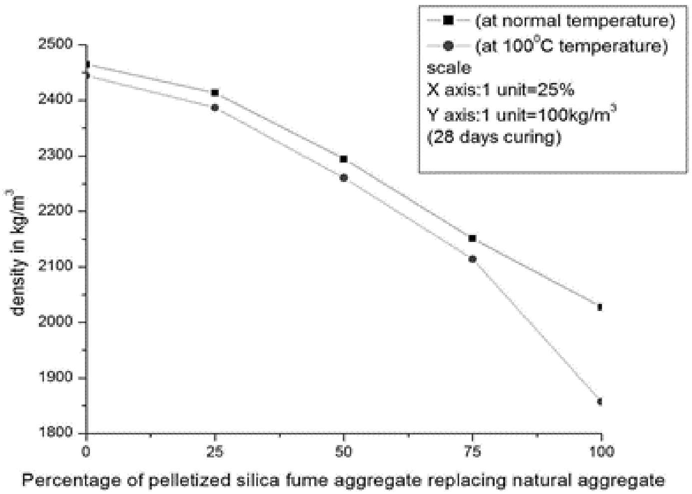

Fig 1. Superimposed variation of Density vsSFA

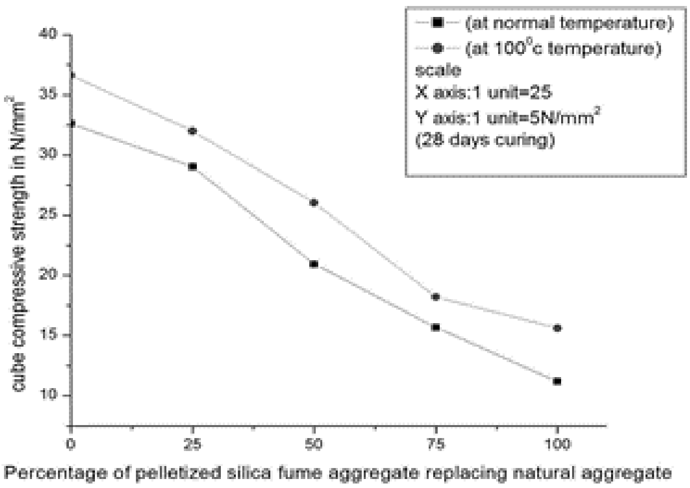

Fig 2. Superimposed Variation of cube Compressive strength vs SFA

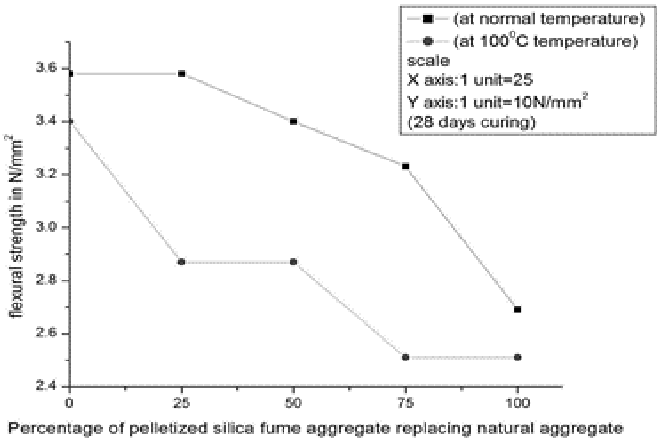

Fig 3. Superimposed Variation of flexural strength vsSFA

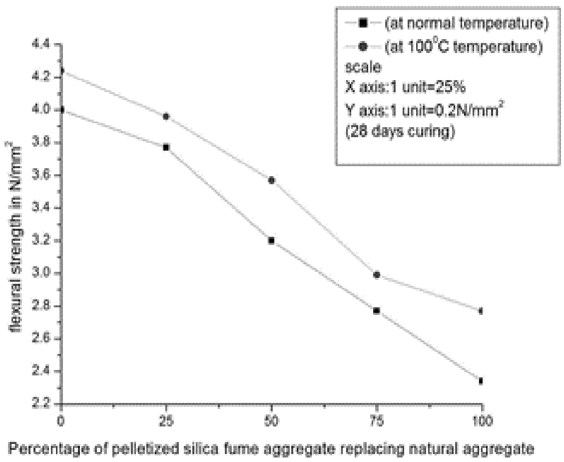

Fig 4. Superimposed Variation of flexural strength based on I.S.CodevsSFA

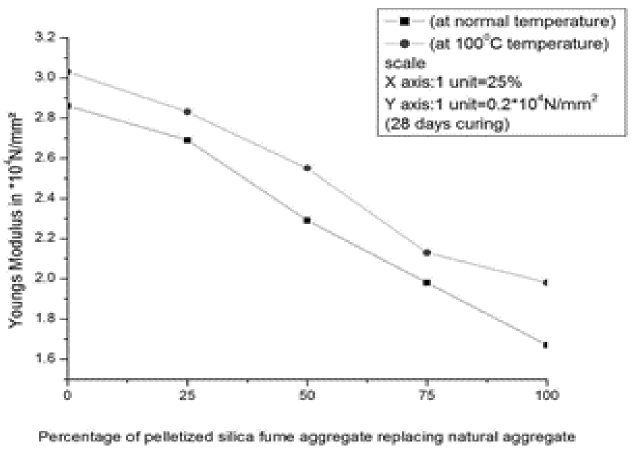

Fig 5. Superimposed Variation of young‟s modulus based on I.S.codevsSFA

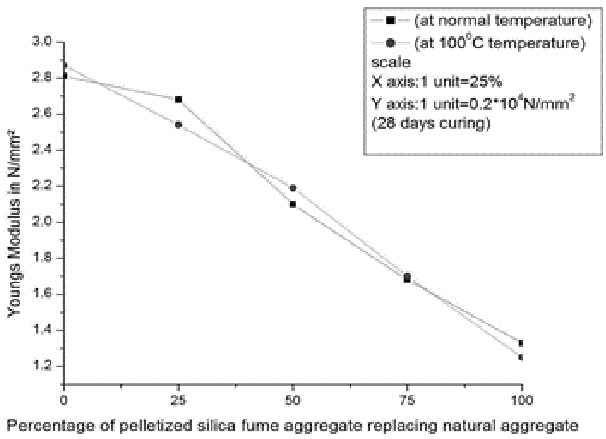

Fig 6. Superimposed Variation of youngs modulus based on empherical formula vsSFA

Bibliography

[1]. Bijen , J.M.J.M, 1986 manifacturing process of artificial light weight aggregate from fly ash , The international journal of cement composites and light weight concrete, 8, PP 191-199.
[2]. Behera JP.et.al (2004). Light weight concrete with sintered fly ash aggregate: A study on partial replacement to normal granite aggregate. IE(I) Journal-CV., 85: PP 84-87.
[3]. Harikrishnan K.I, Rmamurthy, (2006). Influence of pelletization process on the properties of fly aggregate concrete. Waste management 26, PP 846-852.

[4]. V. Bhaskar Desai, D. Jagan Mohan, V. Vijay kumar, " Some studies on strength properties of Metallic aggregates", Proceedings of the International conference on advance in concrete composites and structures, January 2005, pp. 235-246.
[5]. Weigler, H. and Karl, S. Stahlleichtbeton. Bauverlag GMBH, Wiesbaden and Berlin, pp. 38-43, 1972.
[6]. H. Bomhard, Light weight concrete structures, potentialities, limits and realities, The Concrete Society, The Construction Press, Lancaster, UK, 1980, pp. 227–290.
[7]. Abeles PW, Bardhan-Roy BK. Prestressed concrete designer's handbook. In: Cement and concrete association. Wexham Springs: A Viewpoint Publication; 1981.
[8]. F.W .Lydon, Concrete Mix Design, 2nd ed., Applied Science, London, 1982.
[9]. JASS 5 (Revised 1979): Japanese Architectural Standard for Reinforced Concrete, Architectural Institute of Japan, Tokyo, 1982 (March).
[10]. FIP. Manual of Light Weight Aggregate Concrete, 2nd. Edition, 1983.
[11]. Neville AM (1988). Properties of Concrete, ELBS edition of third ed., Longman, Singapore.
[12]. ENV 206: Concrete-Performance, Production, Placing and Compliance Criteria, Final Draft, February 1989.
[13]. Clarke, J.L. Design Requirements. Structural Light weight Aggregate Concrete, Chapman & Hall, London, pp. 45-74, 1993.
[14]. Owens, P.L. (1993). "Light weight aggregates for structural concrete," Structural Light weight Aggregate Concrete, Chapman & Hall, London, pp.1-18.
[15]. Thorenfeldt, E., Design Criteria of Light weight Aggregate Concrete. CEB/FIP International Symposium on Structural Light weight Aggregate Concrete, Sandefjord, Norway, pp. 720- 732, 1995.
[16]. Curcio, F., Galeota, D., Gallo, A., Giammatteo, M. High-performance Light weight concrete for the Precast Prestressed Concrete Industry. Proc.4th. Int.CANMET/ ACI/JCI Symposium, Japan, pp. 389-406, 1998.
[17]. EuroLightCon (1998). "LWAC material properties: State-of-the-art", EuroLightCon Economic Design and Construction with Light Weight Aggregate Concrete, The European Union – BriteEuRam III, Document BE96-3942/R2, December 1998, 109 pp.
[18]. J. Alduaij, K. Alshaleh, M.N. Haque, K. Ellaithy, Lightweight concrete in hot coastal areas, Cem. Concr. Compos. 21 (5–6) (1999) 453–458.
[19]. Khandaker M. Anwar Hossain, "Properties of volcanic pumice based cement and lightweight concrete", Cement and concrete research, vol. 34, No. 2, febrauary 2004, pp. 283-291.
[20]. V. Bhaskar Desai and A. Sathyam(2013), "Basic properties of artificial light weight aggregate by using industrial by product (silica fume)", research in civil and environmaental engineering, VOL.1, NO(04), NOV2013, pp. 195-201.
[21]. V. Bhaskar Desai K.Mallikarjunappa and A. Sathyam(2014), "An Experimental investigation on strength properties of artificial light weight aggregate concrete using agricultural by product such as Ground nut shell ash", proceedings of the national conference on ACE Id-2014, 6-7 February 2014, PP.15-23.
[22]. V. Bhaskar Desai A. Sathyam and K.Mallikarjunappa (2014), "An Experimental investigation on strength properties of artificial light weight blended aggregate concrete", Internatinal journal of earth sciences and engineering, Vol 07, NO.01, Feb 2014, pp.349-355.
[23]. V. Bhaskar Desai and A. Sathyam(2014), "Basic properties of artificial light weight aggregate by using industrial by product (fly ash)", IJCIET, Vol. 5, Issue 6, June 2014, pp.65-72.
[24]. V. Bhaskar Desai and A. Sathyam(2014), "A study on partial replacement of natural granite aggregate with pelletized fly ash aggregate", IJCER, issue 12, Dec 2014, pp.31-40.
[25]. V. Bhaskar Desai, A. Sathyam and sireesha D.L (2014), " An experimental investigation on strength properties of metakolin based on light weight aggregate concrete reinforced with steel fibers", (IOSR-JMCE), Vol 11, issue no.06, Nov-Dec 2014, pp, 30-45.
[26]. Arioz.O, "Effect of elevated temperature on properties of concrete", Fire Safety Journal, 42 (2007), pp. 516 – 522 cited by Morsy. M.S. et al, 2010.
[27]. Bentz. D.P, Garboczi.E.J, ACI Materials journal, Detroit, v.88, n.5, p 518 - 29, sep - oct. 1991 cited by Evandro Tolentino et al, 2002.
[28]. Cong.X and Kirkpatrick.R.J., "effects of the temperature and Relative Humidity on the structure of C - S - H gel, In: Jour. Cement and Concrete research. 25 (1995),pp.1237 - 1245 cited by ivonJonatka et al, 2003.
[29]. Escalante - Garcia.J.I. andSharp.J.H., " Effect of Temperature Hydration of the Main clinker phases in Portland cements. Part 1, Neat Cements. In: jour. Cement and Concrete research. 28 (1998),pp.1247 - 1257 cited by ivonJonatka et al, 2003.

K.Venkateswarlu. "Study of Concrete Modified With Artificial Cold Bonded Pelletized Light Weight Silica Fume Aggregates." IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) , vol. 15, no. 4, 2018, pp. 51-60.