International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319 – 6505, Impact Factor: SJIF: 5.995
Available Online at www.journalijcar.org
Volume 6; Issue 09; September 2017; Page No. 5932-5936
DOI: http://dx.doi.org/10.24327/ijcar.2017.5936.0836

Research Article

BEARING STRENGTH OF STEEL FIBRE REINFORCED SILICA FUME CONCRETE

N.Venkata Ramana*

Civil Engineering Department, University B.D.T. College of Engineering,
Davangere, Karnataka (State) India (Country)

A R T I C L E I N F O

Article History:

Received 14th June, 2017
Received in revised form 3rd July, 2017 Accepted 18th August, 2017
Published online 28th September, 2017

Key words:

Bearing strength, Cube compressive strength, Silica fume, Steel fibres, IS456 code, and Regression models.

A B S T R A C T

This paper presents the bearing strength of silica fume concrete with punch to bearing area ratio of 10. The cube compressive strengths are also found in the experimental work for estimation of bearing strength by using IS456-2000 code provisions. To evaluate cube compressive and bearing strengths cube specimens are cast and tested in the compression testing machine. Total six mixes were prepared with and without addition of crimpled steel fibres. In the mixes the silica fume was used as partial replacement to cement and this dosage is varying from 0 to 25% with an increment of 5% and the steel fibres addition for the mixes are 1 and 2% by volume of specimen. The results are indicated that, the maximum compressive and bearing strengths are obtained for the 15% of silica fume mix and also noticed that as the steel fibre content increases the strengths are increased in all the mixes. Few regression models are developed to estimate the bearing strengths as a function of characteristic compressive strength and percentage of silica fume replacement.

INTRODUCTION

Axial force and moment acting at the base of the column or pedestal must be transferred to the footing either by compression in concrete or by tension/compression in reinforcing steel. Usually the bearing stress can be checked at the inter surface of column and footing. As per the existing codes the bearing stress is function of characteristic compressive strength of concrete. To increase the compressive strength of concrete, the concrete may be designed for high strength concretes or may be increases with incorporation of admixtures. Now days many admixtures are available in the market such as fly ash, silica fume, metakaoline etc. In addition to this the fibre technology came into force from few decades. In this connection the author of this paper made an attempt to estimate the bearing strength of silica fume concrete along with crimpled steel fibres. To know the statues of work progressed in this area recent past literature presented herein.

Carson and Chen(1973) studied the influence of adding steel fibres on the bearing capacity and ductility of concrete through testing 150mm concrete cylinders. It was found that the bearing capacity was significantly higher than that of unreinforced materials. Niyogi(1974) conducted extensive investigation on the bearing strength of concrete. The variables investigated were the geometry of specimens, the bearing area, mix proportions, strength of concrete, amount and form of reinforcement and nature of the bed.

Corresponding author:* **N.Venkata Ramana
Civil Engineering Department, University B.D.T. College of Engineering, Davangere, Karnataka (State) India (Country)

Wee *et al.*(2000) also showed that silica fume, at replacement levels of 5 and 10%by mass of OPC plays a key role in resisting sodium sulphate attack, indicating nosigns of spalling after about 1 year of exposure in 5% sodium sulphate solution.Hekal *et al.* (2002) reported that partial replacement of Portland cement by silica fume (10–15%) did not show a significant improvement in sulphate resistance of hardened cement pastes. Shannag and Shaia(2003) prepared high-performance concrete mixes containing various proportions of natural pozzolan and silica fume (up to 15% by weight of cement). The results also showed that magnesium sulphates had a more damaging effect than sodium sulphates.Mazloom *et al.* (2004) made high-performance concrete containing silica fume. The silica fume content was 0, 6, 10, and 15%, and water–cementitious ratio being0.35 and 100 ± 10 mm, respectively. Köksal *et al.* (2008) studied the compressive strength of steel fibre reinforced concrete with silica fume. Cold drawn steel fibres with hooked ends were used. Behnood and Ziari (2008) designed concrete mixtures to evaluate the effect of silica fume on the compressive strength of the heated and unheated concrete specimens. González-Fonteboa and Martinez-Abella (2008) studied the properties of concrete using recycled aggregates from Spanish demolition debris (RC mixes) and the impact of the addition of silica fume on the properties of recycled concrete. Kadri and Duval (2009) investigated the influence of silica fume on the hydration heat of concrete. Portland cement was replaced by silica fume (10–30% by mass) in concrete with w/(c +sf) ratios varying between 0.25 and 0.45. Suksun horpibulsuk *et.al* (2011), investigated the performance of fully instrumented test wall reinforced with bearing reinforcement and suggested a method of designing BRE wall. You-Fu-Yang et. al

(2015),investigated behavior of concrete filled double-skin tube (CFDST) subjected to local bearing forces. The results showed the CFDST specimens have a high bearing capacity and a good deformation resistant ability on subjecting to local bearing forces. The bearing capacities obtained are compared experimentally. Chao Hou et. al (2015), studied behavior of circular concrete filled double skin tubes (CFDST) subjected to local bearing forces . A finite element analysis was conducted between full range behavior of CFDST & CFST under local bearing. Based on load- transfer mechanism analysis, simplified formulae for predicting the strength of CFDST under local bearing forces are presented. Reasonable agreement between the predicted and measured values is achieved. Ali. A.Sayadi et. al (2016), took up galvanized steel strips as embedded components and foamed concrete as infill material to investigate the effectiveness of interlocking area and bearing area on bond behaviour. The result indicates increase in locking area results in higher tensile capacity along with greater displacement in initial stage. Based on experimental results equations were developed to analytically describe the bond slip behaviour, tensile capacity and bond strength. Omid sargazi and Ehsan seyedi Hosseininia (2017), presented a study on bearing capacity of eccentrically loaded rough ring footings resting over cohesion less soil. Comparison between the results of numerical simulations with those of analytical solutions and experimental data indicates good agreement. Amir Hossein Arshian and Guido Morgenthal (2017), concentrated to assess the ultimate load bearing capacity of laterally restrained RC slabs considering the contribution of compressive membrane action. The sensitivity studies, non-influential parameters are fixed at their mean values and probability of failure is estimated for investigated modeling strategies using full probabilistic approach.

From the above review of literature it is observed that no work has been carried out on bearing strength of concrete using Steel Fibres and Silica fume as admixture. Hence, an attempt has been made in this investigation to study the behaviour of silica fume concrete. The scope of present investigation is to evaluate the compressive and bearing strength of concrete, the cement replacement by the silica fume is in the proportion of 0, 5, 10, 15, 20&25%. In addition to this mixes, few more mixes were prepared with Crimped Steel Fibres by volume 0, 1 & 2% in concrete. For all mixes 108 cubes (54 cubes for bearing strength and 54 cubes for cube compressive strength) of standard size 150mmx150mmx150mm were cast and tested in the laboratory.

Objectives

The specific objectives of the present investigation are

1. To study the fresh concrete property of workability by compaction factor
2. To evaluate the compressive and bearing strengths of concrete
3. Applicability of IS456- 2000 code provision to estimate bearing strengths
4. Developing of Regression Modals to estimate the strengths

MATERIAL USED

Cement: Ordinary Portland cement of 53 grade confirming to IS 8112-1989 standards was used to cast the specimens. The specific gravity of cement was noticed as 3.1.

***Silica Fume*:** The silica fume was obtained from Navabarath Ferro Alloy Plant at Palvancha of Khammam Dist in Telangana (state), India (country).The specific gravity for silica fume was noticed as 2.1 and the silica content was 89%

***Fine aggregate*:** River sand from local sources was used as fine aggregate. The specific gravity of sand is observed as 2.58 and it was conformed to zone II based on sieve analysis.

Natural Coarse Aggregate: Crushed natural granite aggregate from local crusher has been used and which has maximum size of 20mm .The specific gravity of coarse aggregate was observed as 2.66.

Water: Clean fresh water was used for mixing and curing the specimens.

***Fibres*:** Steel Fibres are supplied by "Stewols India Pvt.Ltd, an ISO 9001: 2008 Company" at Nagpur. The most important parameter describing a fibre is its Aspect ratio. "Aspect ratio" is the length of fibre divided by an equivalent diameter of the fibre, where equivalent diameter is the diameter of the circle with an area equal to the cross sectional area of fibre. In the present investigation crimped round fibres were used with aspect ratio of 90 and the physical properties are presented Table1.

Table 1 Details of Crimple fibre

Length of Fiber	50 mm
Aspect ratio	90
Diameter (d)	0.55 mm
Width (w)	2.5 mm
Tensile Strength	450Mpa
Physical form	Clear, bright and undulated along the length
Material Type	Low carbon drawn flat wire

Casting and Testing

Casting

The cubes were cast in steel moulds with inner dimensions of 150 x 150 x 150mm.The cement, silica fume; sand, coarse aggregate and crimped steel fibres were mixed thoroughly manually. The mix proportion was adopted for all mixes as 1:1.63:3.12 (it is designed based on M20 grade concrete) and water cement ration was arrived as 0.5. During mixing of concrete initially 25% of water required is added and mixed thoroughly till to obtain uniform mix. After that, the balance of 75% of water was added and mixed thoroughly with a view to obtain design mix. Care has to be taken in mixing to avoid balling effect. For all test specimens, moulds were kept on table vibrator and the concrete was poured into the moulds in three layers and compaction was provided with a tamping rod, in addition to this table vibrator was also provided.The moulds were removed after twenty four hours and the specimens were deployed to curing pond. After curing the specimens in water for a period of 28 days the specimens were taken out and allow drying under shade. For each mix three cubes were cast to obtain average strength in bearing and compressive strengths.

Testing

Compaction factor test

The compaction factor test apparatus consists of two hoppers, each in the shape of frustum of a cone and one cylinder. The upper hopper is filled with concrete this being placed gently so that no work is done on the concrete at this stage to produce compaction. The second hopper is smaller than the upper one and is therefore filled to overflowing. The concrete is allowed to fall in to the lower hopper by opening the trap door and then into the cylindrical mould placed at the bottom. Excess concrete across the top of the cylindrical mould is cut and the net weight of the concrete in cylinder is determined. This gives the weight of partially compacted concrete. Then the cylindrical mould is filled with concrete in layers of 5cm depth by compacting each layer fully. The fully compacted weight is then determined and compaction factor (C.F) is calculated using standard formula (for formula refer any standard book of concrete technology). The obtained values are tabulated in in Table 2.

Cube compressive strength test

Compression test on cubes is conducted with 2000kN capacity of compression testing machine. The machine has a least count of 1kN. The cube was placed in the compression-testing machine and the load on the cube is applied at a constant rate till to failure of the specimen and the corresponding load is noted as ultimate load. Then cube compressive strength of the concrete mix is then computed by using standard formula and the obtained values are presented in next section table 3.

Bearing strength test

The bearing strength test was conducted on cubes. To analogue the column and footing, a steel plate (25mm thick) was placed on cubes and tested in cube compression machine . The size of the square plate (47.40mm x 47.40mm) is used so as to obtain the ratio, of the bearing area (cube size 150mm x 150mm) to the punching area (47.40mmx 47.40mm) 10. A 2000 KN Compression testing machine was used for all the tests and the axial load is applied at a constant rate as laid down in IS: 516-1959.

Discussion of Test Results

The experimental work has been carried on fresh and hardens concrete. During fresh stage of concrete, the compaction factor test was conducted to know the behavior of workability, for harden concrete compression and bearing tests were conducted. The detailed analysis is presented below.

Workability

The workability of mixes has been measured by Compaction factor test. The values of compaction factors results are presented in Table 2.From this it is observed that the compaction factor decrease with increase in the % of Silica fume in the concrete mix. This type of observations were made by Swami B.L.P *et.al*.(2005) and V.Bhikshma *et.al*(2009) The results indicates that as the silica fume content increases in the mixes the compaction factor decreases which may be due to high specific surface of silica fume.

Table 2 Workability

Sl.No	Nomenclature	Compaction Factor(CF) 0% fibre	Compaction Factor(CF) 1% fibre	Compaction Factor(CF) 2% fibre
1.	NC	0.915	0.898	0.871
2.	SF5	0.892	0.874	0.862
3.	SF10	0.858	0.837	0.822
4.	SF15	0.834	0.821	0.806
5.	SF20	0.816	0.792	0.775
6.	SF25	0.796	0.781	0.762

Compressive Strength

First crack (FC) stage

The compressive strengths for all mixes (for various replacements 0, 5, 10, 15, 20&25%) with 0%, 1% &2% fiber are presented in Table 3. From this, it can be observed that for 0% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 24.07% over NC. For 25% replacement, the compressive strength has decrease by 9.24% when compared with reference concrete. Verma Ajay *et.al* (2012) has been presented in their experimental work as 15% silica fume is optimum. For 1% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 21.06% over NC. For 25% replacement level, the compressive strength has decrease by 5.22% when compared with reference concrete.

For 2% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 17.16% over NC. For 25% replacement level, the compressive strength has decrease by 12.76% when compared with reference concrete or NC.

Table 3 Compressive strength at first crack

Sl.No	Nomenclature	Compressive strength 0% fibre	Compressive strength 1% fibre	Compressive strength 2% fibre
1.	NC	23.68	24.68	26.39
2.	SF5	25.00	26.18	26.57
3.	SF10	27.96	28.34	29.19
4.	SF15	29.38	29.88	30.92
5.	SF20	24.62	25.35	25.60
6.	SF25	21.49	23.39	23.02

Ultimate stage (US)

The compressive strengths for all mixes (for various replacements 0,5,10,15,20 & 25%) with 0%, 1% &2% fiber are presented in Table 4. From this, it can be observed that for 0% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 23.39% over NC. For 25% replacement level, the compressive strength has decrease by 9.81% when compared with reference concrete. But Swamy BLP *et al* (2005), K.Perumal and R.Sundararajan (2004) has reported in their investigation as 10% is optimum. But in the present experimental investigation 15% is found to be optimum. The presence of micor silica fume in the concrete mass is decrease the voids i.e the final product makes as denser and it leads higher strength carrying capacity. The silica fume is reacted with calcium hydroxide and forms CSH gel to enhance the strengths and this effect maximum at 15%

replacement level. For 1% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 21.04% over OPC. For 25% replacement level, the compressive strength has decrease by 9.68% when compared with reference concrete.

For 2% fiber the 28 days compressive strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube compressive strength by 22.31% over OPC. For 25% replacement level, the compressive strength has decrease by 11.01% when compared with reference concrete or NC. Pu-Woei *et.al* (1997) has been presented in their experimental work as the percentage of carbon fiber increases in the mix the strengths were increases. Same types of observations were made in the present experimental work for steel fibers. Based on the rule of mixture the strengths were increased.

Table 4 Compressive strength values at ultimate stage

Sl.No	Nomenclature	Compressive strength 0% fibre	Compressive strength 1% fibre	Compressive strength 2% fibre
1.	NC	32.61	33.97	35.13
2.	SF5	34.26	35.38	36.82
3.	SF10	37.79	39.02	40.19
4.	SF15	40.24	41.12	42.97
5.	SF20	33.86	34.92	35.71
6.	SF25	29.41	30.68	31.26

Bearing Strength

The allowable bearing stress depends on the bearing strength of concrete and this often controls the dimensions of the members. According to ACI 318 the ultimate stress under concentrated forces is called bearing strength. In reality this type of forces are encountered in the area of missiles, projectiles and explosions (S.P Ray and B.Venkateswarulu (1991)). In the present experimental work the author is focused the bearing strength evaluation for pedestal purpose only. In the present experimental work the area ratio was taken as 10 by using 47.4 square plates for 150mm size cube. The 47.4 mm square plate was placed on cube center and tested in compression testing machine. The detailed analyses of results are presented below for each bearing ratio.

First crack (FC) stage

The bearing strengths for all mixes (for various replacements of 0, 5,10,15,20 and25%) with 0%, 1% and 2% fiber are presented in Table 5. From this, it can be observed that for 0% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 30.99% over NC. For 25% replacement level, the bearing strength has decreased by 9.04% when compared with reference concrete. For 1% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 25.67% over NC. For 25% replacement level, the bearing strength has decreased by 5.69% when compared with reference concrete. For 2% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 25.65% over NC. For 25% replacement level, the bearing strength has decreased by 6.73% when compared with reference concrete.

Table 5 Bearing strength at first crack

Sl.No	Nomenclature	Bearing strength 0% fibre	Bearing strength 1% fibre	Bearing strength 2% fibre
1.	NC	87.47	93.01	99.47
2.	SF5	94.05	98.67	106.00
3.	SF10	107.48	111.48	117.82
4.	SF15	114.58	116.89	124.99
5.	SF20	93.86	99.19	104.48
6.	SF25	79.56	87.71	92.77

Ultimate stage (US)

The bearing strengths for all mixes (for various replacements of 0, 5, 10, 15, 20 & 25%) with 0%, 1% & 2% fiber are presented in Table 6. From this, it can be observed that for 0% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 30.48% over NC. For 25% replacement level, the bearing strength has decreased by 11.50% when compared with reference concrete. For 1% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 24.97% over NC. For 25% replacement level, the bearing strength has decreased by 8.30% when compared with reference concrete. For 2% fiber the 28 days bearing strength increases with the increase in the percentage of silica fume up to 15%. For 15% replacement of silica fume there is increases in cube bearing strength by 24.98% over NC. For 25% replacement level, the bearing strength has decreased by 9.29% when compared with reference concrete

Table 6 Bearing strength at Ultimate stage

Sl.No	Nomenclature	Bearing strength 0% fibre	Bearing strength 1% fibre	Bearing strength 2% fibre
1.	NC	122.00	129.85	138.56
2.	SF5	130.09	136.49	146.57
3.	SF10	147.19	152.63	161.27
4.	SF15	159.19	162.28	173.56
5.	SF20	129.06	136.54	143.87
6.	SF25	107.97	119.07	125.95

Relationship between bearing and compressive strength

The bearing strength of concrete is most important parameter during the design of axially loaded elements. For normal concrete the IS 456-2000 recommended the following equation.

$f_f=0.45(f_{ck})\sqrt{(A1/A2)}$-------------------------IS 456-2000

In the above expressions

f_{ck} = Characteristic compressive strength (N/mm^2);

A1 is maximum are of the portion of the supporting surface;

A2 is loaded area at the column base.

The validity of the above equations was demonstrated in Table 7. From this table it is observed that, the IS 456 code provision is underestimating the strength. Hence the author is felt that there is a necessity to develop a regression model (RM) to suit the experimental values. The author developed a regression modal with a correlation coefficient R^2=0.99 for all % of fibres.

fb =4.77fck+0.049(%SF)-33.797---------------- for 0% fibre

fb=4.26fck+0.132(% SF)-14.935---------------- for 1% fibre

fb=4.175fck+0.13(%SF)-7.849----------------- for 2% fibre

In the above expressions

f_b = Bearing strength (N/mm^2)
f_{ck} = Characteristic compressive strength (N/mm^2)
% SF= Percentage of silica fume.

The performance of the proposed model is presented in Table 7. From this table it is observed that the ration between EXP and RM is about 0.98 to 1.00. The ratio inferences the proposed model is best suited to the experimental values and also may concluded that it is better than IS formula.

Table 7 Performance of regression modal

% Fibre	% SF	Bearing strength as per IS456-2000 (N/mm²)	Experimental Bearing strength (N/mm²)	Exp/IS456-2000	Bearing strength (N/mm²) as per RM	Exp/RM
0%	0	29.35	122.00	5.50	121.76	1.00
	5	30.83	130.09	5.58	129.85	1.00
	10	34.01	147.19	5.65	146.95	1.00
	15	36.21	159.19	5.81	158.95	1.00
	20	30.47	129.06	5.60	128.82	1.00
	25	26.46	107.97	6.00	107.73	1.00
1%	0	30.57	129.85	5.62	129.81	1.00
	5	31.84	136.49	5.67	136.01	1.00
	10	35.11	152.63	5.75	152.59	1.00
	15	37.00	162.28	5.80	162.24	1.00
	20	31.42	136.54	5.75	136.51	1.00
	25	27.61	119.07	5.70	119.03	1.00
2%	0	31.61	138.56	5.80	138.74	0.99
	5	33.13	146.57	5.85	147.86	0.99
	10	36.17	161.27	5.90	161.22	1.00
	15	38.67	173.56	5.94	173.51	1.00
	20	32.14	143.87	5.92	143.82	1.00
	25	28.13	125.95	5.92	125.89	1.00

CONCLUSIONS

From the present experimental work the following conclusions were drawn.

1. The optimum dosage for silica fume is found to be 15%. At this stage compressive and bearing strengths were increased when compared with other replacements.
2. At first crack state and ultimate stages, the % of increase is about to 6 to 24% for 15% silica fume replacement when compared with reference concrete.
3. With incorporation of steel fibers (i.e., 1 and 2%) in the concrete mixes the compressive and bearing strengths were increased when compared with respective replacement of silica fume.
4. For bearing area ratio of 10, at first crack and ultimate stages the % of increases about 8 to 30% for 15% replacement of silica fume when compared with reference concrete.
5. The IS code underestimates the bearing strengths for different mixes.
6. For better estimation of bearing strengths, few regression models were evaluated and tested the equations.
7. Radial cracks were observed for all cubes during the bearing test over top surface of the cube.

References

1. Ali A Sayadi *et.al*, 2016,Strength of bearing area and locking area of galvanized strips in foamed concrete, construction and building materials, Vol 114, pp: 56-65.
2. Amir Hossein Arshian, 2017, Probabilistic assessment of ultimate load bearing capacity in laterally restrained two way reinforced concrete slabs, Engineering structures, Vol 150, pp 52-63.
3. BLP Swami, P SrinivasaRao and PSS Narayana, 2005, Studies on cement replacement in concretes by micro silica 920-D:23-24.
4. Behnood, A., Ziari, H, 2008 Effects of silica fume addition and water to cement ratio ontheproperties of high-strength concrete after exposure to high temperatures. Cem.Concr.Compos. 30(2), 106-112.
5. Chao Hou, 2015, Behaviour of circulare concrete filled double skin tubes subjected to local bearing force, Thin-walled structures, vol 93,pp 36-53.
6. Chen, W.F., and carson,J,L., Bearing Capacity of fibre reinforced concrete, ACI SP-44,1973,pp.209-221.
7. González-Fonteboa, B., Martinez-Abella, F, 2008, Concretes with aggregates from Demolition waste and silica fume. Materials and mechanical properties. Build. Environ. 43(4), 429-437.
8. Hekal, E.E., Kishar, E., Mostafa, H, 2002, Magnesium sulfate attack on hardened blendedcement pastes under different circumstances. Cem. Concr. Res. 32(9), 1421-1427.
9. K. Perumal and R. Sundararajan, 2004, Effect of partial replacement of cement with silica fume on the strength and durability characteristics of high performance concrete, pp 25-26.
10. Kadri, E.H., Duval, R, 2009, Hydration heat kinetics of concrete with silica fume.
11. Mazloom, M., Ramezanianpour, A.A., Brooks, J.J, 2004, Effect of silica fume on mechanical properties of high-strength concrete. Cem. Concr. Compos. 26(4), 347–357.
12. Niyogi SK, 1974, Concrete bearing strength support, mix, size effect. J Struct Div-ASCE;100:1685-70
13. Omid sargazi and Ehsan Sayedi Hosseininia, 2017, Bearing Capacity of ring footings on cohesionless soil under eccentric load, Computers and Geotechnics, Vol-92, pp 169-178.
14. Pu-Woei Chen, Xuli Fu, and D.D.L. chung, 1974, Micro structural and mechanical effects of latex, methylcellulose, and Silica fume on Carbon Fiber Reinforced Cement ACI materials journal.
15. Suksun Horpibulsuk *et.al*, 2011, Performance of an earth wall stabilized with bearing reinforcement", Geo textiles and Geo membranes, vol 29,pp 514-524.
16. Shannag, M.J., Shaia, H.A, 2003, Sulfate resistance of high-performance concrete. Cem. Concr. Compos. 25(3), 363-369.
17. S.P.Ray and B.Venkateswarlu,1991, Workability and strength properties of recycle aggregate concrete , ACI material Journal, Vol18, No.2,pp 67-65
18. V. Bhikshma, K. Nitturkar and Y. Venkatesham, 2009, Investigations on Mechanical properties of high strength silica fume concrete: *Asian journal of Civil engineering* Vol. 10, No.3.
19. Verma Ajay, Chandak Rajeev and Yadav R.K, 2012, Effect of micro silica on the strength of concrete with ordinary Portland cement:Vol.1(3), 1-4.
20. Wee, T.H., Suryavanshi, A.K., Wong, S.F., Anisur Rahman, K.M, 2000, Sulfate resistanceof concrete containing mineral admixture. *ACI Mater. J.* 97(5), 536-549
21. You-Fu-Yang *et.al*, 2015, Investigation on square concrete filled double skin steel tube (CFDST) subjected to local bearing force, Thin walled structures, Vol 94, pp 394-409.