International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-4, April 2019

Evaluation of Performance of High Strength Fiber Reinforced Concrete in Durability Aspects

P. Amsayazhi, K. Saravana Raja Mohan, R. Sowmiya,S. Kamalavani,

Abstract:-This paper clears the effects of inclusion of distinct proportions of polypropylene fibers and glass fibers givesthe properties of High strength concrete (M60 mix). A preliminary program was carried out to find the fibers effects on durability. The fundamental aim of the analysis is to study the effect of Polypropylene fiber(0% , 1%,1.5%, 2%) and glass fiber (0% , 1%,1.5%, 2%) and glass and polypropylene combined(0.5%+1.5%), (1.5%+0.5%), (1%+1%) mix by varying content and discovering the optimum fiber content that shows better durability. The specimens were investigated at different age level for durability. A notable change in the durability property was observed. However, further investigations were highly recommended and durability properties of fiber reinforced concrete were studied. The main aim of the paper is to study the durability properties of the fiber reinforced concrete. Polypropylene fiber and Glass fiber gives high strength and reduces the plastic shrinkage crack area due to their flexibility. The fiber has good strength, water absorption, drying shrinkage, freeze-thaw resistance. The experiments are performed on concrete, with and without addition of polypropylene fiber under different temperature. Properties studied includewater absorption, Abrasion test, sorptivity test, Alkali silica test etc.,

Keywords: Polypropelenefibre, Glass fibre, Compressive strength, Flexural strength

I. INTRODUCTION :-

The biggest advantage of using SCMs and fibers is to boost the durability of concrete which thereupon has become decisive to the economies of all nations. The addition of silica fume and fibers have become more regular, because they revamp concrete durability and strength, notably in high early age curing temperatures. High reinstatement levels of fly ash are uncommon because of struggle to change by the cement industry and because of worry about the early-age strength and the quality of concretes produced with increase in cement replacement levels. The difference between normal strength concrete and high strength concrete is when the load is applied to the concrete sample it gives maximum strength but in the normal concrete it gives the strength as it withstand. There is no decisive point of partition between the normal concrete and high strength concrete.

Manuscript published on 30 April 2019.
***** Correspondence Author (s)
P.Amsayazhi, Research Assistant, SASTRA Deemed To Be University, Thanjavur
K.Saravana Raja mohan, Dean, SASTRA Deemed To Be University, Thanjavur
S.Kamalavani, Final year M.Tech Structural Engineering, SASTRA Deemed To Be University, Thanjavur
R.Sowmiya, Final year M.Tech Structural Engineering, SASTRA Deemed To Be University,Thanjavur

© The Authors. Published by Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP). This is an open access article under the CC-BY-NC-ND license http://creativecommons.org/licenses/by-nc-nd/4.0/

According to Indian standard, the compressive strength of the high strength concrete is about more than 65N/mm^2. According to A.L.Ardeshana,DrAtul K Desai[1], Polypropelene triangular fibers properties were discussed and proved that the material also helped for the development of intelligent infrastructure with elegantly integrated sensing. According to VamsiKrishna and srinivasarao [2], the increase in volume fraction of fiber showed decrease in compressive strength after subjected to acid attack. High volume of steel fiber in RC was more vulnerable to acid attack. According to Tara Rahmani et.al.,[3]Polypropelene , glass and steel fibers were tested under electrical resistivity test, water penetration test , gas permeability test, scaling resistance to deicing chemical test. Water penetration and gas penetration of steel fibers was increased. According to K.ChandraMouli et al.,[4] The fibers like Glass, carbon, polypropylene and aramid fibers which improve the compressive strength, Tensile strength, fatigue properties, Durability, shrinkage properties, cavitation, impact resistance, erosion resistance and serviceability of the concrete.Fiber improves the water absorption, toughness of the concrete and impact resistance of the concrete with the increase in the fiber. The fatigue characteristics of fiber reinforced concrete are also increased. According to bentur.A. et al[5]., Considerable differences in degradation of mechanical properties could be observed in composites prepared with different glass fiber strands, and they could be correlated with the SEM observations: higher rates of degradation were obtained in composites in which hydration products grew more readily between the glass filaments. The reduction in mechanical properties is due to the specimens in the water at 207^{o}C causes the growth of hydration. According to svenG.Bergstrom et al.,[6]. The glass fiber reinforced concrete brittle with the time. Sisal fiber reinforced concrete also brittles within the limited time. But the process can be delayed by protective impregnations of the fiber. By replacing the cement with silica fume the alkalinity of the matrix is reduced. According to sashidharamarikunte et al.,[7] The different matrices selected were (a) cement; (b) cement + 25% metakaolin; and (c) cement + 25% silica fume. The specimens are normal cured for 28 days and then it is immersed in the hot water bath at 50^{o}C for 84 days. Then the specimens were tested for flexure and tensile strength. The durability of the GFRC composite increases with the cement containing synthetic pozzolanmetalaolin. According to Rajasekar . A et al.,[8] Copper slag replaced with fine aggregate. It is aimed to produce Ultra High Strength concrete.

Here two types of copper slag is used, raw material or industrial waste obtained from industry and mechanically treated copper slag by grinding into finer size. The tests are indicated compressive strength 150Mpa for untreated copper slag and 200Mpa for treated copper slag. Durability performance has been high for Copper Slag Ultra High strength Concrete.

According to Arunachalam. K et al.,[9]Treated Bagasse Ash (TBA) is replaced with ordinary Portland cement. It is replaced by weight of the cement from 5% to 20%. Test result shows the cylinder compressive strength more than 160Mpa when replaced by bagasse ash. It gives better result when it reaches upto15% to produce good UHSC 20% replacement of sugarcane bagasse ash is enough, durability test were tested.

According to Soylev. A.T et al.,[10] Three types of fiber such as steel, polypropylene and glass fiber are used, which is used to reduce the crack. Durability properties such as electrical resistivity, Water absorption, sorptivity and chloride penetration tests were tested. In this paper two different water-cement ratios and curing types were used. Durability properties were significant in longer-term test Mechanical properties is more effective in fiber concrete when it is in moist curing.

According to Mahmoud Nili et al.,[11]Strength and durability properties of concrete were studied by using polypropylene fibers and silica fume. Silica fume is replaced for cement by the weight of the cement at 8% and polypropylene fiber is added by volume at 0%, 0.2%, 0.3% and 0.5%. The water –cement ratio are 0.46 and 0.36 were used. The result indicates the increase in the compressive strength when the silica fume and polypropylene fiber are added. Electrical resistance is improved with the silica fume but decreased due to the addition of Polypropylene fiber.

According to VahidAfroughsabet et al.,[12] Mechanical and Durability properties of the high-strength concrete were studied with the addition of polypropylene and steel fiber. Hooked-end steel fiber of the length 60mm were used at 0.25%, 0.50%, 0.75% and 1% polypropylene fiber of the length 12mm were used at 0.15%, 0.30% and 0.45%. The combination of the steel and polypropylene fiber at 1% is used for the effect of the fiber hybridization. Compressive strength, Tensile strength, Flexural strength, Electrical resistivity and water absorption were studied. Among all the mixture 0.85% of the steel and 0.15% polypropylene fiber has the best result.

According to Saber Fallah et al.,[13] Mechanical and Durability properties of High Strength Concrete containing silica fume, polypropylene fiber, nano-silica and Macro polymeric fibers. The fiber was investigated and the final result was made by using the nano-silica and silica fume. The macro-polymeric fibers in the concrete mixture give the mechanical properties of high-strength concrete. Mechanical and Durability properties gives improvement when the addition of silica fumes and nano-silica.

According to OkanKarahan et al.,[14] The Durability properties of fly ash and polypropylene fiber, thus the Fly Ash improves the workability of the concrete but there is decrease in the workability of the concrete contains polypropylene fiber, freeze-thaw resistance of polypropylene fiber is found to be slightly increase the concrete without fiber. The fly ash increase the freeze-thaw resistance more than polypropylene fiber. According to ImanSadrinejad et al.,[15] Mechanical and Durability properties of concrete with hybridization of polylefin and polypropylene fibers were studied. The test results of Compressive, Splitting tensile test, water absorption, electrical resistivity and chloride penetration tests were studied. The compressive strength and splitting tensile gives improvement when the addition of both polypropylene fiber and polyolefin fibers.

II. OBJECTIVE:

- To evaluate the material properties of FRC.
- To Characterize the properties of the new family of FRCs, focusing on tensile strength, compressive strength, modulus of elasticity, and durability (resistance to environmental factors) by laboratory testing.

To investigate the behavior of experimental methods and analytical models developed for FRC.

A. Materials

Cement

The Ordinary Portland Cement of grade 53 is conforming to IS 12269:1987 with specific gravity of 3.16 is used. The Initial setting time and final setting time of the cement was 140 minutes and 207 minutes. Table 1shows the chemical composition of the ordinary portland cement.

Silica Fume

Silica Fume is the most commonly used mineral admixture in high strength concrete. It is a good pozzolan and can be used in a big way, Adding of silica fume to the concrete increases workability, strength and impermeability of concrete mixes. It is durable to chemical attacks, abrasion and reinforcement corrosion, increasing the compressive strength. There is a growing demand in the production of concrete mixes, high performance concrete, low permeability concrete and high strength. Table 1 shows the chemical composition of silica fume.

Table no 1 Chemical composition of silica fume and cement(%).

Materials	CaO	SiO_2	Fe_2O_3	Al_2O_3	SO_3	MgO	K_2O	Na_2O	LOI
Cement	66.67	18.91	4.94	4.51	2.5	0.87	0.43	0.12	1.05
Silica Fume	0.001	99.762	0.040	0.043	-	-	0.001	0.003	0.015

Aggregate

The aggregate is conforming to IS:2386(Part-1).The natural dry and clean river aggregate is used. The Fineness modulus of sand is 2.6. The crushed coarse aggregate of 12.5mm size is used in concrete. Sieves analysis as per IS 383-1970. The properties of aggregates are shown in Table no 2.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)
© Copyright: All rights reserved.

Table No 2.Properties of Aggregate.

Fineness modulus	2.63
Silt contents	1.98%
Specific gravity	2.58
Water absorption	1.59

Fibers

Polypropylene and glass fibers are used. The Young's modulus of Polypropylene fiber ranges from 1300 and 1800 N/mm².Glass fiber are good in tensile, compressive, bending and shear forces. The specific gravity is 0.91. The diameter and length of polypropylene fibers are 30-35 micron and 12 mm respectively. The density is 0.9 g/cm³ The Glassman glass fiber is used. The density of glass fiber is 2.7 g/cm³. The diameter and length of this fiber are 13 micron and 12mm respectively.

Super plasticizer

Superplasticizerconplast SP430 is used in concrete. It is used for high degree of workability. Superplasticizerconplast SP430 is a chloride free, superplasticising admixture based on selected sulphonatednaphthalene polymers. It is also called as High Range Water Reducing Admixture. Itmaintain the workability of the fresh concrete.

B. Mix Proportion and preparation

An approximate concrete composition for each cubic meter is given in Table 2. According to the volume method mixture design is made. In this mixture design all the materials are constant expect fiber content. The mixture design contains 596 kg/m³ of cement content and water-cement ratio of 0.3 is chosen. The fibers are added in this mix proportion. Polypropylene and glass fibers are used. 1%, 1.5% and 2% of fibers were used and combining of both the fibers were also used. Table 3 shows the mix proportion of concrete. The mixing procedure for fiber-reinforced concrete is as follows. First, the silica fume and cement are mixed separately. Second, the fine aggregate and silica fume, cement mixture is dry mixed for 2mins. Third, coarse aggregate is added and dry mixed until all materials are mixed properly. Fourth, fiber is added and mixed. Finally the water and super plasticizer is slowly added and casted. Let the specimens are in laboratory for 24 hrs and the demoulded specimens were kept in water curing for 28 days. Then the specimens are tested and the results were obtained.

Table no 3.Mix proportions of the concrete mixtures.

Mix no.	w/c ratio	Cement Kg/m³	Silica fume Kg/m³	Fine agg. Kg/m³	Coarse agg. Kg/m³	SP (%)	Fiber content (%)	
							PP	GF
CC	0.3	596	72	586	900	0.6	-	-
1%PP	0.3	596	72	586	900	0.6	1	
1.5%PP	0.3	596	72	586	900	0.6	1.5	
2%PP	0.3	596	72	586	900	0.6	2	
1%GF	0.3	596	72	586	900	0.6		1
1.5%GF	0.3	596	72	586	900	0.6		1.5
2%GF	0.3	596	72	586	900	0.6		2
1.5%GF 0.5%PP	0.3	596	72	586	900	0.6	0.5	1.5
0.5%GF 1.5%PP	0.3	596	72	586	900	0.6	1.5	0.5
1%GF 1%PP	0.3	596	72	586	900	0.6	1	1

Table no 4. Details of ConstituentMaterials

Material	Description
Cement	Type – OPC 53 grade
Fine Aggregate	River sand falling on zone III having a Fineness Modulus of 2.5
Coarse Aggregate	10mm nominal size aggregate, Fineness Modulus = 2.75
Glass fiber Polypropylene fiber	ϕ = 1 mm, Tensile strength = 300 Mpa ϕ = 2 mm, Tensile strength = 250 Mpa
Fiber length Fiber percentage	12mm 0, 1, 1.5, 2
Mix ratio W/C ratio	M60 0.30

III. TEST PROCEDURE

A. Consistency test

The standard consistency of cement was tested and found to be 27 %. The amount of coarse aggregate, fine aggregate, cement, admixture and water with variable percentage of polypropylene fiber and glass fibers of rectangular shape and 12 mm length. Cubes were casted with and without fiber for comparison purpose. The first batch was without fiber and second batch was with 1%, 1.5%, 2% of polypropylene fiber and 1%, 1.5%, 2% glassfiber were casted.(Each of 8 Nos.)

B.Water Absorption and Porosity

Water absorption and porosity were determined. The sample size of water absorption is 100X100X100mm and for porosity is 100mm diameter and 50mm height. The specimens were cured for 28 days and they are oven dry at 110^0 C for 24 hours. Then the sample is taken from the oven and kept in room temperature, it is dry weighted. It is then cured for 48 hours. After 48 days of water curing the samples are taken and weighted. The water absorption results were expressed in terms of percentage. The specimen for porosity test also cured for 28 days.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)
© Copyright: All rights reserved.

After 28 days of curing it is dried and weighted. The specimen is allowed for porosity test by pouring water in terms of ml. These results are also expressed in percentage.

C.Sorptivity Test

Sorptivity is the test used to determine the surface absorption of water. The test specimen is of size 100mm diameter and 50mm height.

The specimen is cured for 28 days. After curing it is tested for sorptivity test. It is done to calculate the sorptivity coefficient. The specimens are oven dried and it is kept in pan of water. It is kept 5mm above the base of the pan throughout the experiment. The specimen is kept for 5mins and taken out from the water surface. Then it is wiped by a dry cloth and weighted. Likewise the results were obtained for 10mins, 15mins, 30mins and 1hour are noted. Then the graph is plotted using the values.

D.Acid attack Test

The acid attack test was performed by immersing the concrete specimens in different acids for 28 days and 56 days and the compressive strength of the concrete is tested. The acids like Sodium chloride (Nacl), magnesium ($MgSO_4$)and sodium sulphate (Na_2SO_4) solution separately.

E. Drying and Wetting

The concrete specimens are weighted before oven dry after 28 days of curing. It is oven dry at 100 ºC for 24 hours and it is weighted after 24 days and it is kept in water for 24 hours for wetting at normal water. Likewise the specimens are repeated for further cycles, here 3 cycles are noted.

IV. RESULTS AND DISCUSSION

A.Water absorption and Porosity

Water absorption and Porosity of the specimen is determined. The results of water absorption and porosity are shown in Table 5. When the addition of fiber increases the water absorption is also increases. It is resulted that the large pores are occur with the high fiber content. The table shows the 1%, 1.5% and 2% of Polypropylene fiber, glass fiber and combination of both fibers. There is a high water absorption when the high percent of fiber used.

Table 5.Porosity and Water absorption Results.

Sl.No	Sample	Water absorption (%)	Porosity (%)
1	CC	2.5	3.2
2	1%PP	1.6	10.4
3	1.5%PP	0.8	5.3
4	2%PP	3.2	7.8
5	1%GF	2.5	5.3
6	1.5%GF	2.4	2.8
7	2%GF	2.9	1.3
8	1.5%GF 0.5%PP	3.1	2.5
9	0.5%GF 1.5%PP	2.6	2.3
10	1%GF 1%PP	2.3	1.3

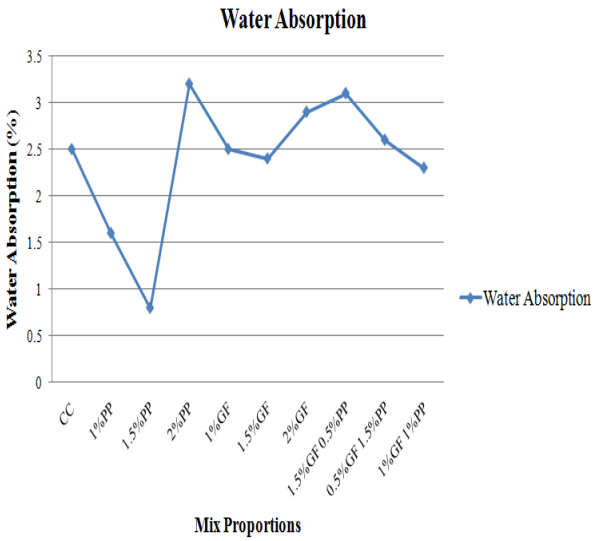

Fig no.1. Water Absorption

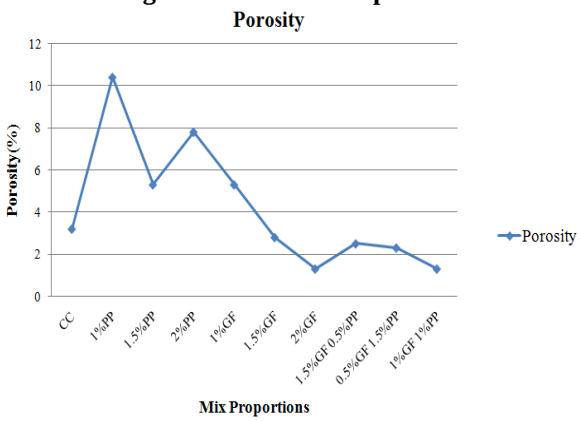

Fig no.2. Porosity

B. Sorptivity Test

The sorptivity test is done and values are noted. The sorptivity coefficient is calculated by using the following formula

$(Q/A) = k\sqrt{t}$

where Q is the amount of water absorbed in cm^3, A is the soecimen's cross sectional area, $\sqrt{t}$ is the time. The sorptivity coefficient k is calculated by plotting the graph between (Q/A) and $\sqrt{t}$. The sorptivity coefficient is given in table 6.

Table 6.Sorptivity coefficient Results.

Sl.No	Sample	Sorptivity coefficient ($x\ 10^{-3}$ $cm/s^{1/2}$)
1	CC	4.52
2	1%PP	6.35
3	1.5%PP	2.93
4	2%PP	4.02
5	1%GF	4.83
6	1.5%GF	4.29
7	2%GF	2.93
8	1.5%GF 0.5%PP	2.45
9	0.5%GF 1.5%PP	2.60
10	1%GF 1%PP	2.55

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)
© Copyright: All rights reserved.

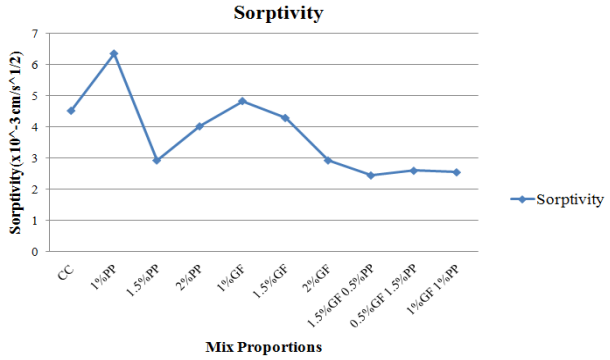

Fig no.3.Sorptivity

C. Drying and Wetting

The specimens weight are taken before oven dry and curing. The values are calculated. There is a weight reduction in the specimens. Addition of fibers reduces the weight after 3 cycles of drying and wetting. The Drying and wetting cycles results are given in Table 7.

Table 7. Drying and wetting results

S.No	Sample	Weight (Kg)		Reduction in weight (%)
		Without cycles	3 cycles	
1	CC	2.44	2.35	3
2	1%PP	2.50	2.44	2
3	1.5%PP	2.56	2.52	1
4	2%PP	2.54	2.50	1
5	1%GF	2.48	2.44	1
6	1.5%GF	2.52	2.46	2
7	2%GF	2.52	2.43	4
8	1.5%GF 0.5%PP	2.46	2.40	2
9	0.5%GF 1.5%PP	2.58	2.50	3
10	1%GF 1%PP	2.54	2.51	1

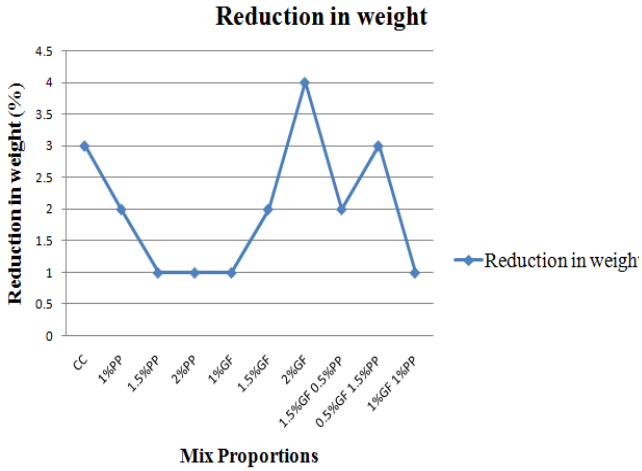

Fig no.5. Drying And Wetting

D. Acid attack test:-

The conventional concrete(without fiber) and fiber (glass and polypropylene) reinforced concrete resistance to sulphate attack was measured. This test is performed by immersing concrete cubes of 100x100x100 mm size in solution of 8% of sodium sulphate(Na_2SO_4). At 28 days and 56 days, there is reduction in the weight and compressive strength of the conventional High Strength Concrete and Fiber Reinforced Concrete are studied.

Next acid test is done in magnesium sulphate solution. For 28 days and 56 days, the cubes are immersed 10% of magnesium sulphate ($MgSO_4$) solution. After 28 and 56 days the specimens were measured for weight and compressive strength. There is a percentage reduction in weight and compressive strength after cured in acid. The values are measured for conventional concrete and fiber reinforced concrete. Then the results of conventional and fiber reinforced concrete were compared. The next test is done for determining the marine environment attack. Here the cubes of size 100x100x100mm are immersed in 7% of sodium chloride (NaCl) solution. The deterioration of conventional concrete specimens and fiber reinforced concrete specimens are evaluated .After 28 and 56 days, the percentage reduction in weight and compressive strength are measured.

Table no 8. Compressive strength after acid curing

% fiber	28 Days in NaCl (loss)	56 Days in NaCl (loss)	28days in Na_2SO_4 (gain)	56days in Na_2SO_4 (gain)	56days in $MgSO_4$ (loss)
CC	63.36	60.10	45.52	66.45	38.80
1%PP	64.80	62.30	46.63	68.90	42.30
1.5%PP	76.34	73.10	48.25	79.93	47.10
2%PP	78.64	75.70	49.52	75.65	61.56
1%GF	70.10	77.45	46.15	77.45	66.70
1.5%GF	69.16	67.20	51.20	72.22	65.22
2%GF	68.62	66.70	46.83	50.34	64.80
1.5%GF 0.5%PP	76.25	73.18	48.23	78.93	48.45
0.5%GF 1.5%PP	78.54	74.70	49.25	75.55	63.60
1%GF 1%PP	71.10	77.45	51.27	74.45	66.80

V. CONCLUSION:-

- The inclusion of polypropylene and glass fibers improved durability of concrete. The increase or decrease in compressive strength of the concrete specimens enhanced with time.
- The compressive strength of the concrete decreases with the increase in the fiber content amount subjected to acid curing and normal curing.
- If high durability is exhibited by the concrete specimens it establishes a good property for the structure.. The polypropylene and glass fibers reduces the cracks by filling the gap with fibers and minimize interconnecting voids.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)
© Copyright: All rights reserved.

REFERENCES

1. A.L.ardeshana, DratulK Desai, "*Durability of fiber reinforced concrete of marine structure"s*, August 2012 pp215-219
2. P. VamsiKrishnal, N. SrinivasaRao, "*Durability studies on steel fiber reinforced concrete*", Aug 2016,vol 03.
3. Tararahmani, Behnamkiani, "*Durability of glass, polypropylene and steel fiber reinforced concrete*", April 2011,dbmc
4. Seshadrisekhar, K.Chandramouli, P. Srinivasarao, "*Durability studies on glass fiber reinforced concrete*", January 2009.
5. A.Bentur**,** M. Ben Bassat**,** D. Schneider,"*Durability of glass, fiber reinforced cements with different alkali resistant glass fibers*",april 1985, vol 64.
6. Sveng. Bergstrom, Hans Erikgram, "*Durability of alkali-sensitive fibers in concrete*", May 1984 pp75-80.
7. Marikunte S, Aldea C, Shah SP,"*Durability of glass fiber reinforced cement composites Effect of silica fume and metakaolin*". April 1997 PP 100-108**.**
8. Rajasekar A, Arunachalam K, Kottaisamy M,"*Assessment of strength and durability characteristics of copper slag incorporated ultra high strength concrete*" January 2019pp402-414.
9. Rajasekar A, Arunachalam K, Kottaisamy M, Saraswathy V,"*Durability characteristics of Ultra High Strength Concrete with treated sugarcane bagasse ash*" May 2018 pp350-356.
10. Soylev TA, Ozturan T, Durability,"*physical and mechanical properties of fiber-reinforced concretes at low-volume fraction*" December 2014,pp67-75.
11. Nili M, Afroughsabet V,"*The long-term compressive strength and durability properties of silica fume fiber-reinforced concrete*"January 2012pp107-111.
12. Afroughsabet V, Ozbakkaloglu T. "*Mechanical and durability properties of high-strength concrete containing steel and polypropylene fibers*" September 2015 pp 73-82.
13. Fallah S, Nematzadeh M, "*Mechanical properties and durability of high-strength concrete containing macro-polymeric and polypropylene fibers with nano-silica and silica fume*" February 2017 pp170-187.
14. KarahanOkan, Cengiz Duran Atis,"*The durability properties of polypropylene fiber reinforced fly ash concrete*"February 2011 pp 1044-1049.
15. ImanSadrinejad, RahmatMadandoust, Malek Mohammad Ranjbar,"*The mechanical and durability properties of concrete containing hybrid synthetic fibers"*. July 2018 pp72-82.

AUTHORS PROFILE

P.Amsayazhi, Research Assistant SASTRA Deemed To Be University Thanjavuramsayazhi@sastra.ac.in

K.Saravana Raja mohan, Dean SASTRA Deemed To Be University Thanjavur srm@civil.sastra.edu

S.Kamalavani, Final year M.Tech Structural Engineering, SASTRA Deemed To Be University Thanjavur kamaliarul27@gmail.com

R.Sowmiya, Final year M.Tech Structural Engineering SASTRA Deemed To Be University, Thanjavur sowmirt@gmail.com

© Copyright: All rights reserved.