

An Experimental Investigation on Strength and Durability of HSC using Manufactured Sand

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ABSTRACT: High strength concrete replaced manufactured sand is the more advantage in the Construction industry. The main objective of High strength concrete to develop the compressive strength of concrete by replacing Natural sand into Manufacture sand and using admixture. To examine the workability of manufactured sand and using admixture in concrete. To investigate the performance of this concrete terms of its compressive strength and split tensile strength. This paper puts forward the applications of manufactured sand as an attempt towards sustainable development in India. It will help to find viable solution to the declining availability of natural sand to make eco-balance. Manufactured sand is one among such materials to replace river sand, which can be used as an alternative fine aggregate in mortars and concretes. The use of manufactured sand in concrete is gaining momentum these days. The present experimental investigations have been made on concrete using manufactured sand as fine aggregate and observed the effects of crushed manufactured sand on strength properties of concrete. This paper reports on the performance of HSC trial mixes having different replacement levels of cement with Silica Fume, Fly Ash. The strength characteristics of these mixes are compared with the mixes without any admixture. Compressive strengths of 60 MPa, 28 days were obtained by using different percent replacement of cement with admixtures.

KEYWORDS: Flexural strengthening, RCPT, Silica Fume, Fly Ash.

I. INTRODUCTION

Now-a-days, the Government have put ban on lifting sand from River bed. Important governing factors for HSCs are strength, long term durability, serviceability as determined by crack and deflection control, as well as response to long term environmental effects. Concrete mix design of M60 grade was done according to Indian Standard code Concrete cube, beam and cylindrical specimens were tested for evaluation of compressive strength, split tensile strength, flexural strength and RCPT respectively.

The concrete exhibits excellent strength with 100% replacement of natural sand, so it can be used in concrete as viable alternative to natural sand. Concrete mixes with different percentages of fly ash as cement replacement material were investigated. The dosages of silica fume were different % of the cementitious materials. The compressive strength of concrete obtained at the ages of 7, 28, 56, days.

RESEARCH SIGNIFICATION

Normal concrete lacks required strength and durability which are more often required for large concrete structures such as high rise buildings, bridges and structures under severe exposure condition. Due to booming construction activities natural sand is becoming scarce due to excessive nonscientific methods of mining from the river beds. For these reasons it is necessary to produce a concrete with improved strength and performance, with suitable materials. This research shows the effective utilization of various by products like silica fume, fly ash and different fibers in High Strength Concrete using manufactured sand.

The main objectives of this project are as below:

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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Vol. 6, Issue 3, March 2017

- To develop high strength concrete by replacing natural sand into manufactured sand and adding mineral admixtures like fly ash, silica fume and different fibers.
- To examine the workability of manufactured sand and using admixture in concrete.
- To investigate the performance of these concrete terms of its compressive strength, split tensile strength and flexural strength and RCPT.

II. LITERATURE REVIEW

In the project it have been achieved to review the literature available in the field of High strength concrete using manufactured sand. Some of important literature connected with topic are furnished below.

Dr. S. Elavenil, et.al, (2013) The mix with M sand as 100% fine aggregate gives initial workability of 170mm, which is much higher than that of the mixes with 100% river sand (RS) and crusher dust. Higher fineness modulus, particles grading, shape, texture and control of micro fines have contributed to better workability of manufactured sand. The good physical properties of manufactured sand has enabled in reduction of free water as well. The effect on the use of manufactured sand on early age and long term volumetric properties, such as shrinkage and creep respectively, are not available and should be studied. The standard mix with 100% of river sand has exhibited compressive strength of 49MPa, 7.5% lower than that of manufactured sand.

Priyanka A. et.al, (2013) The effect of partial replacement of natural sand by manufactured sand on the compressive Strength of cement mortar of proportion 1:2, 1:3 and 1:6 with water cement ration as 0.5 and 0.55 are studied. Results are compared with reference mix of 0% replacement of natural sand by manufactured sand. The compressive strength of cement mortar with 50% replacement of Natural sand by manufactured sand reveals higher strength as compared to reference mix. Manufactured sand has a Potential to provide alternative to natural sand and helps in maintaining the environment as Well as economical balance.

Non-availability of natural sand at reasonable cost, forces to Search for alternative material. Manufactured sand qualifies itself as suitable substitute for River sand at reasonable cost. The manufactured sand found to have good gradation and nice Finish which is lacking in natural sand and this has been resulted in good cohesive cement Mortar.

Dona Maria Joseph, et.al, (2013) Strength development rate after hardening is fast and after 3 days of curing, compressive strength exceeding 28.8 MPa and 26.51 MPa for cube and cylindrical specimens were obtained. This is similar to what the conventional concrete achieves in 28 days. Nearly 20% of compressive strength of Portland cement is increased by using M-Sand for river sand in conventional concrete. The initial setting time of this blended cement is extended to 100 minutes permitting enough time for batching, placing and finishing of concrete perfectly at site. Blended cement concrete is developed with the mixture of Ordinary Portland cement, High Alumina cement, M-sand, coarse aggregate with conplast SP430 super plasticizer for the purpose of accelerating early strength and prolonged setting time. The initial setting time of this blended cement is extended to 100 minutes permitting enough time for batching, placing and finishing of concrete perfectly at site.

Priyanka A, et.al, (2012) The main objective of the work was to systematically study the effect of water cement ratio and percentage replacement of manufactured sand by natural sand as 0.4, 0.45, 0.5, 0.55 and 0%, 20%, 40%, 60%, 80% and 100% respectively on the strength propertied of concrete. The study was carried out on M20 grade concrete with 0.5 water cement ratio. The compressive, split tensile and flexural strength of concrete with 60% replacement of natural sand by manufactured sand reveals higher strength as compared to reference mix. The effect of concrete with partial replacement of manufactured sand on the properties of normal strength concrete with water cement ratio of 0.45 and 28 day's compressive, split tensile and flexural strength of 20Mpa (2900 psi) and workability (slump and compacting factor) were studied. The overall strength of concrete linearly increases from 0%, 20%, 40% and 60% replacement of natural sand by manufactured sand as compared with reference mix. These results were compared with previous work then found that, present study gives better strength and higher water cement ration gives better workability.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijrset.com

Vol. 6, Issue 3, March 2017

C.V. Raghu Pathi, et.al, (2010) The compressive strength of M50 grade concrete with varying percentages of (0%, 25%, 50%, 75%, and 100%) manufactured concrete improved the strengths by 6.89%, 10.76%, 17.24%, 20.68%, respectively. Workability of the M50 grade manufactured sand concrete observed to be 30% less compared to the conventional concrete. The load carrying capacity and Moment carrying capacity of the RC beams of manufactured sand concrete obtained 3 to 12% when compared to conventional concrete. Manufactured sand can be substituted in making structural grade concrete, as it is giving satisfactory performance.

B.Vidivelli, et.al, (2009). The compressive strength of concrete cubes made with Fly ash was determined at the ages of 28,45,60,90 and 180 days results. From the test results it is observed that the compressive strength increased by 1.92% to 21.1% at 10% and 20% replacement fly ash. Similarly for 45, 60, 90, and 180 day's compressive strength is increased. It has been concluded that 20% neyveli fly ash could be incorporated as cement replacement in concrete. Since the concrete specimens containing 10% and 20% fly ash were examined by scanning electron microscopy (SEM) represent dense microstructure which increases the strength in concrete.

S. Bhanja, et.al, (2004). Extensive experimentation was carried out to determine the isolated effect of silica fume on the tensile strength of concrete at water-binder ratios ranging from 0.26 to 0.42 and cement replacements of 0% to 30%. The results of the present investigation indicate that, other mix design parameters remaining constant, silica fume incorporation in concrete results in significant improvements in the tensile strengths of concrete, along with the compressive strengths. The optimum silica fume replacement percentages for tensile strengths have been found to be a function of w/cm ratio of the mix. The optimum 28-day split tensile strength has been obtained in the range of 5–10% silica fume replacement level, whereas the value for flexural strength ranged from 15% to 25%. Both the split and flexural tensile strengths at 28 days follow almost the same trend as the 28-day compressive strength does. Increase in split tensile strength beyond 15% silica fume replacement is almost insignificant, whereas sizeable gains in flexural tensile strength have occurred even up to 25% replacements.

Pshtiwan N. Shakor et.al (2011) as seen from table 5, the 7 days average compressive strength of concrete is maximum when 1.5 % of glass fibres are used. At lower or higher %, about 15% to 20% reduction in strength is observed nevertheless at 28 days, the reduction in strength reduced by 5% to 10%. According to this result, increasing weight of glass fibre in normal concrete affects the cohesiveness between the particle of concrete and these results in degrading of compressive strength, flexural and tensile strength. For (M60) mix, a percentage of glass fibre of 2% gave a flexural strength of (6.15 MPa), which is 10% more than that obtained at 1.5%. Glass fibre does not effect on high performance concrete, if it especially contains big gradation of coarse concrete because it leaves more porosity and spaces between the particles and allows air to move between.

Mahesh K Maroliya et.al (2010). Ultimate compressive strength of SFRPC is 30% higher may be because of more confined and dense concrete while in case of RSFRPC the strength is reducing by 19% as we could not get a good. Flow as a measure of workability which can be improved by readjusting the doses of plasticizers more workable concrete can be obtained and strength can be improved. This is very obvious as compressive strength of RPC is primarily affected by the property of matrix and not due to the influence of the fibers. Split tensile strength of SFRPC and RSFRPC in comparison to plain RPC is found 50% and 30% more respectively addition of fibers is significantly affecting the splitting tensile strength. Flexural strength of SFRPC and RSFRPC in comparison to the plain RPC is found to be 60% and 40% higher respectively. Here addition of fibers significantly increases the flexural strength of RPC. Both steel and Recron FRC specimens failed in ductile manner under static loading because of the effective bridging action of fibers across the tensile cracks. Thus it can be assumed that the structural components made of FRPC would give ample warning before the failure, which is never expected for plain RPC.

Ashish Kumar Dash. et.al (2010) Research on Recron fibre and silica fume with greater fineness as a partial cement replacing material, by which we can minimise the cost and at the same time achieve the durability and strength for the production of High Performance Concrete. It requires a proper mixing proportions for the development of high strength, high performance concrete which may not be possible manually. So it needs some global optimisation techniques to develop the desire result with greater accuracy and time saving.

O.Alidoust, et.al (2007) The investigation develops on the mechanical properties of mortar incorporating polypropylene fibers exposed to high temperature. Also effects of different pozzolanas on strength behavior of samples at elevated temperature have been studied. This is probably due to the additional porosity and small channels created in the matrix of mortar by the fibers melting like compressive strength.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Nemkumar banthia, et.al (2006) He studied plastic shrinkage cracking remains a primary concern for placements with high surface/volume ratios that are subjected to early age drying the results indicate that while polypropylene fibres in general are effective in controlling plastic shrinkage cracking in concrete, a finer fibre is more effective than a coarser one, and a longer fibre is more effective than a shorter one. Further, fibre fibrillations appear to be highly effective in controlling plastic shrinkage cracking.

Song, et.al (2004) He has investigated the strength potential of nylon fibre reinforced concrete versus that of polypropylene fibre reinforced concrete at a fibre content of .6 kg/m³. The strength properties studied includes compressive strength and splitting tensile strength. Their results indicated that compressive and splitting tensile strength of the nylon fibre reinforced concrete improved by 6.3% and 6.7% respectively which is attributed to the fact that nylon fibres have high tensile strength and better distribution through the concrete mass

III.METHODOLOGY

3.1 EXPERIMENTAL INVESTCATION

Materials Used

- Cement
- Manufactured Sand
- Coarse aggregates
- Water
- Silica Fume
- Fly Ash
- polypropylene fibre
- Recron fibre
- Glass fibres

Portland Pozzolana Cement of Grade 53 satisfying the requirements of IS 1489-1991 was used for the investigation. The initial setting time of cement was 30 minutes with a specific gravity of 3.15. It was tested for its physical properties as per Indian Standard specifications. The fine aggregate used in this investigation was clear river sand passing through 4.75 mm sieve with a specific gravity of 2.61, and manufactured sand specific gravity of 2.78. The grading zone of aggregate was Zone II as per Indian Standard specifications IS 383-1970. Machine crushed broken stone in angular shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm and 10 mm and its specific gravity was 2.91. Ordinary clean potable water free from suspended particles and chemical substances was used for both mixing and curing of concrete.

CONCRETE MIX DESIGN

Table 2 .M60 Mix proportions result per unit volume of concrete (with water correction)

Trial Number	Unit	Cement	Fine Aggregate	Coarse Aggregate (20 mm)	Coarse Aggregate (10 mm)	Water	W/C Ratio
1	VOLUME KG/M ³	600	420	927	397	190	0.3
	RATIO	1	0.7	2.20			

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

3.2 EXPERIMENTAL PROGRAM

Reinforcement details of beam

The beams designed as under-reinforced concrete beams and span of beam was 1000 mm, width 100 mm, depth 150 mm.

Top longitudinal main bars: 2 no's 8 mm dia

Bottom longitudinal main bars: 2 no's 10 mm dia

Stirrups: 2 legged 6 mm dia stirrups at 100 mm C/C

IV. TEST CONDUCTED

4.1 Cube Compressive Strength Test

For cube compression testing of concrete, 150 mm cubes were used. All the cubes are testing at the age of 7days, 28days, 56 days of curing using compression testing machine. Loading is continued till the dial gauge needle reverse its direction of motion. The reversal in the direction of motion of the needle indicates that the specimen has fail. The dial gauge reading at that instant is note which is the ultimate load. The ultimate load divided by the cross sectional area of the specimen is equal to the ultimate cube compressive strength.

4.2 Split Tensile Strength Test

This is test to determine the tensile strength of cylindrical specimens. splitting tensile strength tests were carry on cylinder specimens of size 100 mm diameter and 200 mm length at the age of 7, 28, 56 days curing, using compression testing machine. To avoid the direct load on the specimen the cylindrical specimens were kept below the specimens spilt and readings were noted. The splitting tensile strength has been calculated using the following formula:

$$F = 2P/\pi LD$$

Where,

P is the Compressive Load on the Cylinder.

L is the Length of Cylinder.

D is the Diameter.

4.3 Flexural Strength Test

The test was carried out conforming to IS 516-1959 to obtain flexural strength of concrete at the age of 28 days. The beams were tested using flexure testing machine.

1. Loading and load deflection behavior

- The beam specimen was placed on the loading frame as shown in figure. All the beams were tested under two-point loading condition.
- The monotonic load was applied by using screw jack and to record the load precisely, proving ring was used.
- The beam was gradually loaded by increasing the load level in each cycle such as 1.5, 3, 4.5, 6, 7.5 KN, etc. up to the maximum load of that cycle. At the end of each cycle the load was gradually increased and deflections during were noted.
- The beam was loaded up to failure and the values of load at first crack and ultimate failure stage and crack pattern were noted. The crack were marked by different colors show clearly the failure patterns of beam.

As the load was increased in each cycle, the observed deflection was greater than in earlier cycle. The load vs corresponding deflection in each cycle has been plotted as shown in fig.

V.TEST SETUP

The beam specimen setup was shown in the figure.

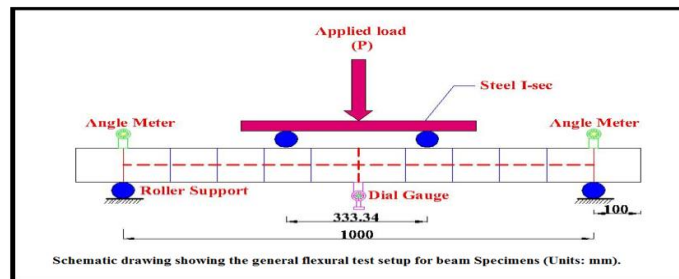


Figure 3.3. Diagram showing a typical two point load beam test setup details.

Rapid chloride permeability test

The Specimen was cylindrical shape, size of 100mm diameter, 50mm length. Three cylindrical specimens were used for each percentage of replacement of slag for determining chloride ion penetration

VI.PROCEDURE

The apparatus consists of two cells. The specimen was mounted and fixed between the cells in such a way that the round edge surface should touch with the solution. After fixing the specimen, the negative side of the cell was filled with 3% NaCl Solution. The positive side of the cell was filled with 0.3M Noah Solution. The positive Side of the cell was filled with 0.3M Noah Solution till the top surface of the concrete Immerses in the solutions. Leakage was checked. Copper rods were used as electrodes. The wires, electrodes, power supply are connected. A.D.C Supplier was used to give electrical potential of 12v. The -ve terminal of D.C.S was connected with electrode of NaCl solution. The +ve terminal of D.C.S was connected with electrode of Na OH solution. As per electro-chemistry principle, due to the applied voltage, the negative ion i.e. Noah reservoir. Therefore the chloride ion moves through specimen. Also the positive ion passes towards the negative terminal i.e. NaCl reservoir through the concrete specimen. Due to the movement of positive and negative ions current was produced. This current was shown in D.C supplier. Reading was taken immediately after voltage supplied at every 30 minutes. This procedure was done for 6 hours duration. Decreases the charge passed values indicates that the concrete has more resistance to chloride ion penetration. The total charge passed during this period was calculated in terms of coulombs using the trapezoidal rule as given in the ASTM C 1202,

$$Q = 900 (I_0 + 2 I_{30} + 2 I_{60} + \dots + 2 I_{330} + 2 I_{360}) \quad (7.4)$$

Where

Q = charge passed (coulombs)

I₀ = current (amperes) immediately after voltage is applied, and

I_t = current (amperes) at 't' minutes after voltage is applied.

If the specimen diameter is other than 95 mm, the value for total charge passed must be adjusted. The adjustment is made by multiplying the value established as above by the ratio of the cross - sectional areas of the standard and the actual specimens.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

$$\text{That is; } Q_s = Q_x (3.75/x)^2 \quad (7.5)$$

Where

Q_s = charge passed (coulombs) through a 95 mm diameter

Specimen

Q_x = charge passed (coulombs) through x inch diameter

Specimen, and

x = diameter (inch) of the non - standard specimen.

A higher amount of electric charge passed in the test represents a higher penetrability of the concrete to chloride ions. The concrete quality (degree of chloride ion penetrability) can be assessed based on the limits as given in ASTM C 1202,

assessed based on the limits as given in ASTM C 1202.

VII. RESULTS AND DISCUSSION

Table: 9.1 Compressive and Split Tensile Strength Test Results.

Sl.NO	Cube Id	Compressive Strength (N/mm ²)			Split Tensile Strength (N/mm ²)		
		7 days	28 days	56 days	7 days	28 days	56 days
1	R-Sand	33.33	55.11	62.66	2.2	3.18	3.81
2	M-Sand	36.88	58.66	64.00	2.67	4.45	5.72
3	SF-5%	38.22	63.11	65.77	3.15	5.25	6.36
	SF-7.5%	35.55	59.55	61.33	2.86	4.77	5.41
	SF-10%	33.77	56.44	60.00	2.77	4.61	4.77
4	FA-10%	35.5	59.55	67.55	3.24	5.4	7.00
	FA-20%	34.2	56.8	64.44	2.90	4.84	6.04
	FA-30%	32	53.77	58.66	2.58	4.30	5.09
5	GF-0.1%	36.61	48.66	59.63	3.45	4.57	6.16
	GF-0.3%	36.89	53.33	62.33	3.81	4.76	6.72
	GF-0.5%	43.10	61.34	64.56	4.12	5.12	7.19
6	PP-0.1%	34.52	51.55	60.78	3.25	4.56	6.55
	PP-0.3%	34.18	49.44	59.89	3.64	4.95	6.89
	PP-0.5%	42.83	59.89	62.76	3.82	5.25	7.43
7	RC-0.1%	33.89	50.77	61.67	3.75	4.78	6.78
	RC-0.3%	35.79	53.62	63.12	3.83	5.31	7.56
	RC-0.5%	44.25	61.58	65.49	3.89	5.60	7.78

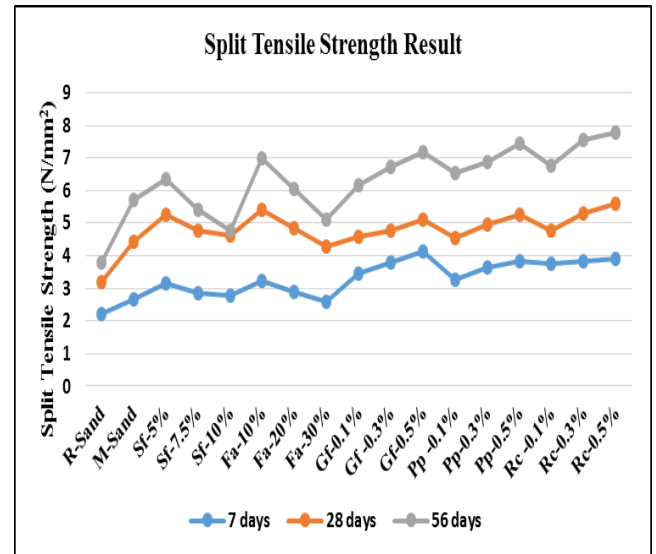
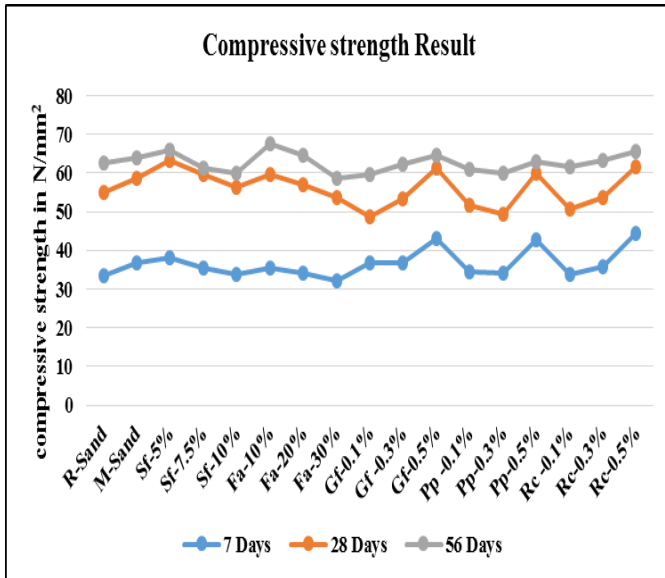
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(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

Chart: 9.1 Comparison of Cube Compressive Strength & Split Tensile Strength



9.2 Flexural Strength Test Results for Different Beams

SL. NO	TEST PARAMETERS	RESULTS					
		CB-1	B-2	B-3	FB-1	FB-2	FB-3
1	First crack load	9 KN	10.5 KN	15 KN	15 KN	13.5 KN	15 KN
2	Ultimate load	24 KN	28.5 KN	31.5 KN	27 KN	28.5 KN	31.5 KN
3	Ultimate moment	4 KNM	4.75 KNM	5.25 KNM	4.5 KNM	4.75 KNM	5.25 KNM
4	Flexural strength	16 N/mm ²	19 N/mm ²	21 N/mm ²	18 N/mm ²	19 N/mm ²	21 N/mm ²
5	Initial stiffness	2.73 KN/mm	3.75 KN/mm	4.5 KN/mm	5 KN/mm	6 KN/mm	7.2 KN/mm
6	Ductility index	2.32	3.15	3.75	3.47	4.27	5.1
7	Energy index	3.5	4.88	7.875	6.9	7.6	8.2
8	Total energy absorption capacity	168 KNmm	256.5 KNmm	283.5KNmm	312 KNmm	325 KNmm	386 KNmm

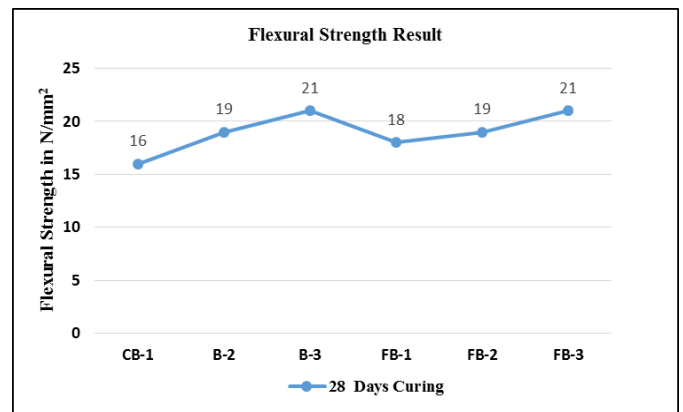
International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 3, March 2017

CB-1	Control Beam
B-2	M-Sand with 5 % Silica Fume
B-3	M-Sand with 10 % Fly Ash
FB-1	M-Sand with 0.5 % glass fibre
FB-2	M-Sand with 0.5 % Polypropylene fibre
FB-3	M-Sand with 0.5 % Recron 3s fibre



BEHAVIOUR OF CONTROL

Model Calculations for Flexural Strength:

$$\text{Ultimate Moment} = WL / 6$$

$$\text{Flexural Strength} = M / Z$$

$$\text{Ductility Index} = \Delta u / \Delta y$$

$$\text{Energy Index} = \frac{\text{Area up to } \Delta u}{\text{Area up to } \Delta y}$$

$$\text{Total Energy Absorption Capacity} = \text{Area up to } \Delta u$$

Where:

- W is the load in KN.
- M is the ultimate moment in KNMM
- Z is the section modulus in mm³
- Δy is the yield deflection in mm
- Δu is the ultimate deflection in mm

Table.4.4: Comparison of chloride ion penetrability

Specimen	Charge Passed in coulombs	Chloride ion penetrability
M-Sand	4935	High
R-Sand	858	Very low
Specimen With Silica fume 5%	1329	Low
Specimen with fly ash 10%	2046	Moderate

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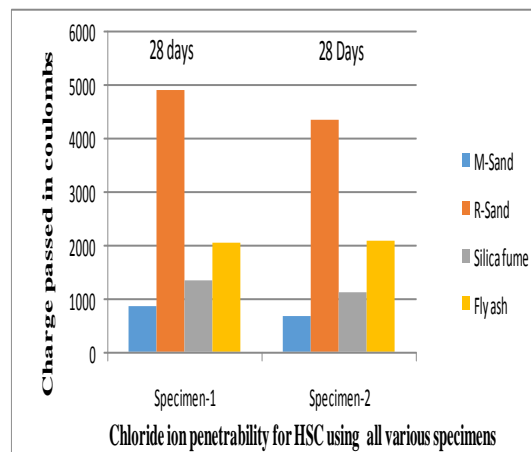
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Vol. 6, Issue 3, March 2017

Table.4.5: Chloride ion penetrability based on charge passed

Charge passed (coulombs)	Chloride ion penetrability
> 4000	High
2000 - 4000	Moderate
1000 - 2000	Low
100 - 1000	Very low
< 100	Negligible



VIII.CONCLUSIONS

This paper effectively shows that from the results and discussion and from table 9.1 we conclude that

1. For M-Sand we get higher compressive strength and split tensile strength compared with river sand.
2. For even the small percentage replacement of cement by both silica fume and fly ash we get high compressive and split tensile strength.
3. For 0.5% replacement of glass fibre, polypropylene fibre, recon fibre we get high compressive and split tensile strength compare with 0.1% , 0.3% replacements.
4. We get maximum First crack load, Ultimate Load, Ultimate moment, Flexural Strength for B-3 and FB-3 and also we get similar results for both of this M-Sand with 10 % Fly Ash and M-Sand with 0.5 % Recon 3s fibre.
5. From the results of Rapid chloride permeability test, Charge Passed in coulombs for M-Sand is high.
6. Finally we conclude that M-Sand with fly ash and recon fibre is suitable for high strength.

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