International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 8 (2015) pp. 19535-19550

http://www.ripublication.com

Strength and Durability Study on Partial Replacement of Cement and Coarse Aggregate with Multi Waste Materials

Baintamilselvan. T

Post Graduate Student, Department of Civil Engineering, PRIST UNIVERSITY, Trichy-Thanjavur Highway, Vallam, Thanjavur - 613 403
baintamil@yahoo. co. in

Vijaya Sarathy. R

Assistant Professor, Department of Civil Engineering, PRIST UNIVERSITY, Trichy-Thanjavur Highway, Vallam, Thanjavur - 613 403
rvsarathycivil@gmail. com

Jose Ravindra Raj. B

Assistant Professor, Department of Civil Engineering, PRIST UNIVERSITY, Trichy-Thanjavur Highway, Vallam, Thanjavur- 613 403
joshravindraraj@gmail. com

Abstract

Concrete is a good building material. Concrete attained excellent growth with the advent of reinforced concrete. The compressive strength of concrete, combined with Cement, fine aggregate and coarse aggregate will give better result in the building work. In this research some material such as Industrial Furnace waste and Lime stone waste along with Portland pozolona cement (PPC) were used for better utilization in Cement Concrete works. Here the sand was fully replaced by M Sand which was received from the Quarry waste. Industrial Furnace slag was replaced partially with binder that is Cement. Lime Stone waste received from local area was partially replaced with course aggregate. Cement and aggregate are cheaper than these waste materials. They are used as a partial replacement of cement. It decreases the overall CO_2consumption and increases the workability of concrete; as a result it improves strength and durability. The strength characteristics such as

compressive, Flexural and split tensile strength along with durability of the Concrete was investigated.

INTRODUCTION

Concrete is the largest production of all other materials in construction industries. The present consumption is nearly 400 million tons per year and the demand is expected to reach one Billion tons within the next decade. Its usage around the world is second only to water. Carefully mixing cement, water, fine and coarse aggregate results in good concrete. Two main properties of concrete are strength and durability, and also the concrete in case reinforced that should be corrosion free so that only the structure will have long life. Effective production of high strength concrete is achieved by carefully selecting, controlling and proportioning all ingredients. Hence, we are exploiting the natural resources in an extremely high manner and results in depletion of the same and creating environmental strain. The increase in demand for the ingredients of concrete is met by partial replacement of materials by the waste materials which is obtained by means of various industries. In this research an attempt is made to study the effect of partial replacement of Coarse aggregate by the lime stones, m-sand for sand and furnace slag for cement.

LITERATURE REVIEW

This paper presents the effect of the use of artificial sand as fine aggregate in concrete as substitutes to naturally available sand. strength of concrete with natural sand increased by 7. 72% after fully replacing by artificial sand at 7 days and 3. 98% at 28 days. [1] Structural characteristics of concrete using various combinations of lateritic sand and lime stone filler as complete replacement for conventional river sand. The laterite quantity is varied from 0% to 100% against lime stone filler at 25% interval. Cubes and cylinders are made in three various grades, 0. 55 water/cement ratio produced higher strength and good workability for M20 concrete mix [2]. Ground granulated furnace slag and saw dust is replaced in different percentages i. e. 0%, 5%, 10%, 15%, 20%, and 25% with the Fine aggregates has given good results [3]The replacement ratios which have been studied were 0. 0%, 5. 0%, 7. 5%, 10. 0% and 15% by weight. [4].

OBJECTIVES

The specific objectives of the work are

1. To compare the compressive strength and tensile strength of control concrete with that of concrete made by replacing the waste products.
2. To study the durability characteristics of concrete made by replacing products.
3. To obtain the optimum percentage of addition of waste products with cement, sand and aggregate for good strength and durability.

METHODOLOGY

Methodology of the work is given in the form of flow chart in Figure 1. Concrete mix design for M20 grade of concrete Shown in table 1. Cement replaced partially with furnace slag and Sand replaced by M-Sand, Coarse aggregate was replaced with lime stone. Mix proportions are tabulated in table 2.

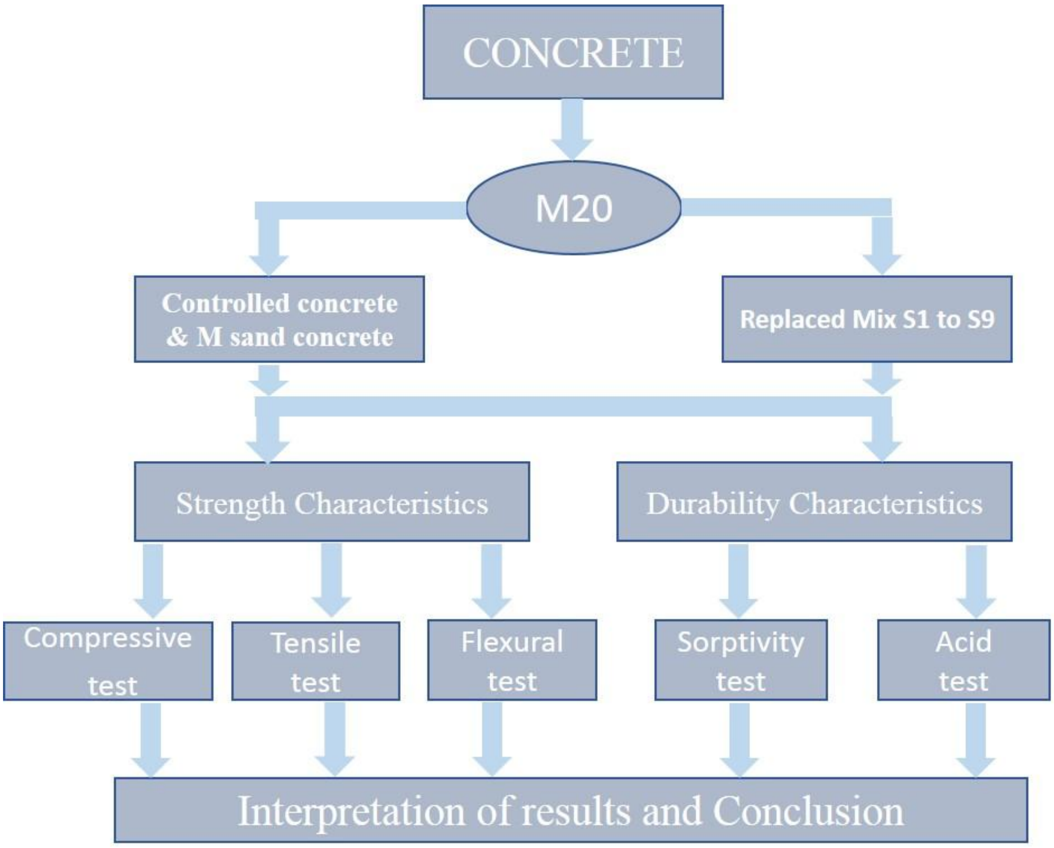

Figure 1 Flow chart of methodology

Table 1 Concrete Mix Design – M20

Mix Proportions M20 (By Mass)			
Water	**Cement**	**Fine Aggregate**	**Coarse Aggregate**
170 lit	365. 0 kg	732 kg	1172. 0 kg
0. 47	1. 00	2. 00	3. 21

Table 2 Mix Proportions

Mix	Cement	Furnace slag	M sand	Sand	Coarse aggregate	Lime stone
S1	90%	10%	100%	0%	90%	10%
S2	90%	10%	100%	0%	85%	15%
S3	90%	10%	100%	0%	75%	25%
S4	85%	15%	100%	0%	90%	10%
S5	85%	15%	100%	0%	85%	15%
S6	85%	15%	100%	0%	75%	25%
S7	75%	25%	100%	0%	90%	10%
S8	75%	25%	100%	0%	85%	15%
S9	75%	25%	100%	0%	75%	25%
CC	100%	0%	0%	100%	100%	0%
MS	100%	0%	100%	0%	100%	0%

Totally 11 mixes were made, in which CC and MS are the controlled concrete and M sand Concrete in all other mixes, Msand is used instead of river sand as fine aggregate. To know the performance of M20 concrete with replace of 100% sand by Msand, the mix MS (Msand mix concrete) is made.

MATERIAL PROPERTIES

CEMENT

PPC 43 grade with specific gravity 3.15 was used in this work.

FINE AGGREGATE

Sand is obtained from cavery river near Trichy and MSand is obtained from Local quarry. Fine aggregates used in this work confirming to IS: 383

FURNACE SLAG

Furnace Slag from Mettur JSW Factory Was used in this work, in accordance with ASTM C595.

LIME STONE

Lime stones are obtained from nearby locality; it is a waste which is dumped in a cement industry

Water

Potable Water without impurities confirming to IS code was used in this work

TESTING OF SPECIMEN

Cube, beam, cylinder cast were done and tested according to IS standards for strength parameter and durability parameters were studied according to ASTM Standards

COMPRESSIVE STRENGTH TEST RESULTS

Result obtained from the compressive test is tabulated in table 3. Sample with 100% replacement of sand to Manufactured sand (MS) shows the maximum performance of 22.22MPa which is better than control concrete. Different Percentage variation of compressive strength are shown in fig 2

Table 3 Average Compressive strength of the samples

SL No	Sample Name	Average Compressive Strength in N/mm^2		
		7th Day	14th Day	28th Day
1	S1	21. 33	23. 56	33. 33
2	S2	18. 67	23. 11	29. 78
3	S3	18. 22	22. 22	25. 78
4	S4	19. 56	23. 11	28. 89
5	S5	19. 11	22. 67	27. 56
6	S6	17. 78	21. 33	24. 89
7	S7	15. 11	16. 89	25. 33
8	S8	13. 78	16. 44	22. 67
9	S9	13. 33	15. 11	19. 11
10	MS	22. 22	24. 89	33. 78
11	CC(W)	19. 11	23. 11	27. 56

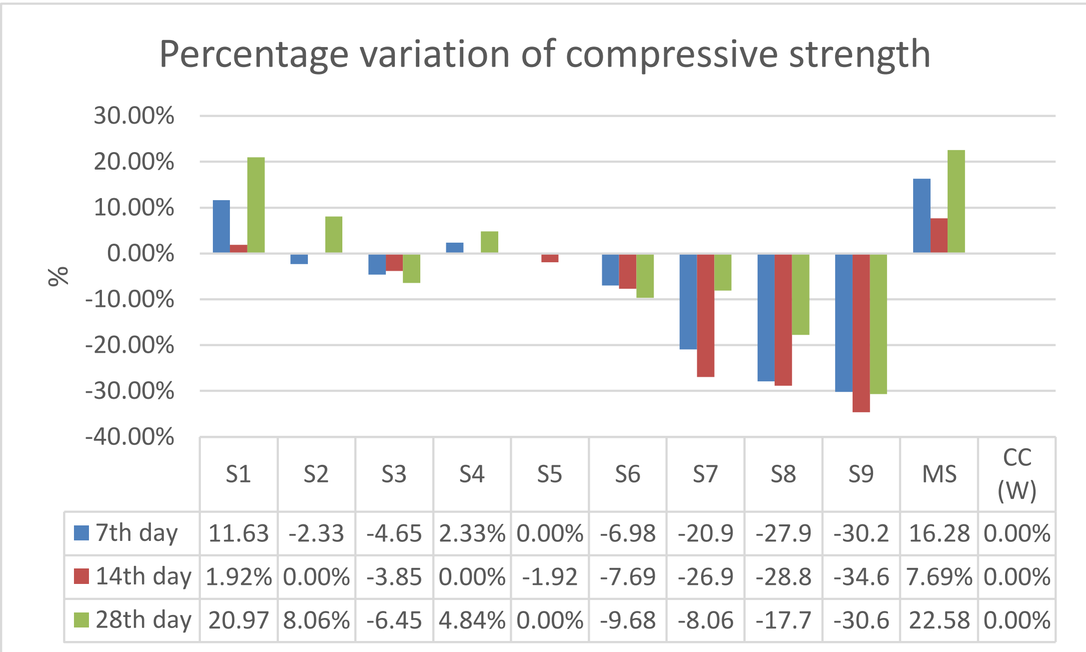

Figure 2 Percentage variation of compressive strength

It is clear from the figure 2 that mix S5 to S9 shows less value in compressive strength with increase in replacing waste products. Cement replaced with slag by 10% and coarse aggregate is added to 15% shows good performance. While replacing M-sand with river sand in the convention concrete, the strength seems to be good and advisable for use.

SPLIT TENSION STRENGTH TESTRESULTS

Split tension test was made and the results for 7th day, 14th day and 28th day were tabulated in table 4

Table 4 Avg Split Tensile Strength of Concrete

SL NO	Sample Name	7th day Split Tensile Strength in N/mm^2	14th day Split Tensile Strength in N/mm^2	28th day Split Tensile Strength in N/mm^2
1	CC	2. 69	3. 25	3. 54
2	MS	3. 54	3. 68	3. 96
3	S1	3. 40	3. 54	3. 68
4	S2	3. 11	3. 25	3. 40
5	S3	2. 69	2. 83	2. 97
6	S4	2. 83	2. 97	3. 11
7	S5	2. 83	2. 97	3. 11
8	S6	2. 41	2. 55	2. 83
9	S7	2. 41	2. 69	2. 97
10	S8	2. 12	2. 41	2. 83
11	S9	1. 84	2. 12	2. 55

MS and S1 Shows good performance. All other samples show less result than the control concrete. sample S1 with minimum replacement gives better results.

FLEXURAL STRENGTH TEST RESULTS

The results for 7, 14, 28th day test are tabulated in table 5. S1 sample shows good performance than other samples.

Table 5 Avg Flexural Strength of Concrete

SL NO	Sample Name	7th day in MPa	14th day in MPa	28th day in MPa
1	CC	0. 32	0. 38	0. 48
2	MS	0. 40	0. 46	0. 56
3	S1	0. 38	0. 44	0. 52
4	S2	0. 36	0. 40	0. 50
5	S3	0. 36	0. 40	0. 48
6	S4	0. 34	0. 38	0. 44
7	S5	0. 32	0. 36	0. 42
8	S6	0. 30	0. 34	0. 40
9	S7	0. 26	0. 30	0. 36
10	S8	0. 26	0. 28	0. 32
11	S9	0. 20	0. 24	0. 26

SORPTIVITY TEST

table 6 shows the Q/A values with square root of time. From the obtained values, sorption coefficient is computed from the graphs below. A graph is drawn between time and penetration depth to find the sorption coefficient. The samples are more impermeable when the sorption coefficient is less and they show good durability performance Form this short term durability characteristics are found out. The graphs are shown in figure 5. 12, 5. 13, 5. 14, 5. 15, 5. 16, 5. 17, 5. 18, 5. 19, 5. 20, 5. 21 and 5. 22 gives the sorptivity coefficient of for CC, MS, S1, S2, S3, S4, S5, S6, S7, S8 and S9 samples.

Table 6: Q/A value

TIME T	ROOT T	Q/A										
		S1	S2	S3	S4	S5	S6	S7	S8	S9	CC	MS
0	0	0	0	0	0	0	0	0	0	0	0	0
60	7. 75	1. 88	1. 92	1. 80	2. 28	2. 05	2. 30	2. 27	2. 01	2. 62	0. 69	1. 83
120	10. 95	1. 96	2. 01	1. 95	2. 41	2. 11	2. 38	2. 46	2. 14	2. 76	0. 95	1. 90
240	15. 49	2. 02	2. 13	2. 10	2. 50	2. 25	2. 52	2. 62	2. 30	2. 92	1. 13	1. 95
480	21. 91	2. 08	2. 25	2. 24	2. 58	2. 38	2. 75	2. 78	2. 43	3. 04	1. 38	2. 00
960	30. 98	2. 14	2. 41	2. 51	2. 74	2. 66	2. 92	3. 03	2. 69	3. 30	1. 76	2. 06
1920	43. 82	2. 27	2. 58	2. 64	2. 92	2. 90	3. 13	3. 34	3. 00	3. 45	2. 25	2. 18
3840	61. 97	2. 42	2. 75	2. 90	3. 20	3. 13	3. 40	3. 60	3. 43	3. 74	3. 34	2. 30
7680	87. 64	2. 52	2. 88	3. 08	3. 28	3. 27	3. 54	3. 72	3. 57	4. 00	3. 71	2. 39
15360	123. 94	2. 62	2. 99	3. 30	3. 43	3. 51	3. 71	3. 81	3. 81	4. 28	4. 00	2. 47

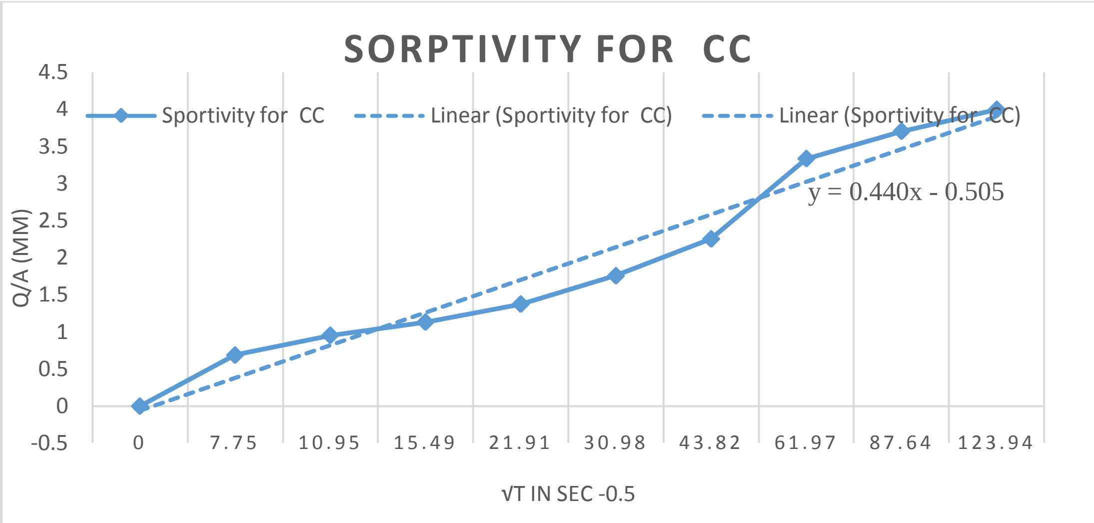

Figure 3 Sorptivity for CC

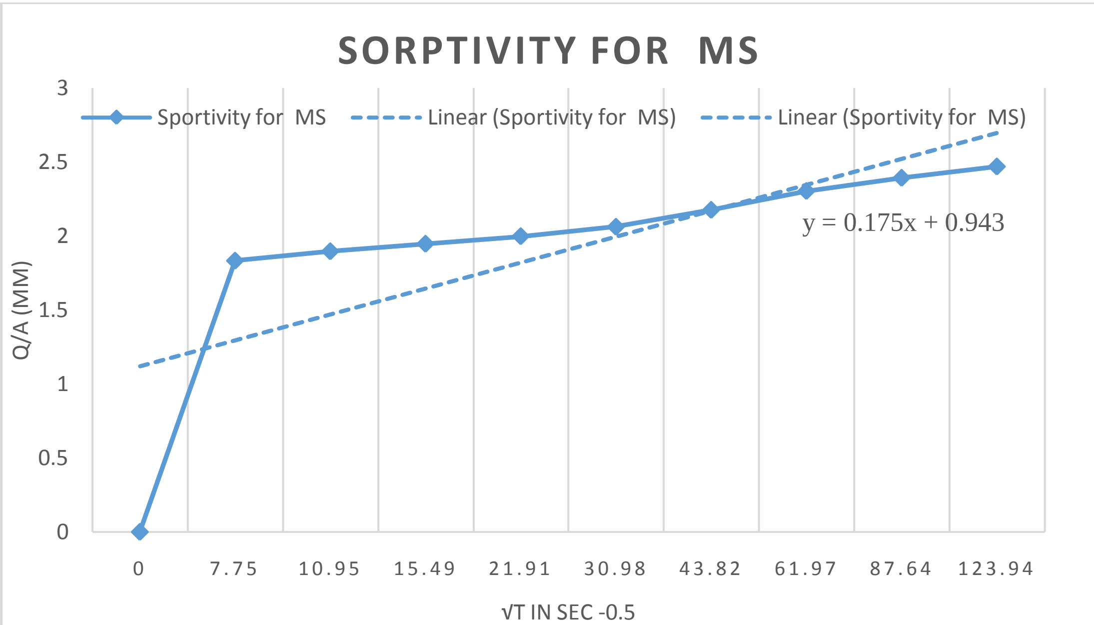

Figure 4 Sorptivity for MS

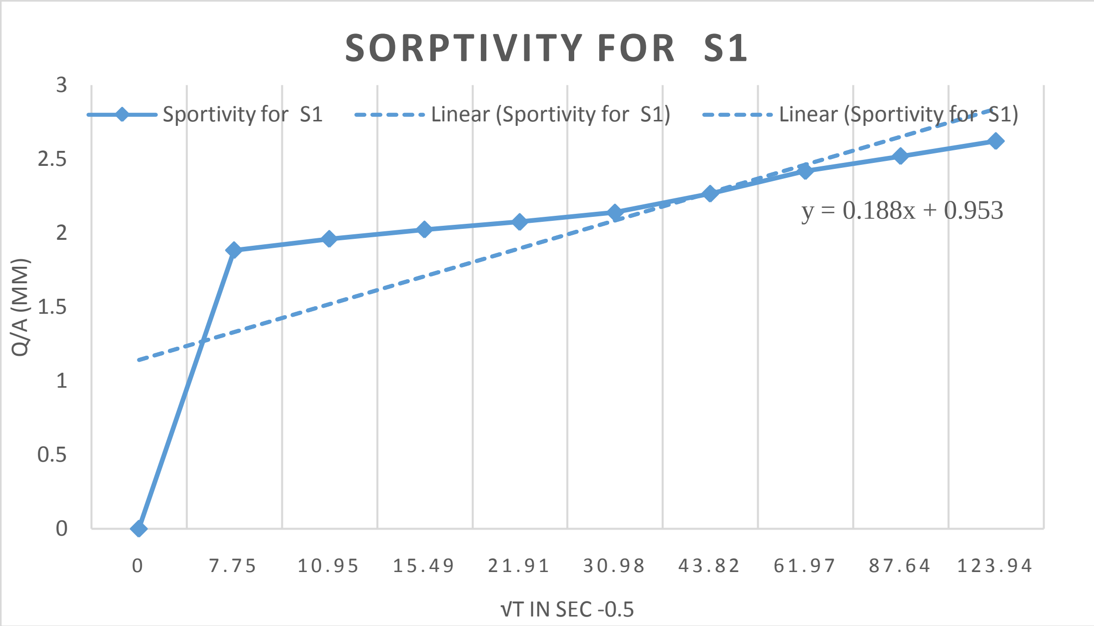

Figure 5 Sorptivity for S1

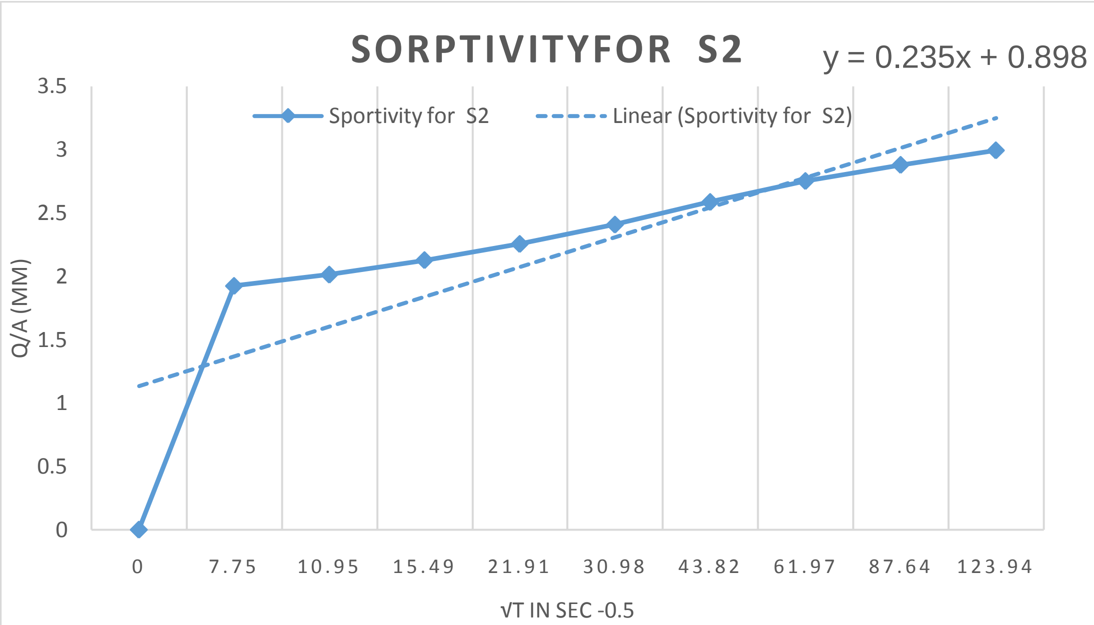

Figure 6 Sorptivity for S2

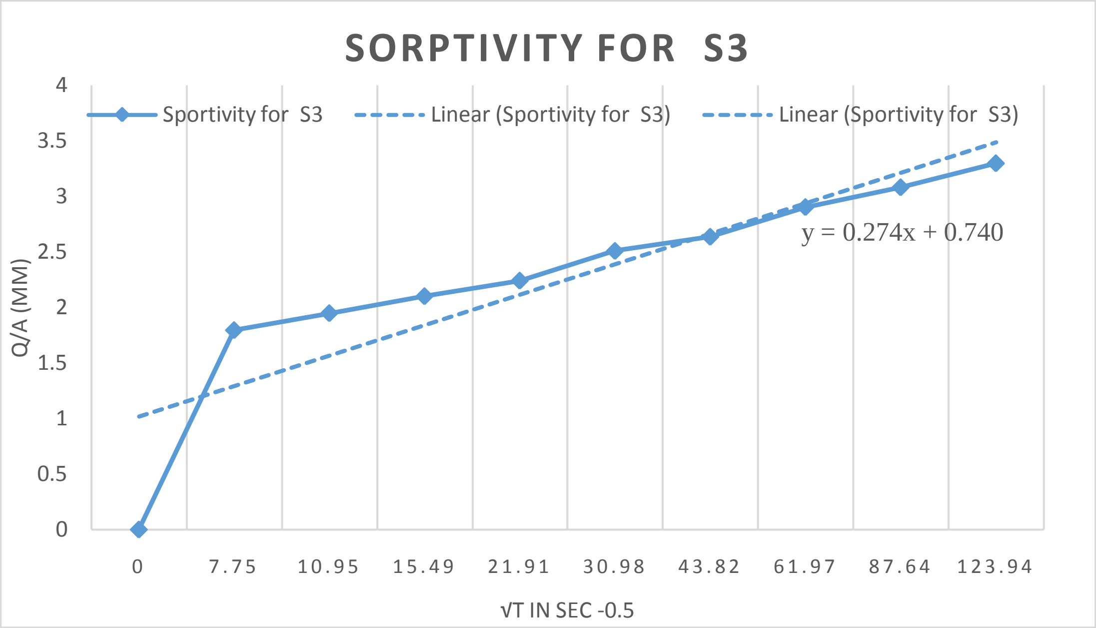

Figure 7 Sorptivity for S3

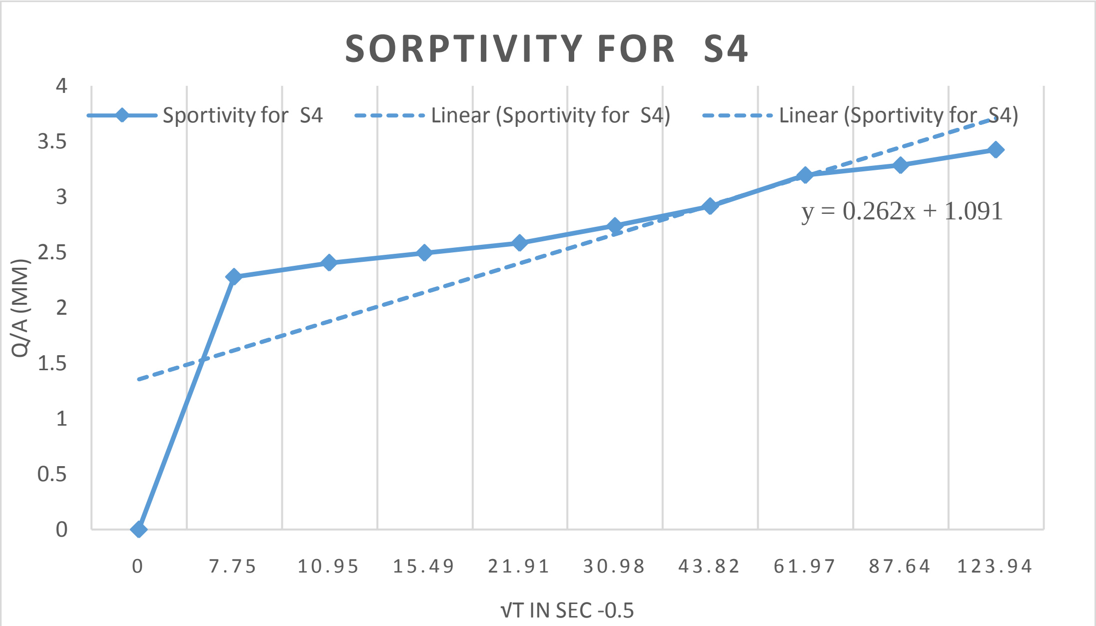

Figure 8 Sorptivity for S4

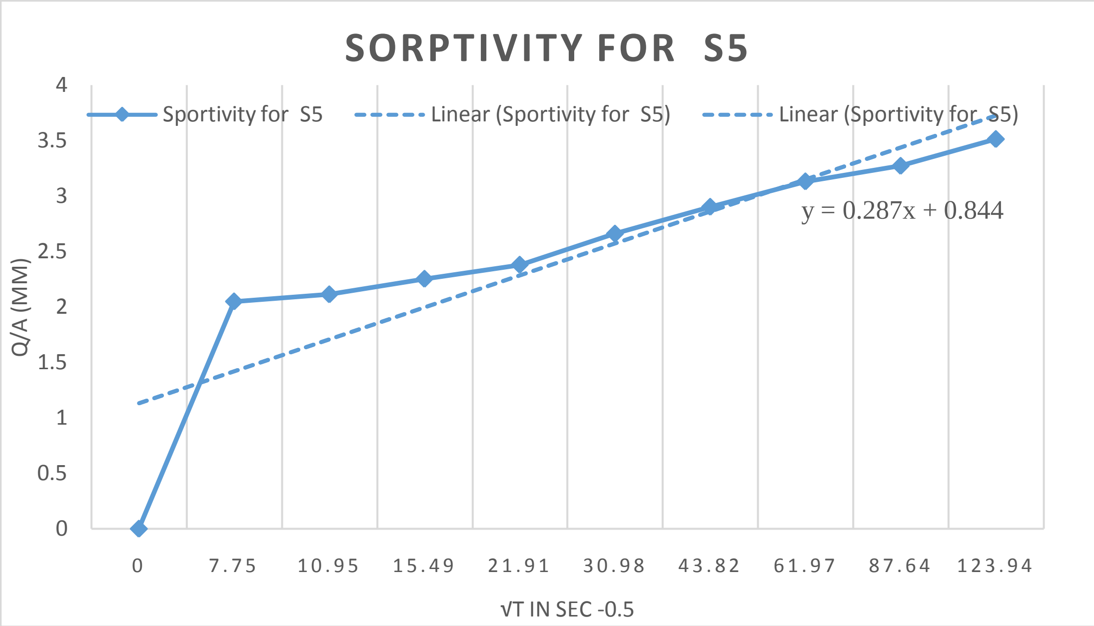

Figure 9 Sorptivity for S5

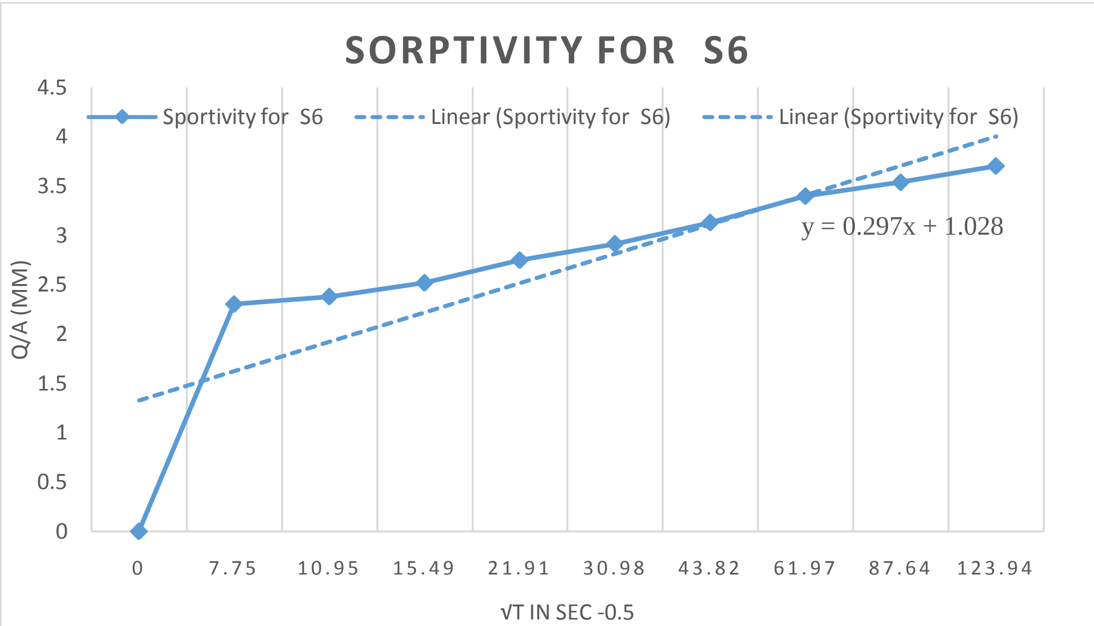

Figure 10 Sorptivity for S6

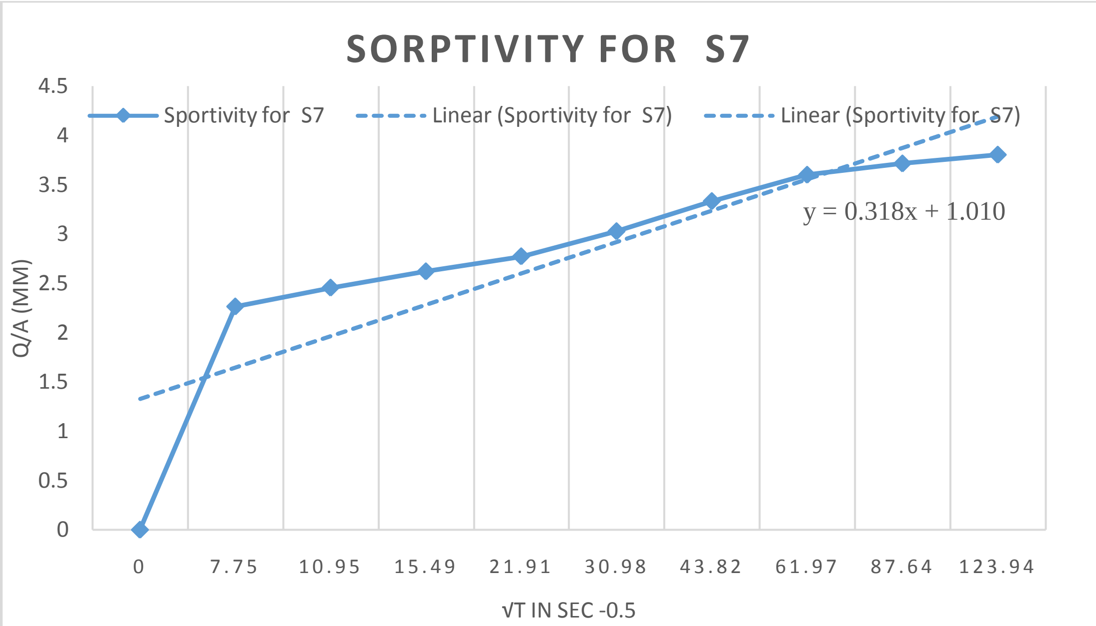

Figure 11 Sorptivity for S7

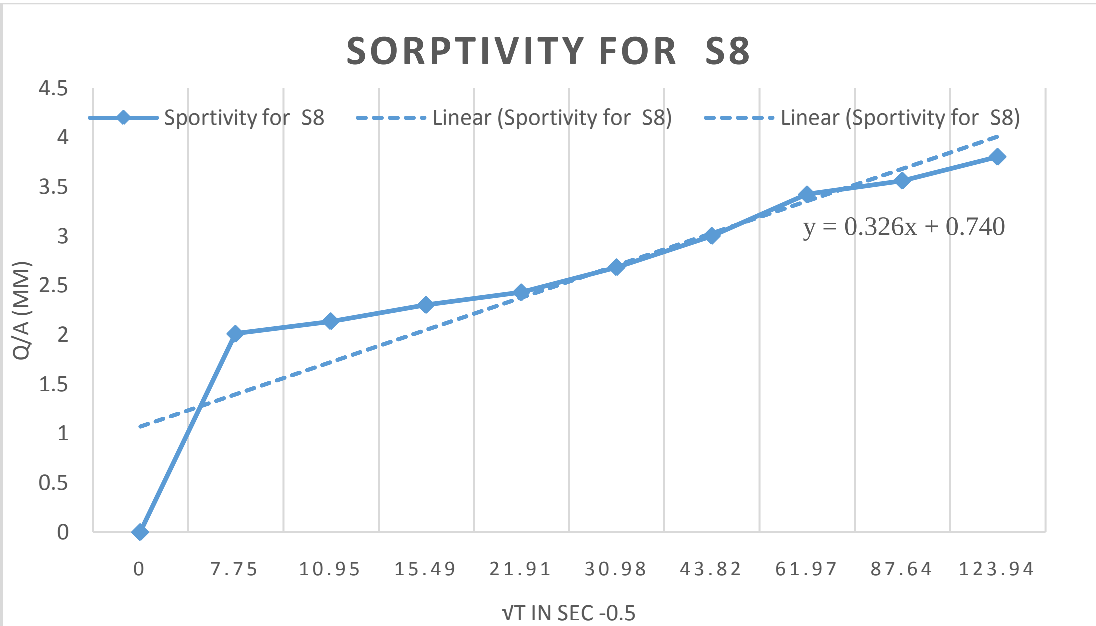

Figure 12 Sorptivity for S8

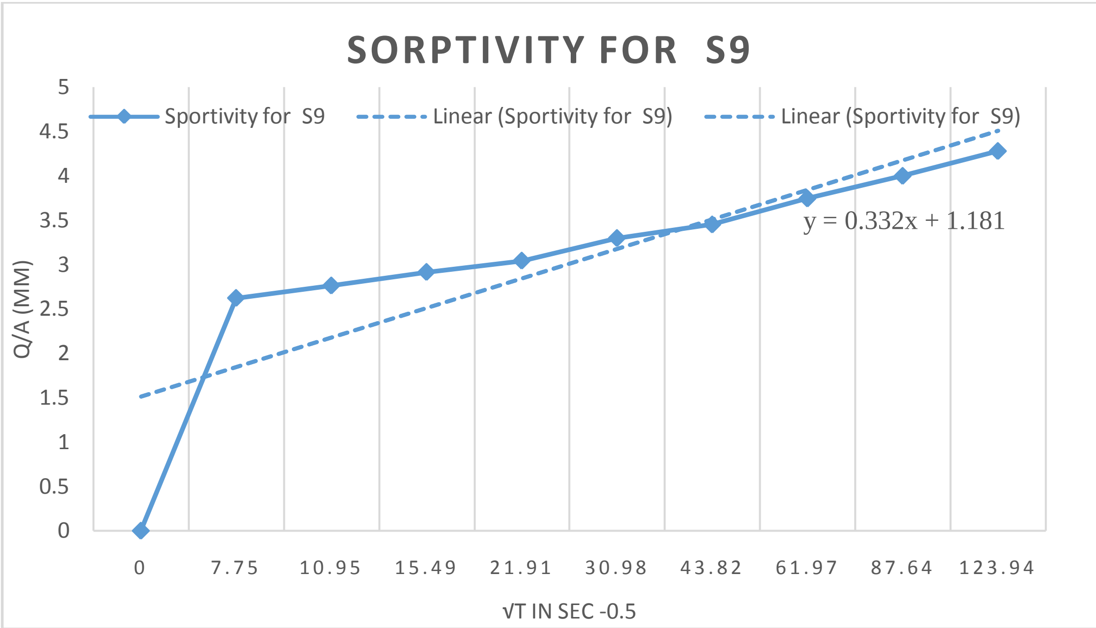

Figure 13 Sorptivity for S9

The sorption coefficient for control concrete is 4. 4 x10^{-1} mm/sec$^{1/2}$. Sorption coefficients are found to be 1. 75 x10^{-1}, 1. 88 x10^{-1}, 2. 35 x10^{-1}, 2. 74 x10^{-1}, 2. 62 x10^{-1}, 2. 87 x10^{-1}, 2. 975 x10^{-1}, 3. 18 x10^{-1}, 3. 26 x10^{-1} and 3. 27x10^{-1} mm/sec$^{1/2}$ for other samples. Coefficient of Sorption for all the mixes is comparatively less than that of the control concrete. Hence the durability of all samples are good. The durability characteristics of MS are higher than the control concrete, since its sorption coefficients is 1. 754 x10^{-1} mm/sec$^{1/2}$. Other than this S1 sample is founded to have the better durability than other samples.

ACID RESISTANCE

Specimens were cured under diluted Water, H_2SO_4, HCL and compressive strength test was done and the results were compared, and the results are shown in fig 14

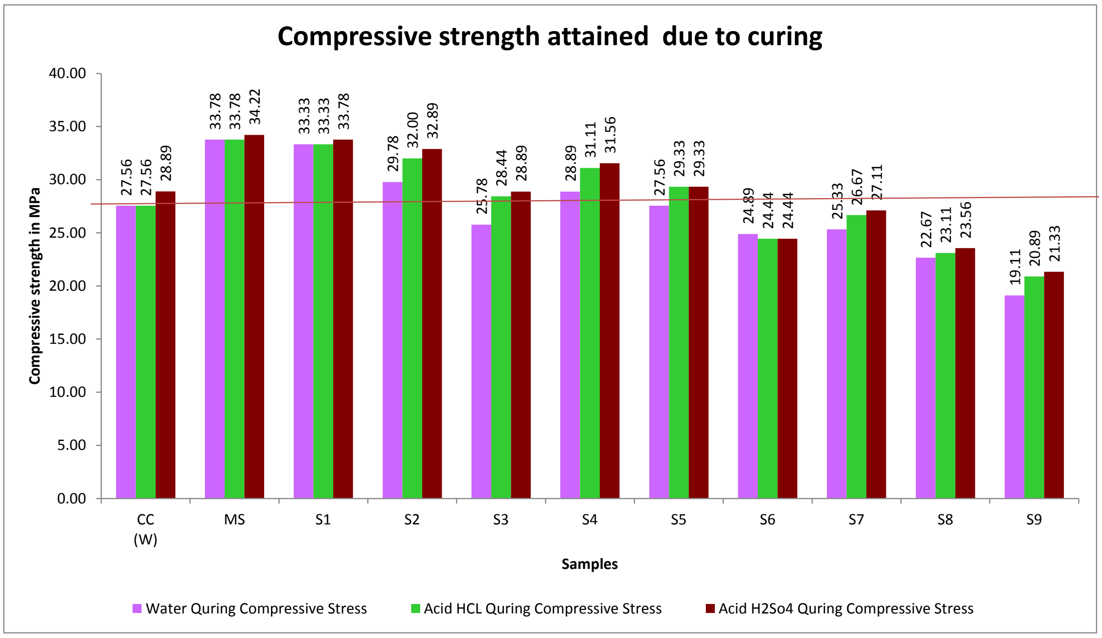

Figure 14 Compressive strength due to curing

In acids, sample MS, S1, S2, S3, S4 and S5 gives good results. With increase in compression strength. Maximum increase in strength is seen in sample MS, which is up to 34. 22MPa. In replacement of coarse aggregate for making concrete, S1 sample shows good performance of 33. 78MPa when cured in sulphuric acid. S5 mix gave optimum strength

Compared to the control concrete, the concrete replaced with alternative Material showed an increase in the strength up to 22. 58% when sand is replaced With M-sand by 100%. By replacing 10% of cement with furnace slag, 10% coarse aggregate by limestone, the compressive strength increase by 20. 97%. Further Increase in replacing furnace slag and lime stone shows the reduction in compressive strength. At 15% (S5) replacing cement with furnace slag and coarse aggregate with lime stone, the compressive strength seems to be equal to that of conventional concrete. In split tensile strength, same MS sample and S1 Sample was found better when compared to control concrete. For flexural strength, the strength of samples reduces with increase percentage of replace. In S1 sample 8. 33% increases than conventional concrete. When the percentage of Replacing increased; the samples gave results with reduced flexural strength. In this Case also, sample S5 with 15% replacement gives a flexural strength equal to Conventional concrete. Durability is an important parameter which gives the life time of the concrete, without losing its strength. Sample MS and S1 gave the water minimum penetration Depth in a stipulated time, which means the particles are closed packed, will allow Very less water percolation. By acid curing the compressive strength of samples got increased. Sample MS and S1 give good compressive strength when cured with dilutes sulphuric acid.

CONCLUSION

From the experiments following conclusions are made

1. In conventional concrete when river sand is replaced by 100% Msand, the Compressive strength increases by 22. 58%.
2. With this 100% replacement of manufactured sand, the mix with 10% replacement of Slag, lime stone, instead of cement and coarse aggregate (S1 sample) give Very good results. Here the compressive strength is nearly 20. 9% more than The conventional concrete. Durability characteristics are also found to be Better than the conventional concrete.
3. Other mixes replacement of 10% cement with furnace slag and 15%, 25% (S2, S3, mixes) replace of lime stone gives better result than Conventional concrete. The same scenario is seen in S4 (Mix with 15% Replace of slag to cement and 10% replace of lime stone to coarse aggregate)
4. The optimum Replacement proportion is seen in mix S5(mix with 15% replacement of slag, limestone to cement and coarse aggregate), which was found better than CC, in All the experimental test

The optimum combination for good strength and durability is obtained by Replacing 100% M-sand for fine aggregate in the conventional concrete and 15%

Furnace Slag with cement & 15% lime stone with coarse aggregate will be an optimum mix combination.

REFERENCES

1. Prof. Wakchaure M. R., Er. Shaikh A. P, Er. Gite B. E "Effect of Types of Fine Aggregate on Mechanical Properties of Cement concrete"International Journal of Modern Engineering Research, Vol. 2, Issue. 5, Sep-Oct. 2012 pp-3723-3726
2. A. Jayaraman, V. Senthilkumar, M. Saravanan, "Compressive and tensile strength of concrete using Lateritic sand and lime stone filler as fine aggregate" International Journal of Research in Engineering and Technology, Volume: 03 Issue: 01 | Jan-2014, PP 79 – 84.
3. Manjit Kaur, Mr. Sanjeev Naval, "Performance of Ground Granulated Blast Furnace Slag Concrete with Partial Replacement of Sand by Saw Dust", IOSR Journal of Mechanical and Civil Engineering (IOSRJMCE) Volume 2, Issue 6 (Sep-Oct 2012), PP 26-30.
4. Ali A. Aliabdo, Abd Elmoaty M. Abd Elmoaty, Esraa M. Auda, "Re-use of waste marble dust in the production of cement and concrete", Construction and Building Materials, 50 (2014) 28–41.
5. Sujata D. nandagawali, Dr. N. R. Dhamge, "Study of Blast Furnace Slag for Improving Mechanical Property of Concrete" International Journal of Engineering Science and Innovative Technology (IJESIT), Volume 3, Issue 4, July 2014, PP473 – 477.

6. K. G. Hiraskar and Chetan Patil, “Use of Blast Furnace Slag Aggregate in Concrete” International Journal of Scientific & Engineering Research, Volume 4, Issue 5, May 2013, PP95-98.
7. Ozgur Cakir, Omer Ozkan Sofyanlı “Influence of silica fume on mechanical and physicalproperties of recycled aggregate concrete” HBRC Journal 29 January 2014; revised 7 May 2014.
8. C. S. Poon, S. C. Kou, L. Lam”Compressive strength, chloride diffusivity and pore structure ofhigh performance metakaolin and silica fume concrete” Construction and Building materials Vol 20, 858–865(2006).