International Journal of Research
Available at https://edupediapublications.org/journals
e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 16
June 2018

An Experimental Investigation report on Cement Concrete with partial replacement of fine Aggregate with Demolished Waste with Sisal Fibre-an Naturally available material.

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Abstract: Concrete is one of the highly used materials by men next to water. Because of vast increase in infrastructure requirements and lack in sufficient materials in production of concrete we have to pave for new type of alternate materials. Many research workers tried construction waste in concrete and some other used sisal fiber in concrete to improve strength and durability properties of concrete. This investigation is based on combining the both demolished waste and sisal fiber in concrete to test various behaviors of concrete. For normal design mixes fine aggregate is replaced by demolished waste collected from demolishing construction site in proportions of 20%,40%,80% and 100%.For each mix well dried sisal fiber is added by 1% and mix is prepared.

This concrete is made in cylinders and various tests like compression test, split tensile test, modulus of elasticity test and various durability tests like moisture migration, moisture absorption, water evaporation are conducted for 1 day, 7days and 28 days.

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I. INTRODUCTION

Concrete is an artificially built up stone resulting from hardening of mixture of cement, aggregate and water with or without a suitable admixture.

1.Fibres have been used to toughen bricks and pottery since the very beginning of civilization, but only in the last twenty five years have the principles of fiber reinforcement of brittle matrices began to be scientifically understood.

Initially, it was suggested that the cracking strain of brittle matrices, such as cement paste mortar and concrete, could be significantly increased by using closely spaced fibers.

The experimental studies showed that the stress at which a brittle matrix will crack can be slightly increased by using high modulus fibers but, in general, the cracking strain of the matrix remains unaltered.

Considerable modification in the behavior of the material was observed once the matrix has been cracked. The Fibers Bridge across the cracks and so provide post-cracking ductility.

Although the strain at cracking does not increase due to fiber reinforcement, the tensile strain at rupture does, resulting in a tough material with high resistance to impact loading

Importance

1. Advanced cement based materials and improved concrete construction techniques provide opportunities for the design of structures to resist several loads resulting from earthquake, impact, fatigue and blast environments.

2. Conventional concrete cracks easily. When concrete is reinforced with random dispersed fiber we get favorable conditions for repeated load conditions. Fibers prevent micro cracks from widening addition fibers make ductile and tough.

3. Construction and demolition waste is generated whenever any construction/demolition activity takes

place, such as, building roads, bridges, flyover, subway, remodeling etc. It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc.

4. A part of this waste comes to the municipal stream. These wastes are heavy, having high density, often bulky and occupy considerable storage space either on the road or communal waste bin/container.

5. It is not uncommon to see huge piles of such waste, which is heavy as well, stacked on roads especially in large projects, resulting in traffic congestion and disruption.

6. Waste from small generators like individual house construction or demolition, find its way into the nearby municipal bin/vat/waste storage depots, making the municipal waste heavy and degrading its quality for further treatment like composting or energy recovery.

7. Often it finds its way into surface drains, choking them. It constitutes about 10-20 % of the municipal solid waste (excluding large construction projects).

8. Natural fibers, as reinforcement, have recently attracted the attention of researchers because of their advantages over other established materials. They are environmentally friendly, fully biodegradable, abundantly available, renewable, cheap and have low density.

9. Plant fibers are light compared to glass, carbon and aramid fibers. The biodegradability of plant fibers can contribute to a healthy ecosystem while their low cost and high performance fulfills the economic interest of industry.

10. When natural fiber-reinforced plastics are subjected, at the end of their life cycle, to combustion process or landfill, the released amount of CO2 of the fibers is neutral with respect to the assimilated amount during their growth.

11. Polymeric materials reinforced with synthetic fibers such as glass, carbon and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials, i.e. wood, concrete and steel.

12.In spite of these advantages, the widespread use of synthetic fiber-reinforced polymer composite has a tendency to decline because of their high-initial costs and also production of synthetic composites requires a large quantum of energy and quality of environment suffered because of the pollution generated during the production and recycling of these synthetic materials.

13.In recent time plant fibers have been receiving considerable attention as substitutes for synthetic fiber reinforcements. Unlike the traditional synthetic fibers like glass and carbon these lignocelluloses fibers are able to impart certain benefits to the composites such as low density, high stiffness, low cost, renewability, biodegradability and high degree of flexibility during processing.

14. Cellulosic fibers like sisal, coconut (coir) and bamboo in their natural form as well as several waste cellulosic products such as shell flour, wood flour and pulp have been used as reinforcing agents of different thermosetting and thermoplastic composites.

15. Due to vast increase in constructions and use of conventional building materials in concrete resulting in exploration of these materials which badly affects sustainable and ecofriendly development of a society. So we have to replace these conventional materials with alternate materials like demolished waste.

16. We can blend these two new materials into concrete to improve the properties of concrete and we can replace the conventional materials

II. LITERATURE REVIEW

1. Joseph et al. (1999) reported that sisal is one of strongest vegetable fibers and several studies have been reported in the literature based on its use as reinforcement in cement matrices (BRS, 1970; Nilsson, 1975; Zonsveld, 1975; Mukherjee &Satyanarayana, 1984; Gram, 1983; Aziz et al., 1984).

2. Studies of sisal fiber reinforced concrete were started in Sweden in 1971 by Nilsson (1975). Cut fibers with a length of 10-30 mm were cast into beams and an improvement in the tensile strength in bending was observed for fiber reinforced specimens. It was found that toughness increased markedly when continuous fibers were used.

3. In 1977 the Building Research Unit (BRU) in Dares Salaam started collaboration on the development of roof sheets on natural fiber reinforced concrete with the Swedish Cement and Concrete Research Institute (Capelins, 1978; BRU, 1978; Mwamila, 1979, 1987; Mawenya & Mwamila, 1979). Test sheets were manufactured for durability experiments. A special roof sheet profile was developed and several buildings in Dares Salaam have been provided with sisal fiber reinforced concrete roofs.

4. The long-term properties of the sisal fiber reinforced-mortar composites were assessed by Toledo Filho (1997) throughout creep, shrinkage and durability tests. The influence of the addition of sisal fibers, of various volume fractions and lengths, on the creep of a mortar matrix was determined using sealed and unsealed specimens subjected to a pressure of 14.4 MPa over a period of 210-350 days.

5. Incorporation of sisal fiber into thermosetting plastics have been reported by various workers (Paramasivam & Abdulkalam, 1974; Pavithran et al., 1987, 1988; Joseph et al., 1996a).Paramasivam & Abdulkalam (1974) have investigated the feasibility of developing polymer based composites using sisal fibers due to the low cost of production of composites and amenability of these fibers to winding, laminating and other fabrication processes..

III. MIX DESIGN

Cement is the important constituent used in concrete production. Ordinary Portland cement of C53 grade which satisfies all the standards of IS12269 and ASTM C642-82 was used. The chemical composition of the cement and its properties are given below.

Chemical composition of cement	%
Silica(sio2)	21.8
Alumina(Al2o3)	6.6
Ferric oxide(Fe2o3)	4.1
Calcium oxide(CaO)	60.1
Magnesium oxide(Mgo2)	2.1
Sodium oxide(Na2O)	0.4
Potassium oxide(K2O)	0.4
Titanium oxide(TiO2)	Nil
Loss of ignition 2.4	2.4

Water absorption of demolished waste

The following test procedure have been adopted to find the water absorption of demolished waste

1. A clean container of non-corrodible material is taken and it is empty weight along with the lid is taken.
2.100gm of demolished waste sample is collected into the container. The total weight of the container along with the container is find out.
3. The container is filled with water and it is allowed at rest for 24 hours
4. The soil sample is made into a state of surface dry condition and its weight is found out.
5. The soil sample is oven dried for about 24 hrs. abd the weight is found out.

1.	Weight of material sample	=100gm
2.	Weight of saturated surface dry sample,W1	=126gm.
3.	Weight of oven dried sample,W2	=90gm.

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 16
June 2018

Now,

4. The water absorption of actual sample before test
W3 =(100-W2) =10 gm

5. The water absorption of demolished waste
(W1-W3-100) =…16………gm

Mix Proportions

The details of mix designs are mentioned in the table below:

Mix	Cement Kg/m3	Water Kg/m3	Extra Water Kg/m3	20mm Kg/m3	12mm Kg/m3	Sand Kg/m3	Demolished Waste Kg/m3	Sisal fiber Kg/m3
M1	350	224	0.00	756.45	863.05	430.5	0.00	0.00
M2	350	224	0.00	756.45	863.05	430.5	0.00	3.5
M3	350	224	13.776	756.45	863.05	344.4	86.1	3.5
M4	350	224	34.44	756.45	863.05	215.25	215.25	3.5
M5	350	224	55.1	756.45	863.05	86.1	344.4	3.5
M6	350	224	68.88	756.45	863.05	0.00	430.5	3.5

IV. TEST RESULTS

The prepared concrete specimens are now tested for their behavior for various tests.

1. Slump test and density of fresh concrete mix

Slump test is used for the measuring the workability of fresh concrete. The behavior of various design mixes prepared for different proportions of demolished waste and constant sisal fiber content for standard slump test which is described as ASTM143-90a(13) and corresponding density measured are given in table below.

Mix design	Slump value(cm)	Density of concrete(kg/m3)
M1	6	2180
M2	8	2700
M3	7	2280
M4	7	2280
M5	8	2240
M6	9	2250

1. Compressive strength of concrete

	compressive load on cylinder, KN									100*200 cyl		
Mix	Day 1			Day 7			28 Days			comp strength, N/mm2		
	1	2	Avg	1	2	Avg	1	2	Avg	1 d	7 d	28 d
M1	40	50	45	61	63	62	149.6	136	142.8	5.7	7.89	18.18
M2	34	40.8	37.4	50.2	48.6	49.4	107.1	108	107.5	4.76	6.2	13.68
M3	68	81.6	74.8	80.8	82.6	81.7	161.5	178	169.7	9.52	10.71	21.6
M4	78.2	85	81.6	90.6	94.2	92.4	221	195	208	10.38	11.71	26
M5	42.5	54.4	48.45	60.4	62.8	61.6	170	204	187	6.16	7.8	23
M6	34	44.2	39.1	58	60	59	160	180	170	4.97	7.5	21.6

e-ISSN: 2348-6848
p-ISSN: 2348-795X
Volume 05 Issue 16
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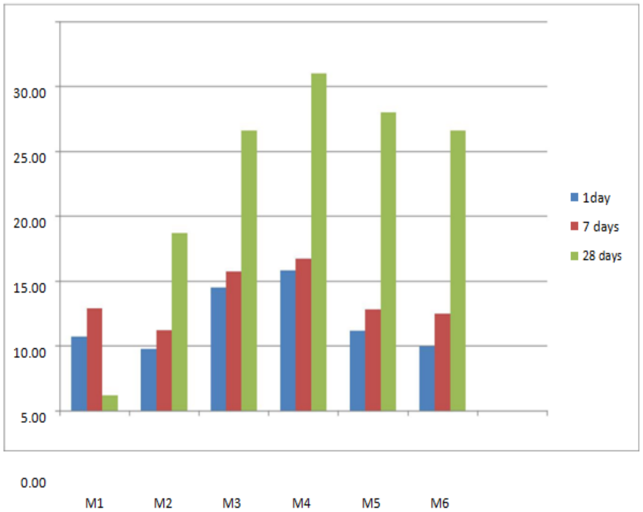
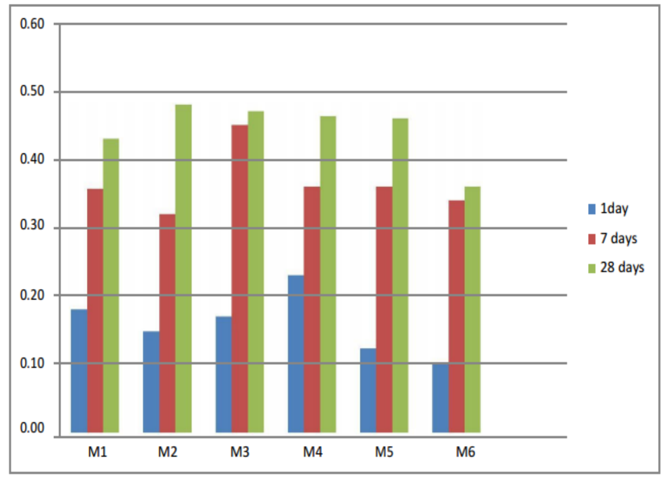


From the above experimental values obtained by the compressive test analysis it is clear that with increase in demolished waste the compressive strength of concrete increase up to M3 mix and the compressive strength will decreases after the increase in demolished waste content in concrete. The sisal fiber usage decreases the compressive strength of concrete as it produces voids and the bond action will be reduced by the smooth texture of sisal fiber.

2. Split tensile test

The test results obtained in split tensile strength test conducted in Universal testing machine for 1,7,28 days are shown in the table given below

										100*200 cyl		
Mix	Day 1			Day 7			28 Day a			split strength,N/mm2		
	1	2	Avg	1	2	Avg	1	2	Avg	1 d	7 d	28d
M1	25	28	26.5	50	49	49.5	68	54	61	0.18	0.35	0.43
M2	20	22	21	43	48	45.5	78	58	68	0.148	0.32	0.48
M3	20	30	25	75	54	64.5	58	55	56.5	0.17	0.45	0.47
M4	32	34	33	62	42	52	60	55	57.5	0.23	0.36	0.46
M5	15	20	17.5	54	50	52	55	50	67.5	0.123	0.36	0.46
M6	10	15	12.5	46	52	49	45	40	42.5	0.1	0.34	0.30



3. Stress strain relationship

The test results obtained in split modulus of elasticity test conducted in Universal testing machine for 1,7,28 days are shown in the table given below

Load	stress	Strains					
		M1(10^{-4})	M2(10^{-4})	M3(10^{-4})	M4(10^{-4})	M5(10^{-4})	M6(10^{-4})
25	0.14	0.5	0.4	0.9	0.9	1.0	1.1
50	0.28	0.9	0.9	1.4	1.6	2.0	2.5
75	0.42	1.4	1.6	2.7	2.3	3.0	3.2
100	0.56	1.9	2.6	3.9	4.2	4.0	4.6
125	0.70	2.4	3.8	4.9	5.8	5.2	4.9
150	0.84	3.0	4.8	5.8	7.2	7.8	8.2
175	0.98	5.2	6.8	7.15	9.0	9.0	9.2
200	1.12	6.2	7.0	8.0	11.2	11.0	11.2
225	1.126	7.2	8.5	9.5	12.6	13.8	14.1
250	1.4	9.4	10.2	11.2	14.0	14.2	14.5

From the above experimental values obtained by the compressive test analysis it is clear that with increase in demolished waste the compressive strength of

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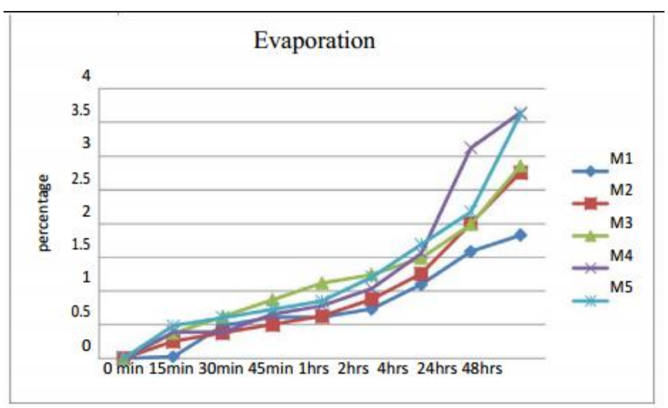
concrete increase up to M3 mix and the compressive strength will decreases after the increase in demolished waste content in concrete. The sisal fiber usage decreases the compressive strength of concrete as it produces voids and the bond action will be reduced by the smooth texture of sisal fiber.

4. Durability tests and analysis

1. Evaporation test

The test results for the evaporation tests conducted for the evaporation test are given in the table below. From the test results given by the graph depicts the fact that with increase in the demolished waste content in the concrete.

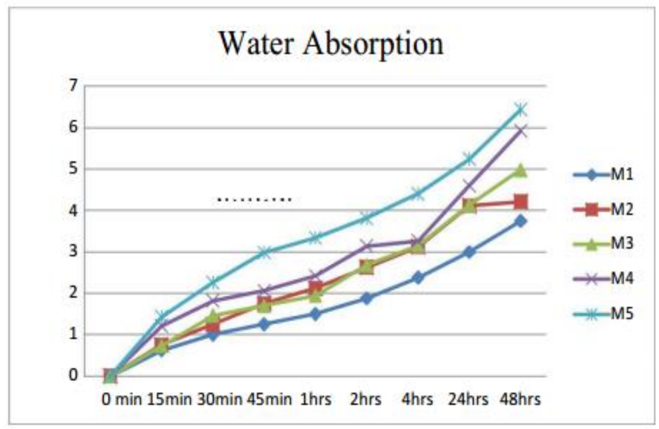
	Loss of weights for different mixes Concrete Mixes(avg)					
Time	M1	M2	M3	M4	M5	M6
15 min	0.020	0.010	0.0140	0.018	0.016	0.018
30 min	0.055	0.010	0.0165	0.020	0.024	0.022
1 hr	0.090	0.020	0.0300	0.040	0.042	0.046
2 hr	0.092	0.025	0.0350	0.060	0.062	0.068
4 hr	0.010	0.080	0.0800	0.090	0.098	0.010
12 hr	0.120	0.100	0.120	0.140	0.142	0.148
24 hr	0.135	0.200	0.180	0.200	0.24	0.26
48hr	0.400	0.430	0.220	0.230	0.27	0.28



2. Water absorption test

The test results for the evaporation tests conducted for the evaporation test are given in the table below. From the test results given by the graph depicts the fact that with increase in the demolished waste content in the concrete.

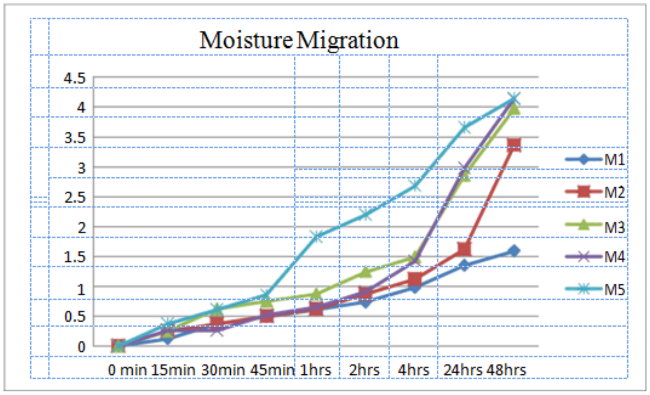
	Increase in weights for different mixes Concrete Mixes					
Time	M1	M2	M3	M4	M5	M6
15 min	3.70	3.700	4.00	3.700	3.80	4.20
30 min	3.720	3.760	4.080	3.730	3.82	4.24
1 hr	3.740	3.770	4.110	3.750	3.90	4.30
2 hr	3.750	3.780	4.115	3.760	4.12	4.40
4 hr	3.760	3.800	4.120	3.700	4.20	4.42
12 hr	3.780	3.820	4.130	3.800	4.40	4.48
24 hr	3.800	3.840	4.140	3.820	4.52	4.50
48hr	3.700	3.750	4.070	3.710	4.60	4.60



3. Moisture migration test

The test results for the evaporation tests conducted for the evaporation test are given in the table below. From the test results given by the graph depicts the fact that with increase in the demolished waste content in the concrete.

MIX	0min	15min	30min	45min	1hrs	2hrs	4hrs	24hrs	48hrs
M1	0	21	25	28	31	34	36	40	48
M2	0	20	29	32	36	38	41	45	51
M3	0	23	37	39	44	46	50	53	55
M4	0	28	39	43	45	49	52	57	59
M5	0	26	42	45	48	52	56	58	62
M6	0	25	40	41	40	42	55	58	60



V. CONCLUSION

1.The results obtained from various tests depicts that the conventional fibers like steel fibers plastic fibres,polymer fibers used in concrete increases the strength and durability properties of concrete whereas the natural fiber will satisfies the above behavior up to some extent only.

2.The sisal fiber is having smooth surface texture and high water absorption because of which the interlocking and bond strength developed in between sisal fiber and ingredients of concrete affected considerably so the strength properties shows decrease in values with increase in sisal fiber content in concretes.

3. The fine aggregates obtained from demolished wastes is having good grading so the concrete obtained by the replacement of fine demolished wastes will increases the strength upto some replacement value. The demolished waste is having low strength like hardened cement particles, impure sand particles so it is having low bond strength as well though the fine demolished waste is well graded it will show decline in its strength properties with increase in replacement.

4. The combination of demolished waste and sisal fiber in concrete will change the durability properties as the sisal fiber and demolished are having high water absorbing properties. Hence water absorption and moisture migration is high in case of obtained concrete.

5. Hence the replacement of fine aggregate with demolished waste increases the strength and durability properties upto 20% replacement keeping sisal fiber of 1%.

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