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EXPERIMENTAL INVESTIGATION ON STRENGTH OF BIO-SELF-CURED CONCRETE

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Abstract—High performance concrete is not only characterized by its high strength, workability, and durability but also by its smartness in performance without human care since the first day. If the concrete can cure on its own without external curing without compromising its strength and durability, then it is said to be high performance self-curing concrete. In this paper, an attempt is made on the performance study of internally cured concrete using biomaterial, named Spinacea oleracea as self-curing agents, and it is compared with the performance of conventional concrete. The present paper focuses on workability and strength study on M60 grade concrete replacing M-sand for river sand and using super plasticizers. The optimum dosages of Spinacea oleracea was taken as 0.3%, 0.6%, and 0.9% by weight of cement from the earlier research studies. From the slump tests performed, it was found that there is a minimum variation between conventional concrete and self-cured concrete. The strength activity index is determined by keeping compressive strength of conventionally cured concrete and self-cured concrete was observed that 7 days,14 days and 28 days.

Keywords: High performance concrete, bio self-curing concrete, Spinacea oleracea

INTRODUCTION

Global Water Availability

70% of the earth surface is covered with water, which amounts to 1400 million cubic kilometres (m km^3). However, 97.5% of this water being sea water, it is salty. Fresh water availability is only 35 m km^3. Out of the total fresh water, 68.7% is frozen in ice caps, 30% is stored underground and only 0.3% water is available on the surface of the earth. Out of the surface water, 87% is stored in lakes, 11% in swamp and 2% in rivers. As all the sweet water is not extractable, only 1% of the total water can be used by human beings.

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Water Resources in India

India is blessed with good rainfall well distributed over 5-6 months in the year. The average annual rainfall in the country is 1170 mm with a wide range between 100 mm in desert areas of Rajasthan to 10000 mm in Cherapunji. The total available sweet water in the country is 4000 billion m^3 per annum. Out of this, over 1047 billion m^3 water is lost due to evaporation, transpiration and runoff, reducing the available water to 1953 billion m^3 and the usable water to 1123 billion m^3

SELF CURED CONCRETE

Self-curing or internal curing is a technique that can be used to provide additional moisture in concrete for more effective hydration of cement and reduced self-desiccation. When concrete is exposed to the environment evaporation of water takes place and loss of moisture will reduce the initial water cement ratio which will result in the incomplete hydration of the cement and hence lowering the quality of the concrete.

Spinacia oleracea is usually called as Palak greens in Tamil Nadu and it is a type of green popularly consumed as food product. Curing agent was prepared from the filtrate extract of Spinacia oleracea after it was ground well. This extract base is added at the time of preparing concrete that is while adding water to the dry ingredients. Placing and compacting the fresh concrete is similar to the conventional concrete, but without curing. The chemical structure shows that it contains (-O-) and (-OH) functional groups. As such, the Spinacia oleracea selected as internal curing agent possesses hydroxyl and ether functional group, which is also revealed in Fourier Transform Infra-Red (FTIR) results.

Spinacea oleracea as self-curing agents, and it is compared with the performance of concrete with conventional concrete. The referral concrete M_{60} was made using 53 grades OPC and the optimum dosage of Spinacea oleracea was taken as 0.3%, 0.6%, and 0.9% by weight of cement.

Fig.1. Extraction process of Spinacea oleracea as a self curing process.

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MATERIALS USED AND THEIR SPECIFICATIONS

Materials play an important role in Concrete. The materials used for preparing self curing concrete are Cement, Fine Aggregate, Coarse Aggregate, Water, Spinacea oleracea and Super plasticizers which are confirming to the requirements of the Indian Standard (IS) specifications are given in table 1.

Table 1 Materials used and their specifications

Sl. No	Material	Type	IS Specification
1	CEMENT	Ordinary Portland Cement (OPC)53 Grade	IS 12269-2013
2	COARSE AGGREGATE	Crushed Angular Aggregate(Size = 20 mm)	IS 2386(Part I &III)-1963
3	FINE AGGREGATE	Natural Sand(Size ≤ 4.75 mm)	IS 2386(Part I &III)-1963
		Natural Sand(Size ≤ 4.75 mm)	
4	WATER	Clean Potable Water(PH Value=7.0)	IS 456 – 2000
5	SELF-CURING AGENTS	Spinacea oleracea	
6	SUPERPLASTICIZERS	Poly Carboxylate Ether (PCE) (Dosage=0.3% Of Total Cementitious Materials	IS 9103

EXPERIMENTAL INVESTIGATION

The materials used for this study were initially investigated and tested. The test was carried out for different materials such as Cement, Fine aggregate, Coarse aggregates, Spinacea oleracea and their results were listed in tables.

Cement

Natural sand and Quarry Dust with fraction passing through 4.75mm and retained on 600 micron sieve is used and will be tested as per IS 2386(Part I& III)-1963. The properties of the fine aggregate and quarry dust are shown in Table 2.

Table 2 Testing of Cement

SL.NO	TYPE OF TEST	VALUES OBTAINED FOR CEMENT
1	Fineness Test by Sieving	4%
2	Standard Consistency Test	26%
3	Initial Setting Time	35 Minutes
4	Final Setting Time	9 Hours
5	Specific Gravity Test	3.15

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Fine aggregate and Quarry Dust Natural

sand and Quarry Dust with fraction passing through 4.75mm and retained on 600 micron sieve is used and will be tested as per IS 2386(Part I& III)-1963. The properties of the fine aggregate and quarry dust are shown in Table 3.

Table 3 Testing of Fine Aggregate

SL.NO	TYPE OF TEST	VALUES OBTAINED	
		FOR SAND	FOR QUARRY DUST
1	Fineness Modulus Test	2.541	2.529
2	Bulkiness Of Sand	6.66%	5.26
3	Specific Gravity Test	2.59	2.57
4	Water Absorption Test	0.53%	0.91

Coarse aggregate

Crushed aggregate confirming to IS 2386(Part I& III)-1963 was used. Aggregates of size 20mm has been selected for the study. The properties of the coarse aggregate are shown in Table 4.

Table 4 Testing of Coarse Aggregate

SL.NO	TYPE OF TEST	VALUES OBTAINED
1	Fineness Modulus Test	2.28
2	Specific Gravity Test	2.27
3	Water Absorption Test	0.4%
4	Aggregate Crushing Value	12.85%
5	Aggregate Impact Value	12.18%
6	Aggregate Abrasion Value	36.55%
7	Flakiness Index	36.30%
8	Elongation Index	45.55%

MIX DESIGN

Mix design can be defined as the process of selecting suitable ingredients of concrete and determining their relative proportions with the object of producing concrete of certain minimum strength and durability as economically as possible. Mix design for each set having different combinations are carried out by using ACI 211.4R-93 method. The mix proportion obtained for normal M60 grade concrete is 1: 0.67: 1.84 with a water-cement ratio of 0.3.

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FRESH CONCRETE

The fresh concrete is made with the mix ratio as per design standards for M60 grade concrete and the workability of the concrete was tested. The properties of fresh concrete are given in table 5.

Table 5 properties of Fresh concrete

S.NO.	TEST	RESULT
1	Slump Value	50mm
2	Compaction Factor	94.70%
3	Flow value	50%
4	Vee-bee consistency	8 seconds

EXPERIMENTAL PROCEDURE

STRENGTH TEST

The specimen of standard cube of size 15cmx15cmx15cm, standard cylinder of size 30cm height and 15cm diameter and prism of size 10cmx10cmx50cm were used to determine the compressive strength, split tensile strength and flexural strength of the concrete. These specimens were tested on 7^{th}, 14^{th} & 28^{th} day_s strength.

Experiments Conducted

The following experiments were conducted on the specimens casted.

- Compression test
- Split tensile test
- Flexural test

Compression Test

Compression test is the most common test conducted on hardened concrete, partly because it is an easy test to perform, and partly because most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The cube specimen is of the size 15 x 15 x 15 cm were tested for compressive strength as per IS 516-1959 using a calibrated compression testing machine.

Split Tensile test

Split tensile strength of concrete is usually found by testing concrete cylinder of size 30cm height and 15cm diameter. The specimens were tested for its tensile strength as per IS: 516-1959 using a calibrated compression testing machine.

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Flexural Strength Test

Flexural strength is the one of the measure of tensile strength of concrete. It is the ability of a prism to resist failure in bending. It is measured by loading un-reinforced slab or prism of size 10cm x 10cm x 50cm. The specimens were tested for its flexural strength as per IS: 516-1959 using a calibrated flexural testing machine.

EXPERIMENTAL RESULTS

STRENGTH TEST

Compressive Strength Test

This test is considered as one of the most important properties of concrete and it is often used as an index of the overall quality of concrete. For this, the cubes of conventional concrete were casted and cured as shown in the fig.2. and tested for its compressive strength at the age of 7, 14 & 28th days as shown in the fig.3. From the test results, it was observed that the strength of self cured concrete is slightly lesser nearer to standard concrete but it had attains its characteristic strength. The tables and graphs listed below shows the relationship between the number of days and mean compressive strength of cube.

Fig.2 curing of test specimens of standard. concrete

Table .6 Comparison of compressive strength of concrete cubes

% of Spinacea oleracea with M - sand	7days (N/mm^2)	14days (N/mm^2)	28 days (N/mm^2)S
0	22.05	48.06	61.99
0.3	21.23	46.69	61.02
0.6	21.50	47.04	63.61
0.9	21.08	46.67	61.63

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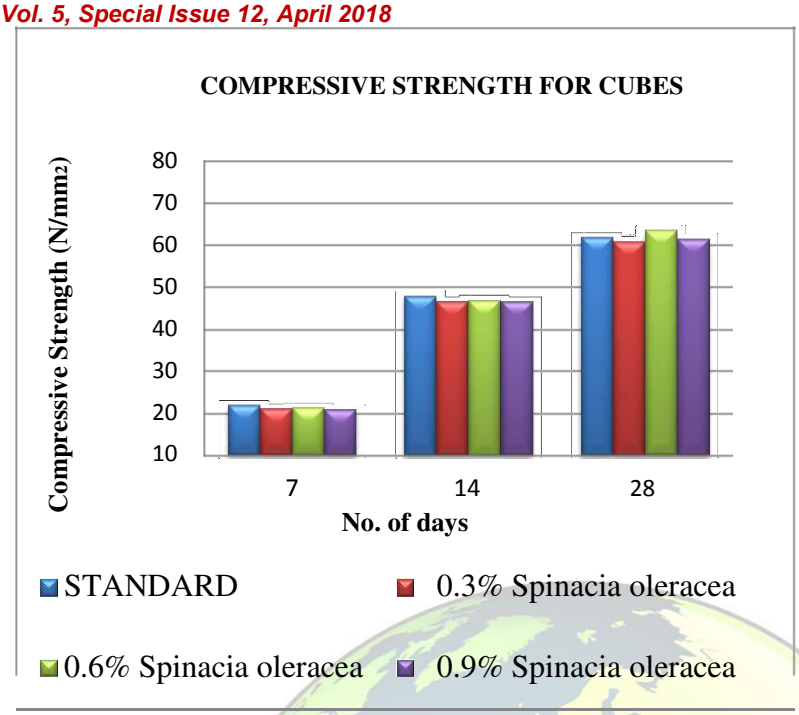

Chart. 1. compressive strength of Standard and Spinacea oleracea of concrete cubes

Fig.3 Split Tensile Test

Split tensile strength:

The cylindrical specimens were tested for its split tensile strength at the age of 7, 14 & 28th days. The test result shown in table 7 revealed that split tensile strength of Spinacea oleracea added concrete is considerably higher than that of standard concrete. Chart.2 shows the relation between no. of days and its mean split tensile strength of cylinders.

Table.7 Split Tensile strength of standard and Spinacea oleracea of cylinders

% of Spinacea oleracea with M – sand	7days (N/mm^2)	14days (N/mm^2)	28 days (N/mm^2)
0	4.52	6.42	9.62
0.3	4.41	6.22	9.13
0.6	4.65	7.02	10.20
0.9	4.30	6.32	9.56

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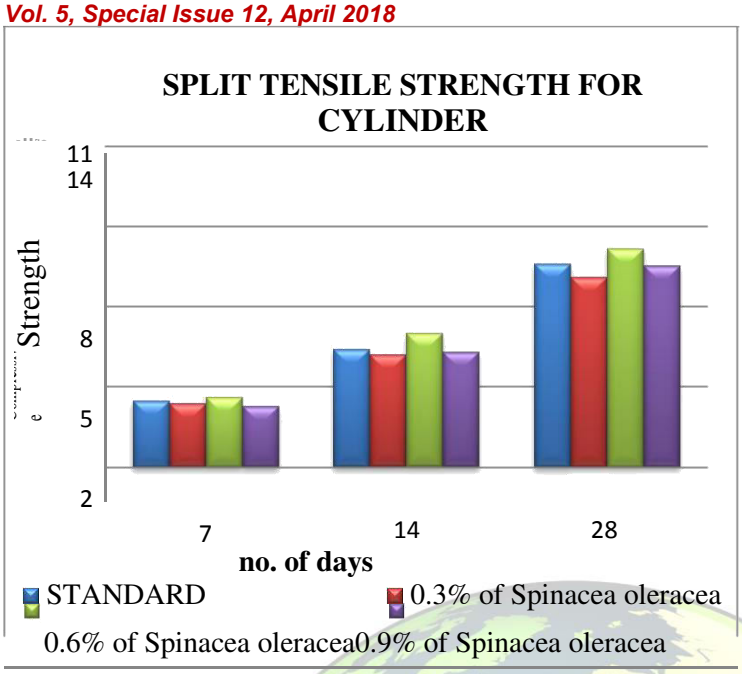

Chart 2. Split Tensile strength of Standard and Spinacea oleracea concrete cylinders

Fig.4. Split Tensile Test

Flexural Strength Test

The concrete prisms were tested for its flexural strength at the age of 7, 14 & 28th days as shown in fig.5. The test result shown in table 8 revealed that flexural strength of Spinacea oleracea added concrete is considerably higher than that of standard concrete. Chart 3 shows the relation between no. of days and its mean flexural strength of concrete prisms.

Table 8 Flexural strength of standard and Spinacea oleracea of cylinders

% of Spinacea oleracea with M - sand	7days (N/mm^2)	14days (N/mm^2)	28days (N/mm^2)
0	7.90	9.70	11.87
0.3	7.80	9.60	11.90
0.6	8.30	10.70	12.65
0.9	7.95	10.10	11.90

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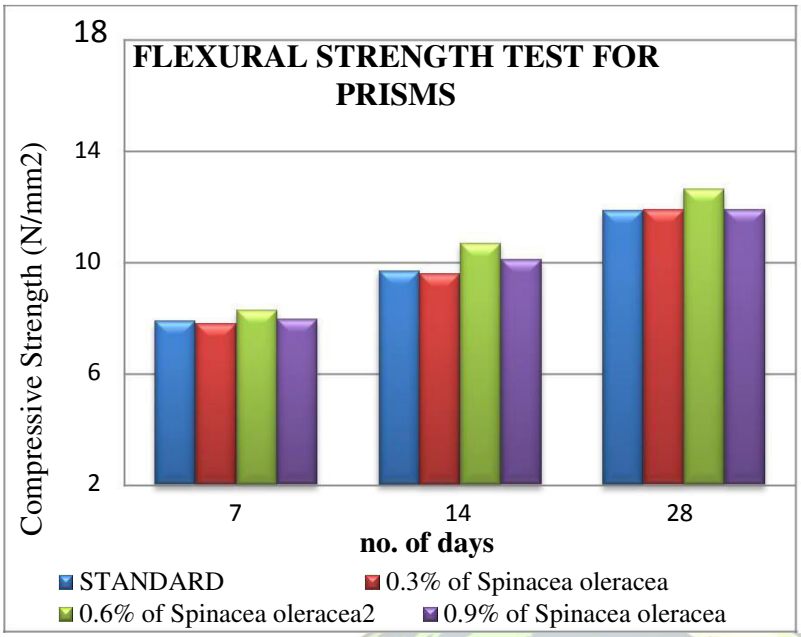

Chart.3 Flexural Strength of Standard and Spinacea oleracea concrete prism

Fig.5 Flexural Strength test

CONCLUSION

This project work is based on the usage of self cured concrete with Quarry dust a cheap material used as complete replacement for sand and addition to that spinacea oleracea are used in the concrete mixtures. From the workability and strength studies, it is revealed that there is a presence of OH ions in the self-curing concrete helps in the effective hydration resulting in better strength properties. It is concluded that the vegetative materials added as internal curing agents perform better workability and strength characteristics in the concrete of grade M60.

1. The experimental investigation was conducted to improve the strength of concrete with quarry dust as fine aggregate with addition of spinacea oleracea as a self-cured concrete.
2. To improve the workability of the concrete mix super plasticizer also used. Properties of materials used in concrete were listed out. Workability and strength characteristics of the self-cured concrete were compared with conventional concrete.

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Vol. 5, Special Issue 12, April 2018

3. Quarry dust has lots of finer dust particle than sand which reduce the workability of concrete. To compensate this problem super plasticizer was used. When quarry dust was used with super plasticizer it will show better workability and flow ability.
4. From this we can conclude that 100% replacement of sand with quarry dust shows good strength and it was conclude quarry dust is the better alternative for natural sand.
5. Compressive strength, split tension strength and flexural strength of self-cured concrete with quarry dust is higher than the conventional concrete. When it was added with 0.6% of spinacea oleracea to concrete.

Thus, from the above results, it is concluded that the Quarry dust as complete replacement for sand and addition to that 0.6% of spinacea oleracea are used in the concrete mixtures in concrete is found to be good ,economic and improves the strength of concrete.

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