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Experimental investigation on concrete with partial replacement of fine aggregate by date and tamarind seed

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ABSTRACT

Reusing Agro product waste by utilizing them into building materials is a moderate solution to achieve sustainable environment. Date Seed (DS) and Tamarind Seed (TS) are lightweight when compare with other concrete ingredient. It reduces the self-weight of the structure. This Study reports that study on mechanical properties of the utilization of date and tamarind seed as a partial replacement for fine aggregate. They are washed, dried, and grained to make medium sand size. The mixes were prepared by weight basis of 10 % to 20 % of date seed and 1.5 % to 2.5 % of tamarind seed for M sand in M25 grade concrete mixes. For each mix, standard size of cubes, cylinders and prisms as per Indian standard were cast and tested to assess the mechanical properties such as compressive, split tensile and flexural strength. The results of this investigations indicated that the replacement of 10% of DS and 1.5% of TS with fine aggregates achieve a closer to the strength of Control Concrete (CC) and further replacement shall reduce the concrete strength.

Keywords: *Agro Product Waste, Date Seed, Tamarind Seed, Compressive Strength, Tensile Strength.*

1. INTRODUCTION

Cement and concrete are the most widely used construction materials from many decades due to its numerous advantages [1]. Concrete is a mixture of cement, fine, coarse aggregate, and water which is mainly derived from natural resources. Increasing population, expanding urbanization, climbing way of life due to technological innovations has demanded a huge volume of natural resources in the construction industry [2]. Natural resources of the world drastically dwindle due to the increasing demand of natural aggregate for the construction industry. This has also degenerated the environment and has given impetus to studies and research for sustainable development by using different waste products in the construction industry. If the weight of the structure is decreased by using lightweight aggregate in concrete, it auspiciously assists both the structural stability and economic viability. Such heavy demands draw attention and preservation of natural aggregates, which are a matter of grave concern. Since aggregates contribute about 60–80% of the volume of the concrete, effective and efficient use of agricultural waste contributes to energy saving, conservation of natural resources and reduction of the cost of construction materials [3].

Adnan Ahmed et al. [4] has investigated the strength performance of concrete containing date seeds (DS) exposed to sodium chloride and sodium sulphate. by replacing the coarse aggregates with date seeds of different composition on weight basis with the same water-cement ratio of 0.5 & concluded that workability decreases to a small extent with increasing content of date seeds. Strength of cubes placed in salt solution for curing has greater values as compared to the cubes placed in the normal water. Smith A. S. J et al. [5] suggested that 10 % replacement of cement with date seed ash having greater strength of 1.6 % compared to control concrete but the replacement make the increases the consistency of cement, so the concrete becomes less workable. Ali Raza et al. [6] has tested four different percentages 0 %, 2 %, 3 % and 4 % of date seed (DS) replaced with coarse aggregate for the mix ratio of 1:2:4.

The compressive strength is decreased by the addition of date seeds. Venkada Seenivasan et al. [7] has investigated that the tamarind powder is replaced with fine aggregate and fly ash is replaced with cement. It was suggested that concrete strength increases with 10 % and 20 % replacement of fly ash and 30 % replacement of tamarind powder. Further increases of fly ash and tamarind powder replacement will reduce the strength of concrete. From the above literature the authors could not be able to find the mechanical properties for replacement of date and tamarind seed for fine aggregate.

In terms of production of dates, India is one of the leading countries in the world. In India many states are producing dates mostly from Tamil Nadu, Karnataka, Andhra Pradesh, Gujarat, Maharashtra, and Rajasthan. In this study. date seeds are collected from the Tirupur District, Tamilnadu. Tamarind is one of the common trees in India. E. M. Yahia et al. [8] Tamarind fruit pulp is brown or reddish-brown and seeds in brown colour. Tamarind pulp, seeds and shell are about 55 %, 34 %, and 11 %, respectively, the seed is made up of the seed coat or testa (20–30%) and the kernel (70–80%). In this study. tamarind seeds are collected from the Erode District, Tamilnadu.

2. MATERIAL CHARACTERISTICS

2.1 Cement

The cement used for this study is Ordinary Portland Cement (OPC) of 53 grade confirming to IS 12296:1987. The specific gravity of cement is 3.15, the normal consistency is 29% and Fineness is about 4 % confirming to IS 4031-1988.

2.2 Coarse aggregate

The coarse aggregate used for this study was angular shaped with size of less than 20 mm. The test is carried out and confirm with IS 2386:1967. The basic properties of coarse aggregate are shown in Table 1.

Table-1: Properties of coarse aggregate

Description	Test Result
Specific gravity	2.69
Water absorption	0.95%
Abrasion test	3.2%
Impact test	24%
Crushing strength	39.25%

2.3 Fine aggregate

The crushed manufactured sand is of cubical shape with grounded edges, washed and graded to as a construction material. The size of manufactured sand is less than 4.75 mm. In this study the manufactured sand having specific gravity 2.60 and water absorption of 2.1 % is used.

2.4 Date and Tamarind seed

The date and tamarind seed are cleaned by washing with normal water, dried in direct sunlight, and crushed to required size of fine aggregate. The tests were carried out on date and tamarind seeds as fine aggregate in-order to obtain their physical properties. The obtained results of both seeds and fine aggregate are shown in Table 2.

Table-2: Properties of Aggregates and seeds

Description	Fine Aggregate	Tamarind Seed	Date Seed
Fineness modulus	2.80(medium)	3.1(coarse)	3.1(coarse)
Gradation	Zone 2	Zone 2	Zone 2
Specific gravity	2.60	1.1	1.13
Water absorption	2.1%	8.1%	5%
Loose bulk density Rodded bulk density	1712.83kg/m³ 1846.17kg/m³	694.83 kg/m³ 801.5 kg/m³	658.83 kg/m³ 756.83 kg/m³

2.5 Super Plasticizer

A super plasticizer, CONPLAST SP430 has been used increases the mobility and makes concrete flow of concrete with low water cement ratio. CONPLAST SP430 complies with BIS: 9103-1999 and BIS: 5705-(part III) and ASTM C494. As Super plasticizer molecules and cement grains are oppositely charged, they repel each other.

Table-3: Physical Characteristics of Super plasticizer

Properties	Results obtained
Type	Sulfonated naphthalene formaldehyde condensate
Specific gravity	1.22

Chloride content	Nil
Dosage	0.6 liters per 100kg of cement
Compatibility	All type of cement except high alumina cement
Solid content	40%
Compressive strength	Early strength up to 40-50%

3. MIX PROPORTIONING

The mix design was carried out achieve a compressive strength of M25 grade as per IS: 10262-2019. To achieve the above target strength the water cement ratio adopted for concrete mix was 0.45 and mix proportion carried out for a slump of 100±20mm with superplasticizer addition. The quantity of material required per one cubic meter of concrete is given below.

Table-4: Mix Ratios

Sample	Cement (kg/m^3)	FA (kg/m^3)	DS (kg/m^3)	TS (kg/m^3)	CA (kg/m^3)	SP	W/C
CC	438	588	0	0	1023	0	0.45
10DS:1.5TS	438	520	59	9	1023	0.2	0.45
10DS:2.5TS	438	514	59	15	1023	0.2	0.45
20DS:1.5TS	438	461	118	9	1023	0.2	0.45
20DS:2.5TS	438	455	118	15	1023	0.2	0.45

4. EXPERIMENTAL INVESTIGATION

4.1 Test on Fresh Concrete

To measure the workability of the concrete slump cone, specimens were cast with desired mix proportions and conducting slump cone compaction factor, Vee Bee test has been carried out. The values are given in table5.

Table-5: Properties of Fresh Concrete

Sl. No	Level of replacement of Date seed (%)	Level of replacement of Tamarind seed (%)	Slump value (mm)	Compaction factor	Vee Bee (seconds)
1	CC		10	0.78	9
2	10	1.5	28	0.82	8
		2.5	29	0.84	10
3	20	1.5	29	0.85	9
		2.5	30	0.86	10

4.2 Test on Hardened Concrete

4.2.1 Compressive strength: The specimens are of cubical shape with standard size of 150 mm × 150 mm × 150 mm conforming to IS 10086:1982. The casted cubes were cured in normal water and tested in CTM conforming to IS 516:1959 with Rate of loading 15 N/mm^2 per minute. The compressive strength of concrete was determined at the age of 7 and 28 days.

Fig.1: Compressive strength test

4.2 Split tensile strength test

The specimen is in cylindrical shape with 150 mm dia and 300mm length conforming to IS 10086:1982. split tensile strength is a method of determining the tensile strength of concrete. The casted specimens were cured in normal water and tested in CTM conforming to IS 516:1959 with Rate of loading 15 N/mm^2 per minute. The Split strength of concrete was determined at the age of 7 and 28 days.

Fig.2: Split tensile strength test

4.3 Flexural strength test

The standard prism of size 100 mm × 100 mm × 500 mm conforming to IS 10086:1982. The casted specimens were cured in normal water and tested in CTM conforming to IS 516:1959 with Rate of loading 15 N/mm^2 per minute. The Flexual strength of concrete was determined at the age of 7 and 28 days.

Fig.3: Flexural strength test

5. TEST RESULTS AND DISCUSSION

5.1 Density

The density of the concrete specimens was measured before testing the specimens. The results show in Figure 3. The density of the controlled concrete are ranges from 2375 kg/m^3 to 2400 kg/m^3. The average density value of the controlled specimen is 2388 kg/m^3. While average density for the specimens with various replacement are given in Table-9. The density is reduced for the increasing the replacement percentage. This is probably because of the Date and Tamarind seed replacement in concrete specimens.

Table-6: Reduction percentage of concrete specimens.

Sl.No	Sample	Mean Density (kg/m^3)	% of Reduction
1	CC	2388	-
2	10DS:1.5TS	2267	5.07
3	10DS:2.5TS	2252	5.70
4	20DS:1.5TS	2198	7.96
5	20DS:2.5TS	2187	8.42

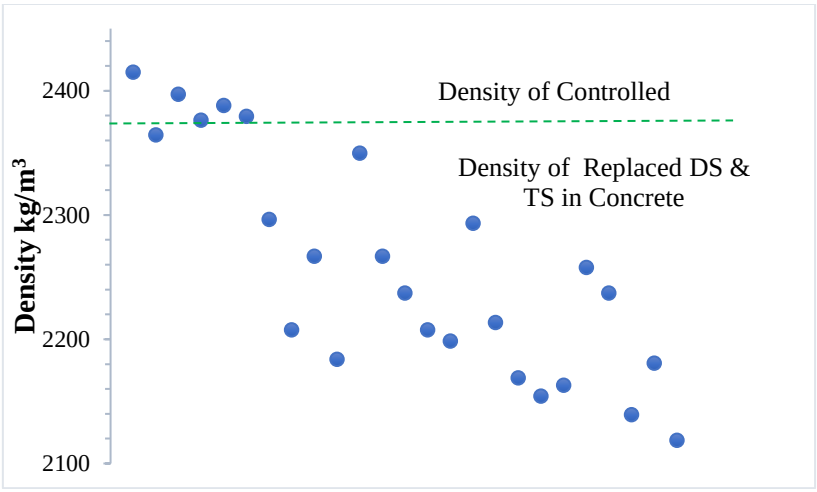

Fig.4: Density of specimen with DS & TS replacement

5.1 Compressive Strength

The casted cubes are tested in CTM with Rate of loading 15 N/mm^2 per minute and the results obtained are tabulated below

Table-7: Compressive Strength Test for Cube

Sl. No	% of Replacement of Date Seed	% of Replacement of Tamarind Seed	Compressive strength (N/mm^2)		Average Weight (kg)
			7 Days	28 Days	
1	CC		19.24	29.60	8.06
2	10	1.5	18.48	28.43	7.45
		2.5	18.10	27.85	7.23
3	20	1.5	17.70	27.23	7.30
		2.5	17.16	26.40	7.08

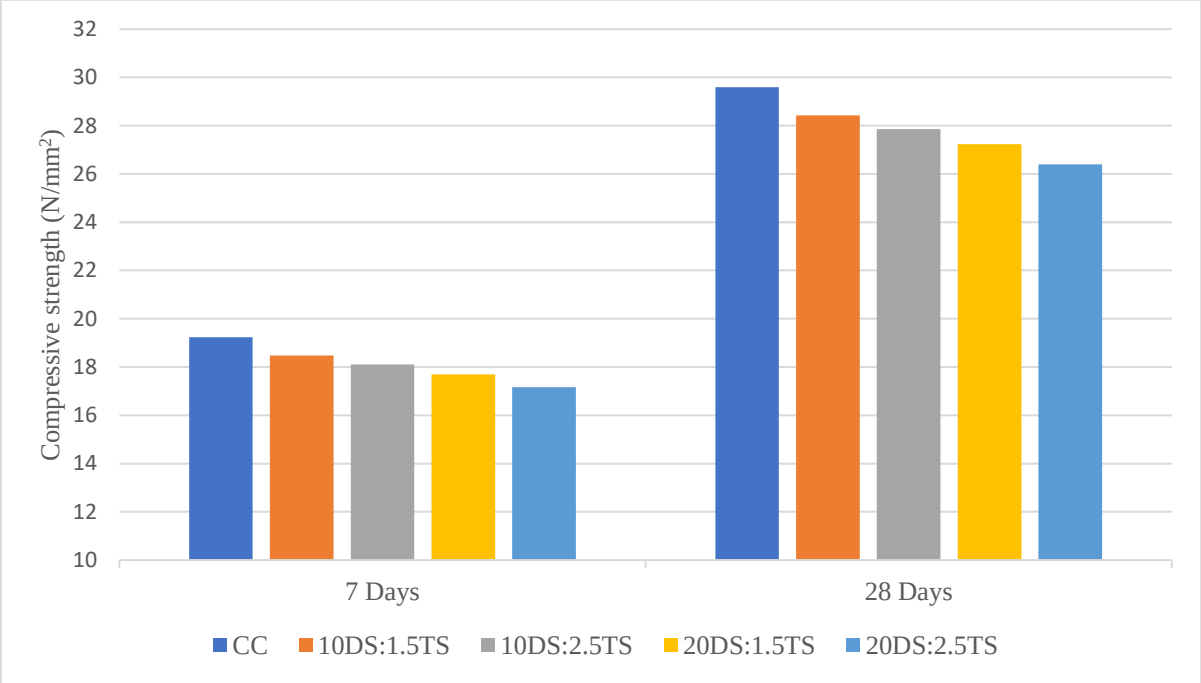

Fig.5: Compressive strength with DS & TS replacement

From the above graphs, the compressive strength of the concrete will reduce the increase in date seed and tamarind seed. It can be noted that both 7th day and 28th day testing of the concrete samples, the sample with 10% of date seed and 1.5% of tamarind seed and has the least decrease value in compressive strength compare to control concrete. The graph indicates that there is a decrease in the weight of the cubes with the increase in percentage of replacement of tamarind seed above 1.5% and date seed above 10%.

5.2 Split Tensile Strength

Table-8: Split tensile strength for cylinder

Sl. No	% of Replacement of Tamarind Seed	% of Replacement of Date Seed	Split tensile strength (N/mm^2)	Split tensile strength (N/mm^2)	Average Weight (kg)
			7 Days	28 Days	
1	CC		3.03	8.25	13.57
2	10	1.5	2.96	8.05	12.07
		2.5	2.94	7.65	11.68
3	20	1.5	2.85	6.82	11.35
		2.5	2.80	6.70	10.85

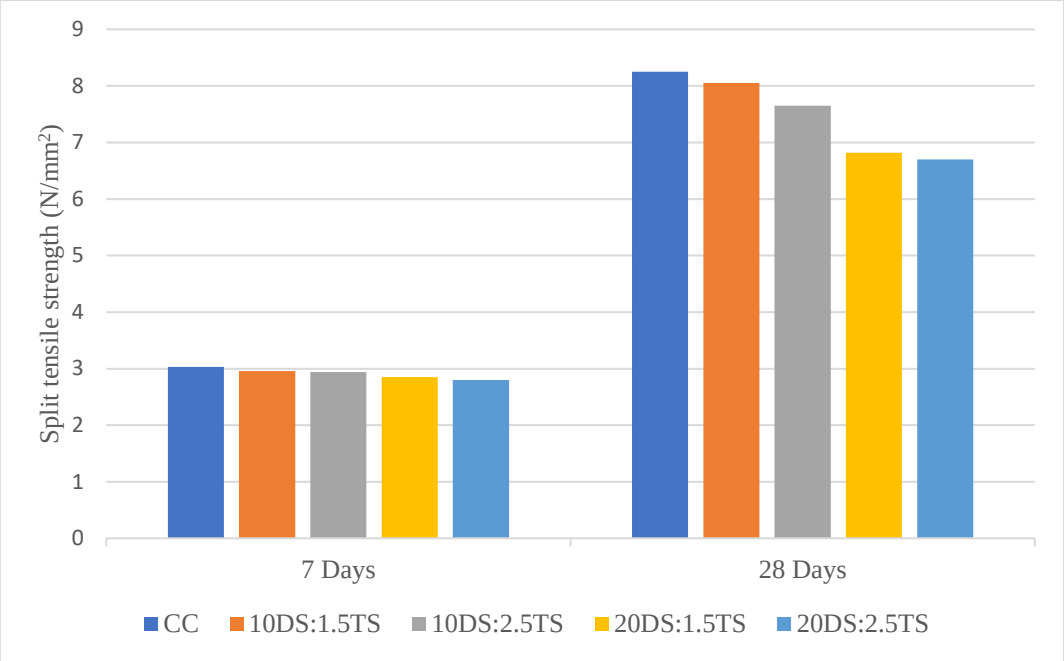

Fig.6: Split tensile strength with DS & TS replacement

From the above graphs, it can be noted that both 7th day and 28th day testing of the concrete samples, the sample with 10% of date seed and 1.5% of tamarind seed has the highest value in split tensile strength among the other Replacement ratios. The graph indicates that there is a decrease in the weight of the cylinder with the increase in percentage of replacement of tamarind seed and date seed.

5.3 Flexural strength

Table-9: Flexural strength for prism

Sl. No	% of Replacement of Tamarind Seed	% of Replacement of Date Seed	Flexural Strength (N/mm²) (7 Days)	Flexural Strength (N/mm²) (28 Days)	Average Weight (kg)
1	CC		2.58	3.67	12.05
2	10	1.5	2.51	3.50	11.15
		2.5	2.49	3.37	10.80
3	20	1.5	2.34	3.23	10.40
		2.5	2.31	3.13	9.95

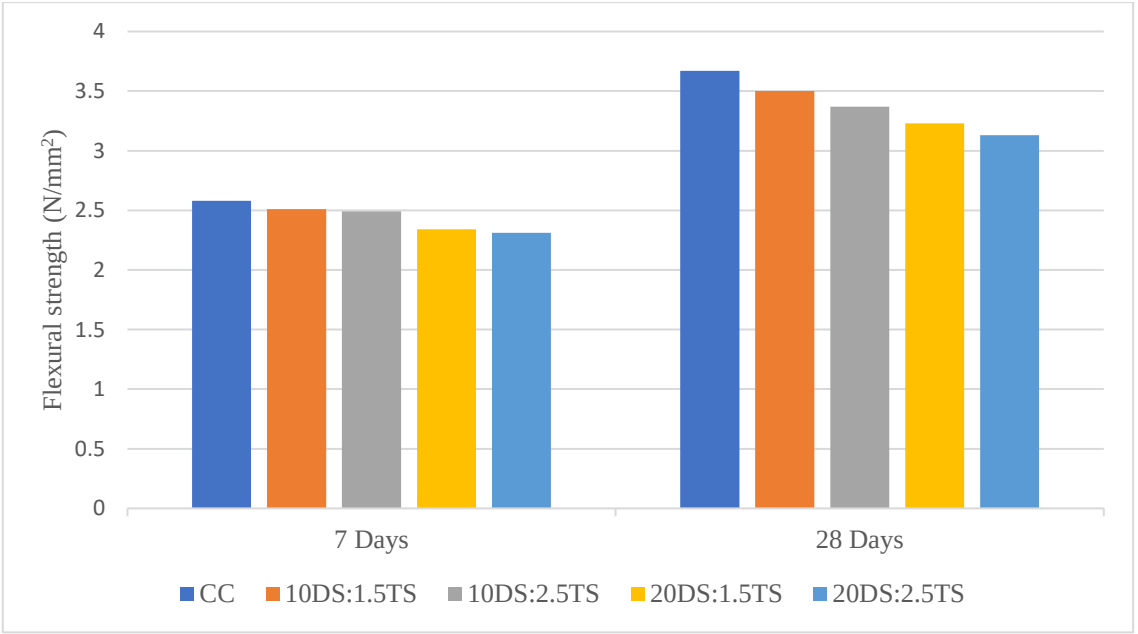

Fig.7: Flexural strength with DS & TS replacement

From the above graphs, it can be noted that both 7th day and 28th day testing of the concrete samples, the sample with 10% of date seed and 1.5% of tamarind seed has the highest value in flexural strength.

5.5 Compressive strength vs Density

The relationship between the density and compressive strength of concrete with date and tamarind seed replacements is shown in Figure 7. From the figure, the density of the date and tamarind seed replaced specimens has significant relationship with the compressive strength. It can be seen that the R^2 of the relationship is 0.84289. This shows that when the density of concrete decreases, the compressive strength of the concrete also decreases and vice versa. This is due to the changes in the functions of fine aggregate like the workability, binding ability because of the smoothness in the surface. A different percentage of date and tamarind seed replacement gives a same result that the compressive strength reduction is more over equal to the reduction in density.

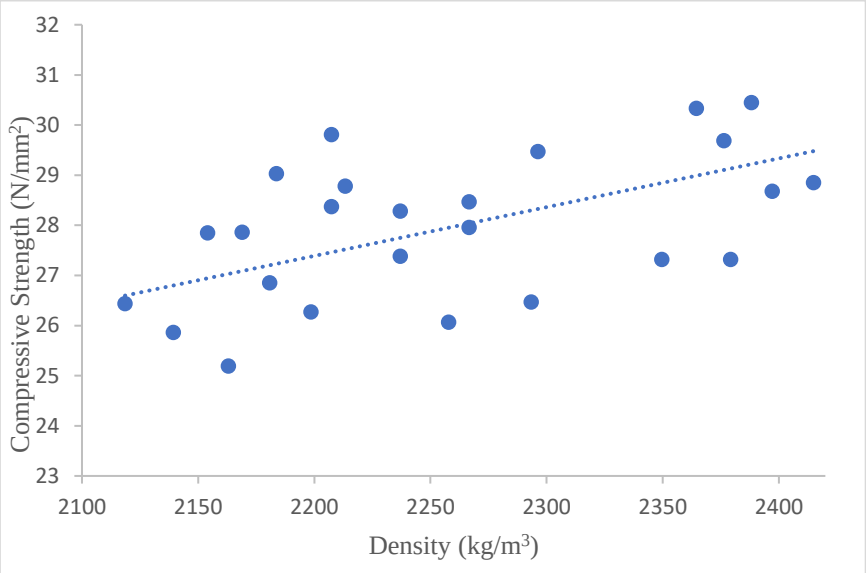

Fig.8: Density vs compressive strength with DS & TS replacement

6. CONCLUSION

- The strength of concrete constantly decreases with respect to increase in date seed and tamarind seed and same will reduce the density.
- From this study the replacement of 10 % of date seed and 1.5 % of tamarind seed will reduce the density of concrete upto 5.07 % and decrease in strength upto 4 % compared to control concrete .For replacement of 20 % of date seed and 1.5 % of tamarind seed will reduce the density of concrete upto 8.42 % and decrease in strength upto 10.81 % compared to control concrete.
- The optimum replacement of 10 % of date seed and 1.5 % of tamarind seed will have the low reduction in strength and as well as density.
- From this study we renowned that the date and tamarind seed has higher water absorption that leads to low workability of concrete. So, usage of super plasticizer is necessary to control the workability of the concrete for the dense area.
- Compare to the physical properties of manufactured sand and date and tamarind seed has comparable physical properties. but seed has a drawback of increase in volume when connection with water due to its physical nature.
- So, from this study date and tamarind seed showing its light weight nature and we shall use it in non-structural areas.

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