Comparative Study on Strength Parameters of Concrete on Addition of Saw Dust Ash and Polypropylene Fibres

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Abstract – *Rapid increase in construction activities has resulted in shortage of conventional construction materials. The production of portland cement is not only costly and energy intensive, but it also produces large amounts of carbon emissions. The production of one ton of portland cement produces approximately one ton of CO_2 in the atmosphere. In today's situation concrete needs special combinations of performance and uniformity requirements that cannot be always achieved by using conventional constituents and normal mixing. Concrete is weak in tension, has limited ductility and little resistance to cracking. This has necessitated research into alternative materials of construction. The effective housing techniques deal with reduction in cost of construction as well as providing strength to buildings. This provided the motivation for exploring the benefits of saw dust ash (SDA) as a replacement material and the addition of polypropylene fibres. Sawdust is one of the major underutilized by-products from saw milling operations. The implementation of waste sawdust can not only decrease environmental damage, but also can save the concrete materials. Saw dust ash can be used as a light weight concrete that has already received attention over the past years. To strengthen the SDA concrete and making it more durable polypropylene fibre is being added. Polypropylene is a synthetic hydrocarbon polymer, the fiber of which is made using extrusion processes by hot drawing the material through a die. In this project cement has been partially replaced with SDA by its weight such as 2.5%, 5%, 7.5%, 10% and 12.5% in M25 grade concrete along with polypropylene fibres. Results showed that maximum increase in the compressive strength observed was 7.5% and split tensile strength observed was 10% with the replacement of SDA along with 1.2% of polypropylene fibres.*

Key Words: Saw dust ash (SDA), Polypropylene fibres, Light weight concrete, Hydrocarbon polymer, Workability, Compressive strength, Tensile strength.

1. INTRODUCTION

The rapid development of construction industry has increased the consumption of cement. But the production of cement involves the depletion of natural resources and greenhouse-gas emissions. Also production cost of cement is increasing day by day. Thus, there is a need to search for alternative materials to cement for use in the construction. Concrete is the most popular building material in the world. Concrete is known to be the most wide spread structural material due to its quality to shape up in various geometrical configurations. It is an assemblage of cement, fine and coarse aggregates and water. Over 300 million tones of industrial wastes are being produced per annum by various industrial and agricultural processes. These materials possess problems of disposal, health hazards and aesthetic problems. The rapid development of construction industry has increased the consumption of cement. But the production of cement involves the depletion of natural resources and greenhouse-gas emissions. Also production cost of cement is increasing day by day. Thus, there is a need to search for alternative materials to cement for use in the construction. The advances in concrete technology have paved way to make the best use of the locally available materials by judicious mix proportioning and proper workmanship, so as to result in a concrete satisfying the performance requirements. Cement industry contributes extensively in the emission of CO_2. It also consumes high levels of energy resources in cement production. By replacing cement with a waste material, such as saw dust, the cement and cement industry together can meet the demand in construction industry and also can help in reducing the environmental pollution. Saw dust is very common due to the availability of saw mills in almost every township in the country. It is one of the major underutilized by-products from saw milling operations. Saw dust ash (SDA) can be used as a constituent of light weight concrete. This idea has already received attention over the past years. The utilization of waste saw dust can not only decrease environmental damage, but also can save the concrete materials.

Concrete made with Portland cement has certain characteristics: it is relatively strong in· compression but weak in tension and tends to be brittle. These two weaknesses have limited its use. Another fundamental weakness of concrete is that cracks start to form as soon as concrete is placed and before it has properly hardened. These cracks are major cause of weakness in concrete particularly in large onsite applications leading to subsequent fracture and failure and general lack of durability. The weakness in tension can be overcome by the use of conventional rod reinforcement and to some extent by the inclusion of a sufficient volume of certain fibers. To improve such properties, fibre reinforced concrete (FRC) has been developed. Fibres are intended to improve strength, toughness and impact strength, to change failure mode by means of improving post-cracking ductility, and to control cracking. Several fibre materials in various sizes and shapes have been developed for use in FRC. Among these fibres, polypropylene has been one of the most successful commercial applications. Polypropylene is a synthetic hydrocarbon polymer, the fiber of which is made using extrusion processes by hot drawing the material through a die. Its use enables reliable and effective utilization of intrinsic tensile and flexural strength of the material along with significant reduction of plastic shrinkage cracking and minimizing of thermal cracking .The common forms of these fibres are smooth-monofilament and have triangular shape. Polypropylene fibres have some unique properties that make them suitable for reinforcement in concrete.

2. MATERIALS USED

The various materials used in this investigation are cement, fine aggregate, coarse aggregate, saw dust ash (SDA), chemical admixture, polypropylene fibre and water.

2.1 Cement

The cement used in this experimental work was “53 Grade Ordinary Portland Cement” having specific gravity- 3.15 and normal consistency- 30%. All the tests were carried out in accordance with procedure specified in IS 12269 – 1987.

2.2 Fine aggregate

The fine aggregate used was M sand and it is collected from the locally available sites. The specific gravity of fine aggaregate is 2.26.

2.3 Coarse aggregate

The coarse aggregate used here was collected from locally available places having maximum size 20mm and specific gravity 2.6. The coarse aggregate is chosen by shape as per IS 2386 (Part I) 1963, surface texture characteristics of aggregate is classified as in IS 383-1970. The void ratio and porosity of coarse aggregate are 0.8 and 0.44 respectively.

2.4 Saw dust ash (SDA)

Sawdust is an organic waste resulting from the mechanical milling or processing of timber (wood) into various shapes and sizes. The resulting ash known as saw-dust ash (SDA) is a form of pozzolana. The saw dust used for this work was collected from nearby sawmill. Samples were carefully collected to avoid mixing with sand by collecting the newly produced ones with shovel and packing into bags. The saw dust collected was sundried for 5 days to aid the burning process. The saw dust samples collected were burnt into ashes by open burning. The ash was then ground after cooling. Sawdust ash obtained is sieved through IS sieve of 300 micron. The specific gravity of saw dust ash obtained was 2.16.

Fig - 1: Saw dust ash (SDA)

2.5 Chemical admixture

Cera - Chem Pvt Ltd, Chennai has developed “CERAPLAST 300” which is compatible with blended cements, especially with slag cements. Ceraplast 300 M is a new generation, high grade, and high-performance retarding super plasticiser specially designed for concrete with replacement of cement upto 70-80 percent by slag. The super plasticizer was added 0.5 to 0.7 % by weight of cement to all mixes.

2.6 Polypropylene fibers

The fibres used were fine polypropylene monofilaments. The fibers were supplied by Jeetmull Jaichandlall Pvt Ltd, Chennai. The length of fibre range from 10mm to 20mm.Polypropylene fibres are synthetic hydrocarbon polymer. They are formed by extrusion processes by hot drawing material through a die. Table - I shows the physical characteristics of polypropylene fibre. Different percentages of fibre used are 0%, 0.6%, 0.9%, 1.2%, 1.5%, 1.8%, and 2.1%. From this, the percentage which gives maximum results is found as 1.2%.

Table - I: Physical characteristics of polypropylene fibres

Specific gravity	0.91
Melting range	162 – 164 ◦C
Thickness	35 – 40 micron
Elongation	15% - 18%
Strength	500 - 550 MPa

Fig - 2: Polypropylene fibre

2.7 Water

The water which is used for making concrete should be clean and free from harmful impurities such as oil, alkali, acid, etc. Potable water is used for the experiment.

3. SCOPE AND OBJECTIVES

The main scopes of the study are;

- To reduce the carbon emissions that would result from the use of saw dust ash as a partial replacement to cement.
- Examine the effectiveness of using SDA as partial replacement of cement
- To reduce the cost of construction as well as to increase the strength of concrete
- To create a sustainable and pollution free environment
- To evaluate the suitability of agro waste as an alternative for cement

The objectives of the study are;

- To analyze the properties of the saw dust ash concrete as compared to the portland cement concrete.
- To prepare light weight structural concrete which may reduce considerably the self load of structures
- To find the optimum percentage of saw dust ash
- To provide an economical construction material
- Safeguard the environment by utilizing the agro waste properly

4. METHODOLOGY

4.1 Mix proportion

Mix design is calculated as per IS 10262:2009 specifications. The concrete mix of M25 grade concrete is adopted with a water cement ratio of 0.5.

4.2 Workability test

Workability of concrete defined as 'that property of freshly mixed concrete which determines the ease and homogeneity with which it can be mixed, placed, consolidated and finished'. It is determined by performing the following tests on fresh concrete as per IS 456:2000.

1. Slump Test
2. Compaction factor test

(a) (b)

Fig - 3: Workability tests (a) Slump test (b) Compaction factor test

4.3 Batching, Mixing and Casting

The batching, mixing and casting was done with proper care and handling. The materials were weighed properly as required and hand mixed thoroughly on a platform and then water was added as per the requirement. Concrete cube and cylinder specimens were cast in steel moulds using different percentages of saw dust ash such as 2.5%, 5%, 7.5%, 10% and 12.5% along with 1.2% of polypropylene fibres. The cube moulds of size 150mmx150mmx150mm and cylinders mould of size 150mm diameter and 300mm length were filled with the mix. The specimens were tamped by tamping rod for around 25 times and the surface of moulds should be levelled properly. The specimens were kept for 24 hours, de- moulded and then allowed for curing. The curing was allowed until the date of testing i.e., for 7th, 14th, and 28th. Then after the days of curing, the specimens were taken out and tested under compression testing machine.

4.4 Compressive strength tests

The aim of this test is to determine the compressive strength of concrete specimens. The cube specimen was taken out from the curing tank after specified curing time and were allowed for dry and the weight of each specimen as well as measure the dimension of the specimen were noted. The specimens were placed in the machine such that load shall be applied to the opposite sides of the specimen, and the specimens were aligned centrally on the base plate of the machine. The movable portion was rotated gently by hand so that it touches the top surface of the specimen. The load was applied gradually till the specimens failed and the maximum load at failure of specimen were recorded. The compressive strength of the specimen was calculated by dividing the failure load by the cross-sectional area of the specimen. Compressive strength of the cubes was determined at curing periods of 7 days, 14 days and 28 days.

4.5 Split tensile strength test

The aim of this test is to determine the splitting tensile of concrete cylinder according to IS 5816-1999. There are some methods are developed to find tensile strength of concrete is briquette test (Direct method – uniaxial tension) and split tensile strength (Indirect method – compressive force). Application of direct method of concrete specimen is not uniform and is difficult. So, compressive force is applied to specimen such that specimen fails due to induced tensile stresses in the specimen. For testing, the cylindrical specimens were taken from curing tank after curing period and it was allowed to dry. The weight and dimension of specimen were noted. The compression testing machine was set and the plywood strip was kept on the lower plate and the specimens were placed horizontally. The specimens were aligned so that the lines marked on the ends were vertical and centered over the bottom plate and other plywood strip was placed above the specimen. The load was applied continuously at a specified rate of loading until the resistance of specimen to the increasing load breaks and no longer load is sustained, the breaking load (P) was noted down. Split tensile strength is found out by equation given below. Fig 4 shows the split tensile strength test conducted on cylindrical specimen.

Splitting tensile strength = $\frac{2P}{\pi DL}$

Where;

P – Maximum applied load
D – Diameter of specimen
L – Length of specimen

(a) (b)

Fig - 4: Testing of specimens (a) Compressive strength test on cube specimens (b) Split tensile strength test on cylinder specimens

5. RESULTS AND DISSCUSSION

5.1 Workability test

The workability test results for various percentages of SDA are shown in Table - II.

Table - II: Workability results

Sl. No	Percentage of fibre (%)	Percentage of SDA(%)	Workability tests	
			Slump test (mm)	Compaction factor test
1	0	0	80	0.91
2	1.2	2.5	79	0.9
3		5	77	0.89
4		7.5	76	0.89
5		10	75	0.88
6		12.5	73	0.87

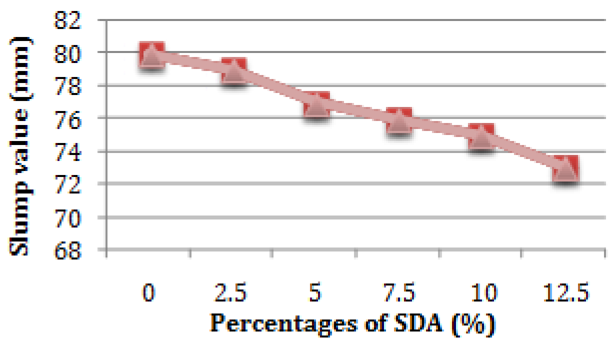

Fig – 5: Relationship between slump value and various percentage of SDA

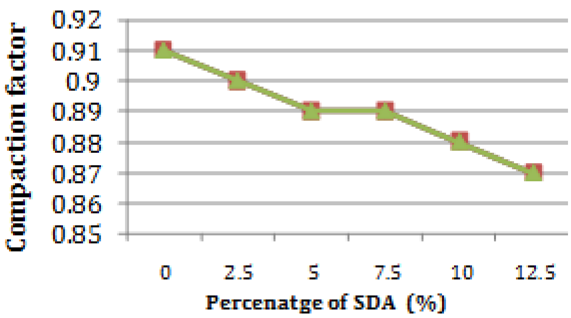

Fig – 6: Relationship between compaction factor and various percentage of SDA

5.2 Compressive strength test

Table - III shows the results of compression test after a curing period of 7, 14 and 28 days.

Table - III: Compressive strength results

Percentage of SDA (%)	Percentage of fibre (%)	Strength obtained after		
		7 days (N/mm²)	14 days (N/mm²)	28 days (N/mm²)
0	0	20.98	25.1	30.2
2.5	1.2	21.5	26.05	30.9
5		22.8	27.3	31.5
7.5		**23.4**	**27.9**	**32.6**
10		22.8	24.2	27.7
12.5		20.1	21.5	23.6

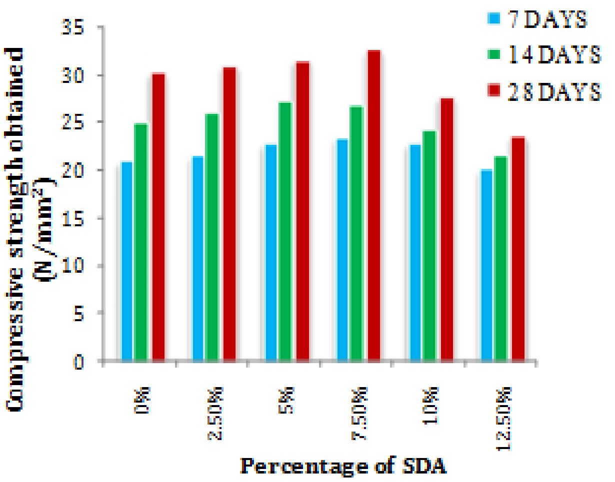

Fig - 7: Relationship between compressive strength and various percentage of SDA

5.3 Split tensile strength test

Table - IV shows the split tensile strength obtained for various percentages of SDA.

Table - IV: Split tensile strength results

Percentage of SDA (%)	Percentage of fibre (%)	Strength obtained after	
		7 days (N/mm²)	28 days (N/mm²)
0	0	2.61	3.15
2.5	1.2	2.69	3.21
5		2.78	3.29
7.5		2.87	3.34
10		**2.99**	**3.73**
12.5		2.5	2.9

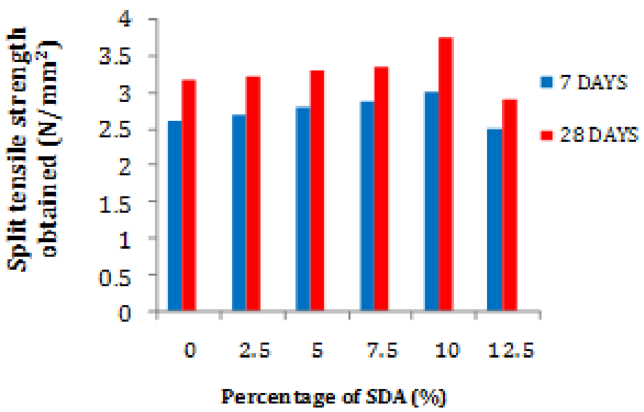

Fig - 8: Relationship between spit tensile strength and various percentage of SDA

6. CONCLUSIONS

Based on the investigations, the following conclusions were drawn.

- The addition of SDA in concrete provides environmental as well as technical benefits.
- The partial replacement of cement with reduces the cost of making concrete.
- Saw dust ash concrete is light weight in nature and it proves to be environmental friendly, thus paving way for green concrete.
- The workability of concrete decreases significantly with the increase of SDA content in concrete mixes.
- The compressive test results have indicated that the strength of concrete decreases with respect to the percentage of SDA added.
- The significant improvements in strength were observed with inclusion of polypropylene fibres in concrete.

- The maximum percentage of increase in compressive strength observed was at 7.5% of SDA with 1.2% of fibre content.
- The maximum percentage of increase in split tensile strength observed was at 10% with 1.2% fibre content.

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