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Partial Replacement of Cement by Saw Dust Ash in Concrete A Sustainable Approach

Mohammad Iqbal Malik[1], Syed Rumysa Jan[2], Junaid Ahmad Peer[3], Syed Azhar Nazir[4], Khubbab Fa Mohammad[5]
[1]*Assistant Professor, Department of Civil Engineering, IUST, Awantipora*
2,3,4,5, Civil Engineering Graduate Student, IUST, Awantipora.

Abstract:- Concrete industry is one of the largest consumers of natural resources due to which sustainability of concrete industry is under threat. The environmental and economic concern is the biggest challenge concrete industry is facing. In this paper, the issues of environmental and economic concern are addressed by the use of saw dust ash as partial replacement of cement in concrete. Cement was replaced by Saw Dust Ash as 5%, 10%, 15% and 20% by weight for M-25 mix. The concrete specimens were tested for compressive strength, durability (water absorption) and density at 28 days of age and the results obtained were compared with those of normal concrete. The results concluded the permissibility of using Saw Dust Ash as partial replacement of cement up to 10% by weight for particle size of range 90micron.

Keywords:- Compressive strength, Durability, split tensile strength, Saw Dust Concrete, Workability.

I. INTRODUCTION

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 global consumption of cement is too high due to its extensive use in concrete. Over 5 billion tonnes of cement is produced in the world per year. However, the production of cement is diminishing the limestone reserves in the world and also requires a great consumption of energy. River sand has been the most popular choice for the fine aggregate component of concrete in the past, but overuse of the material has led to environmental concerns, the depleting of securable river sand deposits and a concomitant price increase in the material. Thus there is the need to search for local materials as alternatives for the construction of functional but low-cost buildings in both rural and urban areas. construction industries are in the stress to identify alternative materials to replace the demand for natural sand and cement. On the other and, the advantages of utilization of byproducts or aggregates obtained as waste materials are pronounced in the aspects of reduction in environmental load and waste management cost, reduction of production cost as well as augmenting of concrete. To overcome the stress and demand for natural fine aggregate and cement, researchers and practitioners in the construction industries have identified some alternative materials such as fly ash, slag, limestone-powder, siliceous materials, saw dust ash. In India attempts have been made to replace cement by saw dust ash. Concrete is by far the most widely used man made construction material and studies indicate it will continue to be so in years and decades to come. About five billion tons of concrete are used around the world each year, enough for close to one ton for each person per year, at a volume of about 400 liters per person. Such versatility of concrete is due to the fact that from the common ingredients, namely, cement, aggregates and water, it is possible to tailor the properties of concrete so as to meet the demands of any particular situation. The advances in concrete technology has paved the 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.

Scientists, Engineers and technologists are thus continuously on the lookout for materials which can be used as substitutes for conventional materials or which possess such properties as would enable their use for new designs and innovations. Concretes using alternative materials fall under the first category. The raw materials for making cement and aggregates are essentially limitless, since practically all of earth's crust can be utilized, if associated costs and energy requirements can be complied with. This course of action cannot be taken as there are other constraints that merit closer examination. One is therefore faced with a question: Is recycling of waste material into a new building material whose binder may not be Portland cement and whose aggregates may not be a mineral a viable solution? Perhaps the answer is affirmative since planned exploitation of waste materials essentially helps to maintain ecological balance.

In this research cement was partially replaced by saw dust ash as 5%,10%,15% and 20% by weight. Concrete specimens were tested for slump test, compressive strength, durability (water absorption) and light weight nature for different saw dust percentages. The results obtained were compared with results of normal M-25 concrete mix and it was found that maximum increase in compressive strength occurred for the concrete mix containing 5% saw dust by weight of cement. Slump tests was carried out on the fresh concrete and compressive strength test on hardened concrete. The concrete cubes were tested at the ages of 7 day and 28 days. The results showed that SDA is a good pozzolan with combined SiO_2, Al_2O_3 and Fe_2O_3 of 73.07%.The slump decreased as the SDA content increased. The compressive strength decreased with increasing SDA replacement. The compressive strength of concrete with SDA was lower at early stages but improves significantly after 28 days. It was concluded 10 % SDA substitution is adequate to enjoy maximum benefit of strength..

This paper summarized the behavior of concrete involving partial replacement of cement by saw dust ash as 0%,5% 10%, 20%, by weight which may help to reduce the disposal problems of saw dust ash and enhance properties of concrete.

II. MATERIALS USED

2.1. Cement and Aggregates

Khyber ordinary Portland cement of 43 grade confining to IS 8112 was used throughout the work. Fine aggregates used throughout the work comprised of clean river sand with maximum size of 4.75mm conforming to zone II as per IS383-1970 with specific gravity of 2.6. Coarse aggregates used consisted of machine crushed stone angular in shape passing through 20mm IS sieve and retained on 4.75mm IS sieve with specific gravity of 2.7.

2.2. Saw Dust Ash

It is a by-product of cutting, grinding, drilling, sanding, or otherwise pulverizing wood with a saw or other tool. It is composed of fine particles of wood. The saw dust used for this project 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 10 days to aid the burning process. The saw dust samples collected were burnt into ashes by open burning at temperature of 200 degree Celsius in a drum. The ash was then ground after cooling. . Sawdust ash obtained is sieved through IS sieve of 90 micron and the retained material obtained is used for experimentation purposes. Chemical composition of saw dust is presented in TABLE 1. Fig.1 shows saw dust ash added to cement for blending and Fig.2 shows sieving of saw dust ash.

III. EXPERIMENTAL INVESTIGATION

3.1. Mix Proportion

The concrete mix design was proposed by using IS 10262 [10]. The grade of concrete used was M-25 with water to cement ratio of 0.45. The mixture proportions used in laboratory for experimentation are shown in TABLE 2.

3.2. Test on Fresh Concrete

Slump Test The workability of all concrete mixtures was determined through slump test utilizing a metallic slump mould. The difference in level between the height of mould and that of highest point of the subsided concrete was measured and reported as slump. The slump tests were performed according to IS 1199-1959.

3.3. Tests on hardened concrete

From each concrete mixture, cubes of size 150mm x 150mm x 150mm have been casted for the determination of compressive strength. The concrete specimens were cured under normal conditions as per IS 516-1959 and were tested at 7 days and 28days for determining compressive strength as per IS 516-1959.

3.4. Water absorption test

The average dry weight of cube specimens after removing from moulds was measured and the average weight of cube specimens after submerging in water for curing was measured at 28 days of age. The percentage of water absorption was measured for each concrete specimen and it gave indirect measure of durability.

3.5. Light weight character

The average dry weight of concrete cube specimens containing 10%, 20%, 30% and 40% saw dust ash in place of cement was compared with average dry weight of normal M-25 concrete cube specimens and the percentage decrease in dry weight was measured.

IV. RESULTS AND DISCUSSION

4.1. Fresh concrete

The slump values of all the mixtures are represented in TABLE 2. The slump increased with the increase in saw dust ash content. Saw dust ash particles absorbed less water as compared to cement and thus increasing the workability of concrete mix. The variation of slump with saw dust ash content is depicted in Fig. 3.

TABLE 1 – Chemical Composition of Saw Dust Ash

Oxide	Percentage(%)
SiO_2	65.30
Al_2O_3	4.0
Fe_2O_3	2.23
CaO	9.6
MgO	5.8
MnO	0.01
Na_2O	0.07
K_2O	0.11
P_2O_5	0.43
SO_2	0.45

4.2. Hardened concrete

The compressive strength test results are presented in TABLE 3. Compressive strength tests were carried out at 7 and 28 days. An increase in compressive strength was observed up to 10% replacement of cement by saw dust ash and there after decreasing. The maximum compressive strength measured was 17% more than that of reference mix at 28 days corresponding to concrete mix containing 5% saw dust ash in place of cement. Compressive strength for concrete mix with 15% saw dust ash content was found to be less than that of reference mix. Fig. 4 depicts compressive strength of cubes of all mix combinations at 7 days and 28 Days.

4.3. Water absorption

Water absorption test was carried out for all mixtures and percentage water absorption was measured. The percentage water absorption increased with increase in saw dust ash content. The highest value of water absorption was found for concrete mix with 20% saw dust ash content. TABLE 4 depicts the percentage water absorption for all mixtures.

4.4. Light weight character

Average dry weight of cube specimens of each mixture as compared to reference mix was studied and it was observed that density decreased with increase in saw dust ash content. The results showed 5% reduction in dry weight of concrete cube specimens for concrete mix with 20% saw dust ash content as compared to reference mix. Thus, saw dust ash concrete is light weight in nature. TABLE 5 depicts the value of dry density and percentage change in dry weight with respect to reference mix.

Fig. 1. Saw Dust ash added to cement for blending

Fig. 2. Sieving of Saw Dust ash.

TABLE 2 - Mixture proportion

Saw Dust Ash %	w/c ratio	Water (Kg/m^3)	Cement (Kg/m^3)	Fine Aggregate (Kg/m^3)	Saw Dust Ash (Kg/m^3)	Coarse Aggregate (Kg/m^3)	Slump (mm)
0	0.45	191.6	425.80	543.5	0.00	1199.36	60
5	0.45	191.6	404.51	543.5	21.29	1199.36	68
10	0.45	191.6	383.22	543.5	42.58	1199.36	70
15	0.45	191.6	361.93	543.5	63.87	1199.36	73
20	0.45	191.6	340.64	543.5	85.16	1199.36	77

TABLE 3 - Compressive strength test

Saw Dust Ash %	Avg. load @ 7days (KN)	Avg. Load @ 28 days(KN)	Avg. Compressive Strength @7 days(N/mm^2)	Avg. Compressive Strength @28 days(N/mm^2)
0	530	620	23.55	27.55
5%	564	730	**25.06**	**32.44**
10%	550	680	24.44	30.22
15%	450	500	20.00	22.22
20%	375	420	16.66	18.66

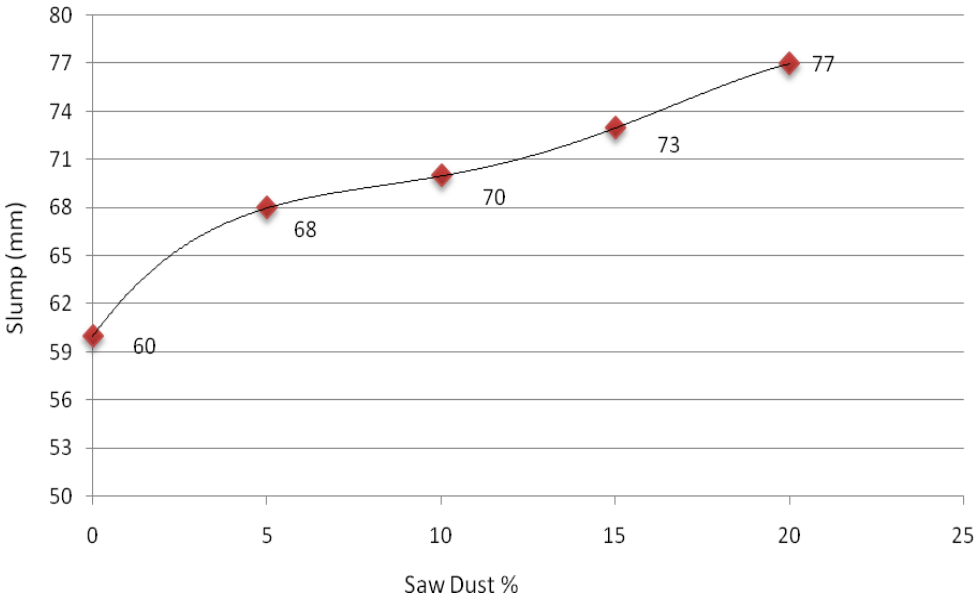

Fig.3 – Variation of slump with saw dust content.

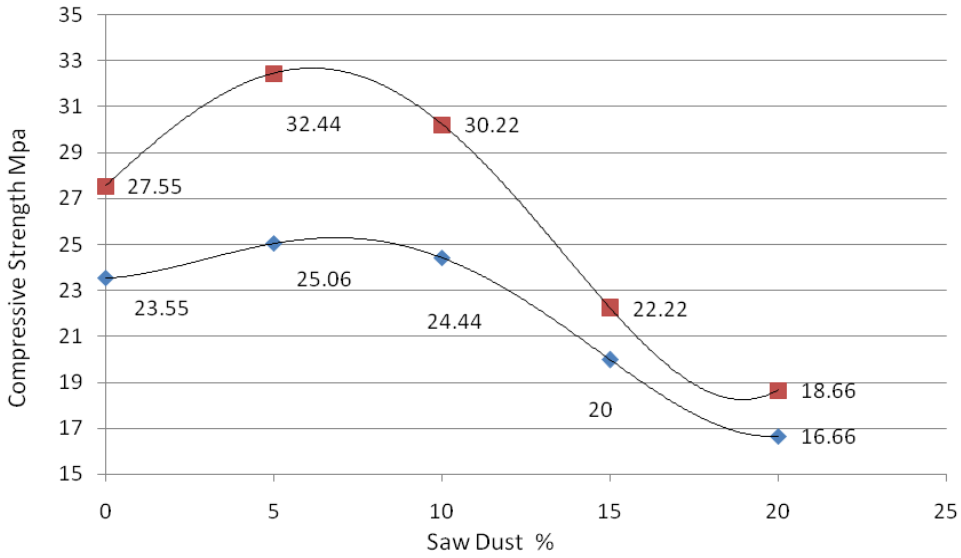

Fig.4 – Compressive Strength of Cubes at 7 days and 28 Days

TABLE 4 – Water absorption test results for cube specimens of size 150mm x 150mm x 150mm

Saw Dust Ash %	Dry weight of cube (gm)	Wet weight of cube (gm)	Water absorbed (gm)	Percentage water absorption
0	8260	8350	90	1.08%
5%	8352	8456	104	1.245%
10%	8225	8340	115	1.398%
15%	8115	8241	126	1.552%
20%	7998	8135	137	1.713%

Table 5 – Light weight test results for cube specimens of size 150mm x 150mm x 150mm.

Saw Dust Ash %	Avg. Dry weight of cube (gm)	Avg. dry density of cube (KN/m^3)	Percentage change in weight as compared to reference (%)
0	8260	24.47	0%
5%	8352	24.75	- 0.358%
10%	8225	24.37	- 1.870%
15%	8115	24.04	- 3.185%
20%	7998	23.70	- 4.580%

V. CONCLUSION

On the basis of results obtained, following conclusions can be drawn:

1. SDA is a suitable material for use as a pozzolan, since it satisfied the requirement for such a material by having a combined (Sio2+Al2O3+Fe2O3) of more than 70%.
2. Concrete becomes more workable as the SDA percentage increases meaning that less water is required to make the mixes more workable .This means that SDA concrete has lower water demand.
3. The compressive strength generally increases with curing period and decreases with increased amount of SDA. Only 10% substitution is allowed at maximum and 5% substitution is adequate to enjoy maximum benefit of strength gain.
4. Use of saw dust ash in concrete can prove to be economical as it is non useful waste and free of cost.
5. Use of saw dust ash in concrete will eradicate the disposal problem of saw dust and prove to be environment friendly thus paving way for green concrete.
6. Use of saw dust ash in concrete will preserve resources particularly cement and thus make concrete construction industry sustainable.

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