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Experimental Study on Strength of Concrete by Partial Replacement of Fine Aggregate with Sawdust and Robosand

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ABSTRACT:

Construction industry relies heavily on conventional materials such as cement, granite and sand for the production of concrete. The River sand which is most commonly used fine aggregate in the production of concrete, poses the problem of acute shortage in many areas, whose continued use has started posing serious problems with respect to its availability, cost and environmental impact. Attempt is being made in this project to use the locally available materials to replace the river sand to produce low cost concrete.Saw dusts are the loose particles or wood chippings obtained as by-products from sawing of timber into standard useable sizes produced by sawmills. Sawdust has been used in concrete, but not widely. Although seriously limited by its low compressive strength, the advantages that sawdust concrete offers are considerable reduction in weight of the structure, thereby reducing the dead loads transmitted to the foundation, high economy when compared to normal weight concrete. The crusher dust produced from granite crushers and waste by product from quarry is one of the alternative materials for river sand. The utilization of crusher dust which can be called as ROBO sand has been accepted as a building material in the western countries also in some states of India. Lots of research has been done regarding the crusher dust as alternative materials for river sand and reported that crushed stone dust can be used to partially replace the natural sand in concrete.Saw dust and robosand in proportion used as fine aggregates in concrete and the compressive and split tensile strength were tested. There were totally five mixes prepared for the investigation, gradually increasing the replacement percentages from 0-100% with sawdust and robosand in proportion. The compressive and split tensile strength gradually decreases for the increasing replacement percentages. The optimum mix found to produce M20 grade of concrete is 10% of saw dust and 40% of robosand, totally 50% replacement of river sand. The weight reduction achieved is 7% and cost reduction is 2% per cubic meter of concrete.

1.1 INTRODUCTION:

Concrete is a mixture of cement, fine aggregate, coarse aggregate and water. Concrete plays a vital role in the development of infrastructure Viz., buildings, industrial structures, bridges and highways etc. leading to utilization of large quantity of concrete. It is difficult to point out another material of construction which is as variable as concrete. Concrete is the best material of choice where strength, durability, impermeability, fire resistance & absorption resistance are required.

1.2.NEED FOR THE STUDY:

River sand is the commonly used fine aggregate in conventional concrete whose continued use has started posing serious problems with respect to its availability, cost and environmental impact. On the other hand natural sand in many parts of the country is not graded properly and has excessive silt.The crusher dust produced from granite crushers is one of the alternative materials for river sand. The utilization of crusher dust which can also be called as ROBO sand or M-sand got through processing the blue metal quarry dust has been accepted as a building material in many states of India. Quarry rock dust does not contain silt or organic impurities and can be produced to meet desired gradation and fineness as per Indian Standards requirement. Consequently, this contributes to improve the strength of concrete. Previous studies indicate that the compressive strength, flexural strength of concrete made of quarry rock dust is nearly 10% more than the conventional concrete.This Experimental study is an attempt to find the optimum usage of robosand and Saw dust in normal concrete by replacing the river sand by 0-100% in steps with 0 to 80% (20% increment) of ROBO sand and 0 to 20% (5% increment) of sawdust in combination. Tests are conducted on concrete cubes and cylinders to study compressive and split tensile strengths. Finally the results are compared with the normal conventional concrete.

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The weight reduction and cost reduction is also calculated. The suitability of the sawdust and robosand concrete is evaluated.

1.3 SCOPE OF THE WORK:

a) Use of saw dust and robosand by sand replacement in normal concrete for real time projects thereby reducing the overall cost of construction.
b) Reduction in mining river sand helps protecting the ground water table.
c) The effective way of utilising waste material leads to clean environment.

1.4 OBJECTIVES OF THE STUDY:

a) To study the properties of saw dust and robosand.
b) To find the strength of saw dust and robosand concrete replacing river sand.
c) To identify the optimum usage of saw dust and robosand concrete.
d) To compare the cost analysis.

2. METHODS AND MATERIALS:
2.1. METHODOLOGY:

The methodology adopted for the study is shown in Fig. 3.1.This consists of characterising the materials used, various mix proportions with respect to the mix design results, Casting of cubes and cylinder specimens and testing the same. Finally the test results are compared with the conventional concrete for the strength, weight and cost. The optimum usage of sawdust and robosand in concrete is found from the analysis.

2.2 MATERIALS USED:

The materials used for the study is briefly explained below. The source of the materials, the tests carried out for their properties and the usage method is also mentioned. Sawdust,Robosand,River Sand,Coarse Aggregate,Water

2.3 CONCRETE MIX DESIGN:

Concrete mix design is defined as the appropriate selection and proportioning of constituents to produce a concrete with pre-defined characteristics in the fresh and hardened states.

In general, concrete mixes were designed in order to achieve a definite workability, strength and durability. The selection and proportioning of materials depend on the structural requirements of the concrete, the environment to which the structure will be exposed, the site conditions, especially the methods of concrete production, transport, placement, compaction and finishing etc.

2.3.1 Mix design results:

Mix design was carried out as per IS: 10262 – 2009. The design results arrived are listed in Table 1.

Table 1 Mix design results:

Sl.No.	Mix Design Results	Values
1	Target Compressive Strength	27.59 MPa
2	Water Cement Ratio	0.47
	Quantity of Materials per cubic metre	
3	Weight of Water	195.5 litres
4	Weight of Cement	395 kg
5	Weight of Fine Aggregate	569 kg
6	Weight of Coarse Aggregate	1250 kg
7	Cement: Fine Aggregate: Coarse Aggregate	1:1.44:3.16

2.3.2 Batching and mixing of materials:

Weigh batching was adopted for the study. The percentage replacements of aggregates by sawdust and robosand were 0%, 25%, 50%, 75% and 100%.This was done to determine the proportion that would give the most favourable result. The 0% replacement was to serve as control for other sample which is finally used for the comparision. The mix proportions studied for the sawdust and robosand concrete are totally 5 proportions as shown in Table 3.3.

Table 2 Mix proportions:

Sl.No.	Mix	River Sand	Saw Dust	Robo sand	Combined Replacement
1	M0	100%	0%	0%	0%
2	M1	75%	5%	20%	25%
3	M2	50%	10%	40%	50%
4	M3	25%	15%	60%	75%
5	M4	0%	20%	80%	100%

3. RESULTS AND DISCUSSION:

3.1. MATERIAL PROPERTIES:

The materials used for the sawdust and robosand concrete specimens were tested in the laboratory for their properties. Sieve analysis test was adopted to find the fineness properties and grading of fine aggregates. The moisture content was tested in oven drying method. The bulk density and specific gravity was tested using density bottle method.

3.1.1 Sawdust:

The properties of saw dust are shown in Table 4.1.It shows the density of light weight aggregate and will reduce the overall density of concrete. When the concrete density is decreased the self weight and dead loads may be reduced in structures, resulting which the design details will be economic and ultimately the construction cost will decrease The moisture content of the saw dust is to be considered while finding water cement ratio as the moisture content is 9.8%. Also sun drying was carried out for further time period before concreting. As this is not a cementitious material and used only as an inert material the fineness modulus is verified and found as satisfactory. The Saw dust affects the setting and hardening of concrete.

Table 3 Properties of saw dust

Sl. No.	Parameters	Values
1	Fineness Modulus	1.90
2	Moisture Content	9.8%
3	Bulk Density	615Kg/m^3

3.1.2 Robosand:

The properties of robosand are shown in Table 4.2. The Fineness property of robosand coincides with river sand. The bulk density of robosand is slightly more than the river sand which may increase the density of concrete overall. The moisture content is very less and satisfactory for usage. The shape of the particles is angular and sharp edges which will decrease the bind ability property to the cement concrete. On the other hand the saw dust will increase the binding property.

Table 4 Properties of robosand:

Sl. No	Parameters	Values
1	Specific gravity	2.4
2	Fineness modulus	2.35
3	Bulk Density	1750Kg/m^3
4	Moisture content	1.85%

3.1.3 River sand:

The properties of river sand are listed in Table 4.3. It satisfies the IS 383 – 1987 requirements in terms of fineness modulus of zone 2 grading requirements. Other properties like density and moisture content are satisfactory for concreting purpose.

Table 5 Properties of river sand:

Sl. No	Parameters	Values
1	Fineness modulus	2.5
2	Bulk Density	1460Kg/m^3
3	Moisture content	1.50%

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3.1.4 Cement

Ordinary Portland cement of 53 Grade conforming to IS 12269 – 1987 was used for the present experimental investigation. The cement was tested as per the Indian Standards IS 4031 – 1988.

Table 6 Properties of cement

Sl. No	Property	Result	Permissible limit as per IS: 12269 – 1987
1	Normal consistency	32%	NA
2	Initial setting time	45 min	Not less than 30 min
3	Final setting time	480 min	Not more than 600 min
4	Specific Gravity	3.15	Not less than 3.15
5	Fineness of cement (90 micron sieve)	5% retained	Not more than 10%

3.1.5 Coarse aggregate:

Aggregates are the important constituent in concrete. They give body to the concrete, reduce shrinkage and effect in economy. The aggregate occupy 70-80 per cent of volume of concrete. The Aggregates were tested as per the Indian Standards IS 2386 – 1963 for impact value and crushing value. The properties of coarse aggregate used are given in Table 4.5.

Table 7 Properties of coarse aggregate:

Sl. No.	Parameters	Value
1	Specific gravity	2.8
2	Water absorption	1.2
3	Crushing value%	15.8
4	Impact value%	17.6

3.2. COMPRESSIVE STRENGTH:

Experimental results for cube compressive strength for mix M0, M1, M2, M3 & M4 for 7 and 28 days are tabulated in Table 4.6. The graphical representation of compressive strength for various mixes at 7 and 28 days is shown in Fig. 1.

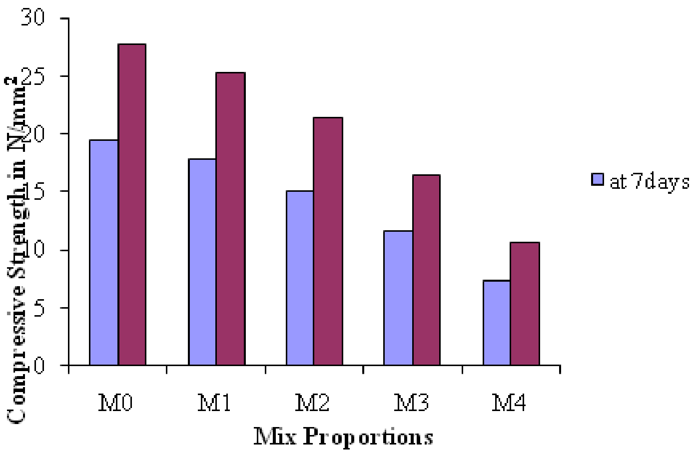

Figure 1 Compressive Strength of cube specimens

It shows the compressive strength for various mixes for 7 days and 28 days. The 28 days strength is more than 7 days strength for all mixes. Compared to normal controlled concrete the compressive strength gradually decreases for sawdust and robosand concrete.

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Table 8 Compressive strength of various mix proportions at 7 & 28 days

MIX	Specimen No.	Weight (kg)	Compressive strength at 7 days			Compressive strength at 28 days		
			Load (KN)	Stress (N/mm^2)	Average (N/mm^2)	Load (KN)	Stress (N/mm^2)	Average (N/mm^2)
M0	1	8.90	432	19.20	19.55	626	27.82	27.78
	2	8.97	446	19.82		620	27.56	
	3	8.93	442	19.64		629	27.95	
M1	1	8.60	391	17.38	17.78	563	25.02	25.24
	2	8.67	402	17.87		567	25.20	
	3	8.59	407	18.09		574	25.51	
M2	1	8.25	334	14.84	15.02	477	21.20	21.42
	2	8.32	352	15.64		483	21.47	
	3	8.33	328	14.58		486	21.60	
M3	1	8.09	275	12.22	11.64	373	16.57	16.44
	2	7.99	258	11.47		377	16.76	
	3	8.01	253	11.24		360	16.00	
M4	1	7.82	160	7.11	7.33	242	10.76	10.58
	2	7.71	170	7.56		233	10.36	
	3	7.72	165	7.33		239	10.62	

3.2.1 Discussions on compressive strength:

(i)The Compressive strength gradually decreases for the increasing replacement percentages. This is a negative sign for using it as Structural concrete. It is found that the 70% of Compressive strength at 28 days is achieved at 7 days which is as per standards.

(ii)Mix M1, gives 25.24 N/mm2 of characteristic compressive strength at 28 days may be used for Foundation concrete where M25 is required also in some non structural precast concrete units.

(iii)Mix M2 gives 21.42 N/mm2 of characteristic compressive strength at 28 days may be used for non load bearing concrete and precast units of M20 grade strength and may also be used for hollow blocks, Flooring and pavement concrete etc.

(iv)Mix M3 & M4 gives 16.44 N/mm2 and 10.58 N/mm2 of characteristic compressive strength at 28 days respectively, which are less than the M20 grade strength and would not be the optimum mixes.

(v)The cracking pattern is irregular for concrete cubes starting from the middle and spreading across the edges.

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Cracking is mild in nature without any breakage the ultimate load is reached.

(vi)From the above results it is identified that the optimum mix proportion for the optimum compressive strength is M2 which is totally 50% replacement of fine aggregate having 10% of saw dust and 40% of robosand. This gives the average characteristic compressive strength of 21.42 N/mm2 which is more than M20.

3.3. SPLIT TENSILE STRENGTH:

Experimental results for split tensile strength for mix M0, M1, M2, M3 & M4 for 7 and 28 days are tabulated in Table 4.7. The graphical representation of split tensile strength for various mixes at 7 and 28 days is shown in Fig. 2

Table 9 Split tensile strength of various mix proportions at 7 & 28 days

MIX	Specimen No.	Split Tensile strength at 7 days			Split Tensile strength at 28 days		
		Load (KN)	Stress (N/mm^2)	Average	Load (KN)	Stress (N/mm^2)	Average
M0	1	181	2.56	2.62	219	3.10	3.18
	2	188	2.66		224	3.17	
	3	186	2.63		232	3.28	
M1	1	182	2.57	2.50	210	2.97	3.11
	2	175	2.48		227	3.21	
	3	174	2.46		223	3.15	
M2	1	139	1.97	2.04	175	2.48	2.55
	2	142	2.01		182	2.57	
	3	151	2.14		183	2.59	
M3	1	93	1.32	1.40	128	1.81	1.77
	2	101	1.43		122	1.73	
	3	103	1.46		125	1.77	
M4	1	68	0.96	0.98	102	1.44	1.36
	2	72	1.02		97	1.37	
	3	67	0.95		89	1.26	

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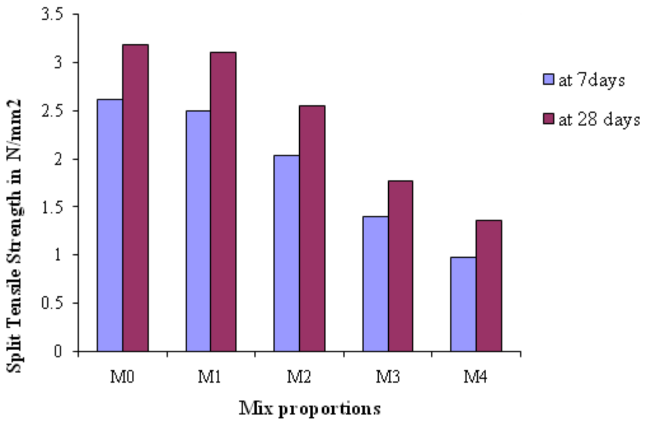


Figure 2 Split tensile strength of cylinder Specimens

3.3.1 Discussion on split tensile strength:

Like Compressive strength the Split tensile strength also gradually decreases for the increasing replacement percentages. The tensile strength of nearly 70% of strength at 28 days is achieved at 7 days. The optimum results are obtained for mix M2.

3.4.WEIGHT REDUCTION:

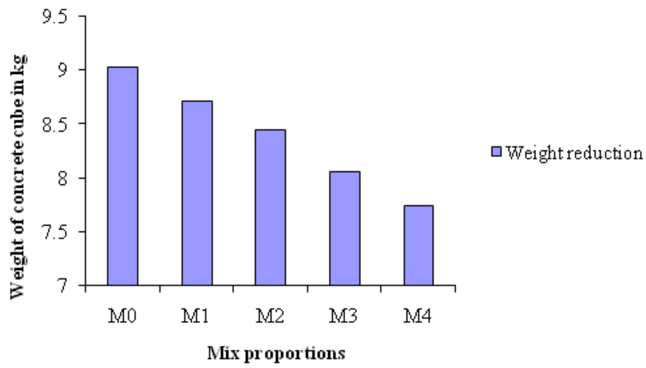
The weight of the concrete cubes is recorded for calculating weight reduction properties of saw dust and robosand concrete. Table 4.8 shows the weight reduction obtained for various mixes in percentage. The graphical representation is shown in Fig. 4.3. It is evident from the graph that the decrease in weight obtained for mixes having higher sawdust and robosand percentages For 25% of total replacement of river sand with sawdust and robosand a weight reduction of 3.5% is achieved. For 50% of total replacement 7.1% is achieved. For 75% of replacement 10% and for 100% replacement 13% is achieved.

Table 10 Weight Reduction of concrete of various mix proportions:

Sl.No.	Mix	Weight of 1 Cube in kg	Weight reduction in %
1	M0	8.93	0
2	M1	8.62	3.5
3	M2	8.30	7.1
4	M3	8.03	10.1
5	M4	7.75	13.2

3.4.1.Discussion on weight reduction:

Weight reduction is calculated and compared based on the nominal mix concrete. Weight of concrete cube gradually reduces as the replacement percentage increases. The density of concrete for the optimum mix is arrived as 24.1 KN/m3 which is nearly 7% less than the nominal mix concrete. Reduction in weight results in reduced self weight of structure which ultimately reduces the structural design details and ultimately reduces the construction cost.



3.5.COMPARISON OF STRENGTH OF CONCRETE:

The compressive strength and Split tensile strength at 28 days for various mix proportions are compared and shown in graph in Fig.4.4. It is clear from the graph that the compressive strength and Split tensile strength gradually decreases for the increasing replacement percentages.

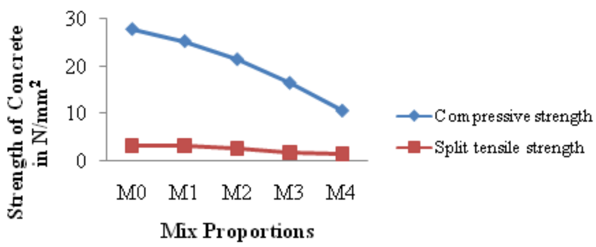


Figure 4 Comparison of strength of concrete

3.6.COST ANALYSIS:

For the optimum mix proportion M2 the cost is compared with the nominal controlled mix concrete. Table 4.9 shows the Cost analysis for M20 grade of optimum mix concrete which is totally 50% replacement with 10% of saw dust and 40% of robosand.

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Table 11 Cost Analysis:

Sl.No.	Materials Required	Cost/kg	Quantity in kg/ m^3		Cost of Concrete in Rs./m^3	
			Nominal mix	Sawdust and Robosand	Nominal mix concrete	Sawdust and Robosand
1	Cement	6.60	395	395	2607	2607
2	River sand	0.85	569	284.5	483.65	241.82
3	Robosand	0.40		227.6		91.04
4	Saw Dust	1.20		56.9		68.28
5	Coarse Aggregate	0.68	1250	1250	850	850
Grand Total					3940.65	3858.14

3.6.1.Discussion on cost reduction:

The Cost is reduced up to Rs.82.51 per cubic meter of Concrete. This is nearly 2% reduction of the total cost per cubic meter of concrete. This will increase when the lead distance for the river sand increases and also where the saw dust is abundantly available such as in tropical areas where the cost of saw dust is very less. The reduction in weight is also indirectly reduces the cost of construction which is not projected in the calculation.

4.CONCLUSIONS:

4.1.GENERAL:

This study presents the effective way of utilising saw dust and robosand aggregates in concrete. Presently, robosand is available at a low price in market and saw dust is available in most of the tropical countries at free of cost or at very lower price. Also from the results it is proved that the concrete obtained using saw dust and robosand aggregates satisfy the minimum requirements of M20 grade of concrete. The Weight is also reduced. Hence it is possible to make M20 grade of normal concrete making use of saw dust and robosand as fine aggregates.

4.2.CONCLUSIONS:

Based on the investigation on sawdust and robosand concrete, the following conclusions were made.

(i)28-day compressive strength and split tensile strength of the concrete decreases gradually for the increasing replacement percentages.

(ii)The cube compressive strength at 7 days results in 70% of the characteristic compressive strength at 28days acquired.

(iii)The 25% replacement gives the compressive strength of 25.24N/mm2 and 50% replacement results in 21.42N/mm2. Both mixes achieve the targeted mean strength of 20N/mm2.

(iv)The compressive strength obtained for the replacement of fine aggregate by 50% totally with sawdust 10% and robosand 40% was proved to be the optimum mix to get M20 grade of Concrete.

(v)This sawdust and robosand concrete can be used in the production of non-load bearing precast concrete units, Flooring and pavement concretes, Hollow blocks and Flooring Tiles.

(vi)For the optimum mix the weight reduction up to 7% and the cost reduction up to Rs.85 per cubic meter of concrete is achieved.

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4.1.SCOPE FOR FUTURE STUDY:

(i)There are possibilities to increase the strength by adding admixtures. Tests are to be carried out with different admixtures which give optimum results.

(ii)The acid resistance tests and water absorption tests are to be carried out as the saw dust is weak in reacting with these liquids.

(iii)The fresh concrete properties are to be analysed and found out experimentally for the practical use of concrete.

(iv)The thermal and fire resistance properties are to be tested for the performance of sawdust under such conditions.

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