Experimental Study on Partial Replacement of Sand with Robosand and Sawdust

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Abstract: Sand is used primarily for construction in India. Sand will become scarce as a result of its rapid use. Robodust and Sawdust is utilized in place of the sand to combat this scarce of shortage. Western nations and a few Indian states have recognized the use of crusher dust, also known as Robosand, as a building material. Crushed stone dust has been extensively studied as a river sand substitute, and it has been found that it can be used to partially substitute for natural sand in concrete. Compressive and split tensile strengths of sawdust and robosand in the proportion utilized as fine aggregates in concrete were going to be examined.
This project's primary goal is to examine the behavior of M25 grade concrete with a 1:1:2 mix design and a water-to-cement ratio of 0.45. In this instance, 25%, 30% of robosand, and 5% sawdust were used to replace some of the fine aggregate. One of the substitutes for river sand is the crusher dust generated by granite crushers and by-products from a quarry.

***Keywords*: Robosand, sawdust, crusher dust, fine aggregates, quarry.**

1. INTRODUCTION

India's construction industry has boomed in recent years, leading to numerous infrastructure development projects all around the country. This is partly attributable to the continuous economic expansion and the politically stable environment, which have drawn both domestic and foreign investment. As a result, there is a greater need for construction materials that are both appropriate and affordable. As the nation works to become a middle-income economy by 2030, demand is expected to increase even more.
Due to its many benefits, particularly its strength, concrete has been utilized as the favored building material for most construction projects. Since aggregates make up between 60 and 75 percent of the overall volume of concrete, choosing the right aggregates is crucial. They not only add to the strength that concrete possesses, but also to its bulkiness, which makes it possible to lay the concrete. The underlying mechanisms influencing concrete strength, cracking, etc. have been better understood thanks to studies on aggregates. This led to changes being made to the aggregates used in concrete with the intention of either improving or totally altering the qualities of the concrete produced, leading to the use of special concretes including light-weight, porous, and no-fines concrete.
Concrete has been made less dense by adding various elements, particularly those that are highly porous. These can be categorized as either natural or artificial aggregates depending on where they came from. Pumice, scoria, and tuff are a few examples of natural light-weight aggregates. These are formed from igneous rocks and are frequently glassy in appearance. However, they contain distinct networks of holes, with pumice showing tube-like spaces, scoria having spherical voids, and tuff having an uneven pore structure. The materials are first crushed and sieved to the proper gradation before usage. Pumice was really employed in the construction of the Pantheon dome in ancient Rome, which is where lightweight concrete first became popular. The structure is still standing today, demonstrating the strength of lightweight concrete.

Need for Robosand: The natural sand that is currently available, according to civil engineers, architects, builders, and contractors, is lacking in many important ways. It lacks the necessary number of fine particles in the right proportion. Other contaminants including coal, bones, shells, mica, and silt, among others, render it unsuitable for use in cement concrete. The life of the work is shortened by the degradation of these materials brought on by the effects of weathering. Lower percolation of rainwater into the ground due to the pulling of the sand from the riverbed results in lower ground water levels.

1.1 Objectives:

1. To research the characteristics of robosand and sawdust.
2. To assess the strength of concrete made with sawdust and synthetic sand in place of river sand.
3. To identify the optimum usage of saw dust and robosand concrete.

2. LITERATURE REVIEW

[2.1] S. Rukmangadhara Rao et al. (2015) "Study on Strength of Concrete Using Robo Sand as a Partial Replacement of Fine Aggregate" studied two grades of concrete M25 and M35 at different replacements of natural sand by robo sand. The results were quite satisfying that when the 50% of natural river sand wasreplaced by robo sand, the compressive strength was found out to be maximum rather than 0%, 75% and 100% replacement. It was concluded that the compressive strength at 50% replacement was 36.15 N/mm² for grade M25 and 49.33 N/mm² grade M35.
[2.1] K. Srinivas Reddy et al. (2016) "Replacement of Natural Sand with Robo/Artificial Sand in Specified Concrete Mix" compared the results of the concrete containing different percentages of robo sand with a reference mix. Compressive strength of concrete (grade M25) was investigated at percentage replacement of 0%, 20%, 40%, and 60% of natural sand with robo sand or quarry dust at a water-cement ratio of 0.44. Results were matched with reference mix of 0% replacement. The compressive strength of cement concrete with 20%, 40%, 60% replacements were much more than that of reference mixes. According to price - service ratio the use of robo sand gives effective results; the cost of robo sand is 30-50% less in market which is good for production of economical concrete. The service of robo sand is also as good enough for as natural sand concrete.
[2.3] Thomas Joseph Odero et al. (2016) has carried the experiment by replacing 5%,10% and 25% by volume of sand with sawdust. In this paper different properties of sawdust and sand (mois- ture content, specific gravity, fineness modulas, grading of aggregate) was tested along with compressive tensile and flexural strength test of SC and OC of 7& 28 days. As lowering the value of sawdust in the concrete mixture giving higher strength in 28 days but by increasing sawdust content the 7 days strength get on increasing. Results showed that the compressive strength decreased with higher sawdust content with replacements beyond 10% resulting in a considerable strength decrease. From the above paper we have a clear ideation that saw-dust can be used in field purpose having 10% of saw-dust of total fine aggregate volume.
[2.4] Naveen Kumar & B. Siva Babu (2017) The study of replacement of river sand in concrete with rock sand that the suitability of Crushed Rock fine (CRF) to replace river sand in concrete production for use in rigid pavement was investigated. Strength tests are studied with River sand and Artificial Sand, for Low grade concrete and high-grade concrete. 7 days Peak compressive strength values for Low grade concrete and High-grade concrete 174.81 Kg/cm 2 and 441 Kg/cm 2 respectively were obtained with River sand, with the replacement of river sand with CRF, as against values of 18667 Kg/cm 2 and 468.14 Kg/cm 2, obtained Based on economic analysis and results of tests, river sand replaced with CRF is recommended for use in the production of concrete for use in rigid pavement.

3. MATERIALS AND PROPERTIES

3.1 Materials collection:
Cement: Cement is a vital component of the infrastructure sector and is produced in a variety of compositions for a wide range of applications. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property. Portland cement is the most widely used cement.
Fine aggregate: Those particles passing the 4.75 mm sieve, and predominantly retained on the 75 µm sieve are called fine aggregate. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent. For increased workability and for economy as reflected by use of less cement, the fine aggregate should have a rounded shape. The result of sieve analysis confirms to zone-II (according to IS: 383-1970)
Coarse Aggregate: The term "coarse aggregate" refers to those particles that are primarily retained on the 4.75 mm sieve and will pass through a 3-inch screen. The coarser the aggregate, the more economical the mix.

Water: A vital component in the creation of concrete is water. Water serves two purposes in concrete mixtures: first, it chemically reacts with the cement to cause it to set and harden, and second, it lubricates the other components and makes the concrete workable. The pH of the water used to make concrete should be between 6 and 8.

Robosand: River sand is replaced by manufactured sand (M-Sand) for making concrete. Crushing hard granite stone yields manufactured sand. The crushed sand is graded, rinsed, and shaped into a cubical shape with grounded edges for use in construction. Man-made sand has a grain size of less than 4.75mm.

Sawdust: Sawdust is obtained from wood. The sawdust is made up of hardwood chippings from diverse species. It was solar dried and stored in water-resistant bags.1.18mm mesh is used to sift the sawdust. It was initially cleaned since it comprises a variety of dust and extraneous debris that would have accumulated during the manufacturing of sawdust. Sawdust was treated before being used in concrete.

3.2 Tests on Materials:

3.2.1 Cement:

3.2.1.1 Initial and final setting time: We need to calculate the initial and final setting time as per IS:4031 (Part-5)-1988. To do so we need Vicar apparatus conforming to IS: 5513-1976, Balance, Gauging trowel conforming to IS: 10086-1982.

3.2.1.2 Consistency test: The basic aim is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principal is that standard consistency of cement is that consistency at which the Vicar plunger penetrates to a point 5-7 mm from the bottom of Vicar mould.

3.2.1.3 Specific gravity test: Specific gravity is the ratio of a given volume of material of an equal volume of water. To determine the specific gravity of cement, kerosene which does not react with cement is used.

Table 1 Test results of Cement

S.NO.	Test	Test Result	IS: 12269-1897 specifications
1	Initial setting time (minutes)	30 minutes	>30 minutes
2	Final setting time (minutes)	600 minutes	<600 minutes
3	Consistency	32%	-
4	Specific gravity	3.1	3.15
5	Fineness	94%	90-100

3.2.2 Fine Aggregate: When the total aggregate material is sieved through 4.75mm IS sieve, the aggregate passing through 4.75mm IS sieve, is called fine aggregate. For examples: River sand, sea sand. But also silt and clay come under this category. The purpose of the fine aggregate is to fill the voids in the coarse aggregate and to act as a workability agent.

3.2.2.1 Gradation Test: In a gradation analysis, a sample of dry aggregate of known weight is separated through a series of sieves with progressively smaller openings. Once separated, the weight of particles retained on each sieve is measured (Figure 2) and compared to the total sample weight.

Table 2 Gradation test on fine aggregate

S.NO	Sievesize (mm)	Weight retained (gm)	% Retained=wt. retained/ wt. taken *100	Cumulative %Retained	% Passed
1	4.75	36	3.6	3.6	96.4
2	2.36	40	4	7.6	92.4
3	1.18	342	34.2	41.8	58.2
4	0.6	298	29.8	71.6	28.4
5	0.3	268	26.8	98.4	1.6
6	0.15	16	1.6	100	0
7	pan	0	0	0	0

Result: Cumulative % retained = 323

Fineness Modulus= 323/100 = 3.23

3.2.2.2 Specific gravity and water absorption test for fine aggregate:

Specific gravity of fine aggregate is the ratio of the weight of the givenvolume of aggregate to the weight of equal volume of water. As IS 2386 Part – 3 (1963) Specific gravity of fine aggregate should lie between 2.65- 2.67. Aggregates having more water absorption are more porous in nature and are generally considered unstable unless they are found to be acceptable based on strength. The limiting water absorption value for fine aggregate lies between 0.3- 2.5% as per BS8007.

Water absorption = 1.35

Specific gravity= 2.57

3.2.2.3 Bulking of fine aggregate:

Bulking of fine aggregate is the phenomenon of increase of moisture content. Bulking test on fine aggregate must be performed before using it in construction. As per IS 2386-3 (1963) bulking of sand should lie between 15%-35%.

Result: Bulking of sand = 25%

3.2.2 COARSE AGGREGATE: Concrete is made with coarse aggregates, which are granular and uneven materials like sand, gravel, or crushed stone. Coarse is typically found in nature and can be obtained by blasting quarries or crushing them manually or with crushers.

3.2.3.1 Gradation Test on coarse aggregate: Coarse aggregate is the one retained on 4.75mm IS sieve. When the aggregate contains sizes differently in suitable proportions it is called graded aggregate.

Table 3 Gradation test on coarse aggregate

S.NO	Sieve size(mm)	wt. of aggregate retain (gm)	% of wt.retain	Cumulative %of wt. retained
1	80	0	0	0
2	40	1327	29.48	29.48
3	20	1688	37.51	66.99
4	12.5	210	4.53	71.52
5	10	225	4.85	76.37
6	4.75	905	20.11	96.48
7	pan	145	3.22	99.7

Cumulative % retained = 440.54

Fineness modulus=440.54/100=4.4054

As per IS 383 (1970) gradation of coarse aggregate should lie between 5.5 - 8.0

3.2.3.2 Specific gravity and water absorption test on Coarse aggregate: The specific gravity of sand is around 2.5 to 3 Aggregates having more water absorption are more porous in nature and are generally considered unstable unless they are found to be acceptable based on strength.

Specific gravity of coarse aggregate = 2.63

Water absorption of coarse aggregate = 0.81%

As per IS 2386 (Part-3) 1963 specific gravity of coarse aggregate lie between 2.5 to 3and water absorption of coarse aggregate lie between 0.1 to 2%.

3.2.3.3 Bulk density of coarse aggregates: The bulk density measures the volume that the graded aggregate will occupy inconcrete. Including the solid particles and the voids between them.

Result: Loose bulk density = 1.356 kg/lt.

Compacted bulk density = 1.522 kg/lt.

As per IS 2386 (Part-iii)-1963 bulk density of coarse aggregate should lie between1450-2082 kg/m3.

3.3 Determination of Physical Properties of Sand and Sawdust:

3.3.1 Grading Test: The grading of the sand and sawdust were determined by sieve analysis. A sample of both materials of known weight was passed through a series of sieves with progressively smaller openings.

Procedure: The test samples were dried to a constant mass by oven drying at about1050C.An approximate sample was taken from the original and the required sample was weighed out. The sieves were then arranged one over the other in relation to their size of opening 10mm, 5mm, 2.36mm, 1.18mm, 0.6, 0.3, 0.150, 0.075, <0.075. The sieves were shaken horizontally with a jerking motion in all directions for at least 2 minutes and until all material passing fell into the tray. Any material retained on each sieve was weighed and the results tabulated. The cumulative weight passing each sieve was calculated as percentage of the total sample. Finally, grading curve for the sample was plotted in the logarithmic chart.

3.3.2 Moisture Content: Moisture content represents the water in excess of saturated surface dry state.

Procedure: The weight of surface dried fines was determined each recorded as (W1). They were then placed in an oven at 105°C 24 hours. After removal from the oven, their weight determined and recorded as (W2). The moisture content is determined asa percentage by (W1-W2W2.

Result: The moisture content of sawdust is 10%.

3.3.3 Specific gravity: Specific gravity is a measure of material density relative to that of water. It shows how many times the material is denser than water.

Procedure: The fines aggregates were passed through sieve number 7. The weight of the empty volumetric flask fitted with a stopper was measured (WI). A sample of the fines(15g) was placed in the volumetric flask and the weight measured (W2). The volumetric flask was then filled with water, stopper fitted and weight determined (W3). Finally, the weight of the volumetric flask filled with water only andfitted with a stopper was determined (W4). The specific gravity is then given by:

G_s= (W2-W1) (W4-W1) -(W3-W2)

Result: The specific gravity of sawdust= 2.4

3.4 Tests on Robosand

3.4.1 Gradation Test on Robosand:

Objective: The whole procedure of sieve analysis is to determine the particle size distribution of fine aggregate and determine whether it is suitable to use in concrete mixing.

Apparatus: A series of IS sieves, weighing balance, Sieve Shaker, Tray.

Procedure:

- Clean all the sieves using a wire brush to be clear of aggregates stuck in somegaps.
- Then we must prepare the sieves onto the shaking machine from top to bottom.
- Weight the sample to exactly 1000g.
- The sample is sieved by using the set of IS sieves for 10 minutes.
- After sieving is done the aggregate on each sieve is weighted individually.
- Cumulative weight passing through each sieve is calculated as a percentage of the total sample weight.

Table 4 Gradation test on Robosand

S.NO	Sieve size (mm)	Weight retained (gm)	% Retained=wt. retained/ wt. taken *100	Cumulative %Retained	% Passed
1	4.75	5	0.5	0.5	99.5
2	2.36	95	9.5	10	90
3	1.18	250	25	35	65
4	0.6	116	11.6	46.6	54.4
5	0.3	270	27.5	73.6	26.4
6	0.15	135	13.5	87.1	12.9
7	pan	0	0	0	0

3.4.2 Specific gravity of Robosand:

Introduction: Specific gravity is a measure of material density relative to that of water. Itshows how many times the material is denser than water.

Apparatus: 100 ml volumetric flask with a stopper, a balance to weigh accurately to 0.5g, distilled water.

Procedure: The fines aggregates were passed through sieve number 7. The weight of the empty volumetric flask fitted with a stopper was measured (WI). A sample of the fines(15g) was placed in the volumetric flask and the weight measured (W2). The volumetric flask was then filled with water, stopper fitted and weight determined (W3). Finally, the weight of the volumetric flask filled with water only andfitted with a stopper was determined (W4).

The specific gravity is then given by:Gs= (W2-W1) (W4-W1) -(W3-W2)

The specific gravity of sawdust = 2.5

4. EXPERIMENTAL DETAILS

4.1 Volume Calculations

4.1.1 Cube Calculations:

Volume of Cube = 0.15*0.15*0.15 = $3.375*10^{-3}$ m^3

Dry concrete volume = $3.375*10^{-3}*1.54$ = $5.1975*10^{-3}$ m^3

M25 Grade of concrete = 1:1:2

Cement volume = ¼*$5.1975*10^{-3}*1400$ m^3

= 0.25*0.0051975*1400

= 1.82 kg

Fine aggregate = ¼*5.1975*10^{-3}*1600 m^3
= 2.079 kg
Coarse aggregate = 2/4*5.1975*10^{-3} =
2.598*10^{-3}*1800 = 4.68 kg

4.1.2 Cylinder Calculations:

Volume of Cylinder = Π/4*0.15*0.15*0.3 =
5.301*10^{-3} m^3
Dry concrete volume = 5.301*10^{-3}*1.54 =
8.163*10^{-3} m^3
M25 Grade of concrete = 1:1:2
Cement volume = ¼*8.163*10^{-3}*1400 m^3
= 0.25*0.008163*1400
= 2.85 kg
Fine aggregate = ¼*8.163*10^{-3}*1600 m^3
= 3.2652 kg
Coarse aggregate = 2/4*8.163*10^{-3} =
4.0815*10^{-3}*1800 = 7.345 kg

4.1.3 Prism Calculations:

Volume of Prism = 0.1*0.1*0.5 = 5*10^{-3} m^3
Dry concrete volume = 5*10^{-3}*1.54 =
7.7*10^{-3} m^3
M25 Grade of concrete = 1:1:2
Cement volume = ¼*7.7*10^{-3}*1400 m^3
= 0.25*0.0077*1400
= 2.695 kg
Fine aggregate = ¼*7.7*10^{-3}*1600 m^3
= 3.08 kg
Coarse aggregate = 2/4*7.7*10^{-3} = 3.85*10^{-3}*1800 = 6.93 kg

4.2 Mixing of Concrete:

The batch mixer for concrete was used to mix the concrete. The procedure was carried out as stated. The proper amounts of each mix's components were fed into the mixer in the following order: coarse aggregates at the bottom, then a layer of fine aggregate, and finally a layer of cement. This was accomplished by adding the required amount of cement to a container with a given weight. Note how much cement is in the container. In order to calculate the quantity to be used as replacement and replacement of fine aggregate, the same container was subsequently filled with robosand and sawdust to the level marked beforehand. The mixer was then shut off, and the mixture was mixed for 5 minutes to create a uniform dry mix. When the concrete was thoroughly mixed, water was added and dispersed uniformly over the mixture as the mixer rotated. Before casting in Molds, the workability of the concrete was assessed.

4.3 Tests on Fresh Concrete Workability

Fresh concrete's ability to fully compress without bleeding or segregation in the final product is measured by the quantity of practical internal work required. Workability is one of the concrete's physical characteristics that influences the material's strength and durability as well as labour costs and the final product's aesthetics. When concrete is put and compacted uniformly, that is, without bleeding or segregation, it is workable. Unworkable concrete requires more work or effort to compact in place, and the completed concrete may also have honeycombs or pockets.

The following factors may affect the workability of concrete, depending on the water-to-cement ratio:

1. Slump cone test
2. Compaction factor test
3. Vee-Bee consistometer test

4.3.1 Slump Cone Test:

Objective: To find the workability of concrete.

Apparatus: Mold for slump test i.e., slump cone, non-porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tampingrod is of steel 16 mm diameter and 60cm long and rounded at one end.

Procedure: Clean the internal surface of the mould and apply oil. Place the mould on a smooth horizontal non- porous base plate. Fill the mould with the prepared concrete mix in 4 approximately equal layers. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate the underlying layer. Remove the excess concrete and level the surface with a trowel. Clean away the mortar or water leaked out between the mould and the base plate. Raise the mould from the concrete immediately and slowly in vertical direction. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested. When the slump test is carried out, following are the shape of the concrete slump that can be observed.

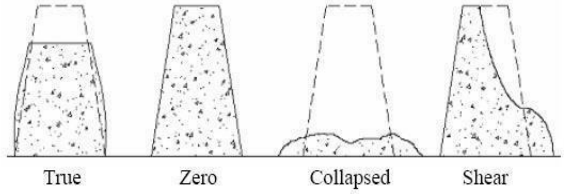

Fig 4.1 Type of concrete slump test results

Result: Slump value = 1cm

True Slump – True slump is the only slump that can be measured in the test. The measurement is taken between the top of the cone and the top of the concrete after the cone has been removed as shown in figure.

Zero Slump – Zero slump is the indication of very low water-cement ratio, which results in dry mixes. This type of concrete is generally used for road construction.

Collapsed Slump – This is an indication that the water-cement ratio is too high, i.e., concrete mix is too wet or it is a high workability mix, for which a slump test is not appropriate.

Shear Slump – The shear slump indicates that the result is incomplete, and concreteto be retested.

4.3.2 Compaction Factor Test:

Objective: Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete.

Apparatus: Compaction factor apparatus consists of trowels, hand scoop (15.2 cm long), a rod of steel or other suitable material (1.6 cm diameter, 61 cm long roundedat one end) and a balance.

Procedure: Place the concrete sample gently in the upper hopper to its brim using the handscoop and level it. Cover the cylinder. Open the trapdoor at the bottom of the upper hopper so that concrete falls into thelower hopper. Push the concrete sticking on its sides gently with the road. Open the trapdoor of the lower hopper and allow the concrete to fall into the cylinder below. Cut of the excess of concrete above the top level of cylinder using trowels andlevel it. Clean the outside of the cylinder. Weight the cylinder with concrete to the nearest 10 g. This weight is known as theweight of partially compacted concrete (W1). Empty the cylinder and then refill it with the same concrete mix in layers approximately 5 cm deep, each layer being heavily rammed to obtain full compaction. Level the top surface. Weigh the cylinder with fully compacted. This weight is known as the weight of fully compacted concrete (W2). Find the weight of empty cylinder (W).

Calculation: The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. It shall normally to be stated to the nearest second decimal place.

Compaction Factor Value= (W1-W) / (W2-W)

Compaction factor of the concrete = The Compaction factor values ranges from 0.7 to0.95

Result: Compaction factor 0.89

Fig 4.2 Compaction Factor Test

4.3.3 Vee-Bee Tests:

Objective: To find the time required to change the shape of the concrete from cone to cylindrical in seconds.

Apparatus: A vibrator table that is rested on elastic supports and dimensions are 380X260X305 in mm, a sheet metal cone who is both ends are open and the dimensions are top diameter 200mm, bottom diameter 100mm, and height 300mm, a standard iron rod, tamp whose diameter is 20 mm and length is 500 mm. and a metal pot.

Procedure: Fill the sheet metal cone with the concrete in three layers as rodding done on each layer is the same as slump test. Then the glass plate girder is brought in such a way it gets in contact with the top surface of the concrete. Start the vibration table and the stopwatch too, so at the time when the concrete is subjected to vibration action. The concrete is permitted to spread out in the cylindrical cone. The time should be noted down from the stopwatch until the concrete surface becomes horizontal after switching off the stopwatch and the vibrating table too. The time is recorded in seconds which is taken by the concrete to change its shape from slump cone to cylindrical is known as Vee bee Test or Vee Bee degree.

Result: Time = 10 sec

Fig 4.3 Vee-Bee Test

4.4 Casting:
The molds used for the preparation of samples were cubes of size (150mm x150mm x 150mm) for compressive strength testing, the prisms of size (500mm x 100mm x 100mm) for flexural testing and the cylinders of size (150m x 300m) for split tensile strength testing. A total of 12 cubes, 12 cylinders and 12 prisms are casted of M25 grade. The molds were cleaned and oiled to enable easily removal of the hardened concrete cubes, cylinders, and prisms once they had set. The concrete was filled in the molds in layers and compact them.

4.5 Curing:
Curing of concrete is the last and one of the most important activities required to be taken. This last step plays a very significant role in concrete performance and needs the full and minute attention of the persons involved in construction and those involved with quality assurance. The cubes, cylinders and prisms were left in the open for 24 hours before being moved to a curing tank where they underwent wet curing. There should be sufficient water available in concrete so that the chemical reaction takes place between water and cement called "Hydration." Because of the hydration process, heat is generated called heat of hydration. Therefore, temperature increases inside the concrete and water evaporate from the concrete and concrete becomes hard.The object of curing is to control the temperature 45 inside the concrete, continuing hydration process and to prevent dryness of concrete. It is necessary that enough water should be available in concrete till attains its full strength.

Fig 4.4 Curing

4.6 Tests on Hardened Concrete
Hardened concrete is a type of concrete that is strong and have the capacity to bear the structural as well as service loads that are applied to it. Hardened concrete is concrete that is completely set and able to take the loads. The strength of the concrete plays a vital role in the construction of any building. The strength of the concrete helps to identify whether the concrete can be used in construction or not. The strength of the concrete is defined as the maximum amount of load which the concrete can bear.
Strength is considered as one of the most important and valuable properties of concrete. The strength of the concrete gives the overall idea of quality of the concrete and the materials used in the manufacturing of the concrete.
The concrete is tested for three types of strength which are: Compressive strength, Flexural test, Tensile strength.

4.6.1 Compressive Strength Test:
Objective: To determine the compressive strength of a cube.
Apparatus: Compression testing machine.
Procedure: Remove the specimen from the water after specified curing time and wipe outexcess water from the surface. Take the dimension of the specimen to the nearest 0.2m. Clean the bearing surface of the testing machine. Place the specimen in the machine in such a manner that the load shall be appliedto the opposite sides of the cube cast. Align the specimen centrally on the base plate of the machine. Rotate the movable portion gently by hand so that it touches the top surface of thespecimen. Apply the load gradually without shock and continuously till the specimen fails. Record the maximum load and note any unusual features in the type of failure.

Fig 4.5 Compression strength test

Compressive strength = Load/Area=P/A, Where A=150*150=22500 N/mm^2

4.6.2 Split Tensile Strength Test:
Objective: To determine the tensile strength of a cylinder.
Apparatus: Testing Machine.
Procedure: Initially, take the wet specimen from water after 7, 28 of curing; or any desired ageat which tensile strength to be estimated. Then, wipe out water from the surface of specimen. After that, draw diametrical lines on the two ends of the specimen to ensure thatthey are on the same axial place. Next, record the weight and dimension of the specimen. Set the compression testing machine for the required range. Place plywood strip on the lower

plate and place the specimen. Place the other plywood strip above the specimen. Bring down the upper plate so that it just touches the plywood strip. Apply the load continuously without shock. Finally, note down the breaking load (P).

Split tensile strength=2P/3.14*H*D

Where P= Load acting on cylinder, H=height of cylinder (300mm) and D=Diameterof the cylinder (150mm).

Fig 4.6 Tensile strength test

4.6.3 Flexural Tensile Strength Test:

Objective: To determine the flexural strength of a prism.

Apparatus: Testing Machine.

Procedure: The test should be conducted on the specimen immediately after taken out of thecuring condition to prevent surface drying which decline flexural strength. Place the specimen on the loading points. The hand finished surface of the specimen should not be in contact with loading points. This will ensure an acceptable contact between the specimen and loading points. Centre the loading system in relation to the applied force. Bring the block applying force in contact with the specimen surface at the loading points. Applying loads between 2 to 6 percent of the computed ultimate load. Load the specimen continuously without shock till the point of failure at aconstant rate.

Flexural strength = PL/BD^2

where P=Load, D=depth of prism (100mm), L=Length of the prism (500mm) andB=Breadth of prism (100mm)

5. RESULTS AND DISCUSSION

Table 5.1 Compressive strength test result 7 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	Area (mm^2)	Compressive strength(N/mm^2)
1	M25	0	0	382.5	22500	17
2	M25	5	25	388	22500	17.24
3	M25	5	30	390	22500	17.33

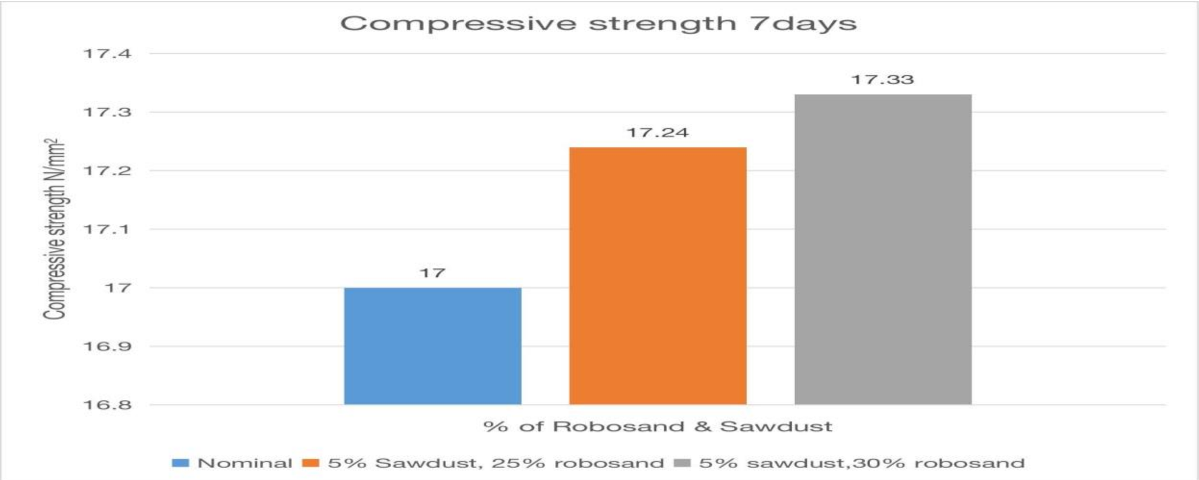

Fig. 5.1 Compression strength test result 7 days plot

The above results states that the addition of sawdust and robosand, the strength isincreased.

Table 5.2 Compressive strength test result 28 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	Area (mm^2)	Compressive strength(N/mm^2)
1	M25	0	0	562.5	22500	25
2	M25	5	25	567	22500	25.2
3	M25	5	30	573	22500	25.46

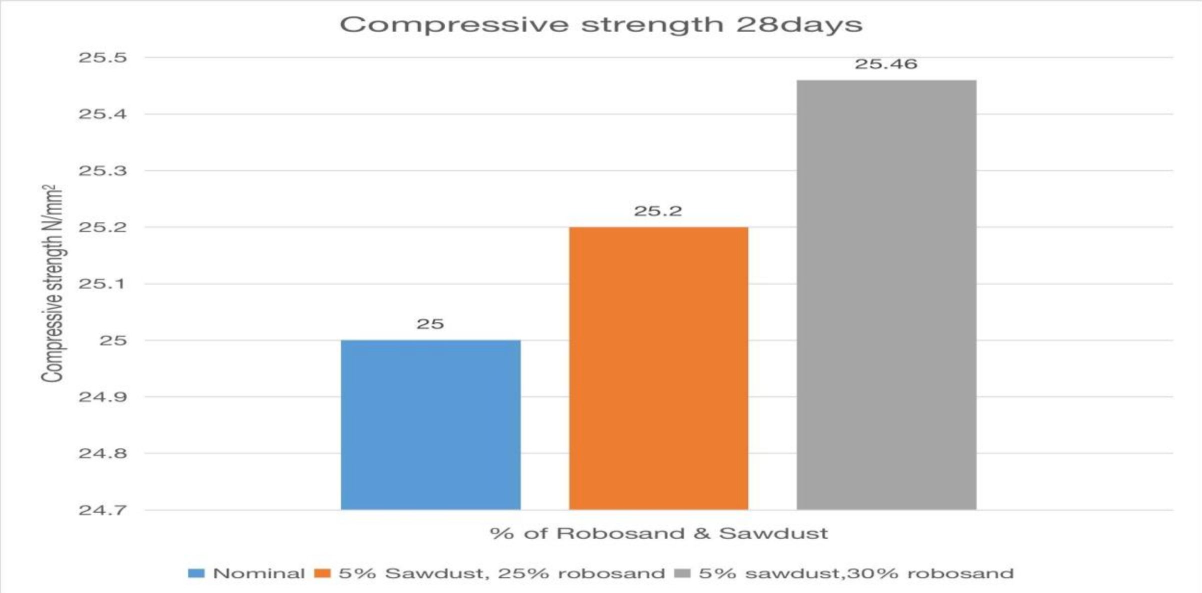

Fig. 5.2 Compressive strength test result 28 days plot

The above results states that the addition of sawdust and robosand, the strength isincreased.

Table 5.3 Split tensile strength test result 7 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	Diameter (mm)	Height (mm)	Split tensile strength (N/mm^2)
1	M25	0	0	182	22500	25	2.57
2	M25	5	25	186	22500	25.2	2.63
3	M25	5	30	188	22500	25.46	2.66

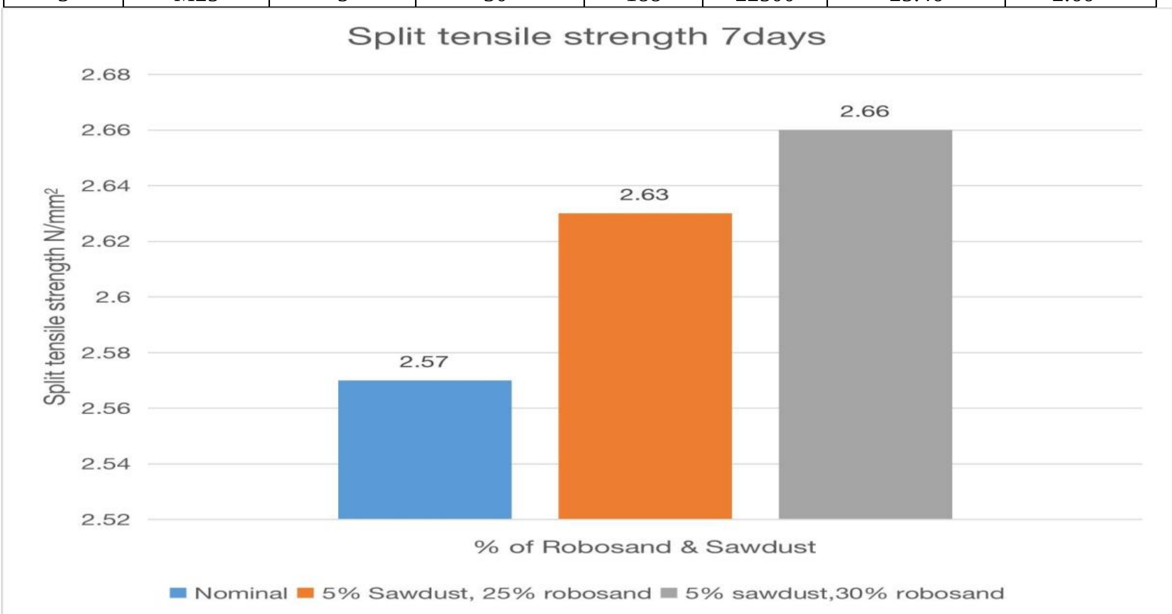

Fig. 5.3 Split tensile strength test result 7 days plot

Table 5.4 Split tensile strength test result 28 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	Diameter (mm)	Height (mm)	Split tensile strength (N/mm^2)
1	M25	0	0	182	22500	25	3.17
2	M25	5	25	186	22500	25.2	3.21
3	M25	5	30	188	22500	25.46	3.28

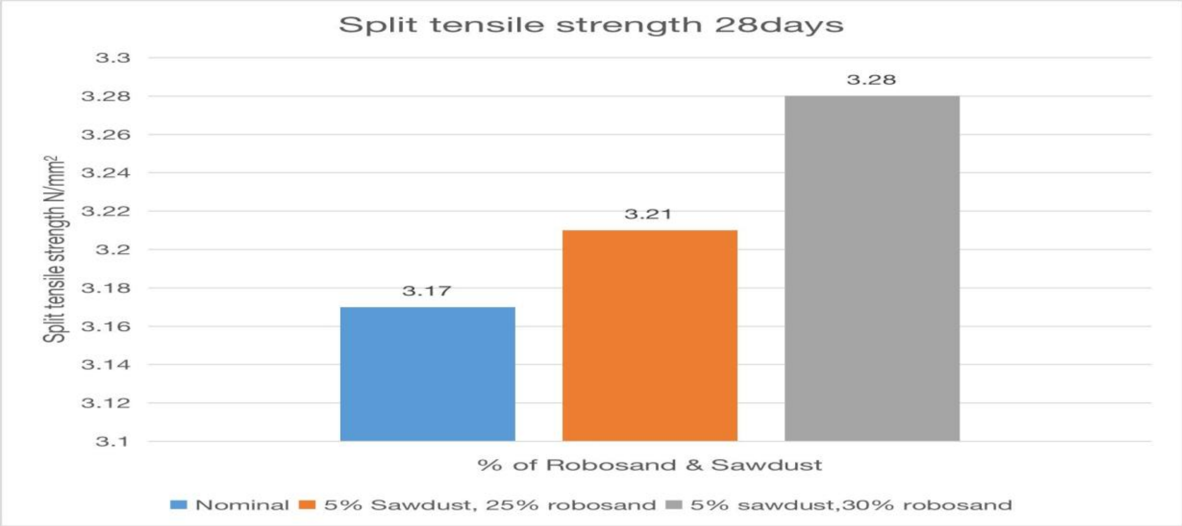

Fig. 5.4 Split tensile strength test result 28 days plot

Table 5.5 Flexural strength test result 7 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	L (mm)	BD^2 (mm^2)	Flexural strength (N/mm^2)
1	M25	0	0	22	22500	10000	2.88
2	M25	5	25	23	22500	10000	2.90
3	M25	5	30	25	22500	10000	2.91

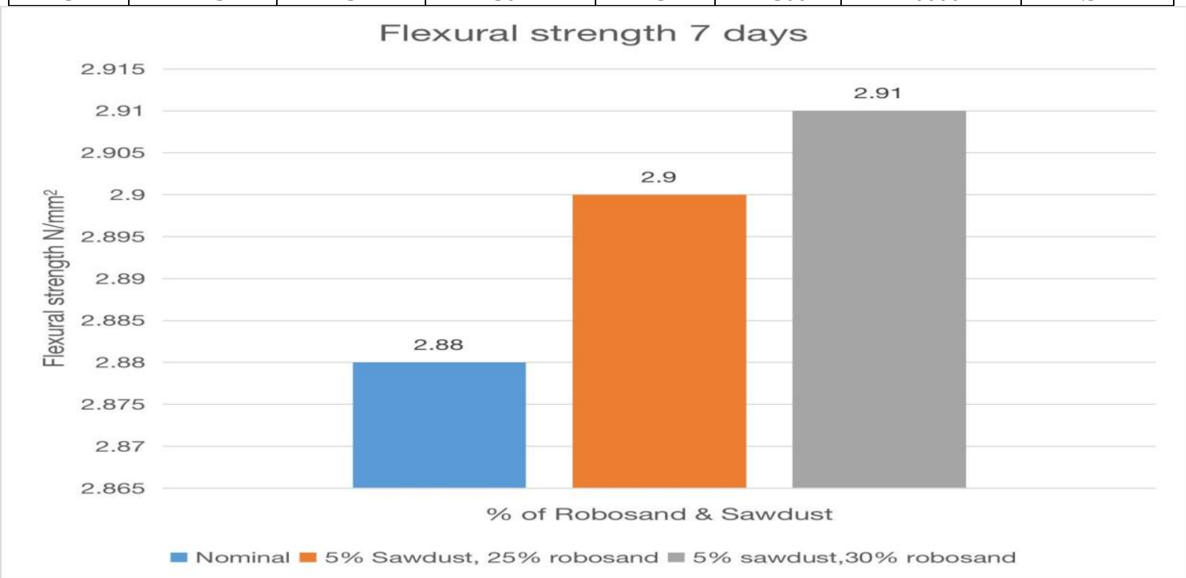

Fig. 5.5 Flexural strength test result 7 days plot

The figure shows the flexural strength of the beam when subjected to the flexural test and its flexural strength is obtained as table clearly shows the strength of 7 days beam increases as the time period increases also as the percentage of the sawdust content increases from 5% and robosand 25%,30%. Flexural strength, also known as modulus of rupture, or bend strength, or transverse rupture strength is a material property, defined as the stress in a material just before it yields in a flexure test.

Table 5.6 Flexural strength test result 28 days

S.NO	Grade of concrete	% of Sawdust	% of Robosand	Load (KN)	L (mm)	BD^2 (mm^2)	Flexural strength (N/mm^2)
1	M25	0	0	30	22500	10000	3.5
2	M25	5	25	32	22500	10000	3.51
3	M25	5	30	33	22500	10000	3.53

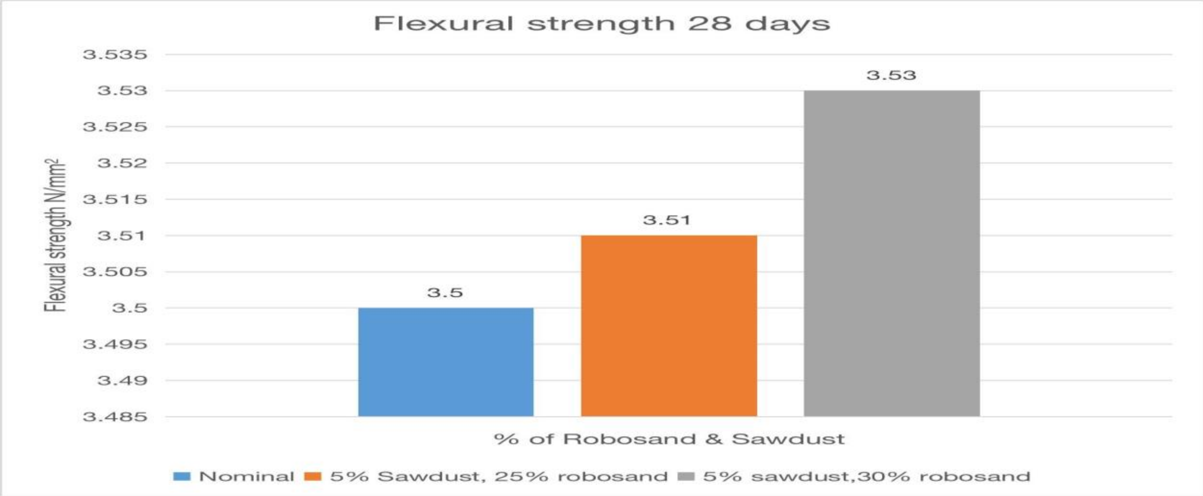

Fig. 5.6 Flexural strength test result 28 days plot

The figure shows the flexural strength of the beam when subjected to the flexural test and its flexural strength is obtained as table clearly shows the strength of 28 days beam increases as the time period increases also as the percentage of the sawdust content increases from 5% and robosand 25%,30%.

6. CONCLUSION

Finally, it can be said that using robo sand instead of river sand for making concrete is a good choice. The majority of the time, there are significant differences in the quality of river sand, which often depends on its source. Thus, it has been determined that robosand can replace river sand, resolving the problem of sand mining from river beds and enhancing the quality of fine aggregate.

From the results of the various tests carried out, the following conclusions could be drawn: Concrete becomes less workable as the proportion of sawdust increases at a constant increase in the water to cement ratio. This could be attributedto the high-water demand resulting from the absorbent nature of sawdust. With an increase in sawdust content, sawdust concrete loses some of its compressive strength. This was clearly exhibited by the 28-day strength by 5% partial replacement of sand with sawdust.

- The Compressive strength was increased by 1.80% at 28 days of curing for 30% robosand + 5% sawdust.
- The Split-tensile strength was increased by 3.35% at 28 days of curing for 30% robosand + 5% sawdust.
- The Flexural strength was increased by 9.09% at 28 days of curing for 30% robosand + 5 % sawdust.

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