

Mechanical Properties of Concrete Using Coconut Shell as Coarse Aggregate

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Abstract- — The economy of all structures is being impacted by the current cost of building materials. It has a significant impact on the global environmental housing system. Conventional aggregates, such as gravel, and fine aggregate, such as sand in concrete, will be utilized for control. Robo sand (stone dust) will be used as fine aggregate to replace the sand in concrete, while natural material such as coconut shell will be researched as a coarse aggregate. In this study, sample specimens are prepared and tested using M25 grade concrete that has a combination of natural material coconut shell content as coarse aggregate in the proportions of 0%, 5%, 10%, 15%, 20%, and 25%, and Robo sand (stone dust) as fine aggregate with a complete 100% replacement of natural sand. for workability, compressive strength, split tensile strength and flexural strength for 7,14 and 28 days respectively and also showing the comparative results with Conventional M25 grade concrete. By this project investigation, concrete may be less dense, light weight concrete by coconut shells and good quality of concrete by Robo sand.

Keywords: coconut shell, coarse aggregate, Robo sand, compressive strength, split tensile strength, flexural strength, replacement, workability & light weight concrete.

I. INTRODUCTION

In essence, concrete is a blend of fine and coarse particles and cement. Strength is just one of the many requirements that high-performance concrete (HPC) must meet. Among the requirements are permeability, early age strength, compaction without segregation, and convenience of placing. The researchers have worked hard to replace the cement with robo sand and baggage ash without compromising the strength. One of the ingredients required to make concrete, river sand (fine aggregate), is now costly and hard to come by. Therefore, alternative materials are in high demand.

Food, clothes, and shelter are the three necessities for human survival. A civil engineer can directly or indirectly address all of humanity's basic necessities. When it comes to creating shelter, man has come a long way. Man first lived in huts, but as time went on, they evolved into load-bearing homes. The growing expense of building materials is a major worry in this created environment. Building materials are becoming more and more expensive every day. The most widely used composite material in the world is concrete, which is made up of aggregates, cement, and water. Global infrastructure development is driving the demand for building materials. Production is expected to increase to more than billion tons per year. Production of concrete is increasing due to high growth of infrastructure development and construction activities in the

world , Production of concrete demands its constituents like aggregates, cement, water and admixtures. Sources of conventional aggregates occupy the major part of the concrete. The large scale production of concrete in construction activities using conventional coarse aggregate. Use of natural aggregates in such a rate leads to a question about the preservation of natural aggregates sources. In addition, operation associated with aggregates extraction and Processing is the principal causes environmental concern. In light of this in the contemporary civil engineering construction, using alternative materials in place of natural aggregate in concrete production makes concrete as sustainable and environmentally friendly construction material. Nowadays most of the researchers have focus on use of the waste materials in concrete according to their properties. Fly ash, Rice husk, Slag and Sludge from the treatment of industrial and domestic waste water has been found suitable as partial replacement for cement in concrete. Apart from the above mention waste material, a few studies shows that agriculture waste coconut shell can also be used as coarse aggregate for concrete.

Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earning and environmental

pollution control. Industrial wastes, such as blast furnace slag, fly ash and silica fume are being used as supplementary cement replacement materials. Currently, there has been an attempt to utilize the large amount of bagasse ash, the residue from an in-line sugar industry and the bagasse-biomass fuel in electric generation industry. When this waste is burned under controlled conditions, it also gives ash having amorphous silica, which has pozzolanic properties⁴. A few studies have been carried out on the ashes obtained directly from the industries to study pozzolanic activity and their suitability as binders, partially replacing cement⁵. Therefore it is possible to use sugarcane bagasse ash (SCBA) as cement replacement material to improve quality and reduce the cost of construction materials such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block.

II. MATERIALS USED

Cement

The raw materials required for manufacture of Portland cement are calcareous materials such as limestone or chalk, and argillaceous material such as shale or clay. There are two processes known as wet and dry processes depending upon whether the mixing and grinding of raw materials is done in wet or dry condition. The raw materials used for the manufacture of cement consist of mainly of lime, silica, alumina and iron oxide. These oxides interact with one another in the kiln at high temperature to form more complex compounds.

The chemical reactions that take place between cement and water is referred as hydration of cement. The hydration of cement can be visualized in two ways. The first is through solution mechanism in which cement dissolve to produce super saturated solution from which the hydrated products get precipitated. Second is that water attacks cement compounds starting from the surface to the interior of compounds with time.

In this study Ordinary Portland cement of 53 grade (ACC cement) has been procured and has been used. The various tests on this material is conducted and resulted in 4.3.



OPC 53 grade cement

Aggregates

Aggregates are the important constituents in concrete. They give body to the concrete, reduce shrinkage and effect economy. Aggregates are inert granular materials such as sand, gravel or crushed stone that are an end product in their own raw materials. They are also the raw materials that are an essential ingredient in concrete. For a good concrete mix, aggregates need to be clean, hard, strong particles free of absorbed chemicals or coatings of clay and other fine materials that could cause the deterioration of cement.

Aggregates are divided into two categories from the consideration of size.

- i). Coarse aggregate
- ii). Fine aggregate

Coarse aggregates are particles greater than 4.75mm but generally range between 9.5mm to 37.5mm in diameter. They can either be from primary, secondary or recycled sources. Primary or virgin aggregates are either land or marine-won. Gravel is a coarse marine-won aggregate, land-won coarse aggregates include gravel and crushed rock. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. In this study coarse aggregate of nominal sizes of 20mm, 12mm are used.



20mm coarse aggregates

Fine Aggregate

Fine aggregate are basically sands won from the land or the marine environment. Fine aggregates generally consist of natural sand or crushed stone with most particles passing through a 4.75mm sieve.

The fine aggregate used in this study is river sand which is obtained from local company and shown in figure 4.4. The basic tests on these materials are conducted and resulted in 4.3.



Fine aggregate

Robo sand

Robo Sand is also called as manufactured sand obtained by crushing natural granite stone. Robo Sand is defined as a crushed granite aggregate produced by crushing natural granite stone. The perfect substitute for river sand is Robo Sand. River sand is one of the basic ingredients in manufacture of concrete. River sand has become expensive and scarce. Therefore looking alternate to the river sand. The crusher dust is known as Robo sand can be used as alternative material to the river sand.

Robo sand: is a material of high quality, in contradiction to non-refined surplus from coarse aggregate production. Water The water, which is used for making concrete and for curing, should be clean and free from harmful impurities such as oil, alkali, acid, etc., in general, the water, which is fit for drinking should be used for making concrete Robo sand possesses similar properties as that of river sand, hence accepted as a building material. Robo Sand or M-Sand was used as replacement of fine aggregate. Robo Sand is a result of crushed stone, here the stones are crushed into smaller granular size of river sand granules and washed to remove the fine rock dirt to improve the quality as per IS: 2386-1975.

S. No	Property	Value
1	Grading	Zone II as per IS code
2	Specific gravity	2.69
3	Fineness	2.81
4	Silt modulus	Absent
5	Surface moisture	0.9%
6	Water absorption	2.27%

III. COCONUT SHELLS

Coconut shell particles are used as reinforcing material for investigation. Shell particles of size between 20 mm – 600 μ are prepared in grinding machine. Coconut shell aggregates are potential candidates for the development of new composites because of their high strength and modulus properties. An approximate value of coconut shell density is 1.60 g/cm³ .

Coconut shell aggregates

Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, in the quantity and quality of water is required to be looked into very carefully. C3S requires 24% of water by weight and C2S requires 21%. It has also been estimated that on an average 23% of water by weight of cement is required for chemical reaction with Portland cement compounds .This 23% of water chemically combines with cement and, therefore, it is called bound water. It has been further estimated that about 15% by weight of cement is required to fill up the gel-pores.

Fineness of Cement

Fineness of cement has a great effect on the rate of hydration and hence the rate of gain of strength. Fineness of cement increases the rate of heat. Finer cement offers a great surface

area for hydration and hence faster the development of strength. Increase in fineness of cement also increases the shrinkage of concrete and hence creates cracks in structures.

Sieve Analysis of Fine Aggregate

Fineness modulus of an aggregate is defined as the sum of the cumulative percentages retained on sieves of standard sizes divided by 100. It can be looked upon as weighted average size of sieve on which the material is retained, the sieves being counted from the finest (for the purpose 150 micron sieve is taken as the lowest).

Grading curve is a graphical representation of the results of sieve analysis in which the ordinate on the ordinary scale represents the percentage passing for each sieve and the abscissa represents the corresponding sieve opening plotted on a log scale in a semi-log paper. Alternately, if the size of each successive sieve is half that of the next large one, plotting sieve sizes with equal abscissa intervals, results in a near semi-log plot. Since the sands used for concrete are obtained either from land quarrying or by crushing larger aggregates, their grading varies from place to place. In order that there is broad classification, IS 2386 classifies sand into four zones, I to IV, based on percentage passing at 600 micron sieve.

Observations and calculations:

Weight of fine aggregate = 1000gm.

Observations of sieve analysis of fine aggregate test

S.N o.	Sieve size Mm	Weight retained	%age weight retained	Cumulative % of weight retained (F)	%age weight passing	Cumulative %age weight passing
1	4.75	0	0	0	100	100
2	2.36	95	9.5	9.5	90.5	190.5
3	1.18	271	27.1	36.6	63.4	253.9
4	600 μ	295	29.5	66.1	33.9	287.8
5	300 μ	309	30.9	97	3	290.8
6	150 μ	30	3.0	100	0	290.8

Fineness modulus = (cumulative % of wt. retained)/100 = 309.2/100 = 3.092

The fineness modulus of fine aggregate = 3.09

Scheme of experimental program:

The details of number of blocks to be tested while the experimentation process is given in the below table:

No Blocks Required For the Experiment

Sl. No	Percentage of coconut shells and Robo Sand	Compressive strength of concrete			Split tensile strength of concrete			Flexural strength		
		7 days	14 days	28 days	7 days	14 days	28 days	7 days	14 days	28 days
1	0%+100%	3	3	3	3	3	3	3	3	3
2	5%+100%	3	3	3	3	3	3	3	3	3
3	10%+100%	3	3	3	3	3	3	3	3	3
4	15%+100%	3	3	3	3	3	3	3	3	3
5	20%+100%	3	3	3	3	3	3	3	3	3
6	25%+100%	3	3	3	3	3	3	3	3	3
total		54 cubes			54 cylinders			54 Prisms		

In each batch 3cubes , 3 cylinders and 3 prisms were casted. Totally 54 cubes, 54 cylinders and 54 prisms were casted during entire experimentation.

Mix Design of Concrete

Concrete mix design is a procedure of selecting the suitable ingredients of concrete and their relative proportions with an objective to prepare concrete of certain minimum strength, desired workability and durability as economically (value engineered) as possible.

As we decide to go for a concrete mix design, collect the following data before hand as few design stipulation are freezed on the basis of these data.

Preliminary Data Required For Mix Design

Purely governed on the local conditions, were the concrete need to be applied

Exposure Condition: Exposure Conditions of the structure: The general environment, to which the concrete will be exposed during its service life, is categorized into five classes to severity, as per IS 456. The exposure condition limits the minimum cement content, maximum water – cement ratio and minimum grade of concrete. As per exposure condition, you have the above data for working the first trial and arriving its mix proportion. If you are getting desired result at lower cement content, you need to put extra as mentioned by IS 456.

Minimum thickness of member: Size of aggregate should not be more than one-fourth of the minimum thickness of member, mostly 20 mm nominal size aggregate is suitable for most works. It is always suggested to go the maximum nominal size of aggregate to save on quantity of cement per unit of concrete.
Cement Grade: Cement type/grade locally available that can be made available throughout construction period

Workability: Placing condition of concrete governs its workability, low – slump of 25-75 mm (lightly reinforced sections in slab, beam, and column) to high – slump of 100-150 mm (slip form, pumped concrete).

Experimental Investigation

Workability

Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. It is the property of concrete which determines the amount of useful internal work, necessary to produce full compaction i.e. workability is the amount of energy to overcome Friction while compacting. Also defined as the relative ease with which concrete can be mixed, transported, moulded and compacted.

Concrete is said to be workable when it is easily placed and compacted homogeneously i.e. without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs may also be visible in finished concrete.

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product.

Slump cone test

A Slump test is a method used to determine the consistency of concrete. The consistency or stiffness indicates how much water has been used in the mix. The stiffness of the concrete mix should be matched to the requirements for the finished product quality.

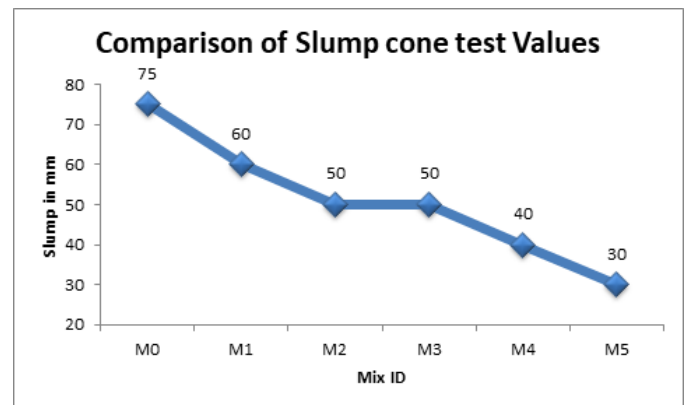
The concrete slump test is used for the measurement of a property of fresh concrete. The test is an empirical test that measures the workability of fresh concrete more specifically, it measures consistency between batches. The test is popular due to the simplicity of apparatus used and simple procedure. The apparatus consists of frustum of a cone and is hollow at top and bottom.

This test is carried out with a metallic mould called slump cone whose top diameter is 10cm, bottom diameter is 20cm and height is 30cm. before conducting test the internal surface of the mould is thoroughly cleaned. Then mould is placed on a smooth, horizontal rigid non-absorbent surface. The mould is then filled in three equal layers with prepared concrete. Each layer is tamped 25 times by tamping rod. After the top layer has been leveled, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in vertical direction. This allows the concrete to subside. The subsidence is referred as slump of concrete. The difference in level between height of the mould and that of the highest point of subsided concrete is measured, this difference is measured in millimeter (mm) is taken as slump of concrete.



Figure 4. 1 Slump cone test

2	5%+100%	M1	60
3	10%+100%	M2	50
4	15%+100%	M3	50
5	20%+100%	M4	40
6	25%+100%	M5	30



From the above table and graph it was observed that the by using coconut shells and robo sand in M25 grade concrete the value of slump decreases from 75mm to 30mm for mix M0 to M5 by using coconut shells and robo sand the water concrete decreases in the concrete mix because of this reason the slump value decreases.

IV. COMPACTION FACTOR TEST

Compacting factor of fresh concrete is done to determine the workability of fresh concrete by compacting factor test as per IS: 1199 – 1959. The compacting factor test works on the principle of determining degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction called the compacting factor is measured by the density ration. The ratio of the density actually achieved in the test to density of same concrete fully compacted.

Compaction factor test results

S. No	Percentage of Coconut shells and Robo Sand	Mix ID	Compaction factor
1	0%+100%	M0	0.96
2	5%+100%	M1	0.92
3	10%+100%	M2	0.86

V. RESULTS AND ANALYSIS

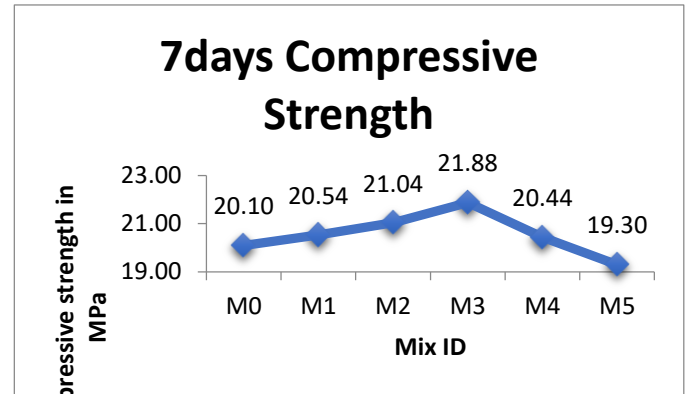
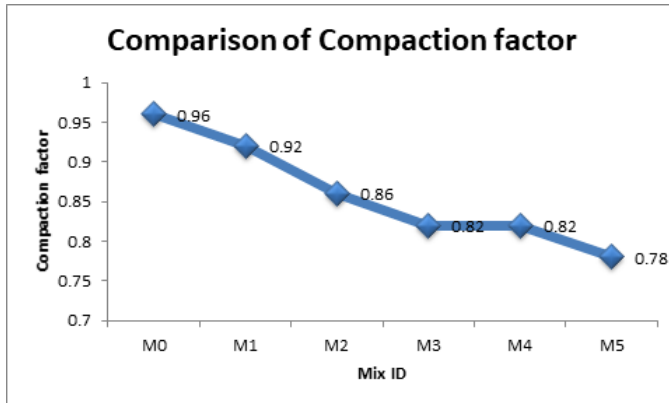
Workability of concrete

Slump cone test results

S. No	Percentage of Coconut shells and Robo Sand	Mix ID	Slump in mm
1	0%+100%	M0	75

4	15%+100%	M3	0.82
5	20%+100%	M4	0.82
6	25%+100%	M5	0.78

5	20%+100%	M4	20.44	30.66	33.73
6	25%+100%	M5	19.30	28.95	31.85

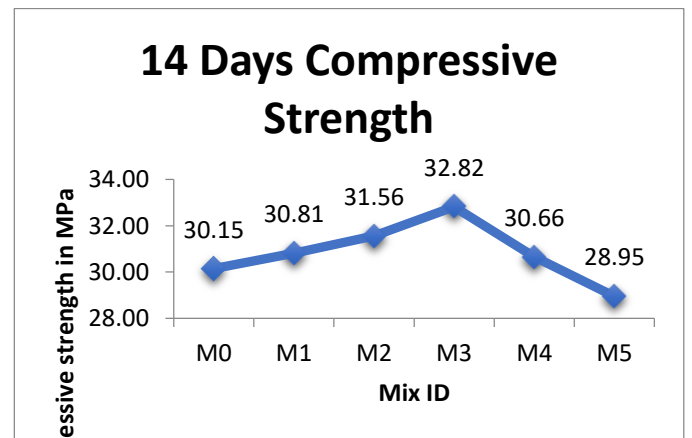


From the above table and graph it was observed that the by using coconut shells and robo sand in M25 grade concrete the value of compaction factor decreases from 0.96 to 0.78 for mix M0 to M5 by using coconut shells and robo sand the water concrete decreases in the concrete mix because of this reason the slump value decreases.

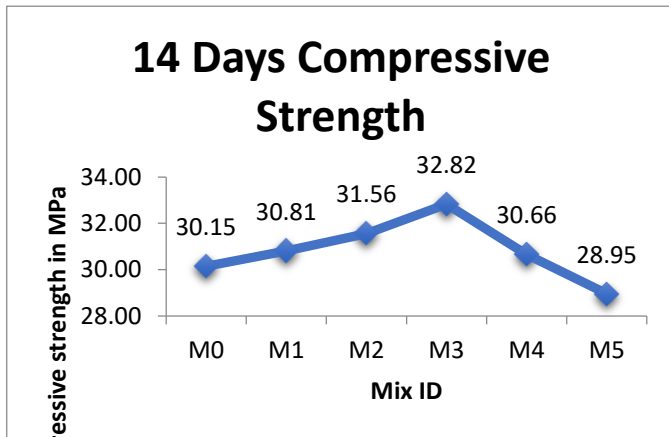
The above plot shows the variation of 7days compressive strength in M25 grade concrete using coconut shells and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.

Compressive strength of concrete

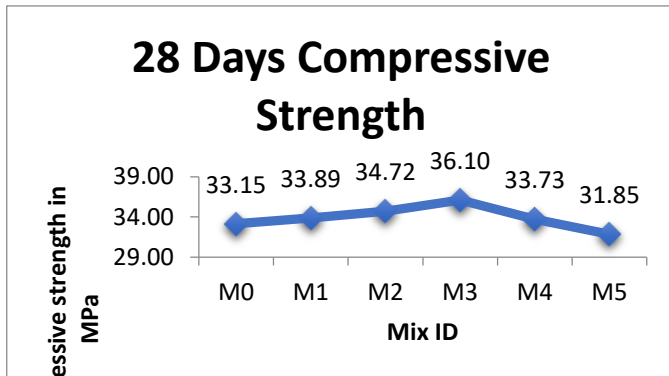
S. No	Percentage of Coconut shells and Robo Sand	Mix ID	Compressive strength of M25 Grade concrete		
			7 Days	14 Days	28 Days
1	0%+100%	M0	20.10	30.15	30.15
2	5%+100%	M1	20.54	30.81	33.89
3	10%+100%	M2	21.04	31.56	34.72
4	15%+100%	M3	21.88	32.82	36.10



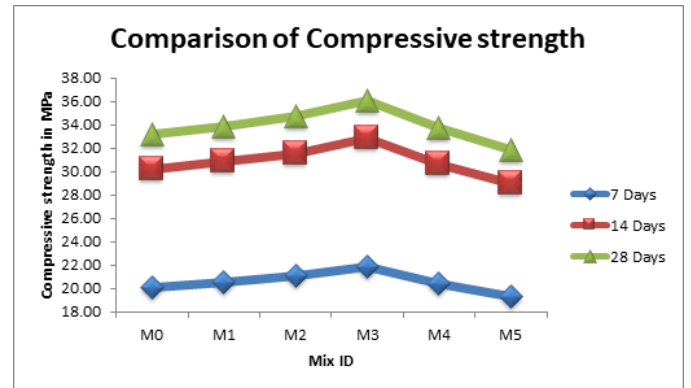
The above plot shows the variation of 14days compressive strength in M25 grade concrete using coconut shells and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 28days compressive strength in M25 grade concrete using coconut shells and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.

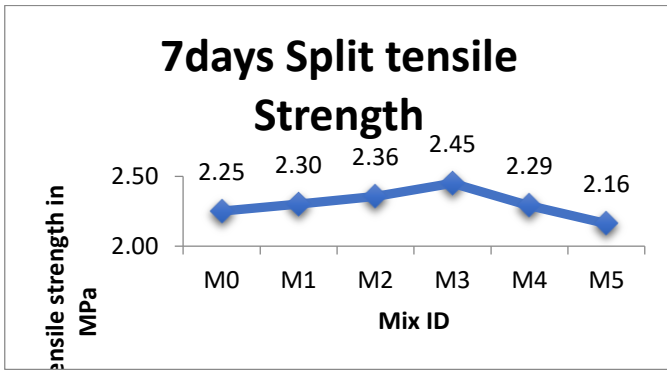


The above plot shows the variation of 7days, 14days and 28 days compressive strength in M25 grade concrete using coconut shells and robo sand the optimal value of compressive strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.

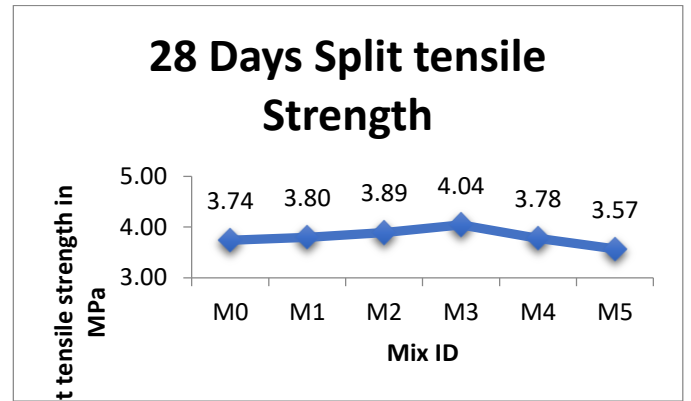


Split tensile strength of concrete

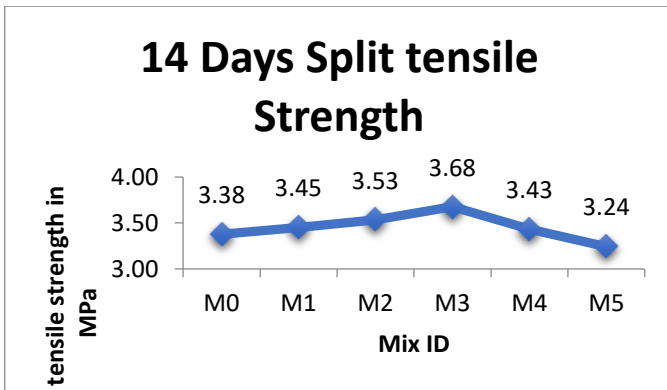
S.no	Percentage of Coconut shells and Robo Sand	Mix ID	Split tensile strength of M25 Grade concrete		
			7 Days	14 Days	28 Days
1	0%+100%	M0	2.25	3.38	3.74
2	5%+100%	M1	2.30	3.45	3.80
3	10%+100%	M2	2.36	3.53	3.89
4	15%+100%	M3	2.45	3.68	4.04
5	20%+100%	M4	2.29	3.43	3.78
6	25%+100%	M5	2.16	3.24	3.57



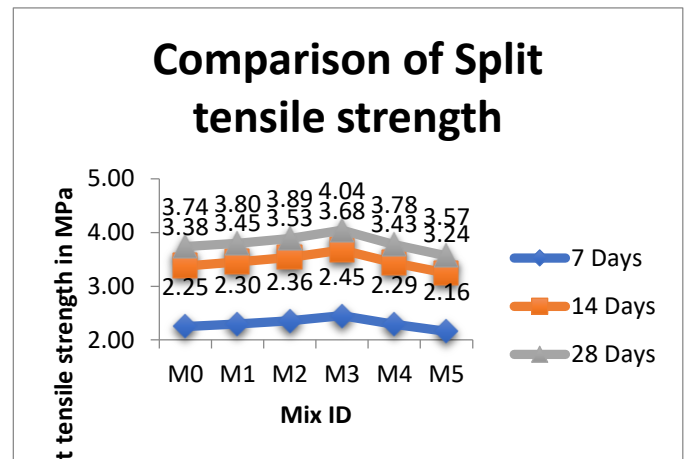
The above plot shows the variation of 7days split tensile strength in M25 grade concrete using coconut shells and robo sand the optimal value of split tensile strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 28days split tensile strength in M25 grade concrete using coconut shells and robo sand the optimal value of split tensile strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 14days split tensile strength in M25 grade concrete using coconut shells and robo sand the optimal value of split tensile strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.

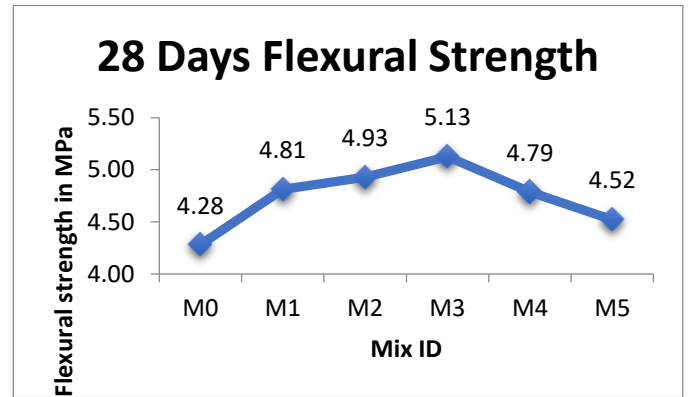


The above plot shows the variation of 7days, 14days and 28 days split tensile strength in M25 grade concrete using coconut shells and robo sand the optimal value of flexural strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decreases to M5 mix in M25 grade concrete mix.

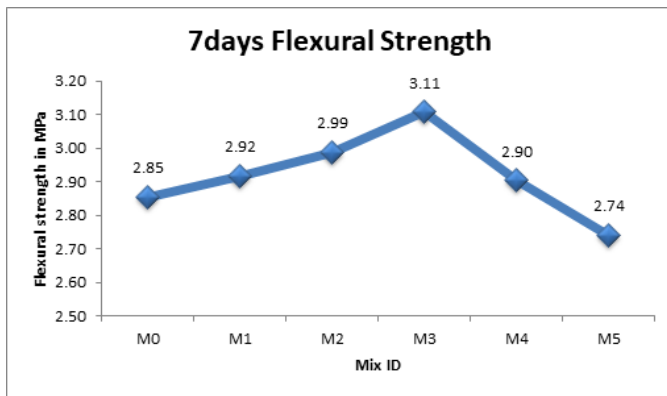
Flexural strength of concrete

S. No	Percentage of Coconut shells	Mix ID	Flexural strength of M25 Grade concrete

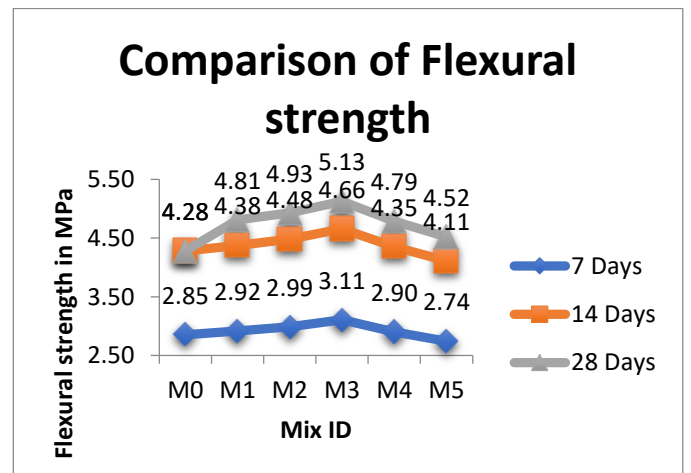
	and Robo Sand		7 Days	14 Days	28 Days
1	0%+100%	M0	2.85	4.28	4.28
2	5%+100%	M1	2.92	4.38	4.81
3	10%+100%	M2	2.99	4.48	4.93
4	15%+100%	M3	3.11	4.66	5.13
5	20%+100%	M4	2.90	4.35	4.79
6	25%+100%	M5	2.74	4.11	4.52



The above plot shows the variation of 28days flexural strength in M25 grade concrete using coconut shells and robo sand the optimal value of flexural strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decrease to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 7days flexural strength in M25 grade concrete using coconut shells and robo sand the optimal value of flexural strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decrease to M5 mix in M25 grade concrete mix.



The above plot shows the variation of 7days, 14days and 28 days flexural strength in M25 grade concrete using coconut shells and robo sand the optimal value of flexural strength was observed at M3 mix. Initially the strength increases from M0 to M3 and then it will decrease to M5 mix in M25 grade concrete mix.

VI. CONCLUSIONS

On the basis of results obtained by this experimental investigation, following conclusions are shown below: -

In this project we had done detailed study and investigation on Coconut shell as Coarse aggregate in replacement of Crushed stone and Robo sand as replacement of fine aggregate. we studied various properties of Coconut shell and Robo sand like physical properties & composition etc. We did various tests on cement, fine aggregate and coarse aggregate.

In some areas crushed stones and natural sand are become costly and also have scarcity. At that time crushed stones are replaced by coconut shell and natural river sand by robo sand which is easily available and cheap cost. Coconut shell and Robo sand are very useful materials as aggregates in concrete preparation and we compared all the properties of coconut shell and Robo sand with conventional aggregates.

Coconut shell have great resistant against crushing, impact and abrasion and also have less specific gravity except water absorption. If we can use coconut shell as coarse aggregate replacement we can get good bonding, good workability and good strength. On the other hand, Robo sand (stone dust) have good strength giving property and improves more quality of concrete.

By replacing the coconut shells and Robo sand, the strength of M25 grade mix concrete increases from 0%CA+100%RS to 15%CA+100%RS is comparatively increasing with normal concrete.

The compaction factor values decreases with increase in the percentage of coconut aggregates and robo sand quantity from 0%CA+100%RS to 25%BA+100%RS

The optimal values of compressive strength found at 15%CA+100%RS at 7days, 14days and 28days curing and the strength values are decreasing after M3 mix.

The optimal values of split tensile strength found at 15%CA+100%RS at 7days, 14days, and 28days curing.

The optimal value of flexural strength is also obtained at M3 mix which is similarly to the compressive strength and split tensile strength.

By using the Robo sand and coconut shells in concrete, it improves the quality of concrete and gives good strength and conserve the natural river sand for future generation.

Hence, we concluded that Robo sand and coconut shells would be used as replacement of fine aggregate and coarse aggregate.

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