EFFECT OF PARTIAL REPLACEMENT OF CEMENT BY GROUNDNUT SHELL ASH AND SAND BY WASHED BOTTOM ASH ON THE CHARACTERISTIC PROPERTIES OF CONCRETE

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Abstract - Concrete is a composite material consisting of cement, fine aggregate, and coarse aggregate, and demand for it is increasing due to construction practices at a large scale. As of now, we are able to use waste material such as fly ash in the manufacturing of cement, but fine aggregate and coarse aggregate are made available from natural resources and are getting depleted day after day. So, the need of an era is to find out some more waste material that can be used in place of these materials or can be replaced in a suitable amount, leading to the bio-conversion of waste material into usable energy and reducing the environmental pollution. So, the material used for replacement in this research is washed bottom ash in place of sand and Groundnut shell ash in place of cement. The main objective of this research is to determine the workability, compressive strength, split tensile strength, and flexure strength of concrete prepared by using washed bottom ash and Groundnut shell ash. The test will be conducted to determine the compressive strength, split tensile strength, and flexure strength. Based on previous research, a comparison of strength and properties of concrete made with replacement compared to the standard concrete is made. Cement is replaced by Groundnut shell ash by 0%,6%,12%,18%,24%,30%,36%, and natural sand is replaced by washed bottom ash by 0%,8%,16%,24%,32%,40%,48% Based on the properties of materials, the M35 grade of concrete mix is prepared. Different specimens of the material are tested for strength. The result shows that concrete workability is fine and within limits after replacing cement with Groundnut shell ash and natural sand by washed bottom ash. However, workability gets reduced at higher replacement of materials. The strength parameters such as compressive strength, flexural strength, and split tensile strength also increase and show an optimum value at 24% cement replacement and 32% replacement of natural sand by Groundnut shell ash and washed bottom ash, respectively. After this, there is a decrease in the strength of concrete. So, after this research work, we find out that the replacement can be done to some extent.

Keywords: GSA (Groundnut shell ash), WBA (washed bottom ash), workability, compressive strength, Split Tensile strength, Flexural strength.

1. INTRODUCTION

As the demand for these materials is escalating day after day due to ever-going constructional activities worldwide, from small buildings to multi-storey buildings, utilization of natural sand increases, leading to the continuous extraction of natural sand from river beds. This extraction is causing severe damage to the natural resources, which pose a severe threat and impact on the environment, such as loss of aquatic life, losing water retaining soil stratum, causing bank slides, loss of vegetation on the banks of rivers, and the society, etc. So, the different states in India have imposed a bar on the natural extraction of sand because of its adverse effects. Also, natural sand is becoming very costly nowadays; in this situation, the need arises to find some readily available alternative that can also reduce the cost of construction. Various materials that have earlier been used to replace natural sand, such as fly-ash, quarry dust or limestone, filtered sand, and copper slag, are used in concrete as well as for mortar mixtures. One of the materials which can also be effectively used as a replacement for sand in concrete is Washed Bottom Ash (WBA), and Groundnut shell ash can be used as a replacement for cement because the chemical composition of Groundnut shell ash and cement were found to be comparable which largely comprise of calcium carbonate (90%). Both of these materials are waste products, so they are cost-effective and efficient in waste management and do not pose any serious threat to the environment. Also, both of these materials are present in abundance in our country. Using these materials in the construction practices, the disposal problem of these materials can be reduced to a large extent. The other factor that contributes to their use in the concrete is their low cost. So, using waste material as an alternate material can make the project economical.

1.1 WASHED BOTTOM ASH (WBA)

The increasing oil and natural gas prices have made coal more economical, especially in a country with vast coal resources such as India. The high demand for coal production due to its use in electricity generation has resulted in the era of enormous amounts of industrial waste such as fly ash and bottom ash. Washed bottom ash is nearly 20% of the residual material of coal combustion in a power plant, boiler, furnace, or incinerator. The portion of the ash that escapes the chimney is referred to as fly ash (80%), and the clinkers that fall under their weight in the bottom hopper is termed as bottom ash (20%) which is cooled by water washing and is termed as Washed Bottom Ash (WBA). Currently, India produces about 100 million tonnes of coal ash per year, of which 15-20% is bottom ash. Fly ash is generally used in cement production, but bottom ash has not been used effectively till date and continues to pollute the environment in different ways. This massive amount of waste generated after coal combustion has become a global issue of concern for developing and developed countries. The disposal of bottom ash landfills has posed a severe environmental problem. The way to deal with this concern is to use the bottom ash effectively. In latest years the utilization of bottom ash has gained significant attention due to its use in engineering construction works as a replacement of fine aggregate.

Fig -1 WASHED BOTTOM ASH

1.2 GROUNDNUT SHELL ASH

The GSA waste is one of the major concerns of the agricultural industry which the common method of disposal in Nigeria is by burning in open air which causes pollution and destroys the soil nutrients. The management of this abundant waste in an environmentally safe way is challenge that must be met. To recycle the waste material in ceramic industry is an advantage of environmental protection and also saving the raw materials. Ceramic bodies, such as white ware, are heterogeneous materials, consisting mainly of natural raw materials with wide range of composition. For this reason, such bodies could tolerate different types of alternative raw materials, even in high percentages. Utilization of these agro-wastes for formulation of white ware body will bring about reduction in the use of natural raw materials, reduces production cost, energy consumption as well as serving as a means of safe disposal of these agro-wastes.

Fig -2 GROUNDNUT SHELL ASH

2. LITERATURE REVIEW

Meghana. K et al. (2019): In this studies the properties like compressive strength, flexural strength, tensile strength, shear strength, and impact strength by varying the ratio of bottom ash in replacement of sand in concrete mixture and the grade of concrete used is M30. The workability characteristics of the concrete with varying ratio of bottom ash were also studied through slump cone test, compaction factor test, Vee-Bee consist meter test.The bottom ash is added in concrete to replace natural sand by 0%, 20%, 40%, 60%, 80%, and 100%. The silica fume by 20 % replacement is also added by weight of cement. The outcome of this experiment work shows that the sand can be replaced with bottom ash up to 40%, and the desired strength of concrete can be achieved.

Vikas R Nadig et al. (2015): carried out investigations on the characteristics properties of concrete integrated with washed bottom ash as a partial replacement for fine aggregates. The main focus is on mechanical properties of concrete such as compressive strength, splitting tensile strength, flexure strength, etc. The outcome of this study shows that replacing sand with washed bottom ash in the range of 30 to 50% at 90 days attains a higher compressive strength and flexural strength than conventional concrete's strength at 28 days. Water absorption is more in Bottom ash Concrete as compared to conventional Concrete. The study also concluded that the strength of concrete made with bottom Ash replacement could be improved by adding suitable fibres and incorporating other materials.

Buari T.A et. al. 2019 This study highlights the effects of incorporating waste glass(WG) and groundnut shell ash(GSA)on both fresh and hardened properties of self-consolidating high performance concrete in sulphate and chloride environment. A total of 180 concrete cubes of 100mm x 100mm x 100mm were produced with waste glass(WG) as aggregate and OPC/GSA as binder, with percentage substitutions varied between 0% - 40% for both materials in the concrete. The concrete were designed and examined for fresh properties and hardened specimens tested through crushing to obtain their compressive strengths at age 7,14,21, and 28 days after curing in water as control and two other different media (CaCl2 and MgSO4 at 5%concentration).

B.A. Alabadan et. al. 2006 In this paper entitled as "Pozzolanic materials have long demonstrated their effectiveness in producing high-performance concrete. Artificial pozzolanas such as rice husk ash have gained acceptance as supplementary cementing materials in many parts of the world. This work evaluates the potentials of groundnut shell ash (GSA) as a partial replacement for ordinary Portland cement (OPC) in concrete. Chemical analysis of the ash was carried out to ascertain whether it possesses pozzolanic or cementing properties and the partial replacement of OPC by GSA was varied from 0% to 70% in the concrete. The compressive strengths of the control and those of other combinations increased with curing age but decreased with increased ash percentage. Though, the strength of the control was higher, replacement of cement with ash up to 30% would be more suitable than others.

Akshay C. Sankh et al.(2014): The papers evaluate the different alternatives to be used in replacement of natural sand because of the exhaustion of natural sand due to its use in concrete. One of the alternatives used which is used during research work is Washed Bottom Ash (WBA). It is found out that the properties of concrete with 30% replacement of natural sand by washed bottom ash is found to be an optimum usage in concrete and to get a favorable strength and better strength development pattern over the increment ages.

3. MATERIAL

3.1 CEMENT There are many types of cement available in the market according to the need and strength desired. The cement we will use in this research work is 43 Grade Ordinary Portland cement conforming to IS: 8112 with brand name Ambuja Cement and the physical properties related to cement is provided by the concerned lab.

3.2 FINE AGGREGATES Fine aggregate consists of crushed sand particles or natural river sand passing through a 4.75mm sieve. In general, river sand is used as a fine aggregate having a particle size of 0.07mm. The extraction is done from rivers, lakes or sea beds.

3.3 COARSE AGGREGATE The particles retained on a 4.75mm sieve are termed coarse aggregate. For making a good concrete mix, coarse aggregated must be hard, clean, and free from any chemical coating of clay and dust on the surface. Crushed stone makes the majority of the particle of coarse aggregate. Coarse aggregates angular in shape are used in this research work that is obtained from the local crusher. Grading of coarse aggregate was done according to IS:383-1970. Aggregates of Nominal size 20mm & 10mm to form a graded aggregate. The concerned lab provided the properties of coarse aggregate.

3.4 GROUNDNUT SHELL ASH

Table -1 Chemical composition of GSA

S.no	Elemental Oxide	GSA (% by mass)
1.	Calcium Oxide (CaO)	14.3
2.	Silicon Dioxide (SiO_2)	62.7
3.	Aluminum Oxide (Al_2O_3)	12.42
4.	Magnesium Oxide (MgO)	2.0
5.	Ferric Oxide (Fe_2O_3)	14.0
6.	Potassium Oxide (K_2O)	15.46
7.	Manganese dioxide (MnO_2)	2.0

3.5 WASHED BOTTOM ASH

Table2 - Chemical composition of WBA

Chemical Composition (%)	Bottom Ash
SiO_2	68
Al2O3	25
Fe2O3	2.18
CaO	1.66
TiO2	1.45
MgO	0.02
SO3	Nil
Loss on Ignition	1.69

4. METHODOLOGY

4.1 MIXING CONCRETE

Thorough mixing of the materials is essential to produce uniform concrete. The mixing should make sure that the mass become homogeneous, uniform in consistency and colour. There are two methods adopting for mixing concrete one is hand mixing and other is machine mixing.

4.2 CURING

Before removing the mould, it is dried for 24 hours, and then specimens are placed in a water tank made to cure specimens. The specimens must be marked for identification so that there must not be any error. The specimens are removed from the tank and dried before putting in the testing machine. The specimens are kept in the tank for 3,7,28 days.

4.3 WORKABILITY TEST

It can be used in site as well as in lab. This test is not applicable for very low and very high workability concrete. It consists of a mould that is in the form of frustum having top diameter of 10cm, bottom diameter of 20cm and height of 30cm. The concrete to be tested if fitted in the mould in four layers. The each is compacted 25 times with the help of tamping rod. After the mould is completely filled it is lifted immediately in the vertically upward direction which causes the concrete to subside.

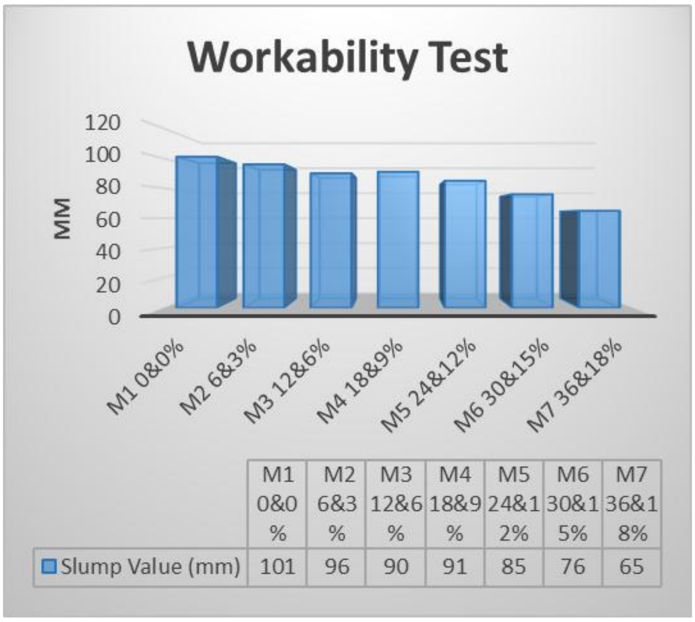


Fig -3: SLUMP CONE TEST

4.4 COMPRESSIVE STRENGTH TEST

Then fresh concrete is filled in mould in 4 layers and after filling each layer tamping should be done 35 times in case of cube and 25 times in case of cylinder by using standard tamping rod. Once the mould is filled then leveled top surface of concrete with trowel. After the day the mould will removed and specimen are dropped in the curing tank under standard temperature of 27±2° c. After 7,14 days and 28 days in this research.

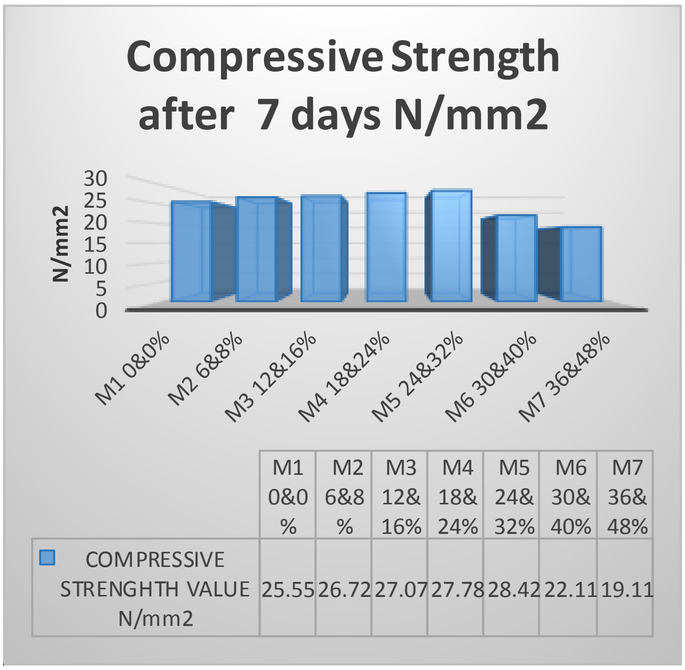


Fig -4: COMPRESSIVE STRENGTH TEST 7

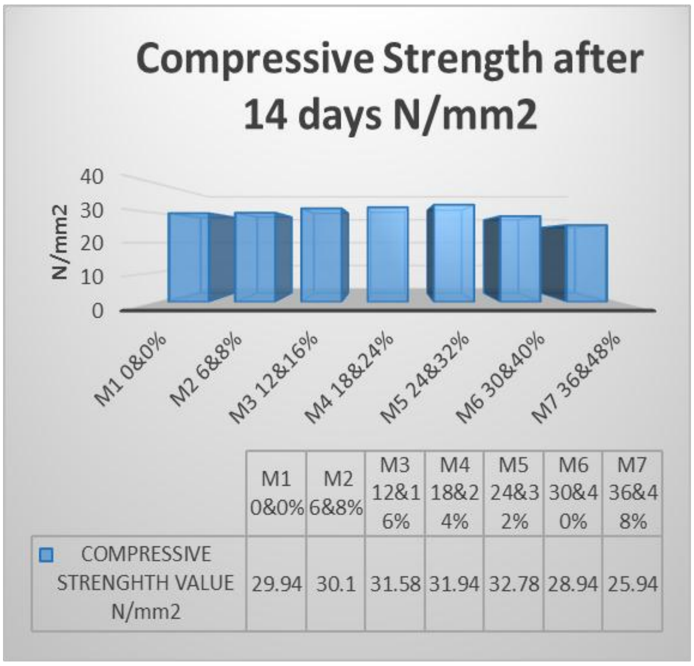
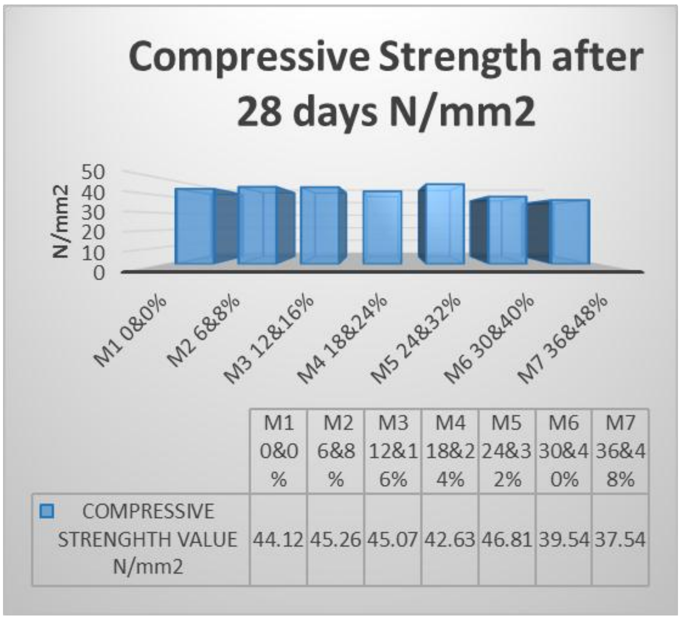


Fig -5: COMPRESSIVE STRENGTH TEST 14

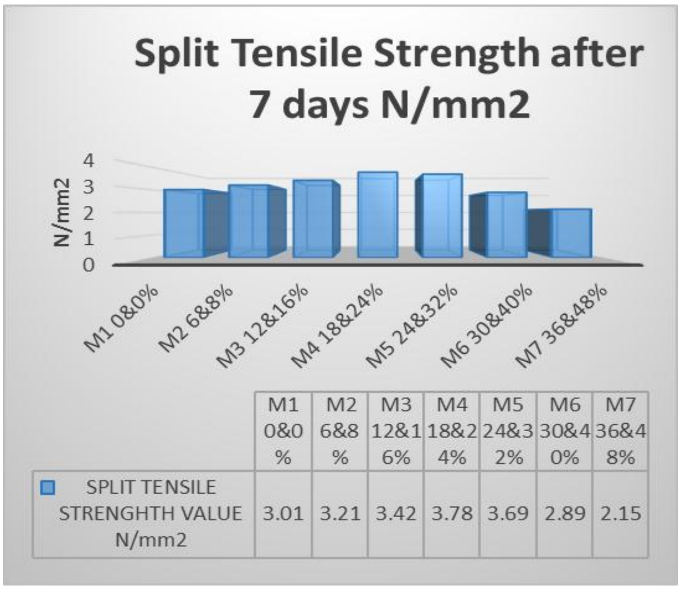


	M1 0&0 %	M2 6&8 %	M3 12&16%	M4 18&24%	M5 24&32%	M6 30&40%	M7 36&48%
COMPRESSIVE STRENGHTH VALUE N/mm2	44.12	45.26	45.07	42.63	46.81	39.54	37.54

Fig -6: COMPRESSIVE STRENGTH TEST 28

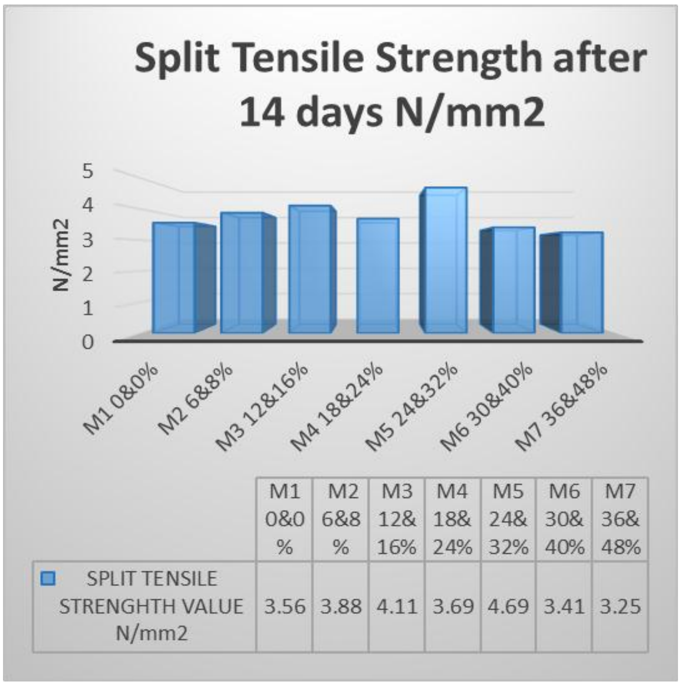
4.5 SPLIT TENSILE STRENGTH TEST

The specimen used for this test is cylindrical and its dimension is 150 mm in diameter and 300mm in length. The instrument used for this testing is universal testing machine. The fresh concrete is prepared in according to the required grades and respective mix proportion. The fresh concrete is filled in mould in layers and each layer is tamping with standard tamping rod with 25 blows for each layer. After the day the mould is removed and specimen is placed in the curing tank for 7,14 days and 28 days in this research at the temperature 27+ 2°c. Then draw the line on the specimen.



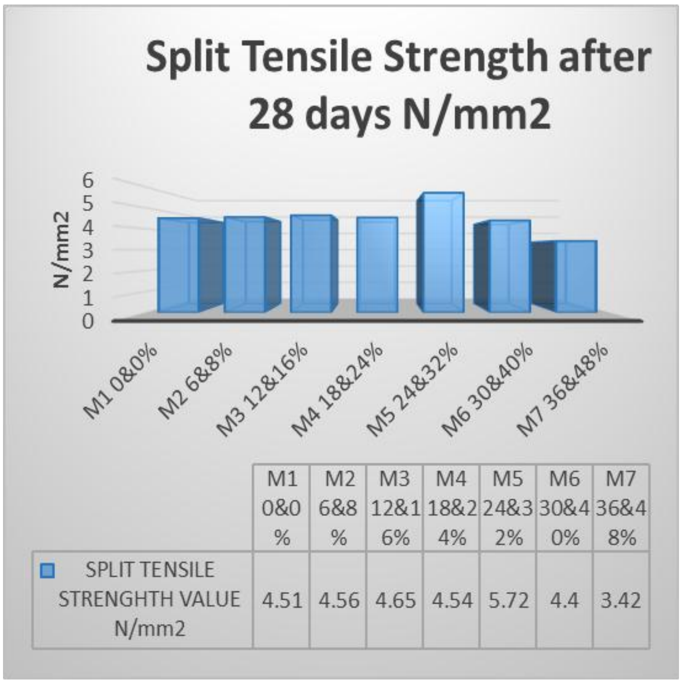
	M1 0&0 %	M2 6&8 %	M3 12&16%	M4 18&24%	M5 24&32%	M6 30&40%	M7 36&48%
SPLIT TENSILE STRENGHTH VALUE N/mm2	3.01	3.21	3.42	3.78	3.69	2.89	2.15

Fig -7: SPLIT TENSILE STRENGTH TEST 7



	M1 0&0 %	M2 6&8 %	M3 12& 16%	M4 18& 24%	M5 24& 32%	M6 30& 40%	M7 36& 48%
SPLIT TENSILE STRENGTH VALUE N/mm2	3.56	3.88	4.11	3.69	4.69	3.41	3.25

Fig -8: SPLIT TENSILE STRENGTH TEST 14



	M1 0&0 %	M2 6&8 %	M3 12&16%	M4 18&24%	M5 24&32%	M6 30&40%	M7 36&48%
SPLIT TENSILE STRENGTH VALUE N/mm2	4.51	4.56	4.65	4.54	5.72	4.4	3.42

Fig -9: SPLIT TENSILE STRENGTH TEST 28

4.6 FLEXURAL STRENGTH TEST

The concrete is prepared at required rate of mass element the mould is filled with concrete in layers and blows 25 times with standard tamping rod. After the day or we can say 24 hours the mould is removed and specimen placed in the water tank for curing at a temperature of 27 + 2 C.

Depending upon the requirement the test specimen is removed from the water tank and wipe it properly for 3,14 and 28 days for testing.

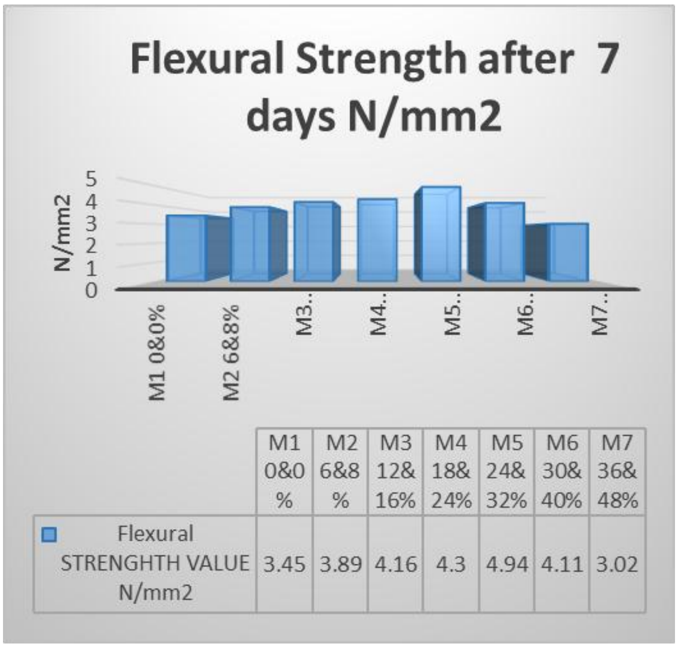


Fig -10: FLEXURAL STRENGTH TEST 7

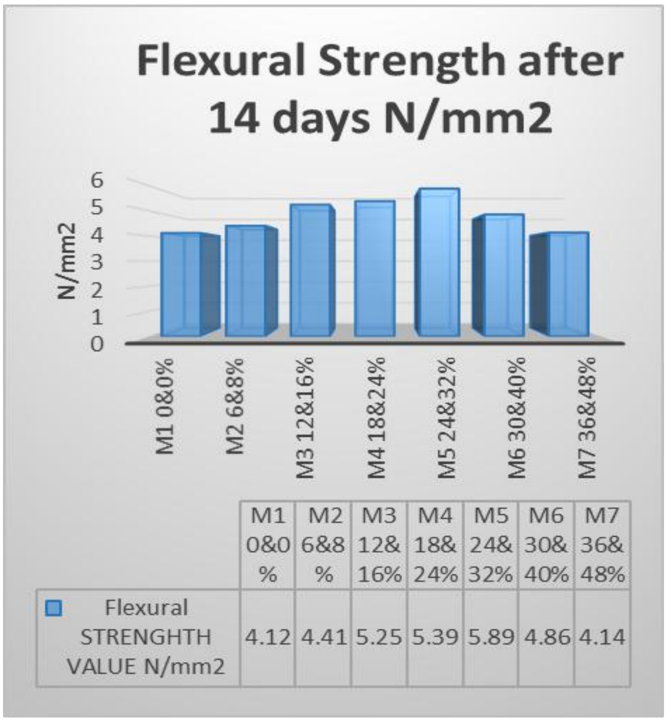


Fig -11: FLEXURAL STRENGTH TEST 14

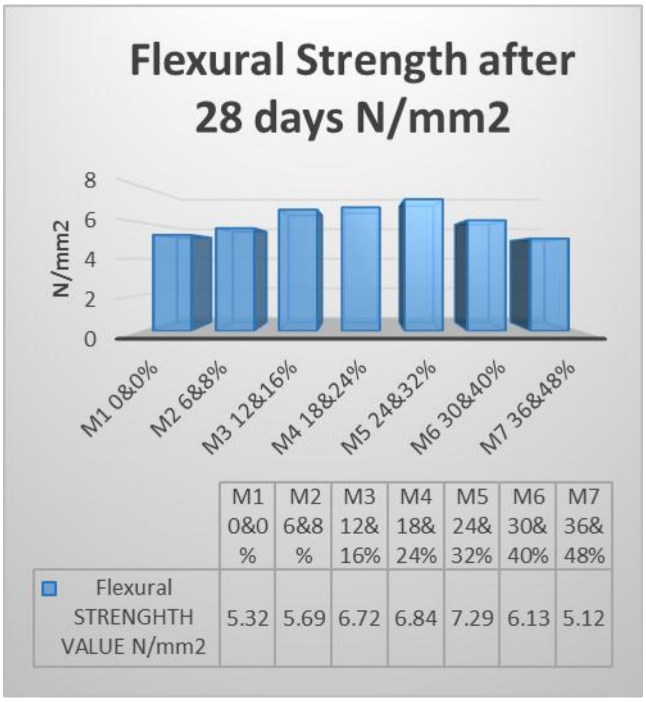


Fig -12: FLEXURAL STRENGTH TEST 28

5. CONCLUSION

• By using these easily available left overs and agricultural waste materials in construction, we can greatly decrease the cost of construction up to a certain level and also not compromising much on the quality while also overcoming the environmental hazards.

• In general, it was also observed in the experiment that the workability of concrete decreases with the increase in the percentage of Groundnut shell ash and washed bottom ash the concrete was less workable.

• All the concrete mix containing Groundnut shell ash and washed bottom ash shows enough workability to be easily compacted and finished. It must be noted that the material used as a replacement must be adequately grounded. Otherwise, the water absorption will increase, which will reduce the workability of the concrete mix.

• The compressive strength results show that as we replace cement with Groundnut shell ash and sand with washed bottom ash, there is an increase in the compressive strength, but at higher replacements, there is a decline in the compressive strength of concrete.

• The max compressive strength is achieved by replacing cement with 24% Groundnut shell ash, and sand by 32% washed bottom ash on 28th day as 46.81 Mpa compared to 44.12 Mpa as of standard concrete.

• The split tensile strength is optimum at 24% replacement by Groundnut shell ash and 32% replacement by washed bottom ash. After a further increase in replacement, it keeps on decreasing. 28th day split tensile strength at this replacement is 5.72 Mpa compared to 4.51 Mpa as of standard concrete.

• The flexure strength is optimum at 12% replacement by Groundnut shell ash and 30% replacement by washed bottom ash. After a further increase in replacement, it keeps on decreasing. 28 days flexural strength at this replacement is 7.29 Mpa compared to 5.32 Mpa as of standard concrete.

• Hence from this research work, it can be concluded that the optimum value of strength for different tests performed on concrete observed at 24% replacement of cement by Groundnut shell ash and 32% replacement of sand by washed bottom ash.

• Using washed bottom ash as an alternate material for natural sand will reduce the mining problem and depletion of natural resources. If using an alternative material as a replacement for cement, Groundnut shell ash powder will result in a decline in environmental pollution, and the problem of landfill dumping can be resolved to some extent.

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