iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: XII Month of publication: December 2023

DOI: https://doi.org/10.22214/ijraset.2023.57799

Experimental Study on the Partial Replacement of Fine Aggregates with Copper Slag and Spent Fire Bricks with Addition of Coconut Fiber

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Abstract: Nowadays, there's associate increasing curiosity within the development of eco-friendly materials. There are number of new by products and waste materials are generated by various industries on a large scale. Concrete prepared with such recycled materials showed enhancement in workability and durability compared to normal concrete and used in the construction of power plants, chemical plants and under-water structures. CS is manufacturing by-product substance formed from the process of manufacturing copper. Bricks come in a variety of varieties because they are a widely used material. Brick aggregate levels are relatively low, and concrete produces excellent results. So it will be better option to use it as substitute or as a recycled material to prevent environment and land degradation, overcoming problem is indeed a need of present time and future also. The extant of destruction can be reduced if sustainability criteria would be considered. The objective of the investigation is to study mechanical properties of concrete, using copper slag, spent fire bricks with addition of coconut fiber percentages compared with the conventional concrete, hence determined the compressive strength, spilt tensile strength and Flexural strength of concrete. All Destructive tests are performed on concrete to check the strength and durability of this concrete at respective as per specified IS Codes. The result shows that concrete workability is fine and within limits after replacing fine aggregates with copper slag, spent fire bricks with addition of coconut fiber. 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 21&21% fine aggregates replacement and 1.5% Addition of coconut fibers respectively. Test results are satisfactory up to 21&21% and 1.5% replacement. After this, there is a decrease in the strength of concrete.
Keywords: SFB (SPENT FIRE BRICKS), CS (COPPER SLAG) CF (COCONUT FIBER), workability, compressive strength, Split Tensile strength, Flexural strength

I. INTRODUCTION

Today Ordinary Portland cement(OPC) has been considered as foremost material for construction purposes across the globe. Cement is the conformist item used in buildings that in fact is accountable for roughly about 5% - 8% of corbon dioxide emissions globally. Cement which is known to be used mostly second after water all over the world and generating so much amount of carbon dioxide in the atmosphere requires an alternate that can replace the cement completely or even if a substitute is capable of replacing cement partially by providing the requisite amount of strength the material should be valued. The demand of use of cement is rapidly increasing, the enviromemtal effect of it might increase considerably. Investigators throught out the globe on different ways for the use of either commercial or wste from agriculturist field, as key materials for industry. Being not only cost effective but may helps us in environmental pollution control. Various organisations are examining substitutes to produce green building materials.

A. Spent Fire Bricks

A brick used to line fireplaces, fireboxes, kilns, and furnaces is known as a fire brick or refractory brick. Using very pure refractory grog, plastic, and non-plastic clays, fire bricks are produced in accordance with IS: 6 and IS: 8 criteria. The various raw ingredients are suitably homogenised and crushed in large presses to get the correct form and size. At a later time, they are heated to 1300 °C in an oil-fired kiln Although a refractory brick is typically made with a low thermal conductivity for better energy efficiency, it is designed primarily to withstand high temperatures. According to IS: 6 and IS: 8 requirements, fire bricks are made from highly pure refractory grog, plastic, and non plastic clays. To achieve the correct shape and size, the various codes are followed in sprit. These are then heated to a temperature of 1,300°C in an oil-fired kiln.

Crushed brick aggregates are composed of crushed bricks that are either finer or coarser in size. Bricks are a material that is very accessible. Natural sand is a scarce natural resource, hence a substitute demand arose.

B. Copper Slag

Copper slag is an industrial product in terms of the content of products made from the process of making copper. It is a crystalline granular material with a high density and its particle size is the shape of the sand and can be used as finer aggregate in concrete. It has the same physical and chemical properties as sand. Copper slag has pozzolanic properties such that it has cement properties and can be used as a partial or complete cement replacement. It is regarded as a waste that can be used in the construction as a complete or partial alternative to cement or aggregate. There may be both environmental and financial benefits to the construction sector from the use of copper slags in concrete.

C. Coconut Fiber In Concrete

Coir fiber has applications in many fields. One of the unusual or more recent application of it is in the concrete.Since,concrete is a brittle material. It possesses very low resistance to cracking, low tensile strength and ductility. When stress is applied to the concrete, it develops crack due to various reasons such as shrinkage. Other factors also lead to the formation of cracks. Internal cracks are caused in concrete due to these reasons which propagates to the outer side causing external cracks in concrete which leads to brittle fracture in concrete. It also has low tensile strength which also leads to crack when subjected to tensile force, this opens up the crack. The inelastic deformation in concrete is caused by these cracks. So, natural fibres have been tried as reinforcement in cement mixtures to produce low cost concrete which can be used in structures. Coconut fiber is readily available in nature in plenty which makes it a good option to be used as reinforcement material. The use of coconut fiber will also result in generating revenue for the farmers who cultivate coconut trees. The demand of these material will increase which will inspire the farmers or cultivators to continue to pursue in this field and get profit from the demand generated.

II. LITERATURE REVIEW

V.Sai Uday,B.A jitha(2017) conducted their experiments to obtain the effect of coconut fibres in concrete structures. Their experiment described the addition in property caused by using coconut fibre in the concrete. They found out that addition of fibre improves the strength of concrete. Addition of coconut fibre improves the compressive strength, flexural strength and split tensile strength of concrete. The experiment was conducted on high strength concrete with the addition of fiber with 5 mix proportions (1%,2%,3%,4%, and 5%) by the weight of cement. The compressive strength and split tensile strength of cured concrete evaluated for 3days,7days and 28days.The fibres used in their experiment were collected from local temples. The fibres were pre soaked in water for 24 hours before use. The study found the optimum fiber content to be at 1%(by the weight of the cement).This results show coconut fiber can be used in construction.

Reis, 2006 performed third-point loading tests on concrete reinforced with coconut, sugarcane bagasse and banana fibres to investigate the flexural strength, fracture toughness and fracture energy. The study revealed that toughness,fractureand energy of coconut fibre reinforced concrete had the greater values as compared to other fibres.Coconut fibre had the strongest strength when compared with other natural fibre. There was an increase in flexural strength of concrete reinforced with coconut fibre up to 25%.These advantages of using coconut fibre over other natural fibres made us to use coconut fibre as the reinforcement material in our project.

Nisha Devi.(2016) The wasteful Spent Fire Bricks should be processed. This research provides us with information on several materials that can be utilized to properly substitute fine aggregates. In order to save natural resources. Analysing the characteristics of M30 grade concrete, concrete with C substituting sand up to 25% is used in this inquiry. In percentages of 0%, 10%, 15%, 20%, and 25%, CSFB was used in place of sand, and 10%, 20%, and 30%, glass powder was used in place of cement. 20% crushed spent fire brick replacement was found to be the ideal percentage. This analysis shows that fine aggregates can be replaced by crushed pent fire bricks.

Ashutosh(2010) This study gives us an idea of several materials that might be utilised in place of fine aggregates, one of which is fire bricks. As fire bricks are employed, the strength of the concrete increases. Additionally, it pushed us to rely less on sand. In this project, partial replacement is carried out at 0%, 22%, 25%, 28%, and 31%. This investigation indicates that 28% replacement provides the greatest tensile strength.so the possible replacement if considered by this analysis will be 28% of replacement. After this point there will be reduced strength as compared to to previous percentages hence optimum will be 28% of replacement.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue XII Dec 2023- Available at www.ijraset.com

R. R. Chavan (2013): found that when 40 percent of the FA was exchanged with copper slag, the maximum compressive strength of concrete had increased by about 55%, and when up to 75% of the fine aggregate was replaced, concrete acquired more strength than control mix concrete. Concrete's flexural strength increased more than the control mix for all percent replacements of fine aggregate with copper slag. At 28 days, the flexural strength of the concrete was greater than the design mix (without replacement), and it was boosted by 14% by replacing 20% of the fine aggregate with copper slag. This also suggests that for all % replacements, flexural strength was greater than for design mix. Due to copper's high toughness, it has higher compressive and flexural strength.
M.C. Nataraja (2014): utilised copper slag natural sand. The workability may increase in terms of slump when copper slag (CS) is replaced with same weight since there is more mortar to surround the aggregate, but the compaction factor is essentially the same as that of natural sand. Copper slag contributed to a modest increase in strength when equated to the control mix. When there is a substantial difference in specific gravity, it is preferable to use equivalent volume replacement rather than weight replacement when there is a substantial difference in specific gravity. Equivalent weight replacement can be employed with greater performance at lower percentages of copper slag replacement, but the material's yield is dramatically reduced. Proper mix design, taking specific gravity of sand into consideration, is one of the elements for ensuring specified performance requirements are satisfied and the yield is reached.

III. MATERIALS

A. Cement

The term cement is frequently used to refer to crushed materials which develop strong bonding qualities when combined with water. Cement is not only binding material in concrete but it also helps in providing strength to the concrete. The binding particle that are present in the cement is due to its chemical composition. These materials are called as hydraulic cements, Portland cement being the most important in construction. Cement is fine greyish powder which, when mixed with water, forms a thick paste. There are many types of cement such as Ordinary Portland cement, Rapid hardening cement, low heat cement etc. The cement used in this work is ordinary Portland cement of 53 grade of Ambuja cement.

B. Coarse Aggregates

The particles which retains on the sieve and are larger than 4.75mm are referred to as coarse aggregates. For making a good mix of concrete aggregates need to be hard, clean and strong particles which are free of coatings of clay or any absorbed chemical and other fine materials that could cause the deterioration of concrete. Coarse aggregates are rounded or irregular gravel stones. It constitute the majority of coarse aggregate used in concrete with crushed stone making up most of the remainder. Coarse aggregates should be carefully handled to avoid dirt contamination. It should be clean and dry.

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C. Fine Aggregates

Aggregates consists of two types, fine aggregates and coarse aggregates. Fine aggregates consists of natural stone or crushed particles passing through 4.75mm size sieve. Aggregates which account for one –third percentage of the total volume of concrete, are divided into two separate categories-fine and coarse. Natural gravel and sand are typically dug or dredged from a pit, river, lake, or seabed. The crushing of big boulders, cobbles, quarry rock, and large size gravel also produces crushed aggregate. Aggregates strongly influence concrete's freshly mixed and hardened properties, mixture proportions and economy. There is although always a variation of aggregate properties is expected, characteristics include durability, grading, particle shape and surface texture, abrasion and skid resistance, unit weights and voids, absorption and surface moisture.

D. Copper Slag

Copper slag is an industrial product in terms of the content of products made from the process of making copper. It is a crystalline granular material with a high density and its particle size is the shape of the sand and can be used as finer aggregate in concrete. It has the same physical and chemical properties as sand. Copper slag has pozzolanic properties such that it has cement properties and can be used as a partial or complete cement replacement. It is regarded as a waste that can be used in the construction as a complete or partial alternative to cement or aggregate. There may be both environmental and financial benefits to the construction sector from the use of copper slags in concrete. If copper slag is not disposed of properly, the main cause of CO2 and other harmful gas vapours is global warming which destroys the ozone layer which is harmful to the planet Earth.

Table no. 1 Properties of CS

S. No	Property	value
	Iron oxide (Fe_2O_3)	30-40%
	Silicon Dioxide (SiO_2)	26-30%
	Aluminium (Al_2O_3)	1.0%-3.0%
	Calcium Oxide (Cao)	1.0%-2.0%

E. Coconut Fibre

Coir or coconut fibre is a natural fibre extracted from the outer husk of coconut. It is versatile natural fibre. Most of the times, fibre is of golden or brown colour when cleaned after removing from coconut husk and hence the name “The Golden Fibre”. The coir is a fibrous material found between outer coat and internal hard shell. The husk contains fibre of varying length. After grinding the husk, the long fibres are removed and used for various industrial purposes, such as mat making and rope making. The remaining material, composed of short and medium-length fibres as well as pith tissue, is commonly referred to as waste-grade coir. The waste grade coir may be screened to remove part or all of the fibre, and the remaining product is referred to as coir pith. It provides excellent insulation against temperature and sound.

F. Spent Fire Brick

Using very pure refractory grog, plastic, and non-plastic clays, fire bricks are produced in accordance with IS: 6 and IS: 8 criteria. The various raw ingredients are suitably homogenized and crushed in large presses to get the correct form and size. At a later time, they are heated to 1300 °C in an oil-fired kiln.

IV. METHODOLOGY

A. Mixing Concrete

All the ingredients of concrete are mixed together however this mix should be homogenous and uniform in color and consistency. The mixing can either be done by hand or with the use of mixer.

B. 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.

C. 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 7,14,28 days.

D. 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.

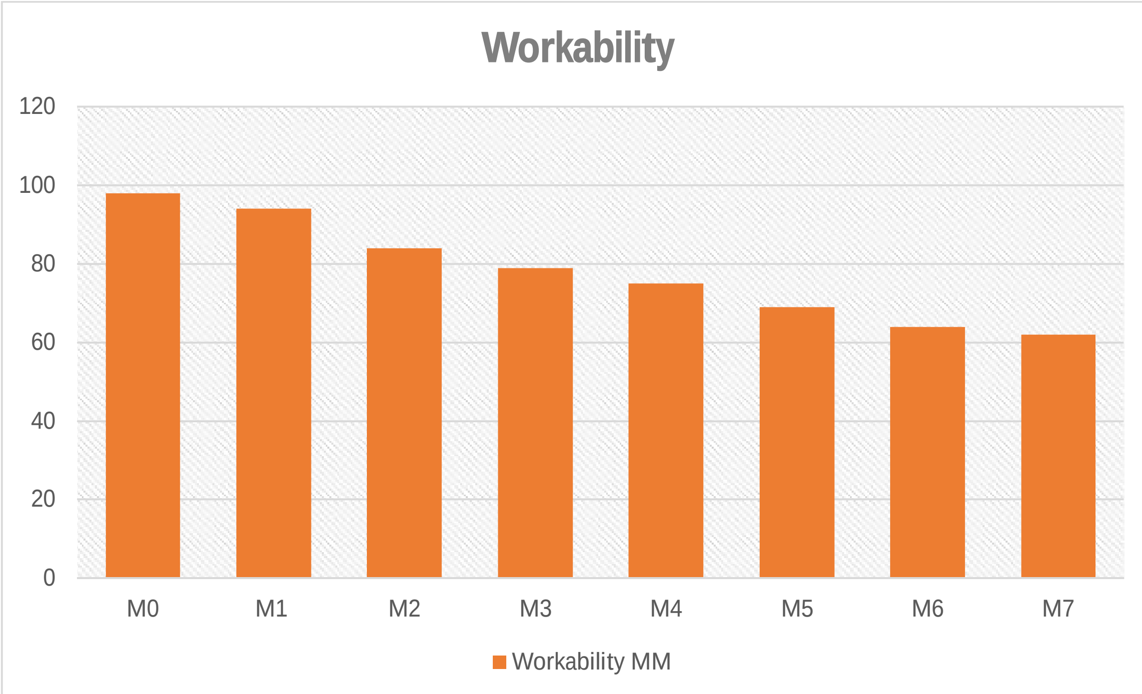

Fig -1: Slump Cone Test

E. 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.

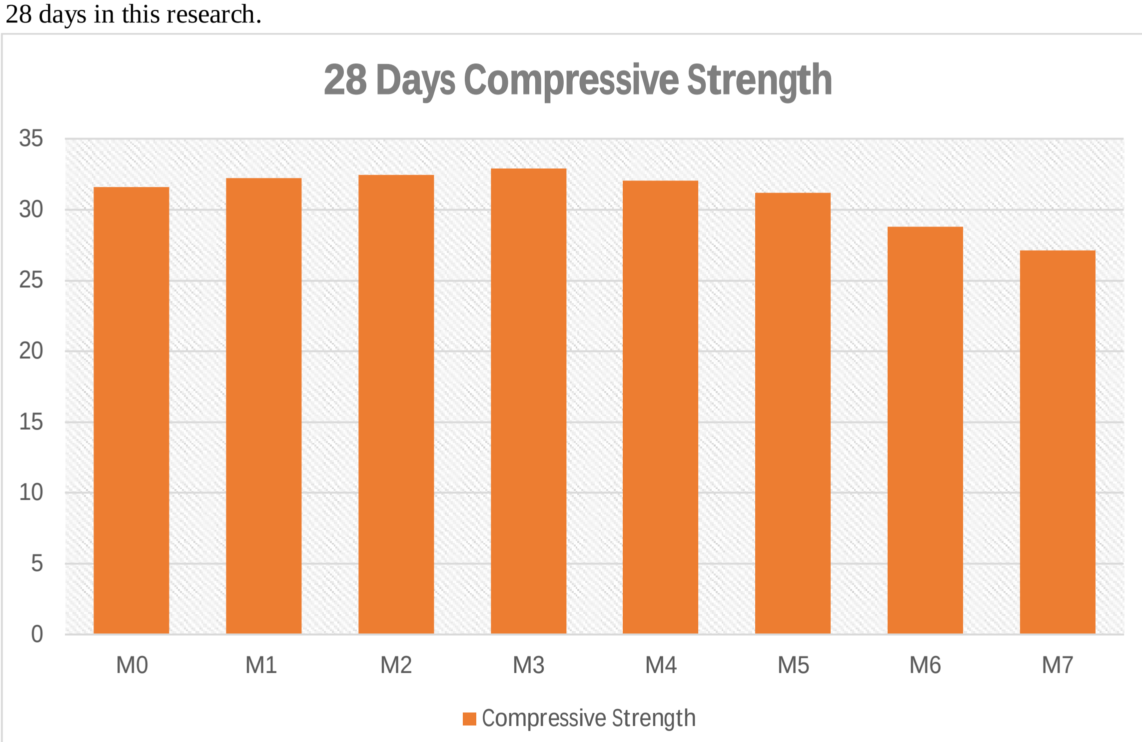

Fig -2: Compressive Strength Test 28

F. 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.

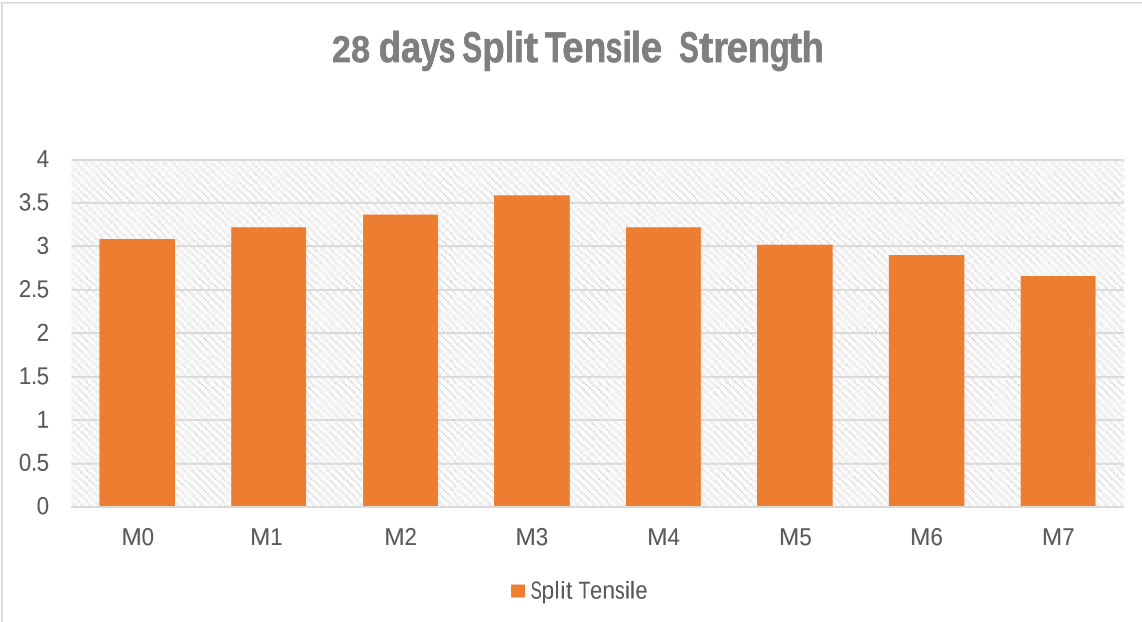

Fig -3: Split Tensile Strength Test 28

G. 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 7,14 and 28 days for testing.

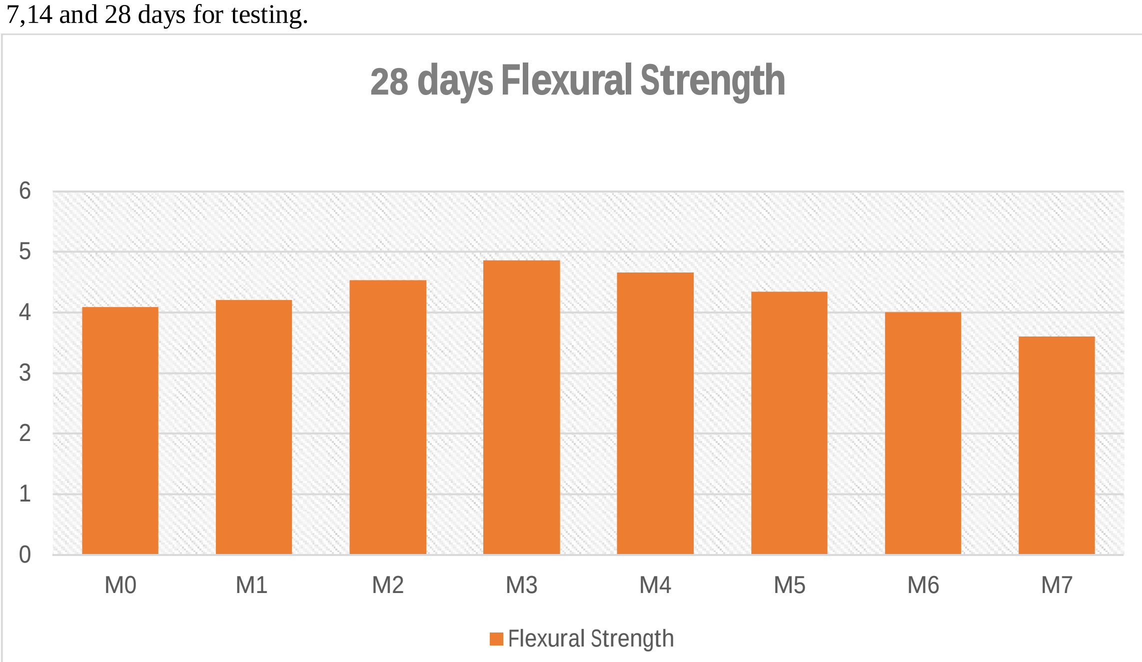

Fig -4: Flexural Strength Test 28

V. CONCLUSION

1) Coconut fiber acted as a reinforcement and hence acted as resistance to the cracks, thus increasing the flexural strength.
2) By replacing the fine aggregates with the copper slag and spent fire bricks addition with coconut fiber strengths get increased, also the replacement can be taken into consideration up to certain percentage workability factors gets enhanced as well.
3) The compressive strength of the concrete on comparing with conventional concrete gets increased till 21&21% of replacing the fine aggregates with the copper slag and spent fire bricks addition with coconut fiber for reinforcement 1.5% was used.
4) The flexural strength of the concrete on comparing with conventional concrete gets increased till 21&21% of replacing the fine aggregates with the copper slag and spent fire bricks addition with coconut fiber for reinforcement 1.5% was used.
5) In case of tensile strength, the optimum percentage that was noticed, was at 21&21% of replacing the fine aggregates with the copper slag and spent fire bricks addition with coconut fiber for reinforcement 1.5% was used

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