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AN EXPERIMENTAL STUDY ON STRENGTH OF CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT BY WOOD ASH AND FINE AGGREGATE BY COPPER SLAG

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Abstract - This research is done to find out the maximum percentage of wood ash as partial cement Replacement and Copper Slag as partial replacement of fine aggregate. The construction industries are in the search to find alternative products that can reduce the cost of construction. Demand for cement has been growing every day. In this Research, different wood ash concretes were developed by replacing 6-36% of wood ash for cement. Concrete plays an important role and a large quantity of concrete is being utilized in every construction. The wood ash which usually disposes of is used as an alternate for the cement.The aim of this project is to halt the pollution of the environment by the improper disposal of the Wood ash waste, by using it as an replacing material in form of ash in conventional concrete with grade M40, as it is normally used in construction sites. Copper slag is one of the waste materials which can be a promising future in the construction industry as a partial or full substitute of either cement or aggregates just because of its physical similarity to the fine aggregates. For each ton of copper production, about 2.2 tons of copper slag is generated. This slag is currently used for many purposes like landfilling, construction of abrasive tools, roofing granules, cutting tools, and railroad ballast material, which are not very high-value-added applications. The Copper Slag is replaced with sand in the percentage of 9% to 54%. Result shows that the wood ash replaced with Cement show positive results. Workability reduces with increasing % age of wood ash and copper slag. The maximum proportion of replacement has been found by conducting the following strength tests: Compressive strength test, Flexural strength test and Split Tensile Strength Test.

Keywords: Wood Ash, Copper Slag, Compressive Strength, Split Tensile Strength, Flexural Strength..

1. INTRODUCTION

Concrete is widely considered for its strength to withstand heavy loads and that‟s why this matrix is used for construction purposes. The matrix is usually prepared by mixing three major components namely cement, coarse aggregate and fine aggregate. All of them has their specific role in the matrix like cement acts as a binder and has binding properties which holds the aggregates together. The size for the fine aggregates must not be more than 4.5 mm, and it acts as structural filler and most of the volume is being occupied by fine aggregates in concrete. The whole dimensional stability totally depends on fine aggregates. And it also influenced all the major properties of concrete like hardness. The size of the coarse aggregates must not be less than 4.5mm and the coarse aggregates used in this research of size 12 mm to 20 mm. The irregular shape of the coarse aggregates make stronger bond than any gravel does. As the bonding between aggregate and mortar influence the flexure strength of the sample. The by products such as fly ash, copper slag, silica fume etc are considered as waste from several years and is dampened in the open land which eventually will not be beneficial for the land‟s fertility. So, from the past few decades, research has been carried out of how that waste product could be used for the structural construction purposes.

1.1 WOODASH

There are several minerals in wood ash, which can be extracted for further use. A big ingredient calcium carbonate, which is 25% or even 45% (depending on feedstock and burning condition). Less than 10 percent is potash and less than 1 percent is phosphate; there are some elements of iron, manganese, zinc, copper and some metal parts. These numbers however, vary as combustion temperature is an important element for the determination of wood ash. Many of these are in the form of oxides, mainly. If we mix the ashes to water the insoluble silica and calcium carbonate will settle to bottom and sodium salt and soluble potassium will dissolve. We can then remove the water (containing the “good stuff”) and throw the insoluble ingredients’ away. To isolate soluble carbonates from chlorides, we will exploit the solubility of hot water. This mixing was done to facilitate easy pozzolanic reaction and reduced water content due to uniform size distribution. The wood ash can contribute to reducing the heat loss rate of building was given their relatively low thermal conductivity compared to gypsum board.

1.2 COPPER SLAG

The optimum use of industrial waste or secondary material has strengthen the production of cement and concrete in the construction field. There are number of new

by products and waste materials are generated by various industries on a large scale. Dumping or disposal of waste materials causes environmental problems, so, recycling of waste materials has a great potential in the concrete industry. The by products such as fly ash, silica fume and slag were considered as waste materials from the few decades. 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. For every ton of copper production; about 2.2 tonnes of CS is generated. It is expected that approximately 24.6 million tons of slag are produced from the world copper industry (Gorai et al. 2003). While CS is broadly used in the sand blasting manufacturing trade and in the manufacturing of abrasive tools, the remainder is disposal of waste without any future reuse or reclamation. CS possesses mechanical and chemical characteristics that qualified the material to be used in concrete as a partial replacement for Portland cement. CS also demonstrates pozzolanic properties because it contains low SiO2. Under activation with NaOH, it can exhibit cementitious property and can be used as partial or full replacement for Portland cement. The utilization of CS substitution as cement replacement in concrete, for instance, ordinary Portland cement substitution in concrete, or the dual benefit of eliminating the cost of disposal, and lowering the cost of the concrete. Further, the use of CS in the concrete industry as a replacement for cement can have the benefit of reducing the costs of disposal and helps in protecting the environment. DWood ash it the fact that a number of studies

2. LITERATURE REVIEW

S.Choudhary, A.Manir(2015) : In this study, test was done on wood ash was prepared from the unregulated burning of raw dust and is tested for its suitability as a partial replacement of cement in conventional concrete. The saw dust was acquired from a unit of wood polishing. The wood ash characteristics like physical , chemical and mineralogy is presented and analyzed. The strength parameter (compressive strength, split tensile strength, and flexural strength) of concrete with blended wood ash cement are evaluated and studied. Two different ratio of water to cement (0.4 and 0.45) and five different replacement of wood ash (5%, 10%, 15%, 18%, 20%) inclusion of control specimen for both water to cement ratios is considered. Outcomes of compressive strength test, flexural strength test and split tensile test suggested that the strength characteristics of mixture of concrete decrease slightly, but increase in wood ash content but strength increase later. The result of the XRD test and wood ash chemical analysis showed that it contain amorphous silica and thus can be used as a substitute that replace cement. It was concluded that wood ash could be mixed with the cement without adversely affecting the properties of concretes strength With the use of a new statistical theory of the Support Vector Machine (SVM), strength parameters were predicted by making a suitable model and as a result, the soft computing application in structural engineering has been successfully given in this research paper.

Batt and garg (2017) Wood ash is created as waste from combustion in boiler, in pulp and paper mills, steam power plants and some other generating installations for thermal power. Wood is a renewable energy resource and an environmental friendly material. The increased demand for the use of waste wood for the purpose of energy production and thus creation of more ash waste from wood. The research focuses on wood ash in corporation in combination with ordinary Portland cement when using it for various structural works. The detailed study in sieve analysis, consistency, and water absorption, setting time and slump tests of wood ash produced important result to emphasize the detailed study process. Uncontrolled saw dust burning to form wood ash is used as a partial cement substitute, and therefore changing its physical and chemical properties in this way. Such properties are somewhat found the same as fly ash. The concrete mix are replaced with the amorphous wood ash as an admixture of cement having grain size less than 75 microns in proportions of 5%, 10%, 15%, 20%, 25% and 30% by weight of cement. In this Study, a research work is conducted for determining the change in workability or consistency of concrete.

Mehnaza Akhter (2017) This research is done to investigate the present thesis deals with the findings of experimental studies on effects of wood ash on compressive strength and setting time of cement and concrete. Influence of wood ash on cement and concrete compressive strength by varying percentage of wood ash 0% 10%, 20%, 30%, and 40% by weight of cement. The wood ash in this paper as partial replacement of cement in concrete is used and its effects on concrete properties was achieved. For the compressive strength test, cubes measuring 70.6mm 70.6 mm x70.6mm Cubes of size were used and specimens of size 150 mm X 150 mm X 150 mm for compressive strength test of concrete. Water cured all the specimens and processing is performed for 7 days and 28 days.The result of compressive strength of cement and concrete with wood ash were observed and compared with the results of normal concrete and concrete showed the significant improvements in the results of compressive strength. The optimum percentage of various agro waste replacement is obtained..

Teik Thye Lim, and Chu J (2006) studied done the research work on the Use of spent copper slag for land reclamation, they came to the conclusion the material copper slag is not likely to cause notable changes in the redox condition of the subsurface over a long period of time. In case of geotechnical and physical properties, the by-product in the copper extraction i,e; copper slag is a good filling material. In general, the spent copper slag is suitable to be used as a fill material for land reclamation.

Vashisht Patil, Prof. M. C. Paliwal(2020) This research is done to investigate This huge amount of production prompts utilization of natural resources and it is very unsafe for environment. Enormous amount of waste by-products are delivered from the manufacturing enterprises, for example, mineral slag, fly ash, silica fumes, rice husk ash and so on. the rice husk ash is an agricultural byproduct which is obtained from the rice mills. The research work here deals with the partial replacement of cement with RHA in concrete at various percentage such as 0%,5%,10%,15%,20% and 25% by mass of cement. Various experimental investigations are carried out to find out the compressive strength, split tensile strength and of concrete samples cured for period of 7 and 28 days . the results obtained from the experiments with satisfactory replacement of cement with rice husk ash are presented in this research paper.

Harsha Bhaskaran et.al 2016 This paper presents the partial replacement of cement by egg shell powder. In order to reduce the impact of carbon dioxide emission and to protect the environment, cement is been replaced by egg shell powder. This study represents the influence in properties of concrete when cement is replaced by 5%, 10% and 15% of egg shell powder. Properties are experimentally investigated based on compressive strength, split tensile strength and flexural strength of concrete. Compressive, tensile and flexural strength up to 7 days of age were compared with conventional concrete; from the results obtained, it is found that egg shell powder can be used as cement replacement material.

3. MATERIALS

3.1 CEMENT Cement is a strong binder and is used in construction which sets and hardens and it actually bind different materials together. The cement is used as a component in the production of mortar in masonry and for construction process and the associate degree of concrete to make a tough building material for constructing durable things.

S.No	Properties	Test Results
1	Normal Consistency	0.32
2.	Initial Setting time	55 mins
3.	Final Setting time	340 mins
4.	Specific Gravity	3.15

3.2 FINE AGGREGATES Aggregates consists of two types, that are fine aggregates which are smaller and fine in size and other is coarse aggregates which are comparatively bigger in size than fine aggregates. A fine aggregate consists of natural stone or crushed particles passing through 4.75mm size sieve. River sand is generally used as a fine aggregate having particle size of 0.07mm.Naturally available gravel and sand usually is used as fine aggregates. The extraction is done by digging or dredging from river, lakes, pit or sea beds.

3.3 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 aggregate are rounded or irregular gravel stones. Crushed stone make up the majority of the small particles of coarse aggregate. Coarse aggregates should be carefully handled to avoid dirt contamination. It should be clean and dry

3.4 WOOD ASH

COMPONENT	MASS%
SiO2 31.8	31.8
Al2O3	28
28 Fe2O3	2.34
CaO	10.53
NaO	6.5
K2O	10.38
MgO	9.32

Table -1: **Chemical composition of WOOD ASH**

3.4 COPPER SLAG

S No	Composition	Results
1.	Fe (FeO or Fe3O4)	30-40%
2.	SiO2	35-40%
3.	Al2O3	Upto 10%
4.	CaO	Upto 10%
S No	Composition	Results
1.	Fe (FeO or Fe3O4)	30-40%

Table -2: Chemical composition of COPPER SLAG

4. METHODOLOGY

4.1 CASTING In order to test compressive strength of concrete, concrete specimens of standard cubical mould of size 150*150*150mm were casted in eleven different batches having different replacement percentage of Rice Husk Ash and ESP. The specimen used for this test is cylindrical and its dimension is 150mm in diameter and 300mm in length. The test is made on the beam of size 700 mm× 150mm × 150mm.

4.2 CURING All the materials when mixed adequately to achieve homogeneous mixture. After mixing the concrete was checked for required slump and then filled into moulds of required tests. The mould filled with concrete was compacted by table vibrator to achieve proper compaction. Mould surface was finished with trowel and date of casting with mix designation number is marked on it. The concrete specimens were then removed from moulds after 24 hours and then placed in curing tanks for curing process for 28 days at normal room temperature

4.3 SLUMP CONE 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

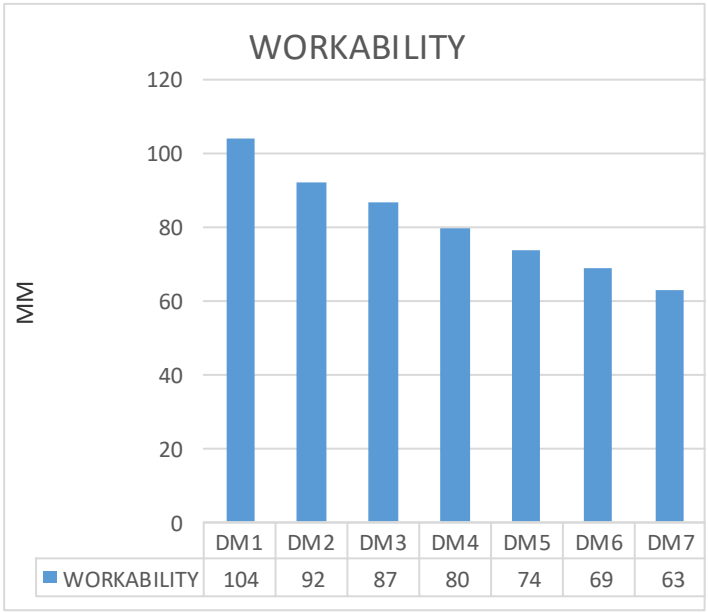


Fig -1: SLUMP CONE TEST

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 days,14 days and 28 days in this research.

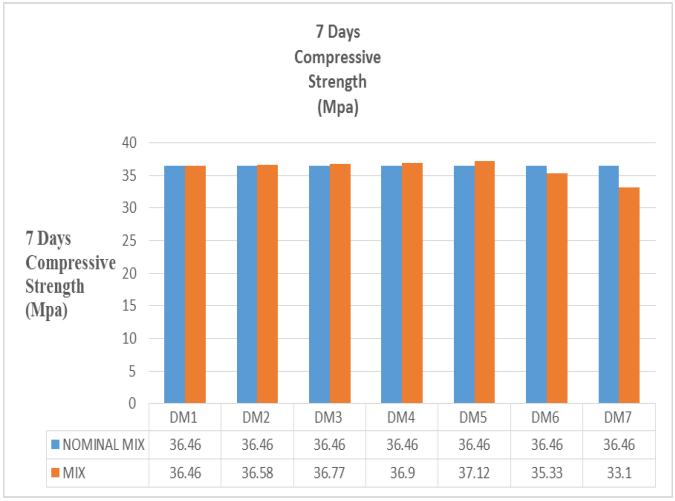


Fig -2: COMPRESSIVE STRENGTH TEST 7 days

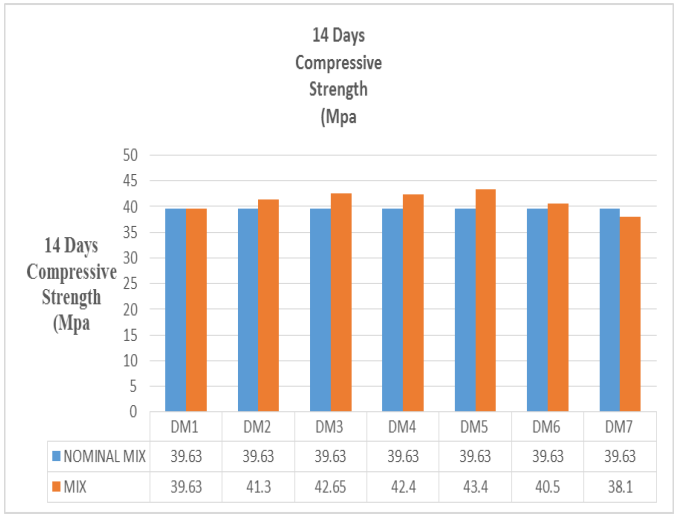


Fig -3: COMPRESSIVE STRENGTH TEST 14 days

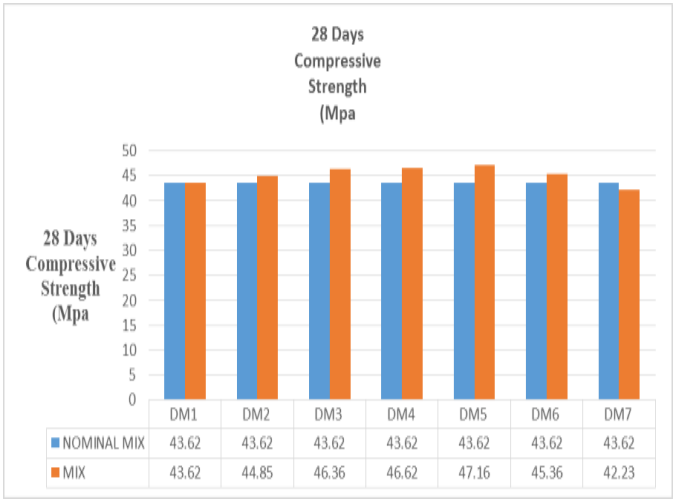
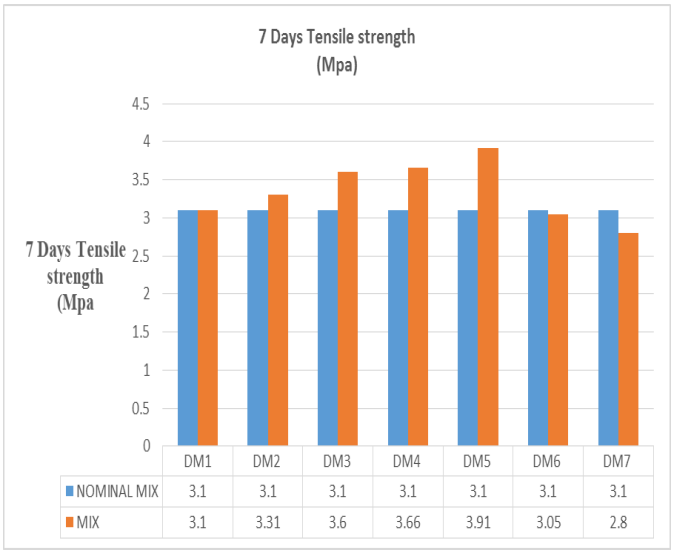


Fig -4: COMPRESSIVE STRENGTH TEST 28 days

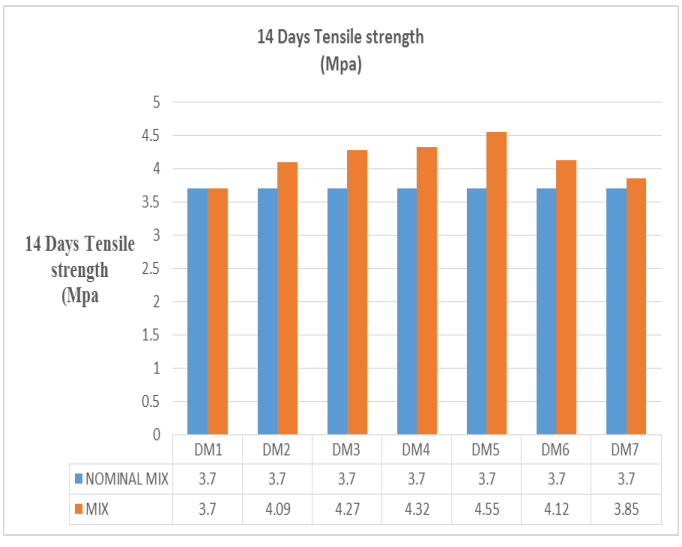
4.5 SPLIT TENSILE STRENGTH

The specimen used for this test is cylindrical and its dimension is 150mm 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 days, 14 days and 28 days in this research at the temperature 27+ 2°c. Then draw the line on the specimen



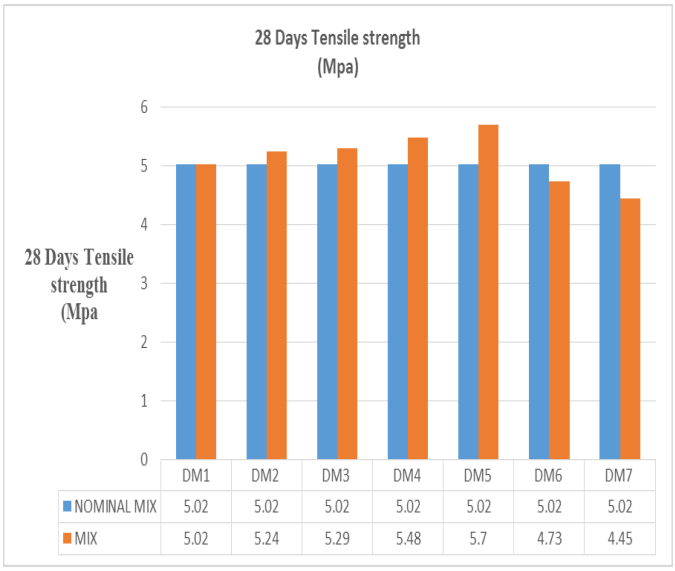
	DM1	DM2	DM3	DM4	DM5	DM6	DM7
NOMINAL MIX	3.1	3.1	3.1	3.1	3.1	3.1	3.1
MIX	3.1	3.31	3.6	3.66	3.91	3.05	2.8

Fig -5 SPLIT TENSILE STRENGTH 7 days



	DM1	DM2	DM3	DM4	DM5	DM6	DM7
NOMINAL MIX	3.7	3.7	3.7	3.7	3.7	3.7	3.7
MIX	3.7	4.09	4.27	4.32	4.55	4.12	3.85

Fig -5 SPLIT TENSILE STRENGTH 14 days

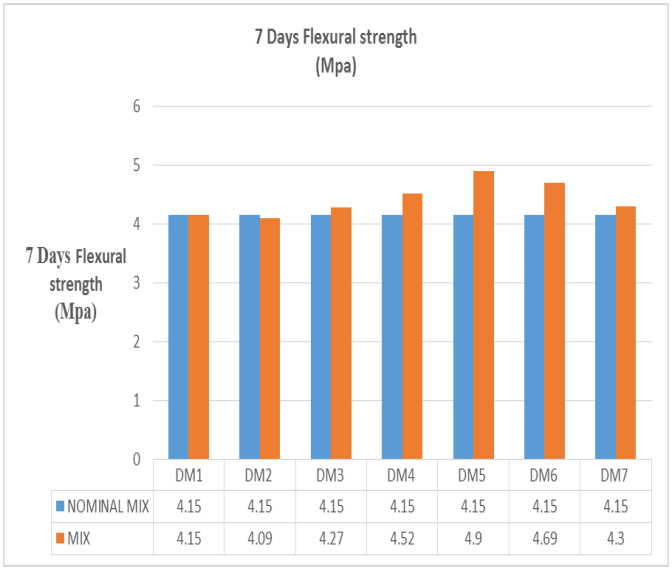


	DM1	DM2	DM3	DM4	DM5	DM6	DM7
NOMINAL MIX	5.02	5.02	5.02	5.02	5.02	5.02	5.02
MIX	5.02	5.24	5.29	5.48	5.7	4.73	4.45

Fig -6 SPLIT TENSILE STRENGTH 28 days

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 7 and 28 days for testing.



	DM1	DM2	DM3	DM4	DM5	DM6	DM7
NOMINAL MIX	4.15	4.15	4.15	4.15	4.15	4.15	4.15
MIX	4.15	4.09	4.27	4.52	4.9	4.69	4.3

Fig -7 FLEXURAL STRENGTH 7 days

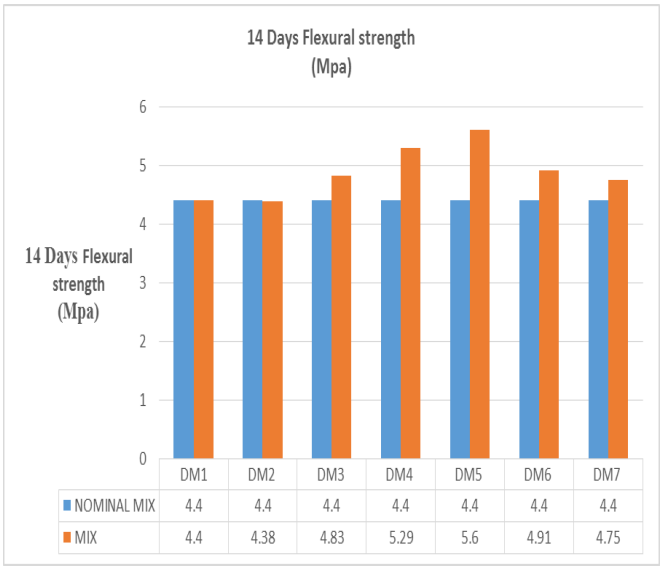


Fig -7 FLEXURAL STRENGTH 14 days

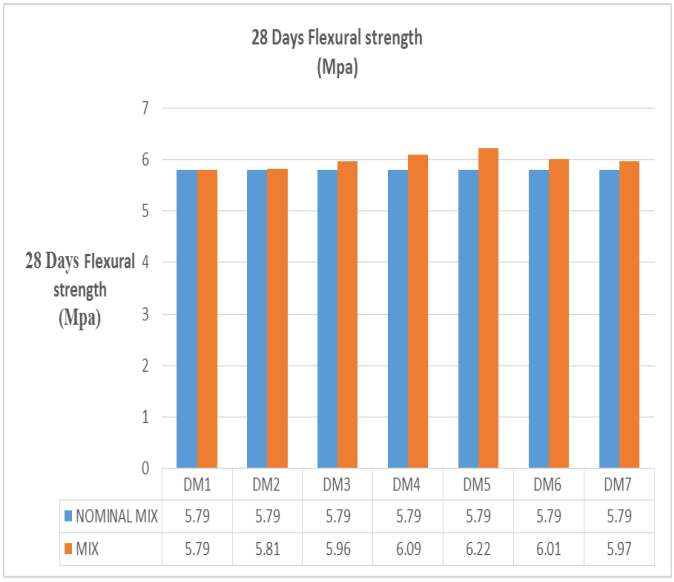


Fig -8 FLEXURAL STRENGTH 28 days

5. CONCLUSIONS

1. Workability results show that workability of concrete decreases a bit with the increase in the quantity of Wood ash and copper slag. The wood ash and copper slag are totally mixable with other concrete aggregates. All the concrete containing wood ash and Copper slag show good enough workability to be easily compacted and finished.

2. The Compressive strength results show that by replacing cement with wood ash and Fine aggregates with copper slag, there is increase in compressive strength but aggregates in higher volume decreases strength. After 24 % wood ash and 36% Copper slag volume addition and replacing Cement and fine aggregates in the same proportion, there is decrement of compressive strength.

3. The optimum compressive strength is achieved at 24% replacement of the Cement by wood ash and 36% replacement of fine aggregates with Copper Slag and shows an increases over conventional concrete at 28 days.

4. The optimum value of split tensile strength is at 24% replacement of Cement by wood ash and 36% replacement of the fine aggregates with Copper Slag. After that it keeps decreasing. It shows an increase of at 28th day.

5. The flexure strength also showed maximum strength when 24% of Cement is being replaced by wood ash and 36% of fine aggregates is being replaced with Copper Slag, and increased the strength up to at 28th day. Both help in increasing strength at low volume replacement.

6. The optimum value of strength in compression, split tensile and flexure came at 24% replacement of the Portland cement by wood ash and 36% replacement of the taken fine aggregates with Copper Slag.

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