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Effect of Partial Replacement of Fine Aggregate with Copper Slag and CRT With Addition of Aramid Kevlar Fiber

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Abstract: Concrete is the most widely used construction material and the second most consumed substance in the world. Different Copper Slag and CRT concretes were created in this study by using Aramid Kevlar fiber in place of fine Aggregates. Every construction makes use of a significant amount of concrete because of its importance. Cathode-Ray Tube (CRT) technology has lagged behind as a result of the constant replacement of new technologies, such as LED Display Panel and Liquid Crystal Displays (LCD), which is leading to an increase in the number of discarded CRTs that need to be disposed of each year globally. The heavy waste material known as CRT funnel glass can increase the weight per unit of concrete. In terms of the components of products made during the copper production process, copper slag qualifies as an industrial product. It is a crystalline granular substance that can be utilized as a finer aggregate in concrete because of its high density and sand-like particle size. Aramid Kevlar fiber are completely synthetic organic polymers, aromatic polyamides are sometimes known as kevlar fiber. The properties of this aramid-kevlar fiber are extremely diverse and they have low density. This project's goal is to stop environmental damage caused by inappropriate disposal by employing it as an additional material in specially developed Copper Slag and CRT concretes by Replacing the fine Aggregates and adding Aramid fiber, which is typically used on construction sites. The 36&24% of Fine Aggregates with Copper Slag and CRT and 0.6% of Aramid Kevlar Fiber were used as reinforcement. The compression strength test, flexural strength test, and split tensile strength test were used to determine the maximum proportion of replacement.

Keywords: CS (Copper Slag), CRT (Cathode Ray Tube), AKF (Aramid kevlar Fibers) workability, compressive strength, Split Tensile strength, Flexural strength

I. INTRODUCTION

Concrete is the second most consumed substance in the world and it is the most commonly used construction material. Major volume of concrete is contributed by aggregates. About 70–80% volume of the structural concrete is occupied by the aggregates, in which coarse aggregate (CA) contributes 40–50% and fine aggregate contributes 25–30%. Conventionally, naturally available materials like crushed rocks and river sand are used as coarse and fine aggregate respectively. Nowadays scarcity of resources is a major problem resulted by the excessive depletion of natural aggregates. The protection of environment is one of the major challenges in today's world. We can aid to this problem by reusing and recycling the waste products, reducing the use of natural materials and using environmentally friendly materials. In order to have sustainable development one must focus on these environmental problems. Minimizing the waste can be achieved by using waste products as aggregates and other materials in construction practices. This will not only minimize the waste but also preserve our natural resources. This will help in increasing its life span and thus reducing dumping of waste, space for landfill disposal and extracting natural resources.

A. Aramid Fiber Faber

Aramid kevlar fiber is known as the aromatic polyamides because they are the totally man-made polymers organic. They produced from the chemical liquid blend. This aramid kevlar fiber are contains properties range are very wide and they having that are low density. But they are well impact resistant. Now aramid kevlar fiber molecules present are characterized by the chain of rigid polymers they are powerful hydrogen bond to link. Aramid kevlar fiber is treated in commercially way in the foam of meta-aramid fiber in 1960. They have high strength properties used for different-different various applications.

B. Cathode Ray Tube (CRT)

A Cathode Ray Tube (CRT) is the glass video display component of an old electronic video device. Reuse or repair of these tubes are not practical options, CRTs can be recycled. Due to the presence of lead located in the funnel glass, CRTs marked for disposal are considered hazardous waste. CRTs and CRT glass were once easily recycled into new CRTs. However, the demand for new CRTs has collapsed in favour of new flat panel technologies. Because of rising costs, negative economic incentives and shifts in CRT glass markets, some CRT processors and recyclers are choosing to store the glass indefinitely rather than send it for recycling or disposal, which increases the risk of mismanagement and/or abandonment of CRTs.

C. 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. . 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. Due to the low quantity of CaO in copper slag, granulated copper slag has pozzolanic properties. Copper slag can develop cementitious characteristics as the CaO level rises. According to a study, a copper slag with about 19 percent CaO showed excellent cementitious characteristics when activated with NaOH. After 4 hours of curing at 80°C, the strength of copper slag mortars activated with NaOH is even greater than that of PC mortars. Before even being immersed in water and a corrosive prepared by adding 230 g/L NaCl, 64 g/L MgCl2, 15 g/L KCl, and 14 g/L MgSO4, these PC mortars and copper slag were activated with NaOH. Whether they are submerged in the water or the corrosive solution, the strength of the NaOH-activated copper slag mortars gradually increases over time. Copper slag is black and glassy in nature. Its particles are irregular and has specific gravity of 3.54 and bulk density of 1.89.

II. LITERATURE REVIEW

Hilton et al. in 2019 CRT glass pozzolana recycled in concrete at a 20% by weight cement replacement, produces a significant benefit in concrete and confirms that it is a lower carbon material with cementitious properties for the higher energy cement. It will also lessen the overall environmental impact of the cement..

Kim et al. 2018 concrete's fine aggregates were swapped out for CRT waste funnels. Heavy weight waste glass has been added to concrete mixtures, and it has been suggested that these mixtures exhibit remarkable endurance and can be utilized to build radiation shielding structures. The air content increased somewhat as the waste glass content grew, and the slump value increased as the waste glass substitution ratio increased. Low water cement ratio and low air content could cause the loss in compressive and flexural strength to worsen.

Naganur et al. (2014) Increased as the percentage of copper slag rose. The greatest gain in compressive strength was noted at a replacement level of 40%. Concrete's strength started to decline as copper slag substitution reached 50% of the sand content. Thus, the characteristics of concrete were assessed up to a 60% replacement level. The density of concrete grows together with the age of CS. The replacement ratio for concrete's splitting tensile strength has increased to 40%. The splitting tensile strength of concrete produced with control mix has been shown to be lower than that of concrete produced with replacement percentages more than 40%. Corrosion of the reinforcement has been seen to worsen as With increase in the percentage of copper slag, the concrete has been found to be more vulnerable to acid attack. after 30 days of immersion in H2SO4 solution, The loss of weight has increased with increase in copper slag percentage in concrete.

Madhavi, T.Ch. et al. (2014): used Concrete's mechanical properties can be enhanced by substituting copper slag, an industrial waste product, for cement and sand. Copper slag can be utilised up to 30%, however using it more than 50% results in a loss of strength.

George Soupionis (2021) In this paper, the reinforcement of concrete combining composite materials with carbon,glass and aramid fibers is discussed. Accordingly, cement specimens reinforced with chopped carbon fibers were manufactured via the retrofitting method and coated using various different types of fabrics (carbon, glass and aramid), and epoxy resin systems were developed and studied using compressive strength tests. In addition, polymeric matrix (epoxy resin) composite materials reinforced with different types of fabric (carbon, glass and aramid (Kevlar® 49)) were manufactured and their shear and bending strengths were measured. Before reinforcing cement specimens, all fabrics (carbon, glass and aramid (Kevlar® 49)) were placed in a vacuum chamber and were processed via pre-impregnation. This specific reinforcing method significantly improved the mechanical properties of cementitious structures with compressive strength values that reached 81 MPa. In a similar way, the bending and shear strengths of the materials under study were measured at 405 MPa and 33 MPa, respectively.

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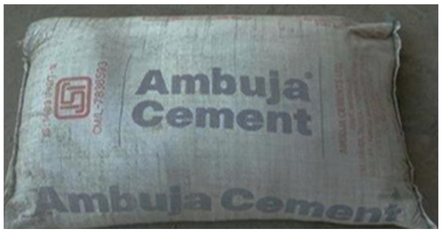
III. MATERIALS

A. Cement

Cement is a fine, grey powder. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulphate (which controls the set time) and up to 5% minor constituent it is mixed with water and materials such as coarse aggregates and fine aggregates to make concrete. The cement and water form a paste that binds the other materials together as the concrete hardness. It is a material with adhesive and cohesive properties which is capable of bonding mineral fragments into a compactsolid. It is used in the making of concrete with property of setting and hardening, of which when the chemical properties reacts with water. OPC does not disintegrate in water as it sets and hardens in water. The cement contains two basic ingredients namely argillaceous and calcareous.



B. Coarse Aggregates

Aggregate which has a size larger than 4.75 mm or which retrained on 4.75 mm IS Sieve are known as Coarse aggregate. Materials which are large to be retained on 4.75 mm IS sieve and contain only that much of fine material as is permitted by the specifications are termed as coarse aggregates. The graded coarse aggregate is described by its nominal size i.e., 40 mm, 20 mm, 16 mm and 10 mm. Since the aggregates are formed due to natural disintegration of rocks or by the artificial crushing of rocks or gravel, they derive many of their properties from the parent rocks. 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.

C. 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 seabeds. Fine aggregate that was present at the site was extracted from Jammu. Sieve analysis would be done to find out the zone conforming IS: 383-1970. The physical properties of sand were provided by the concerned lab.

D. CRT

Recycled CRT glass fine aggregate were used in the preparation of cement mortar. The Waste CRT tubes were collected from Local Scrap yard of Moradabad and then Crushed to produce fine aggregates the aggregates produced were then sieved through 4.75 and 0.075mm sieve to get desired size. The maximum size of fine CRT aggregates used was 2.5 mm.

They were crushed by hammer and sieved from 4.75mm sieve.

Table no. 1 Properties of CRT

Sr	Physical Property	Fine Aggregate	CRT Aggregate
1	Color	Grey	Blackish
2	Shape	Angular	Angular
3	Fineness modulus	2.88	2.76
4	Specific Gravity	2.59	2.910
5	Bulk density (kg/m³)	1425	1555

E. 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. 2 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%

F. Aramid Kevlar Fiber

Aramid kevlar fiber is known as the aromatic polyamides because they are the totally man-made polymers organic. They are produced from the chemical liquid blend. This aramid kevlar fiber are contains properties range are very wide and they having that are low density. But they are well impact resistant. Now aramid kevlar fiber molecules present are characterized by the chain of rigid polymers they are powerful hydrogen bond to link. Aramid kevlar fiber is treated in commercially way in the foam of meta-aramid fiber in 1960. They have high strength properties used for different-different various applications.

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Table no. 3 Properties of AKB

Fiber	Density g/cm3	Melting Point(*c)	Maxi. Service Temp(*c)	Glass Transition temp(*c)	Tensile properties		
					Ult.Strenght Mpa	Elastic Modulus gpa	Ult. Elongation (%)
Aramid	1.39	-	300	-	3000	70	4

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.

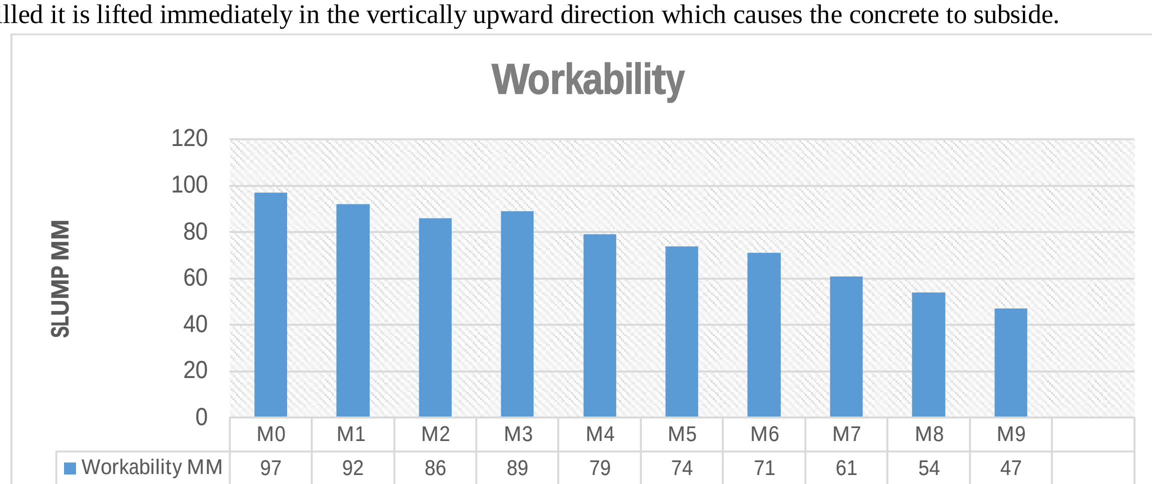

Fig -1: SLUMP CONE TEST

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.

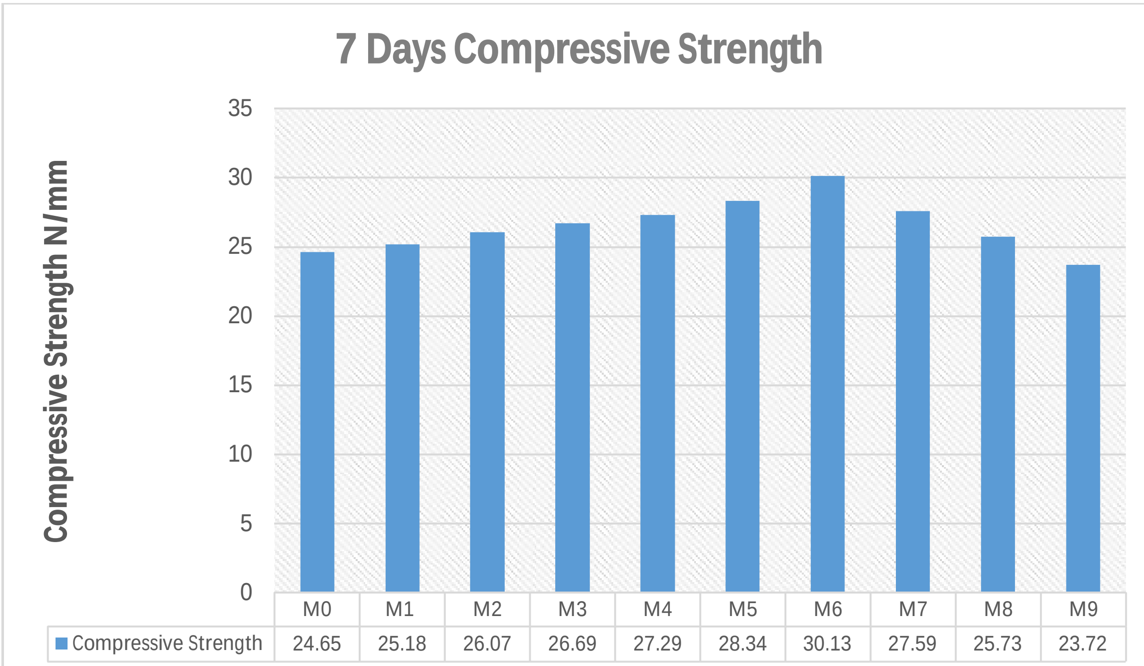

Fig -2: Compressive Strength Test 7

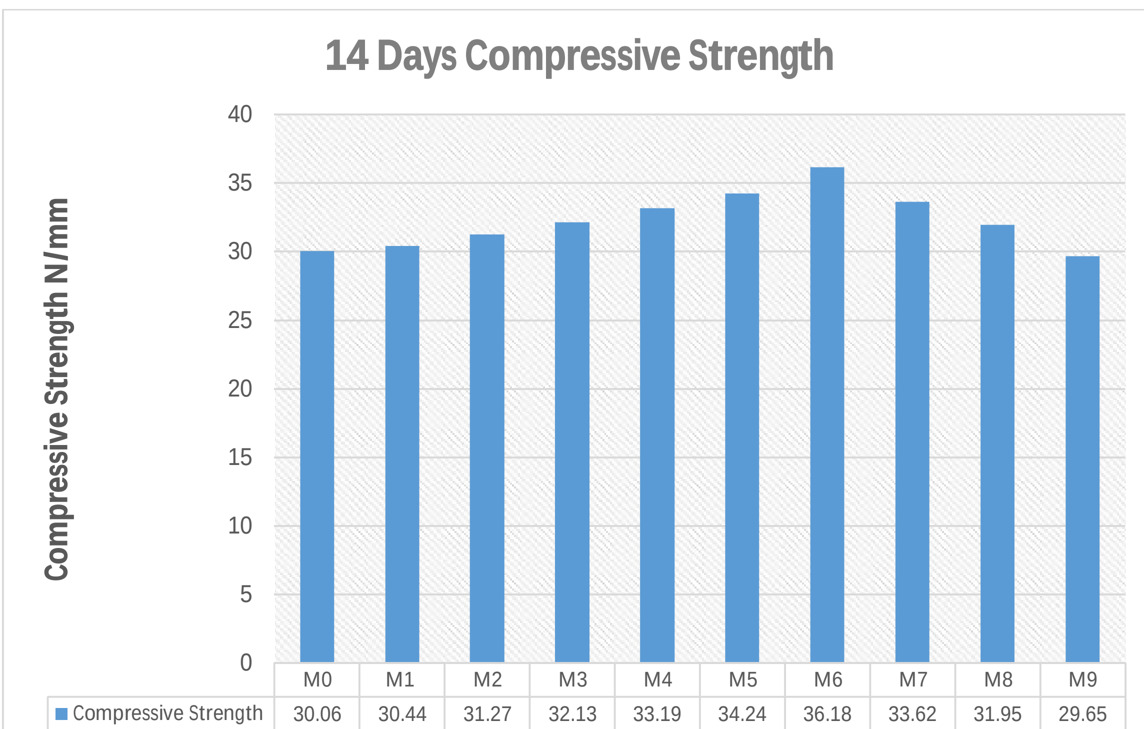

Fig -3: Compressive Strength Test 14

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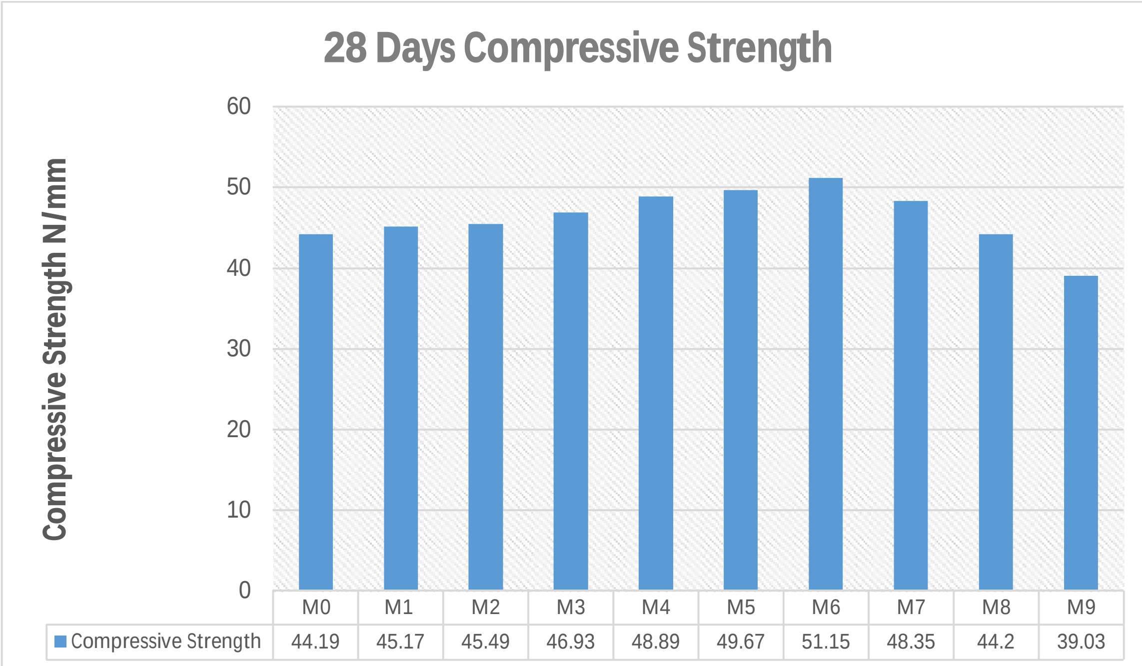

Fig -4: Compressive Strength Test 28

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.

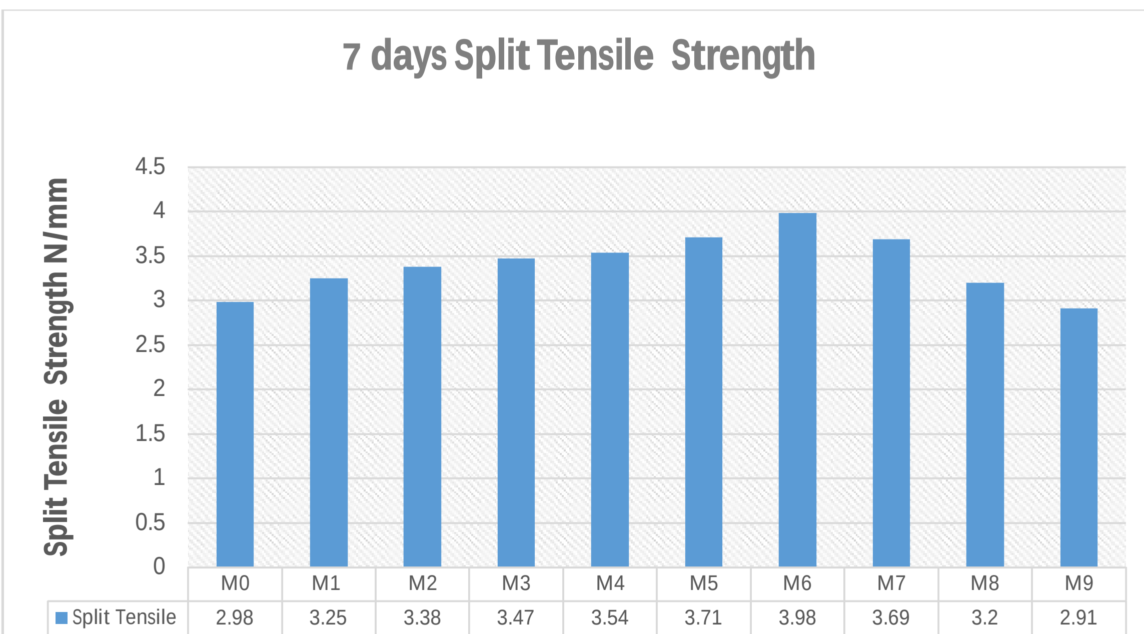

Fig -5: Split Tensile Strength Test 7

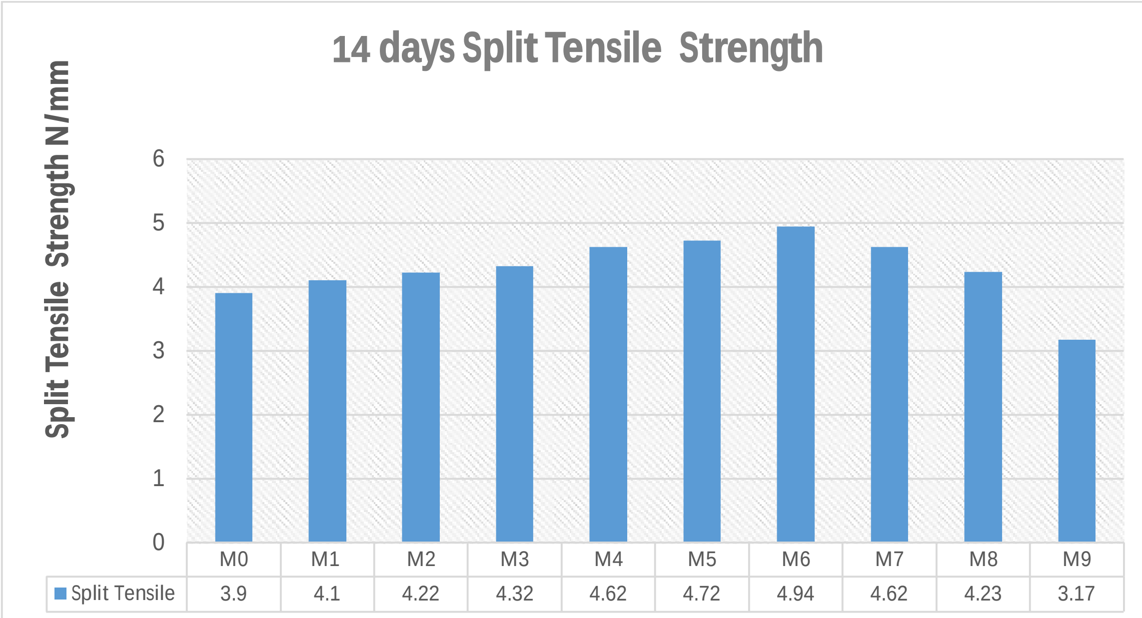

Fig -6: Split Tensile Strength Test 14

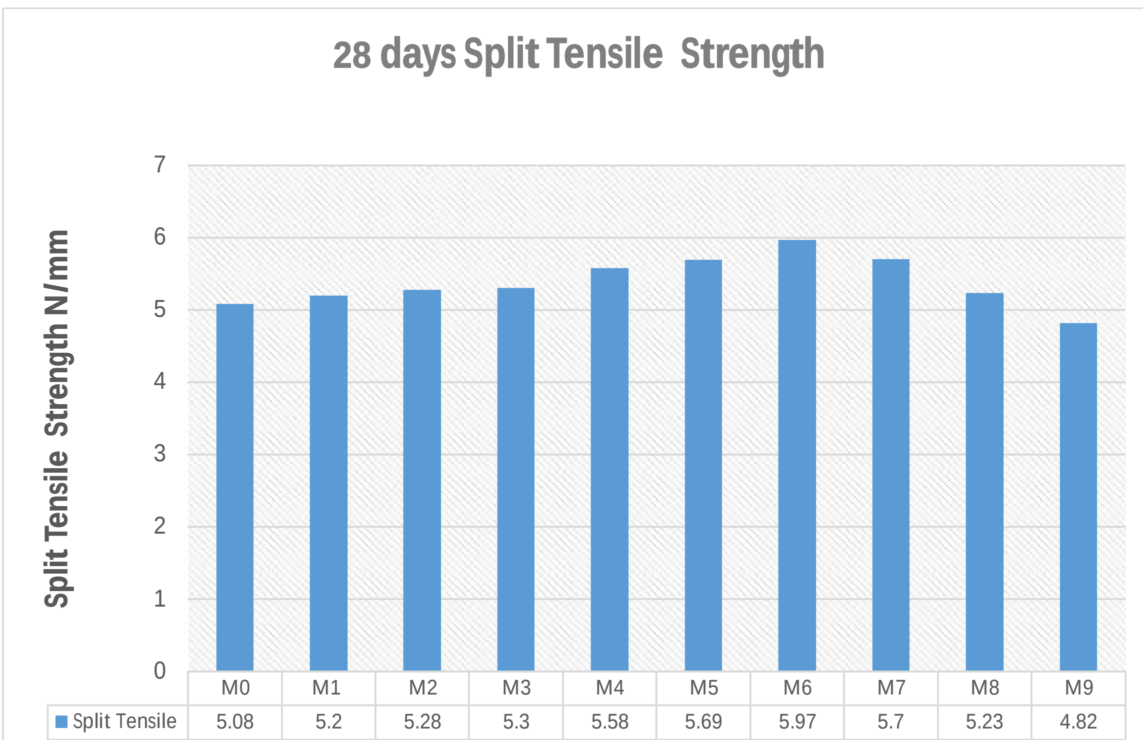

Fig -7: Split Tensile Strength Test 28

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.

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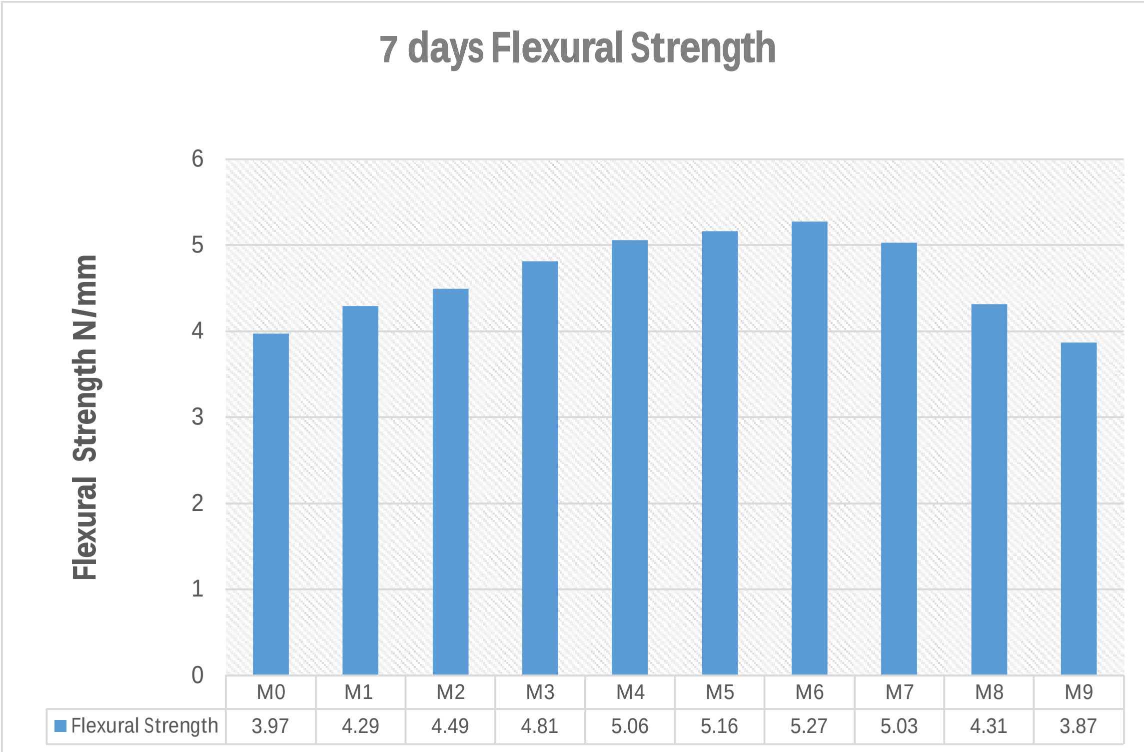

Fig -8: Flexural Strength Test 7

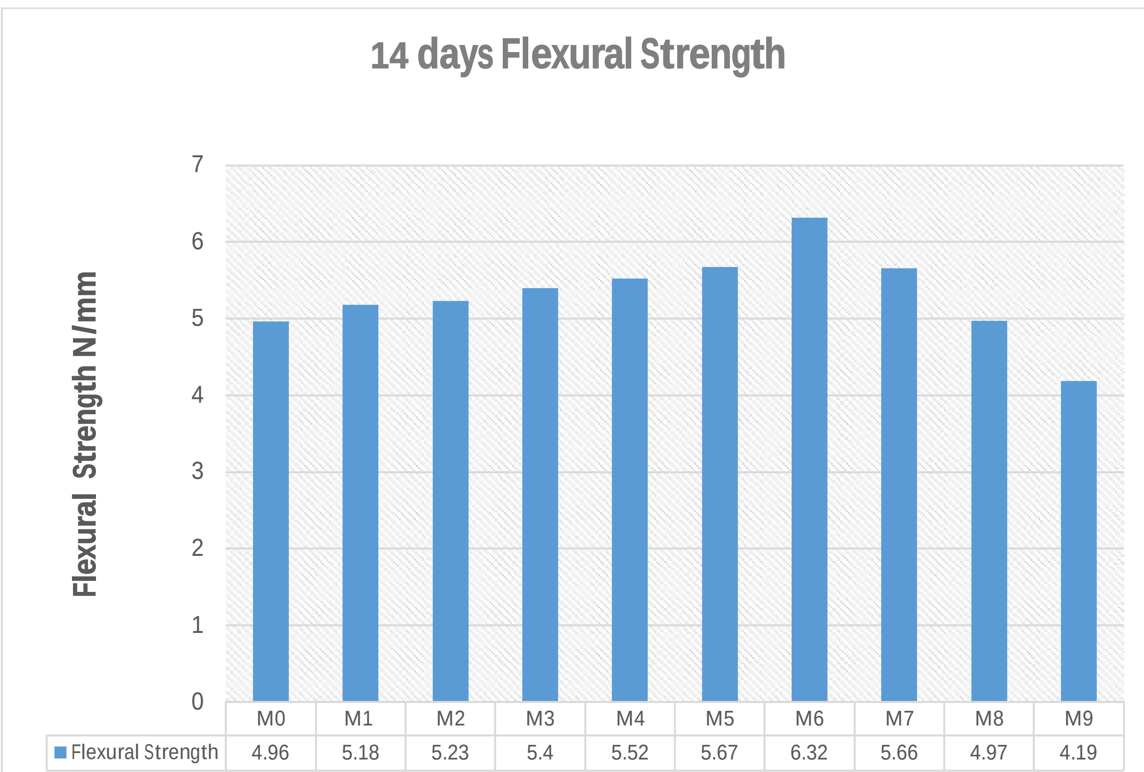

Fig -9: Flexural Strength Test 14

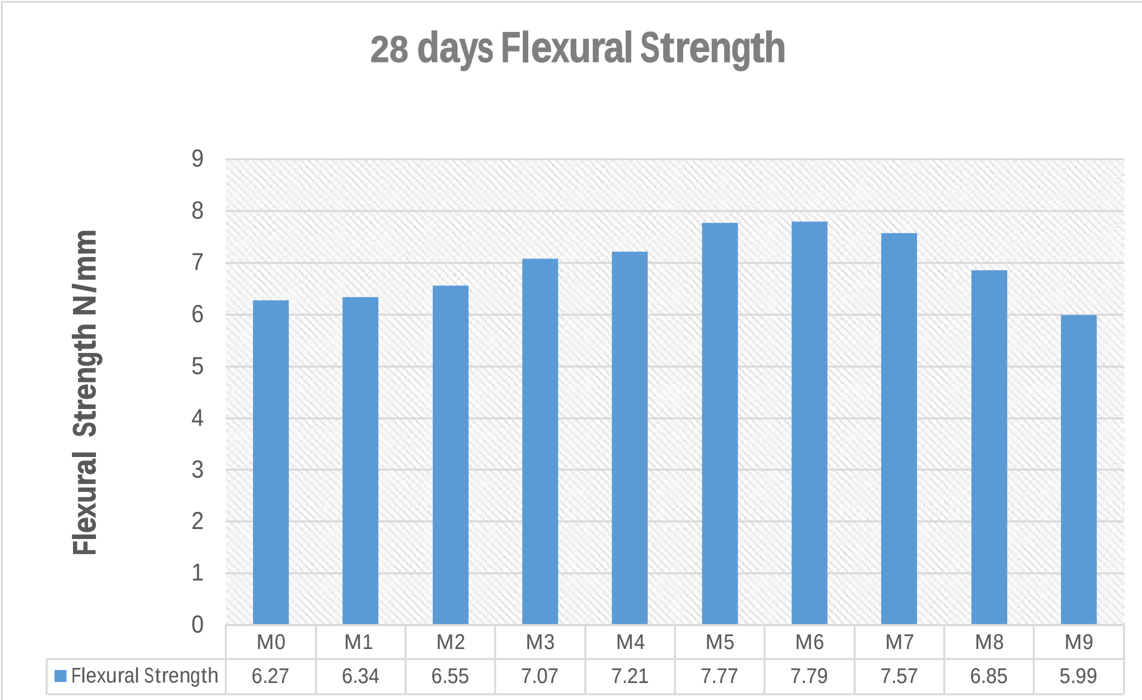

Fig -10: Flexural Strength Test 28

V. CONCLUSION

On filling up the moulds hand compaction should be opted, as to reduce the segregation of the fibre in the concrete mould.

1) Aramid kevlar 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 CRT with addition of Aramid kevlar fiber strengths get increased, also the replacement can be taken into consideration up to certain percentage workability factors gets enhanced as well.
3) In case of compressive strength test conducted on cubes of size 150 x 150 x 150 mm, the compressive strength increases up to certain replacement and later on starts to get decreased as well.
4) The compressive strength of the concrete on comparing with conventional concrete gets increased till 36&24% of Fine aggregates with the Copper Slag and CRT and for reinforcement 0.6% of Aramid kevlar fiber was used. The strength obtained at 7^{th} day is 30.13 N/mm^2.
5) After 14 days of curing, the maximum compressive strength obtained was 36.18 N/mm^2 for same replacements and addition.
6) After 28 days of curing, maximum compressive strength obtained was 51.15 N/mm^2
7) In case of compressive strength, the optimum percentage that was noticed, was at 36&24% of Fine aggregates with the Copper Slag and CRT and for reinforcement 0.6% of Aramid kevlar fiber was used.
8) The flexural strength of the concrete on comparing with conventional concrete gets increased till 36&24% of Fine aggregates with the Copper Slag and CRT and for reinforcement 0.6% of Aramid kevlar fiber was used. The maximum strength obtained at 7^{th} day is 5.27 N/mm^2.
9) After 14 days of curing, the maximum flexural strength obtained was 6.32 N/mm^2 for same replacements and addition.
10) After 28 days of curing, maximum flexural strength obtained was 7.79 N/mm^2.
11) In case of flexural strength, the optimum percentage that was noticed, was at 36&24% of Fine aggregates with the Copper Slag and CRT and for reinforcement 0.6% of Aramid kevlar fiber was used.
12) After 7 days of curing, the maximum tensile strength obtained was 3.98 N/mm^2 for same replacements and addition.
13) After 14 days of curing, the maximum tensile strength obtained was 4.49 N/mm^2 for same replacements and addition
14) After 28 days of curing, maximum tensile strength obtained was 5.97 N/mm^2.
15) In case of tensile strength, the optimum percentage that was noticed, was at 36&24% of Fine aggregates with the Copper Slag and CRT and for reinforcement 0.6% of Aramid kevlar fiber was used.

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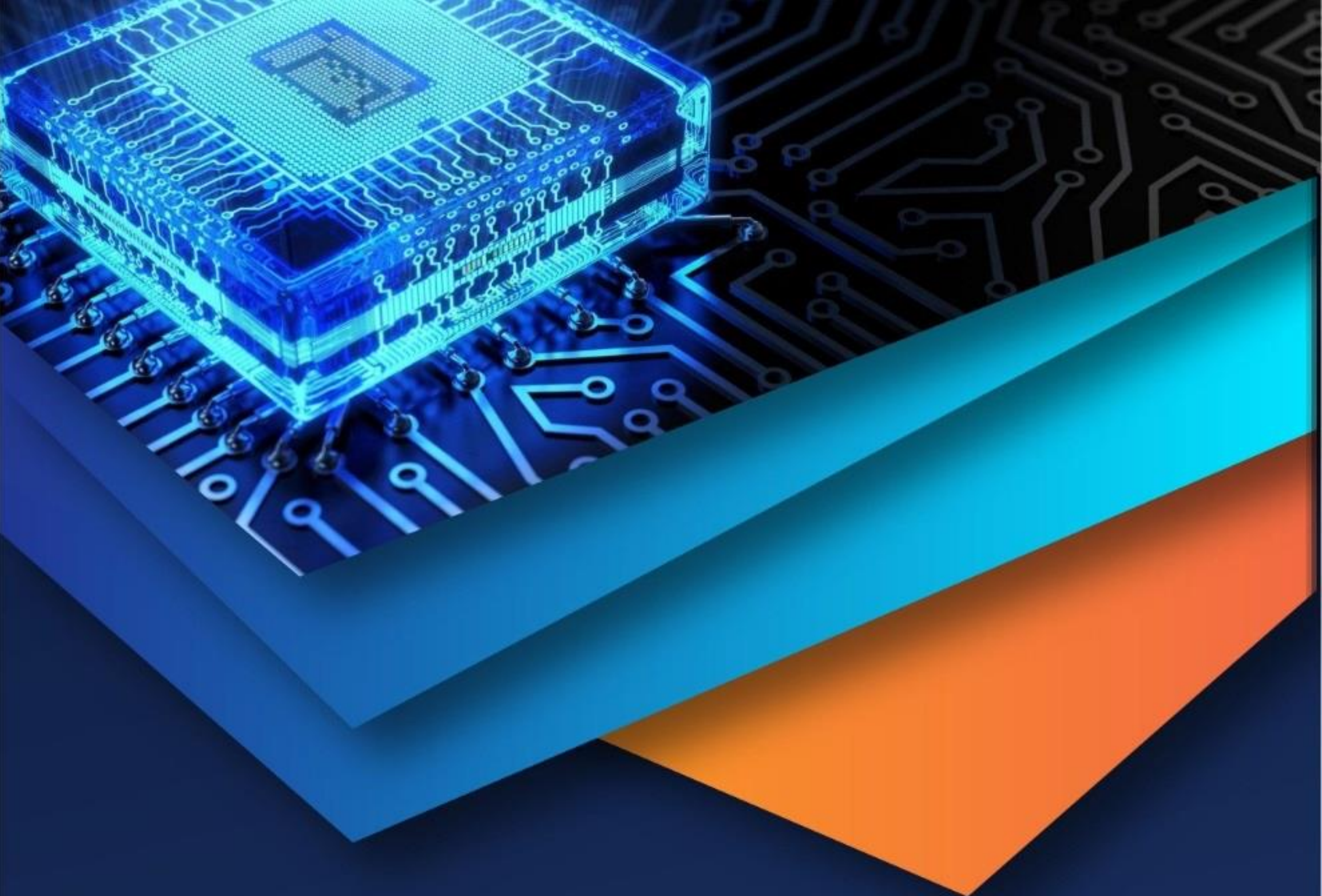

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