A STUDY ON MECHANICAL PROPERTIES OF NORMAL CONCRETE BY PARTIAL REPLACEMENT OF METAKAOLIN WITH CEMENT AND SAND WITH COPPER SLAG

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by

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DECLARATION

I, **FAVAS.K (11506360)**, hereby declare that this submission is my own work and that to the best of my insight and conviction, it contains no material beforehand distributed or composed by other individual or office. No material which has been acknowledged for reward of other degree or certificate of the college or other organization of higher learning with the exception of where due affirmations have been made in the content. It was arranged and displayed under the direction and supervision of **Mrs. Geeta Mehta (Assistant professor) .**

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This is to certify that **FAVAS.K** under Registration No. **11506360** has prepared the dissertation-1 report titled **"A STUDY ON MECHANICAL PROPERTIES OF NORMAL CONCRETE BY PARTIAL REPLACEMENT METAKAOLIN WITH CEMENT AND SAND WITH COPPER SLAG"** under my direction. This is a bonafide work of the above competitor and has been submitted to me in fractional satisfaction of the prerequisite for the honor of Masters of Technology in Civil Engineering.

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ABSTRACT:

Abundant availability of natural resources has become a dream for present day engineering society due to large scale consumptions. To overcome the problem of scarcity of natural resources and to save the environment from the pollution due to dumping of waste materials like copper slag and metakaolin, the civil engineers have given their opinion that there is significance potential for reuse of copper slag, metakaolin for value added application to maximize economic and environment benefits. Here an attempt has been made in this investigation to characteristic strength of normal concrete on partial replacement of cement with metakaolin and sand with copper slag. The highlight in this research paper is that cement is partially replaced with 10% metakaolin has been kept constant throughout and sand is partially replaced with copper slag at 15%, 20% and 25% of ranges. The strength parameters of the specimen like compressive strength, split tensile strength and flexural strength are discovered at a curing period of 7days, 14days and 28 days. The scope of this project is to determine and compare normal concrete by incorporating various percentages of copper slag and metakaolin.

Keywords: Strength, metakaolin, curing, copper slag, partial replacement

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CHAPTER-1

INTRODUCTION

1.1. GENERAL

The construction of modern and complicated civil engineering structures have become a part of today’s fast developing world. Concrete known for its high compressive strength, workability and durability plays a vital role in construction.

In the recent times, construction activity has increased in India. Fast growth in the construction industry in our country relies on the use of natural resources for infrastructure development. Large-scale production of Portland cement and the rapid exploitation of the environment for aggregates in the last decade, have a dramatic impact on the environment. The available of natural resources is reducing in India, slowing down the growth in construction activity. The rapid depletion of natural resources along with the substantial increase in waste generation poses a serious problem.

In day to day life, several types of byproducts and waste materials are generated through commercial and industrial activities. These waste materials need to be effectively recycled or safely disposed. The utilization of such waste materials in concrete not only makes it economical but also helps for decrease disposals. Hence appropriate technology is needed to know their use in concrete.

A fine example of use of waste material in concrete would be metakaolin, which can replace by cement and copper slag with sand. Although studies indicate use of Copper slag influences the performance of concrete, not much research has been done regarding its use in concrete. Copper slag is a by-product in the manufacture of copper. For every ton of copper produced, roughly 3 tons of copper slag gets generated. The Tutoring plant of Sterlite has a capacity of 400,000 ton of copper per annum and generates roughly 1.2 million ton of copper slag. This polluting material needs to be properly disposed. This waste material is used for many purposes, mostly for land filling to grid blasting.

CHAPTER-2

TERMINOLOGY

Table 1: Series of terminologies

SL.NO	SYMBOL	TERMINOLOGY
1.	MK	METAKAOLIN
2.	CP	COPPER SLAG
3.	OPC	ORDINARY PORTLAND CEMENT
4.	V	VOLUME
5.	Gm	GRAMS
6.	CTM	COMPRESSION TESTING MACHINE
7.	Hr	HOUR
8.	m^3	CUBIC METER
9.	%	PERCENTAGE
10.	i.e	IT IS ABBREVIATED AS "THAT IS"

CHAPTER-3

REVIEW OF LITERATURE

3.1. GENERAL

B.B.Sabir et.al (2005) stated that the paper deals that replacement of cement with the metakaolin in concrete and mortar it make great increment in pore structure finally leads to concrete resistance to harmful solution .The paper also clearly means that metakaolin is very effective pozzolans and result enhanced early strength with no detriment and some improvement in the long term strength. Mortar and concrete were observed as great improvement in resistance to transportation of water and diffusion ions which leads to degradation of matrix [1].

Murali.G et.al (2012) stated that use of metakaolin as a partial replacement substance for cement in concrete. The usage of metakaolin in concrete effectively improved the strength properties. The optimum level of replacement was reported as 7.5% describing that 7.5% of Metakaolin increased the compressive strength of concrete by 14.2%, the split tensile strength by 7.9% and flexural strength by 9.3% [2].

J.M. Khatib et.al (2012) said that it deals with density, ultrasonic pulse velocity and compressive strength of mix containing high volume of metakaolin as partial substitution of cement. In this paper, up to 50% of metakaolin was used to replace cement in increment of 10. After De-molding, here specimens are cured in water at 20degrees for 28 days. when we finding density it behaves decrease with increasing metakaolin content, usually the percentage of metakaolin will be above 30%. Strength of concrete can be increases up to 40% metakaolin addition, maximum strength will be obtaining at 20% addition where the strength 47% higher. At the range of 50% amount metakaolin strength going to reduces.10% and the 30% Metakaolin mixes exhibit an increase in strength of around 37% [3].

A. Mitrović et.al(2012) stated that this literature discussing that compressive strength from 46,45 48,47,49 Mpa from the various addition of metakaolin 5%,10%,15%, 20%,25% in these order is following .When it reaches to 28 days the compressive strength @consecutive level f additions shows that 56,57,59,58,60 Mpa..while checking 7days flexural strength it shows that 9,8,6,7,6 Mpa from which we can understood that by increasing percentage metakaolin flexural strength having slight increment at less percentage of addition .when it comes more metakaolin within a 5 to 35% level beyond that it shows fluctuation in setting times [4].

M. V. Patil et.al (2012) said that fine workability of concrete is obtained by the slump of 25 mm. While performing the achieve this, approx. water cement ratio was 0. 48. Compressive strength of concrete containing copper slag with 10% 20% 30% 40% 50% 60% and 80% fine aggregate replacement. And it seems to compressive strength of concrete with copper slag is more than copper slag, which was found about 32.45Mpa, compared with 23.87Mpa for the control mixtures. i.e. 3.94% more strength is achieved by concrete than the control mix at 7days. Flexural strength increase by adding copper slag percentages at 28 days and there is better increase in strength with that of strength of control mix [5].

Anand Narendran et.al (2013) said that compressive strength and tensile strength of normal concrete and concrete containing Nano-Metakaolin partially replaced with cement at various percentages (2, 4, 6, 8, 10, 12,14, 16, 18 and 20%) mix design for M20, M30, M40 and M50 grades and concluded that, In partial replacement of cement with Nano-Metakaolin has a greater effect on the strength of concrete. The amount of cement that can be replaced with Nano-Metakaolin is 10% thus increasing in cost for 10% replacement varies between 11%-13% for all grades of concrete. Hence Nano-Metakaolin may be used as an effective pozzolanic material for partial replacement of OPC in concrete [6].

Arivalagan et.al (2013) said that in this method of replacement of fine aggregate with copper slag was done to finding the compressive strength of cubes, flexural strength of beams and split tensile strength of cylinders. The copper slag is added with sand to find out the results of concrete proportion ranging from 5, 20%, 40%, 60%, 80% and 100%. The higher (35.11Mpa) compressive strength was obtained at 40% copper replacement. The literature also discussed the effect of copper slag on RCC concrete elements which indicated that an increment in compressive strength, split tensile strength, flexural strength. In this result, the value of slump which lies between 90 to 120 mm and the flexural strength of beam and also get increased by (22% to 51%) due to the replacement of copper slag [7].

Kharade et.al (2013) the researcher stated that copper slag is not having the tendency of absorbing the water in large amount and the percentage of copper slag in concrete increases the workability of concrete. The paper says that when fine aggregate was replacing by 20% copper slag, compressive strength of concrete can have increased by 29% at 28 days. When replacement of copper slag was done up to 80% the strength increases, but if this replacement of copper slag was done up to 80% the strength increases above 80%, the strength directly getting decreased. It also shows that the strength at 100% replacement was reduced by 7% at 28 days. The flexural as and compressive strength was increased due to the high toughness property of copper slag [8].

Suriya prakash et.al (2014) said that various percentage of copper slag replacement with sand (0%, 10%, 20%, 30%, 40% & 50%) and partial replacement of fly ash with cement 30% in concrete understood that the compressive strength of concrete cubes with 40% replacement of fine aggregate with copper slag shows an increase of 15% when compared to the normal concrete cube. Similarly, there was increased in the split tensile strength of concrete with 40% replacement of fine aggregate with copper slag seems to be an increase of 34% when compared to normal concrete [9].

Binaya Patnaik et.al (2014) said that in this research paper reviews that by using copper slag cost of concrete reduces. Here copper slag used as a fine aggregate by using copper slag toughness of copper slag attribute increased compressive strength. Copper slag having low water absorption because of coarser nature and also glassy surface may leads to increased workability. By replacement of copper slag copper waste from industry can manage in proper way. In river sand and copper slag contains (sio_2) silica. By this method self-weight of concrete increases because of higher density of copper slag. Water absorption of copper slag is measured as 0.24% it seems that less than that of natural sand (1. 2%).Hence copper slag content increases water content which leads to workability [10].

Satyendra Dubey et.al (2015) stated that in this paper discussing that series of experiments are conducted in concrete with a addition of metakaolin as partial replacement of ordinary Portland cement In different percentage of addition of metakaolin is 0%,5%, 10%, 20% in M_{25} grade of concrete .while checking the compressive strength of concrete it shows that 31.8,35.8,38.8,32.5,32 N/mm^2 .The 28 days compressive strength goes on increasing and it was found to be maximum at 10% replacement [11].

CHAPTER-4

OBJECTIVE OF THE STUDY

4.1. OBJECTIVES OF THE STUDY

The objectives of the present study are listed below:

- To reduce the disposing problem of the waste produced from the industries sectors.
- To study the changes in normal concrete properties when it is treated with different materials.
- To study the various characteristics of normal concrete when it cements is replaced metakaolin and sand with copper slag at different proportion like 15%, 20%,25%.
- To use the waste that produced form the industries.
- To suggest the best material for the mechanical properties improvement by replacing cement by copper slag.

4.2. NEED OF REPLACING CEMENT BY COPPER SLAG

- To economize project: By including waste material partially instead of normal concrete, which helps to contractor to get benefit economically.
- Savings through design: Suggesting the most suitable material to obtain good features and its percentage to be adding in the concrete. By this the mechanical properties of normal concrete do increase to a larger extent. By this the project cost, time and material is reduced.
- Saving the waste: By using the material which is the waste product in the nature. The percentage of the waste can be reduced and solving the problem of dumping the waste.

CHAPTER-5

RATIONALE AND SCOPE OF STUDY

5.1. SCOPE OF THE STUDY

- In this research study is done for replacement of cement with metakaolin and sand with copper slag comparing the mechanical properties.
- In this investigation carried out for finding mechanical properties by varying proportion of cement and sand by replacing waste materials like metakaolin, copper slag.
- This study is done as per IS codes same may be considered as per ASCE codes
- To reduce heavy metal emissions in the air by replacing cement by copper slag
- To control CO_2 emission while making cement

CHAPTER-6

MATERIALS AND RESEARCH METHODOLOGY

6.1. MATERIALS

6.1.1. PROPERTIES OF CEMENT

Cement is binding material which having good role in concrete, its having a peculiar property of strong adhesive premises. It can bind all other mixtures of concrete through a series of chemical reaction termed as hydration reaction with the help of water and does it hardens. Cement is a bluish grey colored fined powder, which is manufactured by smashing, milling and proportioning of CaO (calcium oxide, 67% - 61%), SiO_2(silica, 23%- 19%) & Al_2O_3(alumina, 6%-2.5%) in a kiln at 2600 F. Portland cement also named as Ordinary Portland Cement (OPC) is categorized into three grades i.e. OPC 33 grades, 43 grades, 53 grades on account of their 28day compressive strength. In this thesis, OPC 43 grade of cement is used for mix design.

Table 2: Cement Properties

Sl. no.	Characteristic of cement	Test values
1.	Fineness of cement	1.5%
2.	Standard consistency of cement	30.5%
3.	Specific gravity	3.145
4.	Initial setting time	45 minutes
5.	Final setting time	8.5hr
6.	Soundness of cement	3.5 mm

6.1.2. FINE AGGREGATES

Aggregates maintain the bulk of a concrete mixture and give order firmness to concrete. To growth the density of resulting mix, the aggregates are randomly used in two or more dimensions. The main significant purpose of the fine aggregate is to creating workability and uniformity in mixture. The fine aggregate necessity in cement paste to grip the coarse aggregate particles in different this action makes plasticity in the mixture and prevents the possible separation of cement and coarse aggregates, especially when it is important to move the concrete a bit from the setting up of the mixing plant., it can fulfill certain conditions, when the concrete is appropriate, solid, durable and reasonable.

Fine aggregate is obtained from natural disintegration of rocks and by crushing natural gravel and by crushing hard stone. According to IS 383:1970, depending upon the region from where it is available, is divided into four parts i.e. Zone I, II, III, IV and it should retain in IS sieve 4.75mm. Now a day's brown sand is used for the casting of specimen.

6.1.2.1. Specific Gravity of fine aggregate

The normal value of specific gravity of fine aggregate is as determined

Table 3: Specific gravity of fine aggregates

Sl.no	Weight in gm				Specific gravity
	W_1 (gm)	W_2 (gm)	W_3 (gm)	W_4 (gm)	
1	378	665	1220	1072	2.63

The specific gravity of fine aggregate = 2.63

6.1.2.2. Fineness Modulus of Fine aggregate

Table 4: Sieve analysis of sand

I.S sieve size(mm)	Weight retained (gm)	Weight retained (gm)	Cumulative % wt. retained	% Finer
4.75 mm	10	10	1	99
2.36mm	70	80	8	92
1.18mm	250	330	33	67
600 µ	400	730	73	27
300 µ	120	850	85	15
150 µ	110	960	96	4
PAN	40	1000	100	0

6.1.3. COARSE AGGREGATES

Crushed stone having a size of 10mm-20mm which retained over IS sieve 4.75mm is used as a course aggregate while casting the concrete specimens. According to qualities of various sorts of aggregate, coarse aggregate has a tendency to improve the strength of the concrete material by interlocking the angular particles while the smooth round shaped aggregate helps to keep fluidity of the fresh concrete mixture. Aggregates are locally available which is used in concrete mix after removing the dirt and dust particle and drying it in oven. IS 383:1972 is used for the specification of coarse aggregate. Below the testing results of coarse aggregate is discussed.

6.1.3.1. Specific gravity of Coarse aggregates

Table 5: Specific gravity of coarse aggregate

Sl.no	Weight in gm				Specific gravity
	W_1 (gm)	W_2 (gm)	W_3 (gm)	W_4 (gm)	
1.	450	104.2	160.2	122.9	2.70

The specific gravity of coarse aggregates = 2.70

6.1.3.2. Water absorption of coarse aggregates

Table 6: Water absorption of coarse aggregates

Sl.no	Weight of oven dried specimen (g)	Weight of saturated specimen (g)	Weight of water absorbed (g)	percentage of water absorption in %
1.	1000	1011	11	1.1

Water absorption of the coarse aggregates is = 1.1%

6.1.3.3. Sieve Analysis of Coarse aggregates

Table 7: Sieve analysis for 20mm coarse aggregates

Sl.no	IS-Sieve (mm)	Wt. Retained (gm)	%age Retained	%age Passing	Cumulative % retained
1.	80	0.00	0.00	100.00	0.00
2.	40	0.00	0.00	100.00	0.00
3.	20	59	1.97	98.03	1.97
4.	10	2932.4	97.75	.28	99.72
5.	4.75	5.8	0.19	.09	99.91
6.	Pan	2.80	0.09	0	
7.	Total	3000.0		Sum	(201.6 + 500)/100 =7.016

Table 8: Sieve analysis for 10mm coarse aggregate

Sl. no.	IS- Sieve(mm)	Wt. retained (gm)	% Retained	% passing	Cumulative Retained
1.	40	0	0	100	0
2.	20	0	0	100	0
3.	10	2022	67.40	32.60	67.40
4.	4.75	933	31.1	1.5	98.5
5.	Pan	45	1.5	0	
6.		Total =3000 gm		Sum	165.9
					FM = (165.9 +500)/100=6.66

6.1.4. COPPER SLAG

The use of industrial wastes in cement concrete is an economical and eco-friendly material. Copper slag is a glassy granular material with high specific gravity. Particle sizes are of the order of sand and have a potential for use as fine aggregate in concrete. Copper slag is producing during the manufacture of copper metal. Currently, about 2600 tons of copper slag is produced per day and a total accumulation of around 1.5 million tons. This slag is currently being used for many purposes ranging from land-filling to grit blasting. These applications used only about 15% to 20% and the remaining dumped as a waste material and this causes environmental pollution.

Fig 1: Copper Slag

Table 9: Physical Properties of Copper slag

Physical Properties	Copper slag
Particle shape	Irregular
Appearance	Black & glassy
Type	Air cooled
Percentage of voids	42.40%
Bulk density	2.07 g/cc
Water absorption	0.31 to 0.42%
Moisture content	0.1%

Table 10: Chemical properties of Copper slag

S.No.	Chemical Component	% of Chemical Component
1	SiO2	26.92
2	Fe2O3	69.32
3	Al2O3	0.24
4	CaO	0.17
5	Na2O	0.67
6	K2O	0.25
7	LoI	7.65
8	Mn2O3	0.32
9	TiO2	0.52
10	SO3	0.22
11	CuO	1.20
12	Sulphide sulphur	0.26
13	Insoluble residue	1.74
14	Chloride	0.016

6.1.5. METAKAOLIN

Metakaolin material which is generated by heat treating Kaolin as a one of the most abundant natural minerals to a temperature of 600^0 – 8000^0 C. Kaolin material which is in the form fine white clay mineral that has been traditionally used. Metakaolin is produced under controlled conditions and hence its composition, white appearance and performance are relatively consistent. It can react rapidly with the calcium hydroxide (CaOH) in the cement paste, converting it into stable cementations compounds thus refining the microstructure of concrete thereby reducing its permeation properties. Due to high surface area and high reactivity, relatively small addition rates of metakaolin produce relatively large increase in strength properties, impermeability and durability while its light color gives an aesthetic advantage.

Fig 2: Metakaolin

Table 11: Chemical properties of Metakaolin

Constituent	Metakaolin (%)	Cement (%)
SiO2	60-65	22
Al2O3	30-35	6
Fe2O3	1.00	3
CaO	0.2-0.8	63
LOI (%)	1.5	1.5
MgO	0.2-0.8	1.5
K2O	0.5-1.2	0.5

Table 12: Physical properties of Metakaolin

Properties	Value
Density (gm/cm3)	2.18
Bulk Density (gm/cm3)	1.26
Particle shape	Spherical
Color	Off-white
Specific gravity	2.50

6.2. METHODOLOGY

6.2.1. RESEARCH METHODOLOGY

In the literature review or past studies, we will collect some data about the project that we are going to do experiments and their suggestions.

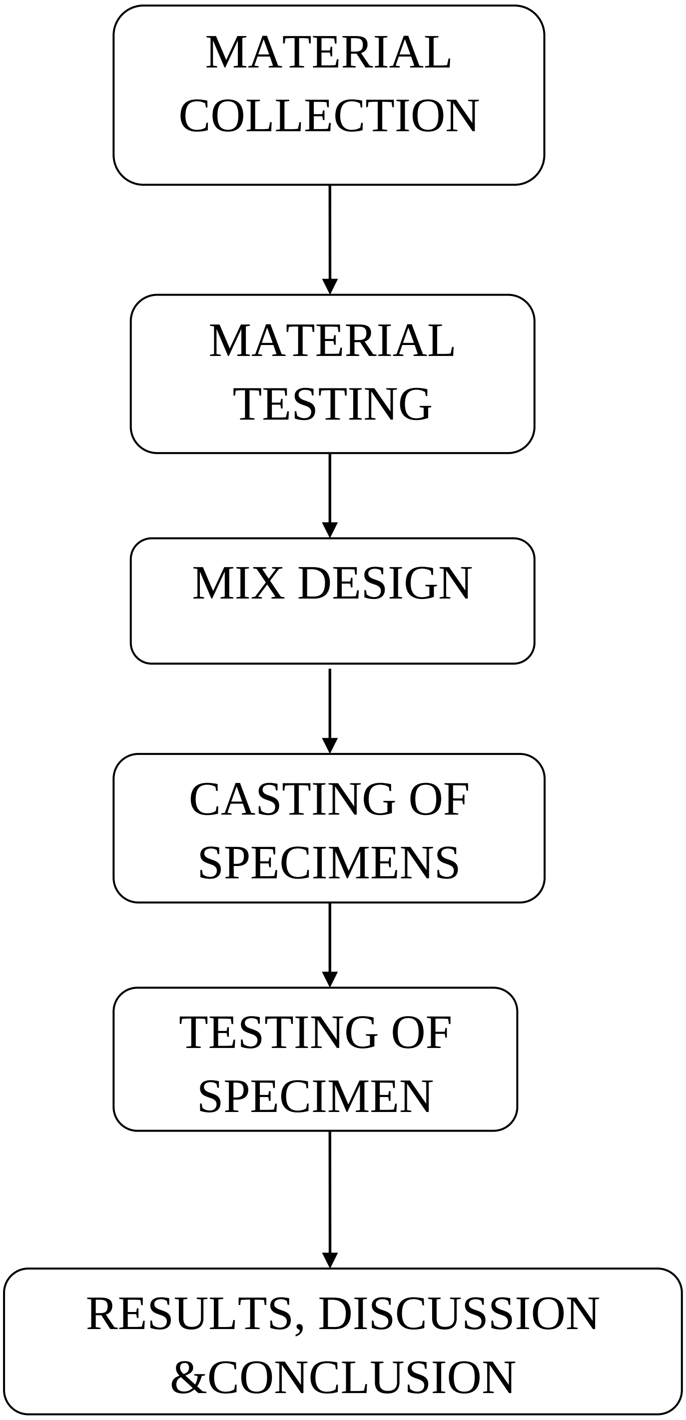

Fig 3: Flow chart for Research methodology

6.3. MIX DESIGN FOR M_{30} GRADE

Based on the Indian standard (IS 10262-2009), Design mix of M30 grade concrete was prepared by partially replacing the cement with three different percentage of GGBS and fine aggregate with CBA by weight of 10%, 20%, 30%Here, concrete grade made is M30.

OPC 43 grade cement is used conforming to IS code 8112

Specific gravity of cement= 3.15.

Specific gravity of fine aggregate= 2.65.

Specific gravity of coarse aggregate= 2.69

Fine aggregate taken from zone-II

Minimum cement content 320 kg/m^3

Maximum cement content 450 kg/m^3

Maximum water cement ratio is 0.45

Workability 100 mm slump

Crushed angular aggregate is used.

Degree of supervision is good.

Target strength of mix proportioning:

f*ck= fck+ 1.65s

f*ck= target average compressive strength at 28 days.

fck= characteristic compressive strength at 28 days.

S= standard deviation.

Taken s= 5 MPa

Therefore, target strength = 30+ 1.65*5 = 38.25 MPa

cement content:

Minimum cement content for severe exposure condition is 320 kg/m^3

Cement taken 438.13 kg/m^3

Hence ok.

water- cement ratio:

Maximum water cement ratio= 0.45

Water cement ratio taken = 0.45

Water taken = 0.45*438.18= 191.18 kg

Hence ok.

Volume of coarse aggregate and fine aggregate:

V= [W + (C/Sc) + (1/P) *(Fa / Sfa)] * (1/1000)

V= [W + (C/Sc) + {1/(1-P)}. (Ca / Sca)] * (1/1000)

Where,

V= volume of fresh concrete minus the volume of entrapped air.

W= mass of water (kg) per m^3 of concrete.

C= mass of cement (kg) per m^3 of concrete.

SC= specific gravity of concrete.

P= ratio of fine aggregate to total aggregate by absolute volume.

Fa= mass of fine aggregate (kg) per m^3 of concrete.

Ca= mass of coarse aggregate (kg) per m^3 of concrete.

SFA= specific gravity of fine aggregate

SCA= specific gravity of coarse aggregate

As per IS 10262, for 20mm maximum size entrapped air is 2 %.

Assuming fine aggregate by percentage of volume of total aggregate = 35 %0.98 = [197.16 + (438.13 / 3.15) + (1/ 0.35) (Fa/ 2.65)] (1 / 1000)

Fa= 580.60 kg

Taking fine aggregate = 581 kg/m^3

0.98 = [197.16 + (438.13 / 3.15) + (1 / 0.65) (Ca/ 2.69)] (1 / 1000)

Ca= 1205.62 kg

Taking coarse aggregate = 1206 kg/m^3.

Ratio of 20mm coarse aggregate to 10mm coarse aggregate is 0.6: 0.4

Therefore,

Cement = 438.13 kg/m^3

Fine aggregate = 581 kg/m^3

Coarse aggregate (20 mm) = 723.6 kg/m^3 coarse aggregate (10mm) = 482.4 kg/m^3

So, The Mix proportion for M_{30} is shown below

water : cement : FA : CA(20mm) : CA(10mm) = 0.45 : 1 : 1.32 : 1.65 : 1.1

CHAPTER-7

RESULTS AND DISCUSSIONS

7.1. HARDENED STRENGTH PROPERTIES

7.1.1. COMPRESSIVE STRENGTH

Table 13: Compressive strength results

TYPE OF MIX	7 DAYS	14 DAYS	28 DAYS
CONTROL MIX	26.9	29.4	30.4
15% CP +10%MK	29.3	31.33	33.1
20% CP +10%MK	26.66	29.24	31.09
25% CP +10%MK	21.28	23.11	24.44

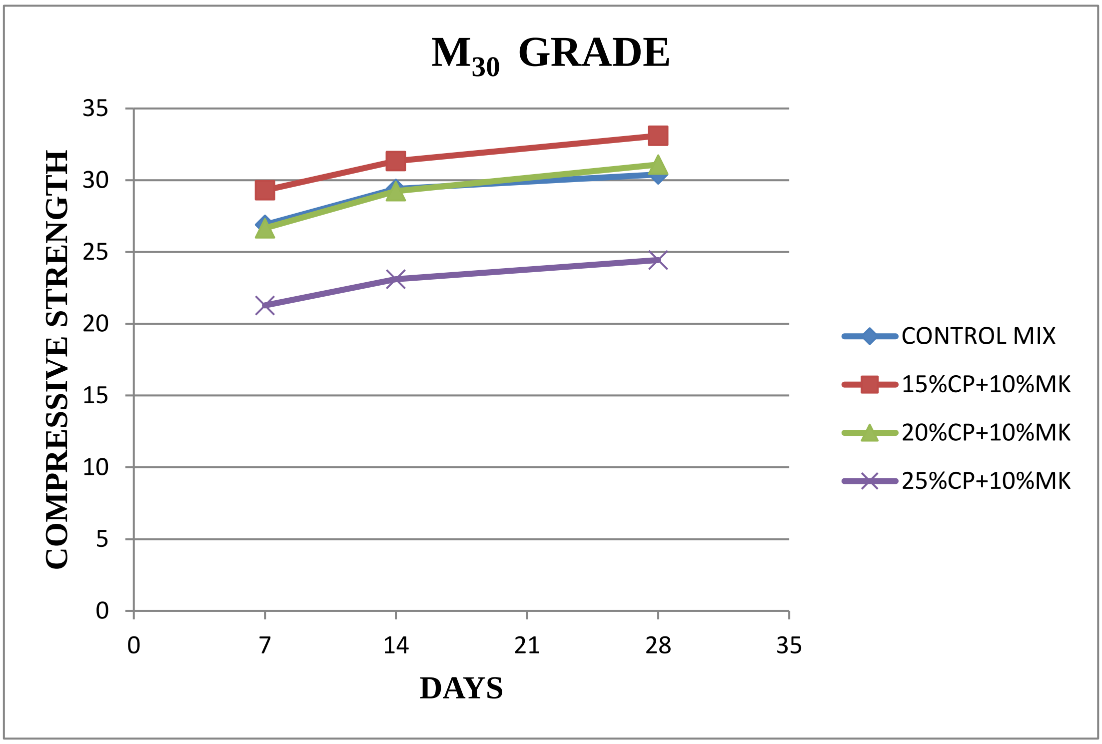

Fig 4: Graph representing compressive strength

From the graph, we observe that till 25%CP replacement there is increase in compressive strength but further percentage of replacement leads to decline in compressive strength when compared to the control mix.

7.1.2. FLEXURAL STRENGTH

Table 14: Flexural strength results

TYPE OF MIX	7DAYS	14DAYS	28 DAYS
CONTROL MIX	5.49	6.28	6.84
15% CP +10%MK	5.67	6.21	6.93
20% CP +10%MK	4.99	5.97	6.48
25% CP +10%MK	4.45	5.38	6.16

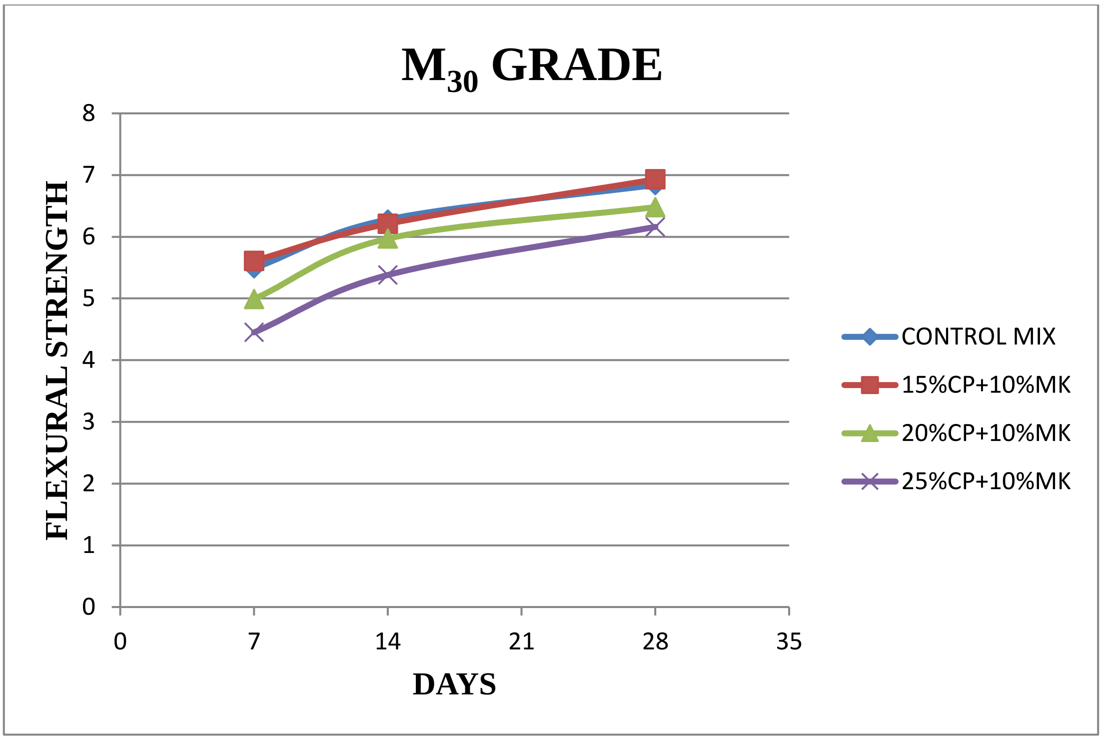

Fig 5: Graph representing Flexural strength

From the graph, it can be observed that with percentage of replacement of copper slag and metakaolin there is no much increase in flexural strength as compared to the control mix.

7.1.3. SPLIT TENSILE STRENGTH

Table 15: Split tensile strength results

TYPE OF MIX	7 DAYS	14 DAYS	28 DAYS
CONTROL MIX	2.4	2.8	3.7
15% CP +10%MK	2.56	3.04	3.8
20% CP +10%MK	2.53	2.90	3.47
25% CP +10%MK	2.23	2.78	3.2

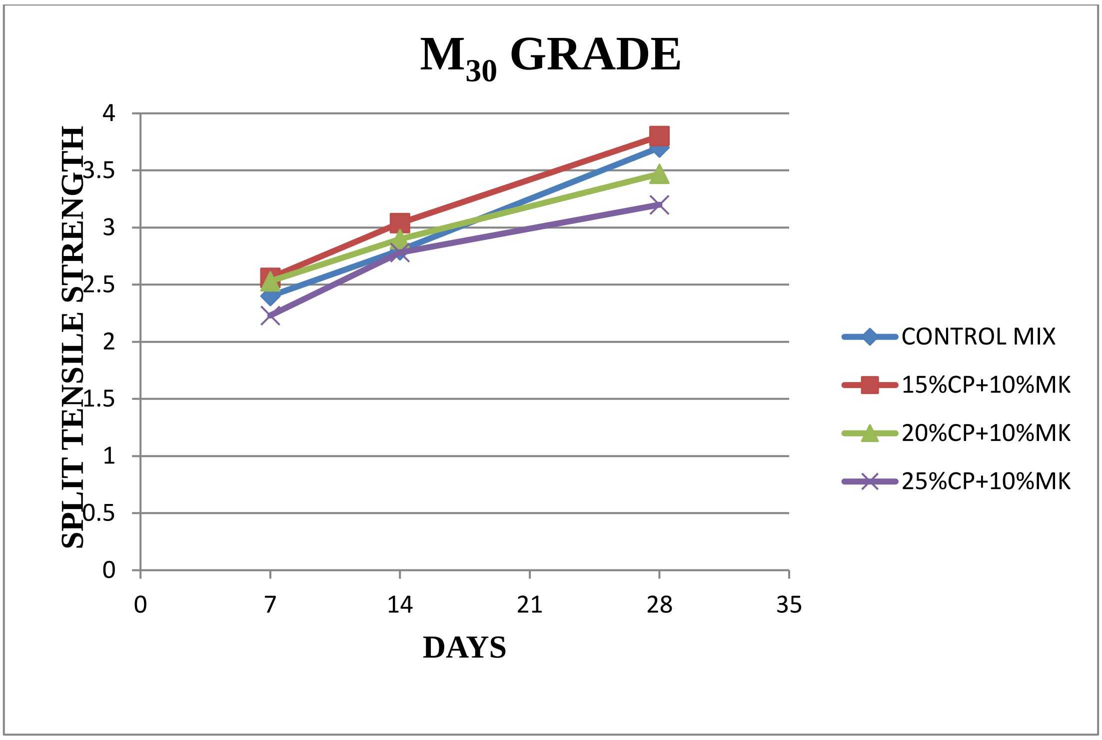

Fig 6: Split tensile strength results

From the graph, it can be concluded for 28days of curing period the split tensile strength gets reduced at 20%CP and 25%CP replacement. But till 15%CP partial replacement there is substantial increase in split tensile strength as compared to the control mix.

7.2. LAB INVESTIGATIONS

The casting of cubes, beams and cylinders were performed. The cement used is OPC-43 grade and mix design opted is M_{30}. So, the casting proceeded according to the mix design. After casting the curing of specimens are done for 7days, 14days, and 28days and hence tested. The size of cube is 150mm×150mm×150mm. The size of cylinder is 200mm in height and 100mm in diameter. The size of beam being casted is 100mm×100mm×500mm. For cubes the lab testing is done on CTM and the compression strength is derived from the test. Again, the testing of beams is carried out and the flexural strength is found using CTM. Then cylinders are further tested on CTM to generate the split tensile strength of the specimens.

The various specimens are casted in batches down below:

Batch 1: Control Mix of M_{30} grade of concrete is prepared for 7days, 14days, 28days.

Batch 2: Specimens containing 15%CP and 10%MK are prepared for 7days, 14days, 28days.

Batch 3: Specimens containing 20%CP and 10%MK are prepared for 7days, 14days, 28days.

Batch 4: Specimens containing 25%CP and 10%MK are prepared for 7days, 14days, 28days.

Fig 7: Compression Test

Fig 8: Flexural test

Fig 9: Split tensile test

CHAPTER-8

CONCLUSION AND FUTURE SCOPE

From the thesis, it can be concluded with partial replacement of copper slag and metakaolin there is improvement in strength parameters till a certain extent.

For compressive strength with addition of percentage of Copper slag and percentage of metakaolin there is increase in compressive strength till 20%CP partial replacement. Further replacement will reduce the compressive strength of the specimen. At 15%CP and 10%MK partial replacement there is an 8.15% increase in compressive strength. At 20%CP and 10%MK partial replacement there is 2.21% increase in compressive strength. At 25%CP and 10%MK partial replacement there is 24.38% reduction in compressive strength. The highest gained compressive strength is 33.1Mpa.

For flexural strength with addition of %CP and %MK there is increase in flexural strength till 15%CP. Further replacement will reduce the flexural strength of the specimen. At 15%CP and 10%MK partial replacement there is 1.29% increase in flexural strength. At 20%CP and 10%MK partial replacement there is 5.55% reduction in flexural strength. At 25%CP and 10%MK partial replacement there is 11.03% reduction in flexural strength. The highest gained flexural strength is 6.93Mpa.

For split tensile strength, with addition of %CP and %MK there is increase in split tensile strength till 20%CP. Further replacement will reduce the split tensile strength of the specimen. Again, if further replacement is carried out then the trend gets reversed. At 15%CP and 10%MK partial replacement there is 2.63% increase in split tensile strength. At 20%CP and 10%MK partial replacement there is 6.62% increase in split tensile strength. At 25%CP and 10%MK partial replacement there is 15.62% reduction in split tensile strength. The highest gained compressive strength is 3.8Mpa.

The future scope of this research work lies when the waste derived from industries can be implemented in construction industries to make the environment a greener place to live thus making the construction work cheaper and efficient.

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