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Experimental Study of the Physical Properties of Concrete Prepared by Partial Replacement of Cement with Alccofine, Metakaolite and GGBS

Nayyer Ansari[1], Deepak Kumar Bandewar[2]
SIRTS

Abstract: Cement concrete is the most broadly used construction material in the world. Maintenance and repair work of concrete structures is an increasing problem involving the significant expenditure. As a result of study carried out worldwide, it has been made possible to process the material to satisfy more strong performance requirements, especially durability. To reduce the expenditure for making of concrete we should consider the industrial waste materials for partial replacement of cement with supplementary cementitious materials like alccofine, GGBS and meta-kaoline. We consider these materials because these are available at very low cost. For this purpose we prepared number of samples by the various mixes with variable percentage of these materials in the mix. After the selection of the mix on these prepared specimens we perform workability and compressive strength test in the laboratory. By these tests we come to know that when we replace cement by Alcofine up to 10% the compressive strength increases 414.53 but after this range of addition it starts reducing the strength. when we replace cement by GGBS up to 15% the compressive strength increases 421.40 but after this range of addition it starts reducing the strength and same when we replace cement by Meta-kaoline up to 10% the compressive strength increases 448.44 but after this range of addition it starts reducing the strength

Keywords: Alccofine, GGBS, Meta-kaoline, Compressive strength, workability.

I. INTRODUCTION

A. Conventional Concrete

Concrete is most widely used construction material in the world. Concrete is a composite material formed by the combination of (a) cement, (b) aggregate and (c) water in particular proportion in such way that concrete produce meets the need of the job on hand particularly as regards its workability, strength, durability and economy. In our country the concrete is generally prepared at the sites and therefore need to be carefully supervised and controlled in order that it performs the way its technically expected to perform. Lot of care is to be taken in every stage of manufacturing of concrete.

The various stages of manufacturing concrete are:

1) Batching
2) Mixing
3) Transporting
4) Placing
5) Compacting
6) Curing
7) Finishing

B. Special Concrete

1) Fibre Reinforced Concrete

Fibre reinforced concrete (FRC) is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibres that are uniformly distributed and randomly oriented. Fibres include steel fibres, glass fibres, synthetic fibres and natural fibres. Within these different fibres that character of fibre reinforced concrete changes with varying concretes, fibre materials, geometries, distribution, orientation and densities.

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The concept of using fibres as reinforcement is not new. Fibres have been used as reinforcement since ancient times. Historically, horsehair was used in mortar and straw in mud bricks. In the early 1900s, asbestos fibres were used in concrete, and in the 1950s the concept of composite materials came into being and fibre reinforced concrete was one of the topics of interest. There was a need to find a replacement for the asbestos used in concrete and other building materials once the health risks associated with the substance were discovered. By the 1960s, steel, glass (GFRC), and synthetic fibres such as polypropylene fibres were used in concrete, and research into new fibre reinforced concretes continues today.

2) Polymer Concrete

In the constructions industry new building materials with improved properties are required for satisfying the new utilization domains for modern construction or for repair works. The application of polymer on concrete has significantly progressed in the last 30 years. Polymers are either incorporated in a cement-aggregate mix or used as single binder. The composites made by using polymer along with cement and aggregates are called polymer-modified mortarorpolymer-modified concrete, while composites made with polymer and aggregates are called polymer mortar or polymer concrete, depending on the maximum size of aggregate granule.

In the composition of polymer concrete there is not cement: the aggregates are bonded by the resin. Function of the type of polymer it can obtain concretes with synthetic resin, concretes with plastic resin or simple concrete with resin. The composite does not contain hydrated cement paste. Polymer concrete presents some advantages compared to the cement Portland concrete such as: rapid hardening, high mechanical strengths, improved resistance to chemical attack, durability, etc. One of the most important disadvantages is the high cost of resin that limited the use domains of polymer concrete. The performances of polymeric concrete depend on the polymer properties, type of filler and aggregates, curing temperature, components dosage, etc. The aggregates can be silicates, quartz, crushed stone, gravel, limestone, calcareous, granite, clay, etc. Near the aggregate, the filler is very important. Different types of fine materials can be used such as fly ash, silica fume, phosphor-gypsum, cinder, etc.

The different ingredients used for casting the concrete are as follows:

a) Waste Material: Due to sustained pressure of industrial and developmental activities, there are appreciable disturbances in the ecological balance of nature. As with most large manufacturing industries, by-product materials are generated. These industrial by-product and waste materials must be managed responsibly to insure a clean and safe environment. The concept of environmental geo-techniques has emerged as an answer to the need to understand the ecological problems, connected with Fly ash, CKD, Quarry fines, Silica fines**.**

- *Fly ash:* Fly ash is one of the residues generated in combustion, and comprises the fine particles that rise with the gases. In an industrial context, fly ash usually refers to ash produced during combustion of coal. It is having a fineness of about 4000-8000 cm^2 /g. Fly ash is generally captured by electrostatic precipitators or other particle filtration equipment's before the flue gases reach the chimneys of coal-fired power plants Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably. It may include one or more of the following elements or substances in quantities from trace amounts to several percents arsenic, beryllium, boron, cadmium, chromium, chromium VI, cobalt, lead, manganese, mercury, molybdenum, selenium, strontium, thallium, and vanadium, along with dioxins.
- *CKD:* Cement manufacturing is a critically important industry in the world worldwide production accounted for about 2.5 billion metric tons. Over the past several years dramatic advances have been achieved in the management and use of cement kiln dust, thus reducing its dependency on landfill disposal. Sustainability is the cornerstone of the cement industry, not only in the products that use cement, but also in its manufacturing process. Many of the older, inefficient plants are being replaced by more modern plants or being renovated with new technologies to be more efficient as well as more environmentally friendly. The majority of CKD is recycled back into the cement kiln as raw feed. In addition, new technology has allowed the use of previously land filled CKD to be used as raw feed stock. Recycling this by-product back into the kiln not only reduces the amount of CKD to be managed outside the kiln, it also reduces the need for limestone and other raw materials, which saves natural resources and helps conserve energy.
- *Quarry Fines:* In 2005, 216 million tonnes of saleable aggregate was produced; corresponding 55 million tonnes of quarry fines and 24 Million tonnes of quarry waste were also produced. The need to minimize fines production is driven by the Aggregates Levy (which has priced quarry fines out of the market in favour of recycled aggregate) and the Landfill Tax (which has made it expensive to dispose of fines). Future developments are likely to be driven by the need to respond to climate change .New crusher designs will be more automated, offer improved energy efficiency, have a greater production capacity and improved reliability.

b) *Supplementary Cementing Materials (S.C.M.):* Supplementary cementing materials (SCMs) such as Meta-kaolin, Alccofine and GGBS are increasingly used in recent years as cement replacement material. They help to obtain both higher performance and economy. These materials increase the long term performance of the concrete through reduced permeability resulting in improved durability.

- *Meta-kaolin:* The necessity of high strength high performance concrete is increasing because of demands in the construction industry. Efforts for improving the characteristics of concrete over the past few years suggest that cement replacement materials along with chemical admixtures can improve the durability and corrosion characteristics of concrete. High Reactive Meta-kaolin (HRM), is a pozzolanic material that can be utilized to produce highly durable concrete composites. However, information to understand the behaviour of this mineral additive in concrete is insufficient. Some of the recent information is discussed in this paper highlighting the role of meta-kaolin in high strength high performance concrete.
- *GGBS:* GGBS is non-metallic product consist of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form glassy sand like grains, further these grains ground to fineness less than 45µ. IS146:2000 suggest, GGBS obtained by grinding granulated blast furnace slag conforming to IS 12089 may be used as part replacement of OPC provided uniform blending with cement is ensured. When the GGBS is use as a replacement of cement the water requirement reduces to obtain the same slump. It also reduces the heat of hydration the main advantage of use of GGBS is reduction in permeability and increase resistance to chemical attack. Therefore GGBS is best applicable in the marine structure or concreting in the saline environment. This slag suitable for the use in combination with Portland cement in concrete, particular uses include concrete containing reactive aggregates, Large pours to reduce the risk of early-age thermal cracking, Concrete exposed to sulphates or aggressive ground & Concrete exposed to chlorides.
- *Alccofine:* ALCCOFINE 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. The raw materials are composed primary of low calcium silicates. The processing with other select ingredients results in controlled particle size distribution (PSD). The computed blain value based on PSD is around $12000cm^2/gm$ and is truly ultrafine. Due to its unique chemistry and ultrafine particle size, ALCCOFINE1203 provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance. ALCCOFINE 1203 can also be used as a high range water reducer to improve compressive strength or as a super workability aid to improve flow.

II. MATERIAL AND METHODOLOGY

A. *Materials*

1) *Meta-kaoline*

Meta Cem grades of Calcined clays are reactive aluminous silicate pozzolanformed by calcining very pure hydrous China clay. Chemically Meta Cem combines with Calcium Hydroxide to form Calcium Silicate and Calcium Alluminate Hydrates. Unlike other natural pozzolan MetaCem is water processed to remove uncreative impurities producing an almost 100 percent reactive material. The particle size of MetaCem is significantly smaller than cement particles. IS 456:2000 recommends use of Meta-kaolin as Mineral admixture.

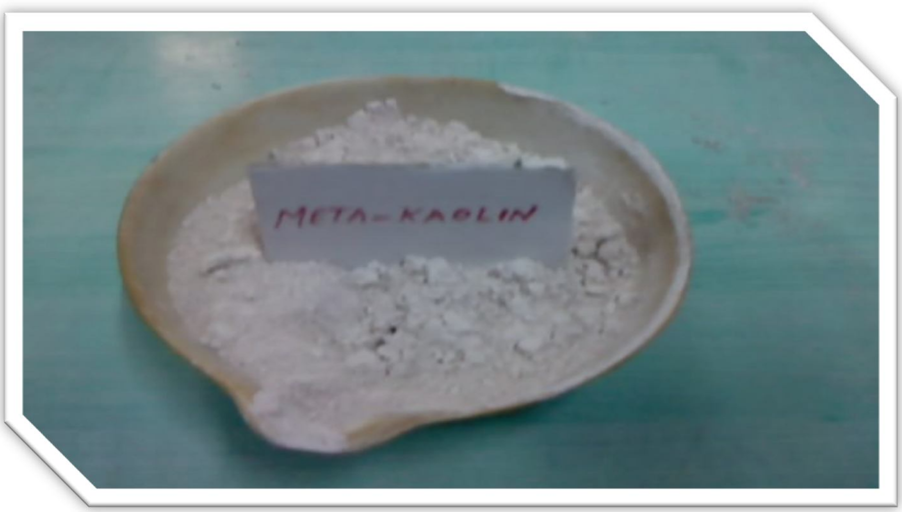

Fig No 1: Meta-kaolin

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Table No 1: - Properties of Meta-kaolin

PROPERTIES	UNITS	METACEM 85	TEST METHOD
Physical Form	-	Off white powder	-
Specific Gravity	-	2.5	ISO 787 / 10
Bulk Density	gm/ltr	300 ± 30	DIN 468
Average Particle Size	µ	1.5	Sedigraph
Residue 325 #	%	0.5 max	-
Pozzolan Reactivity - mg $Ca(OH)_2$	-	>1000	Chappel Test

- *Benefits*

MetaCem is a thermally structured, ultrafine Pozzolan which replace industrial by products such as Silica fume / Micro silica. Commercial use of Meta-kaolin has already begun in several countries worldwide. Blending with Portland Cement MetaCem improves the properties of Concrete and Cement products considerably by:

- ✓ Increasing Compressive & Flexural Strength
- ✓ Providing resistance to chemical attack
- ✓ Reducing permeability substantially
- ✓ Preventing Alkali-Silica Reaction
- ✓ Reducing efflorescence & Shrinkage

- *Chemical Composition - WT*

SiO_2+ Al_2O_3 + Fe_2O_3	> 96 %
Loss on Ignition	<1%

2) GGBS

Ground Granulated Blast Furnace Slag (GGBS): GGBS is obtained by quenching molten iron slag (a by-product of iron and steel making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. GGBS is used to make durable concrete structures in combination with ordinary port land cement and/or other pozzolanic materials. GGBS has been widely used in Europe, and increasingly in the United States and in Asia (particularly in Japan and Singapore) for its superiority in concrete durability, extending the lifespan of buildings from fifty years to a hundred years. Use of GGBS significantly reduces the risk of damages caused by alkali-silica reaction, higher resistance to chloride, and provides higher resistance to attacks by sulphate and other chemicals. GGBS is procured from visage steel plant (VSP).

Fig No.2: GGBS

The fineness modulus of GGBS using Blaine's fineness is 320 m^2/kg and other properties of GGBS given in table as below

Table No 2:- PROPERTIES OF GGBS

Chemical Properties	GGBS (%)
SiO_2	34.06
Al_2O_3	18.8
Fe_2O_3	0.7
CaO3	2.4
SO_3	0.45
MgO	10.75
S	0.65
MnO	0.49
Na_2O	0.31
K_2O	0.98
Cl	0.008

- *Physical Properties*

Mean particle size	5 - 30 micron
Colour	Off-white
Odour	Odourless when dry but may give rise to sulphide odour when wet
pH	When wet, up to 12
Viscosity	N/A
Freezing point	N/A
Boiling point	>1700°C
Melting point	>1200°C
Flash point	N/A (not flammable)
Explosive properties	N/A
Density at 20°C	2.4 - 2.8 g/cm3
Water solubility at 20°C	<1g/l

Typically the strength development will be as shown in the following table:

Table No 3:- Strength achieved as percentage of 28-day strength

Age	0% GGBS	50% GGBS	70% GGBS
7-days	75%	45 to 55%	40 to 50%
28-days	100%	100%	100%
90-days	105 to 110%	110 to 120%	115 to 130%

- Source Of Material:

Navdeep Construction Company RMC plant at Bhandup, Mumbai.

3) Alccofine

Alccofine is nothing but ultrafine slag. Alccofine performs in superior manner than all other minerals admixtures. Due to high CaO content, alccofine 1203 triggers two way reactions during hydration pozzolanic and hydraulic the result is denser pore structure and higher strength gain

- *Classifications of Alccofine*

Alccofine 1100 series – High calcium silicate products (cement base)
Alccofine 1200 series – Low calcium silicate products (slag base)
Alccofine 1300 series – Alumino silicate products (fly-ash based)

Fig No.3: Alccofine

- *Optimum Particle Size Distribution*

Use of alccofine 1203 enhance the performance of concrete in terms of durability due to its superior particle size distribution Alccofine 1203 has particles range 0.1 to 17 microns means average particle size is 4 microns

Table No 4: Physical Properties:

Fineness (cm^2/gm.)	Sp. Gravity	Bulk density (kg/ m^3)	Particle distribution		
			D_{10}	D_{30}	D_{90}
8000	3.1	700-900	1.5	5	9

Table No 5: Chemical Properties

CaO	SiO_2	SO_3	Al_2O_3	Fe_2O_3	MgO	Cl
61-64	21-23	2-2.4	5-5.6	3.8-4.4	0.8-1.4	0.03-0.05

Table No. 6: Setting Time

Initial setting time	Final setting time
60-120	120-150

- *Advantages*

✓ Durability is improved.
✓ Strength gain is improved.
✓ Improves the workability and cohesiveness.
✓ Better retention of workability.
✓ Reduces segregation.
✓ Lowers the heat of hydration.
✓ Improves the flow ability.
✓ Many decorating effects such as corrosion, carbonation and sulphate attack may be minimized or stopped.

Table No 7: Application

SCM alccofine 1203	High rise structure Marine structure Ports
Grouting alccofine	Tunnels Dams Bridges Underground work's

- Source of Material:

Ambuja testing laboratory at J.B. Nagar Andheri, Mumbai.

B. Methodology

1) Method of Mix Design

Mix design procedure: As per I.S. 456 -2000

Concrete Mix Design: As per given Grade of Concrete.

Material supplied: 1) Cement (P. P. C.)
2) Sand
3) Aggregate

Step: 1) Collection of data from laboratory.

A) Cement sample tested as per I.S. 1489-1991 Part - I & test results are tabulated in Table- I.
B) Sand: Physical properties are given in Table-II.
C) Coarse aggregates: Physical properties are given in Table – III.

Step: 2) Decide target strength of mix design (f_t)

$$f_t = f_{ck} + t \cdot s$$

where,

f_t = Target comp. strength of concrete at 28 days.
f_{ck} = characteristic comp. strength of concrete at 28 days.
t = statistical coefficient based on number results expected to be lower than the compressive strength.
s =standard deviation based on degree of control.

Step: 3) Combining of all in aggregate 20mm nominal size by Graphical method.

Desired grading calculated from standard grading curve for 20mm aggregate curve.

As per the graph:

Sieve	40 mm	20mm	10mm	4.75 mm	2..36 mm	1.18 mm	600 µ	300 µ	150 µ
% passing									

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Step: 4) Selection of W/C ratio, Water content & Air content.

For 20 mm graded aggregate:

A) Water content: _______ Kg/m^3
B) Air content: _______% by volume
C) W/c ratio: ________

Step: 5) Adjustment of water content for change in condition.

Change in condition	Water content adjustment
1) For sand conform to Zone 1	+1.5%
2) For sand conform to Zone 2	Nil
3) For sand conform to Zone3	-1.5%
4) For sand conform to Zone 4	-3%
For increase in Comp. Factor	
0. 44	+ 1. 5 %
0. 45	+ 1. 5 %
0. 46	+ 1. 5 %

Step : 6) Quantities of different ingredients:

Particulars	Mix-1	Mix-2	Mix-3
For W/c ratio	as per decided	as per decided	as per decided
Total Volume considered (m^3)	1.00	1.00	1.00
Volume of air (m^3)	From standard format	From standard format	From standard format
Volume of water (m^3)	From standard format	From standard format	From standard format
Weight of cement (kg) #	As per calculation	As per calculation	As per calculation
Volume of cement (m^3)	As per calculation	As per calculation	As per calculation
Volume of sand + aggregate (m^3)	As per calculation	As per calculation	As per calculation
Volume of sand (m^3)	As per calculation	As per calculation	As per calculation
Volume of 12 mm aggregate (m^3)	As per calculation	As per calculation	As per calculation
Volume of 25 mm aggregate (m^3)	As per calculation	As per calculation	As per calculation
Weight of sand (kg)	As per calculation	As per calculation	As per calculation
Weight of 12 mm aggregate (kg)	As per calculation	As per calculation	As per calculation
Weight of 25 mm aggregate. (kg)	As per calculation	As per calculation	As per calculation

Step: 7) Design proportion for one bag of cement in Kg.

Mix	Water	Cement	Sand	12mm aggr.	25mm aggr.	Total aggr.
Mix-1						
Mix-2						
Mix-3						

Step: 8) Actual quantities of materials to be added in one bag batch of concrete, Adjustment of water& sand due to absorption & free surface moisture.

W/C ratio	Extra water for Absorption of C. A. in Kg	Reduced water for free surface moisture in Kg	Net quantity of water in Kg

2) *Actual proportions for one bag of cement, that to be actually added in Kg*

Mix with W/C ratio			
Cement (Kg)			
Water (Kg)			
Sand (Kg)			
Coarse aggr. 12 mm (Kg)			
Coarse aggr. 25 mm (Kg)			

3) *Procedure To Determine Workability Of Fresh Concrete By Slump Cone Test*

a) The internal surface of the mould is thoroughly cleaned and applied with a light coat of oil.
b) The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
c) The mould is then filled in four layers with freshly mixed concrete, each approximately to one-fourth of the height of the mould.
d) Each layer is tamped 25 times by the rounded end of the tamping rod (strokes are distributed evenly over the cross section).
e) After the top layer is rodded, the concrete is struck off the level with a trowel.
f) The mould is removed from the concrete immediately by raising it slowly in the vertical direction.
g) The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured.
h) This difference in height in mm is the slump of the concrete.

4) *Procedure To Determine Workability Of Fresh Concrete By Compacting Factor Test*

a) The sample of concrete is placed in the upper hopper up to the brim.
b) The trap-door is opened so that the concrete falls into the lower hopper.
c) The trap-door of the lower hopper is opened and the concrete is allowed to fall into the cylinder.
d) The excess concrete remaining above the top level of the cylinder is then cut off with the help of plane blades.
e) The concrete in the cylinder is weighed. This is known as weight of partially compacted concrete.
f) The cylinder is filled with a fresh sample of concrete and vibrated to obtain full compaction. The concrete in the cylinder is weighed again. This weight is known as the weight of fully compacted concrete.

Workability	Compaction factor
Very low	0.75-0.80
Low	0.80-0.85
Medium	0.85-0.92
High	Above 0.92

$$\textbf{Compacting factor} = \frac{\textbf{Weight of partially compacted concrete}}{\textbf{Weight of fully compacted concrete}}$$

III. MIX DESIGN AND OBSERVATIONS

A. Method of Mix Design

Mix design procedure: As per I.S. 456 -2000

Target strength: M-30

Material supplied: 1) Cement (P. P. C.)
2) Sand
3) Aggregate

Step: 1) Collection of data from laboratory.

A) Sand: Physical properties like sieve analysis, water absorption, specific gravity.

B) Coarse aggregates: Physical properties like sieve analysis, water absorption, specific gravity.

Step: 2) Decide target strength of mix design (f_t)

$$f_t = f_{ck} + t \cdot s$$

Where,

f_t = Target compressive strength of concrete at 28 days.

f_{ck} = characteristic compressive strength of concrete at 28 days.

t = statistical coefficient based on number results expected to be lower than the compressive strength.

s =standard deviation based on degree of control.

$f_t = f_{ck} + t \cdot s$

$f_t = 30 + (1.65 \times 6)$

$f_t = 39.9$ N/mm^2

Step: 3) Combining of all in aggregate 20mm nominal size by Graphical method.

Desired grading calculated from standard grading curve for 20mm aggregate curve

Table No 8 :-11% of different ingredient calculated from the graph

4.75& below	4.75-10	10-20	20-40
36%	12%	14.5%	37.5%
36%	26.5%		37.5%

Step 4) Determination of Water Cement Ratio:

From graph for strength of 39.9 N/mm^2

W.C. Ratio is = 0.375

= 0.40

= 0.42

Step 5) Determination of water content and sand content:

From IS code; For maximum size of agg. 25 mm:

Water Content is 180 Kg/m^3 and

For Sand = 33%

Step 6) Adjustment of water content for change in condition:

Desired grading (according to Zone B between standard curve 2nd and 3rd) from graph attached here with.

Table no: 9 water content for change in condition:

Change in condition	Water content adjustment
1) For sand conform to Zone II	Nil

2) For increase in Compaction Factor 0. 44 0. 45 0. 46	 + 1. 5 % + 1. 5 % + 1. 5 %

Water content = $180+\frac{180 \times 1.5}{100}$
= 182.7 kg/m^3

Step 7) Cement content:

We have,

W/C ratio = 0.375

Water = 182.7 kg/m^3

Hence, Weight of cement = $\frac{182.7}{0.375}$
= 487.2 kg

Absolute volume of water and cement per cubic meter of concrete:

Volume of water is $\frac{182.7kg}{1000}$ = 0.1827 m^3

Volume of cement is $\frac{487.2}{3.15} \times \frac{1}{1000}$ = 0.1546 m^3

Total volume = 0.3373 m^3

Step 8) Quantities' of aggregate:

Total volume of aggregate = (1.000 – 0.3373)
= 0.6627 m^3

Absolute volume of sand (36%)

= 0.6584 × 0.36
= 0.2386m^3

Absolute volume of C.A. = 0.6627 – 0.2386
= 0.4241 m^3

Weight of sand = 0.2386 × 2.63 × 1000
= 627.52 kg.

Weight of coarse aggregate (12 mm) = 0.1756× 2.91 × 1000
= 510.99 kg.

Weight of coarse aggregate (25 mm) = 0.2485× 2.94 × 1000
= 723.14 kg.

a) Table No. 10:- Mix proportion by weight:

Water	Cement	Sand	C.A 12mm	CA 25mm
182.7	487.2	627.52	510.99	723.14
0.375	1.0	1.179	0.743	1.808

b) Table No. 11:- Mix proportion by Volume:

Cement	Sand	C.A 12mm	CA 25mm
0.3373	0.2386	0.1756	0.2485
1.0	0.6115	0.3484	0.8387

c) Table No. 12:-Quantity per bag of cement by weight:

Water	Cement	Sand	C.A 12mm	CA 25mm
0.375	1.0	1.179	0.743	1.808
18.75	50	58.95	37.15	90.4

B. *Correction for Water*

A) Extra water required for absorption in coarse aggregate 0.5%

$127.55 \times \frac{0.5}{100} = 0.63$ kg.

B) Quantity of water to be deduction for free moisture present in sand at 1.5 %

$58.95 \times \frac{1.5}{100} = 0.88$ kg.

Actual quantity of water to be added per bag of cement:

= 18.75+ 0.63 – 0.88

= 18.50 kg.

C) Actual quantity of sand required to allow for mass of free moisture:

= 58.95 + 0.88

= 59.83 kg.

Table No 13:- The quantities' per batch of one cement bag are:

Water	Cement	Sand	C.A 12mm	CA 25mm
18.75	50	59.83	37.15	90.4

Table No. 14:- Quantities of different ingredients:

Particulars	Mix-1	Mix-2	Mix-3
For W/c ratio	0.375	0.40	0.42
Total Volume considered (m^3)	1.00	1.00	1.00
Volume of air (m^3)	0.20	0.20	0.20
Volume of water (m^3)	0.1827	0.1827	0.1827
Weight of cement (kg) #	487.2	456.75	435
Volume of cement (m^3)	0.1546	0.1450	0.1381
Volume of sand + aggregate (m^3)	0.6627	0.6723	0.6793
Volume of sand (m^3)	0.2386	0.2420	0.2445
Volume of 12 mm aggregate (m^3)	0.1756	0.1782	0.1800
Volume of 25 mm aggregate (m^3)	0.2485	0.2521	0.2547
Weight of sand (kg)	627.52	636.46	643.04
Weight of 12 mm aggregate (kg)	510.99	518.56	523.80
Weight of 25 mm aggregate. (kg)	723.14	733.61	741.18

Table no. 15:-Actual design proportion for one bag of cement in Kg:

Mix	Water	Cement	Sand	12mm aggr.	25mm aggr.	Total aggr.
Mix-1	18.50	50	64.40	52.50	74.20	259.60
Mix-2	19.7340	50	69.68	56.77	80.34	276.524
Mix-3	20.7125	50	73.91	60.23	85.17	290.023

Table No. 16:- Concrete Mix Design

Trial mix	W/C ratio	Ingredient content in Kg					Mix proportion by weight				Compressive strength in Kg/cm^2			
		Water	Cement	Sand	12 mm aggr.	25 mm aggr.	Cement	Sand	12 mm aggr.	25 mm aggr	28 days field	7 days lab required	7 days lab observed	28 days lab observed
M 1	0.375	182.7	487.2	627.52	510.99	723.14	1.000	1.288	1.05	1.484	300	266.14	294.85	413.85
M 2	0.40	182.7	456.75	636.46	518.56	733.61	1.000	1.394	1.135	1.606	300	266.14	281.25	398.66
M 3	0.42	182.7	435.00	643.04	523.80	741.18	1.000	1.478	1.205	1.703	300	266.14	275.33	393.25

Table No. 17:- Concrete Mix Design Recommended

Trial mix	W/C ratio	Ingredient content in Kg					Mix proportion by weight				Compressive strength in Kg/cm^2			
		Water	Cement	Sand	12 mm aggr.	25 mm aggr.	Cement	Sand	12 mm aggr.	25 mm aggr	28 days field	7 days lab required	7 days lab observed	28 days lab observed
M 2	0.40	182.7	456.75	636.46	518.56	733.61	1.000	1.394	1.135	1.606	300	266.14	281.25	398.66

Table No. 18:-Mix Proportion for 1kg of cement and cementitious material

Mix	Water	Cement	SCM	Sand	12mm aggr.	25mm aggr.
Mix-1	0.4	0.95	0.5	1.272	0.803	1.949
Mix-2	0.4	0.9	0.10	1.272	0.803	1.949
Mix-3	0.4	0.85	0.15	1.272	0.803	1.949
Mix-4	0.4	0.8	0.20	1.272	0.803	1.949

Table No.19:- Quantity required per 60kg (Normal Concrete)

Mix	Water	Cement	Sand	12mm aggr.	25mm aggr.	Total Weight
Select Mix	4.36	11.0389	15.3838	12.5340	17.7319	61.05

Table No. 20:- Quantity required per 60 kg (Alccofine Concrete)

Mix	Water	Cement	Alccofine	Sand	12mm aggr.	25mm aggr.	Total aggr.
Mix-1(5%)	4.36	10.4869	0.5519	15.3838	12.5340	17.7319	61.05
Mix-2(10%)	4.36	9.9350	1.1039	15.3838	12.5340	17.7319	61.05
Mix-3 (15%)	4.36	9.3831	1.6558	15.3838	12.5340	17.7319	61.05
Mix-4(20%)	4.36	8.8311	2.2078	15.3838	12.5340	17.7319	61.05

Table No.21:-Quantity required per 60 kg (GGBS Concrete)

Mix	Water	Cement	GGBS	Sand	12mm aggr.	25mm aggr.	Total aggr.
Mix-1(5%)	4.36	9.9350	1.1039	15.3838	12.5340	17.7319	61.05
Mix-2(10%)	4.36	9.9350	1.1039	15.3838	12.5340	17.7319	61.05
Mix-3 (15%)	4.36	9.3831	1.6558	15.3838	12.5340	17.7319	61.05
Mix-4(20%)	4.36	8.8311	2.2078	15.3838	12.5340	17.7319	61.05

Table No 22:-Quantity required per 60 kg (Meta-kaoline Concrete)

Mix	Water	Cement	Meta-kaoline	Sand	12mm aggr.	25mm aggr.	Total aggr.
Mix-1(5%)	4.36	9.9350	1.1039	15.3838	12.5340	17.7319	61.05
Mix-2(10%)	4.36	9.9350	1.1039	15.3838	12.5340	17.7319	61.05
Mix-3 (15%)	4.36	9.3831	1.6558	15.3838	12.5340	17.7319	61.05
Mix-4(20%)	4.36	8.8311	2.2078	15.3838	12.5340	17.7319	61.05

C. Result of Slump cone test Carried out in Laboratory

All the tested concrete mixes gave the "Zero slump" as the mix is rich mix of M-30.

D. Results of Compaction Factor test Carried out in Laboratory

Table No: 23 Workability of Material

Material used	Weight of partially compacted concrete(W_1)	Weight of fully compacted concrete(W_2)	Compacting factor	Workability
Alkofine	19.110	22.610	0.72	V. low
GGBS	20.500	23.100	0.88	Medium
Metakoline	20.500	22.210	0.92	Medium

E. Testing Reports of 28 Days

Table No. 24:- Normal concrete:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15 (w/c=0.4)	4	86100	382.66	398.66
	5	90000	400.00	
	6	93000	413.33	

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Table No. 25:- 5% Replacement of cement by Alccofine:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	A_4	87000	386.67	400.00
	A_5	91000	404.44	
	A_6	92000	408.89	

Table No. 26:- 10% Replacement of cement by Alccofine:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	B_4	95625	425.00	414.53
	B_5	96250	427.50	
	B_6	88000	391.11	

Table No. 27:- 15% Replacement of cement by Alccofine:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	C_4	69750	310.00	383.70
	C_5	101250	450.00	
	C_6	88000	391.11	

Table No. 28:- 20% Replacement of cement by Alccofine:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	D_4	95100	422.50	337.22
	D_5	72750	322.50	
	D_6	60000	266.67	

Table No. 29:- 5% Replacement of cement by GGBS:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	E_4	99000	440.00	430.74
	E_5	99750	443.33	
	E_6	92000	408.89	

Table No. 30:- 10% Replacement of cement by GGBS:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	F_4	95000	422.22	436.29
	F_5	100500	446.66	
	F_6	99000	440.00	

Table No. 31:- 15% Replacement of cement by GGBS:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	G_4	99000	440.00	421.40
	G_5	99750	442.50	
	G_6	86000	382.22	

Table No. 32:- 20% Replacement of cement by GGBS:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	H_4	88500	392.50	380.46
	H_5	90000	400.00	
	H_6	78500	348.89	

Table No. 33:- 5% Replacement of cement by Meta-Kaoline:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	C_4	99400	441.78	439.11
	C_5	100000	444.45	
	C_6	97000	431.11	

Table No. 34:- 10% Replacement of cement by Meta-Kaoline:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	C_4	100700	447.55	448.44
	C_5	102500	455.55	
	C_6	99500	442.22	

Table No. 35:- 15% Replacement of cement by Meta-Kaoline:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	C_4	68000	302.22	383.70
	C_5	100000	444.44	
	C_6	94000	404.44	

Table No.-36:- 20% Replacement of cement by Meta-Kaoline:

CUBE SIZE	CUBE NAME	LOAD (Kg)	STRENGTH(Kg/cm^2)	AVG
15X15	C_4	93000	412.50	356.57
	C_5	98000	435.00	
	C_6	50000	222.22	

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Table No.-37:-Test results of compressive strength of sample with Alccofine

S.No.	QUANTITY OF MATERIAL (%)	7 DAYS STRENGTH (Kg/cm^2)	28 DAYS STRENGTH (Kg/cm^2)
1	0	281.25	398.66
2	5	363.70	400.00
3	10	397.03	414.53
4	15	319.81	383.70
5	20	317.41	337.22

Table No.- 38:-Test results of compressive strength of sample with GGBS

S.No.	QUANTITY OF MATERIAL (%)	7 DAYS STRENGTH (Kg/cm^2)	28 DAYS STRENGTH (Kg/cm^2)
1	0	281.25	398.66
2	5	290.52	430.74
3	10	299.62	436.29
4	15	250.74	421.40
5	20	227.77	380.46

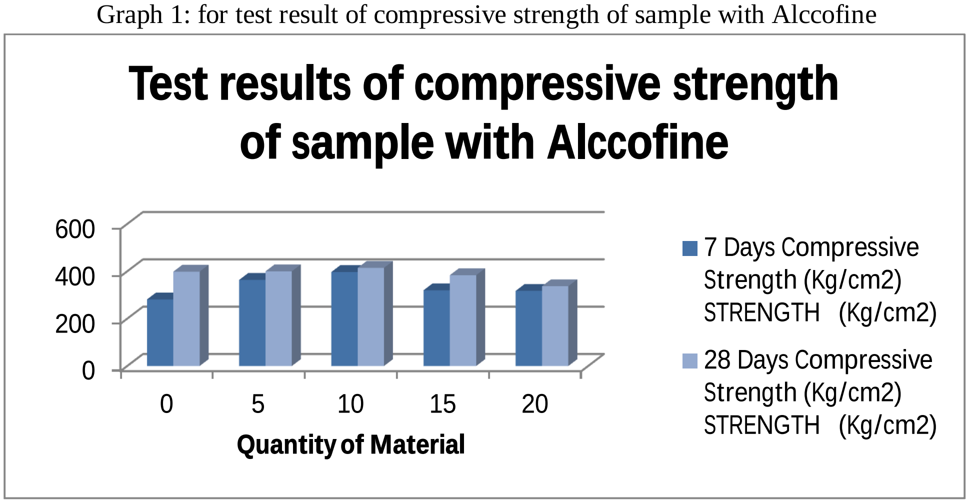
Table No.-39:-Test results of compressive strength of sample with Meta-kaoline

S. No.	QUANTITY OF MATERIAL (%)	7 DAYS STRENGTH (Kg/cm^2)	28 DAYS STRENGTH (Kg/cm^2)
1	0	281.25	398.66
2	5	310.10	439.11
3	10	316.29	448.44
4	15	307.33	383.70
5	20	259.62	356.57

IV. RESULTS AND DISCUSSION

A. Results

Graph 1: for test result of compressive strength of sample with Alccofine



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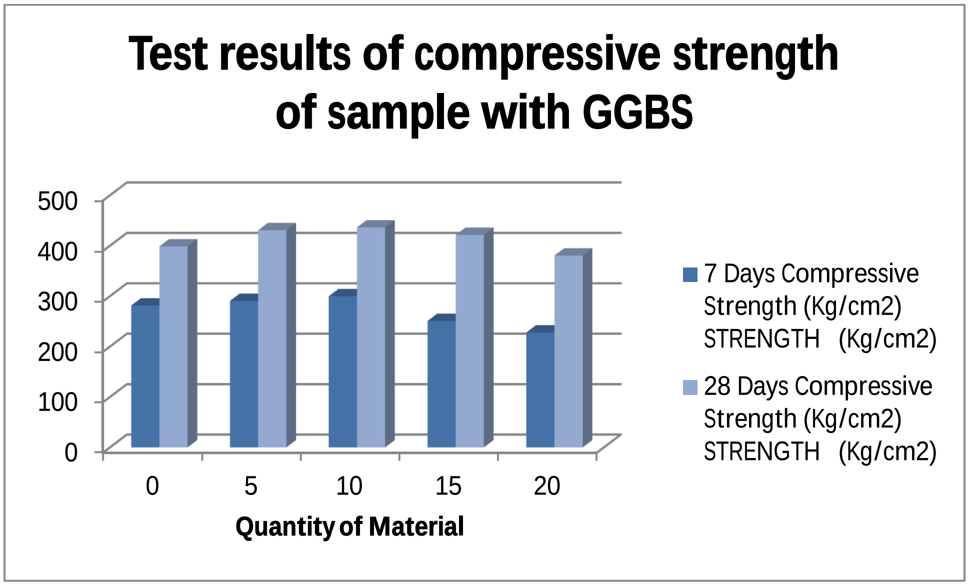
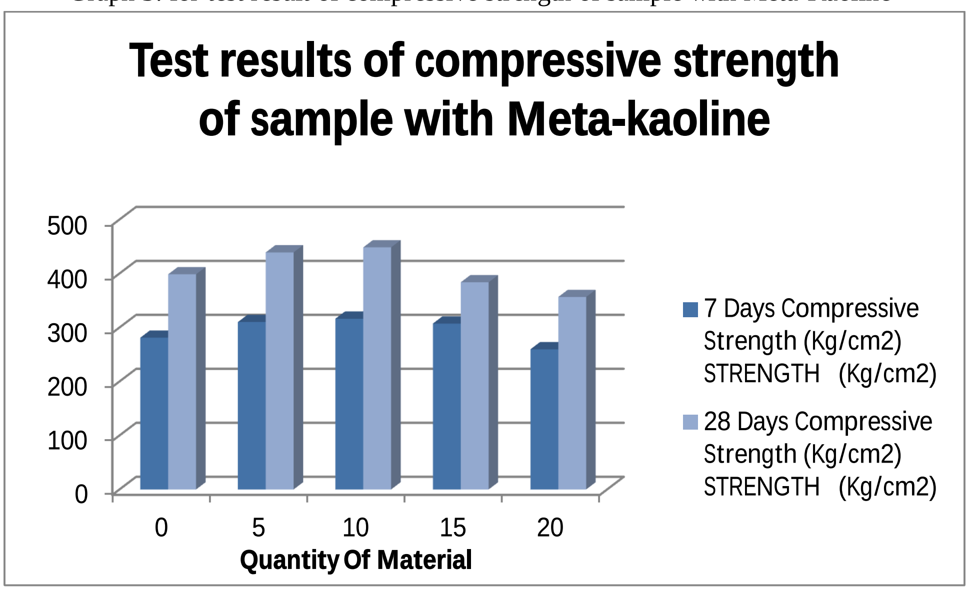
Graph 2: for test result of compressive strength of sample with GGBS



Graph 3: for test result of compressive strength of sample with Meta-Kaoline



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V. CONCLUSION & RECOMMENDATION FOR FUTURE WORK

By conducting the study of 5%, 10%, 15% and 20% replacement of cement by different wastes and tested for workability and compressive strength we conclude that,

1) Using alccofine as a replacing material we get full design strength and workability for 5% and 10% of replacement.
2) Using GGBS as a replacing material we get full design strength and workability for 5%, 10% and 15% of replacement.
3) Using meta-kaoline as a replacing material we get full design strength and workability for 5%,10% and 15% of replacement.

Thus we conclude that we can replace cement by:

- Alccofine 10%
- GGBS 15%
- Meta-kaoline 10%

Even for high strength mix such as M-30.

A. Recommendation For Future Work

Further research and investigation were highly recommended and should be carried out to understand more mechanical properties of prepared concrete. Some recommendation for future studies are mentioned below:

1) The effect of addition of fibre in our concrete mix can be checked by preparing the test samples with addition of different fibres.
2) More investigations and laboratory tests should be done to study on the mechanical properties of our concrete mix. Such application of prepared concrete was recommended in testing on concrete slabs, beam and walls or conducting more tests such as abrasion, shatter, shear, impact, blasting or creeping of concrete.
3) The addition of various different admixtures in variable % can be checked.
4) The addition of other supplementary cementitious material like Rice Husk ash, Sugar Cane ash, Fly ash and their combination in concrete mix can also be checked for compressive strength, Flexural strength and Split tensile strength.

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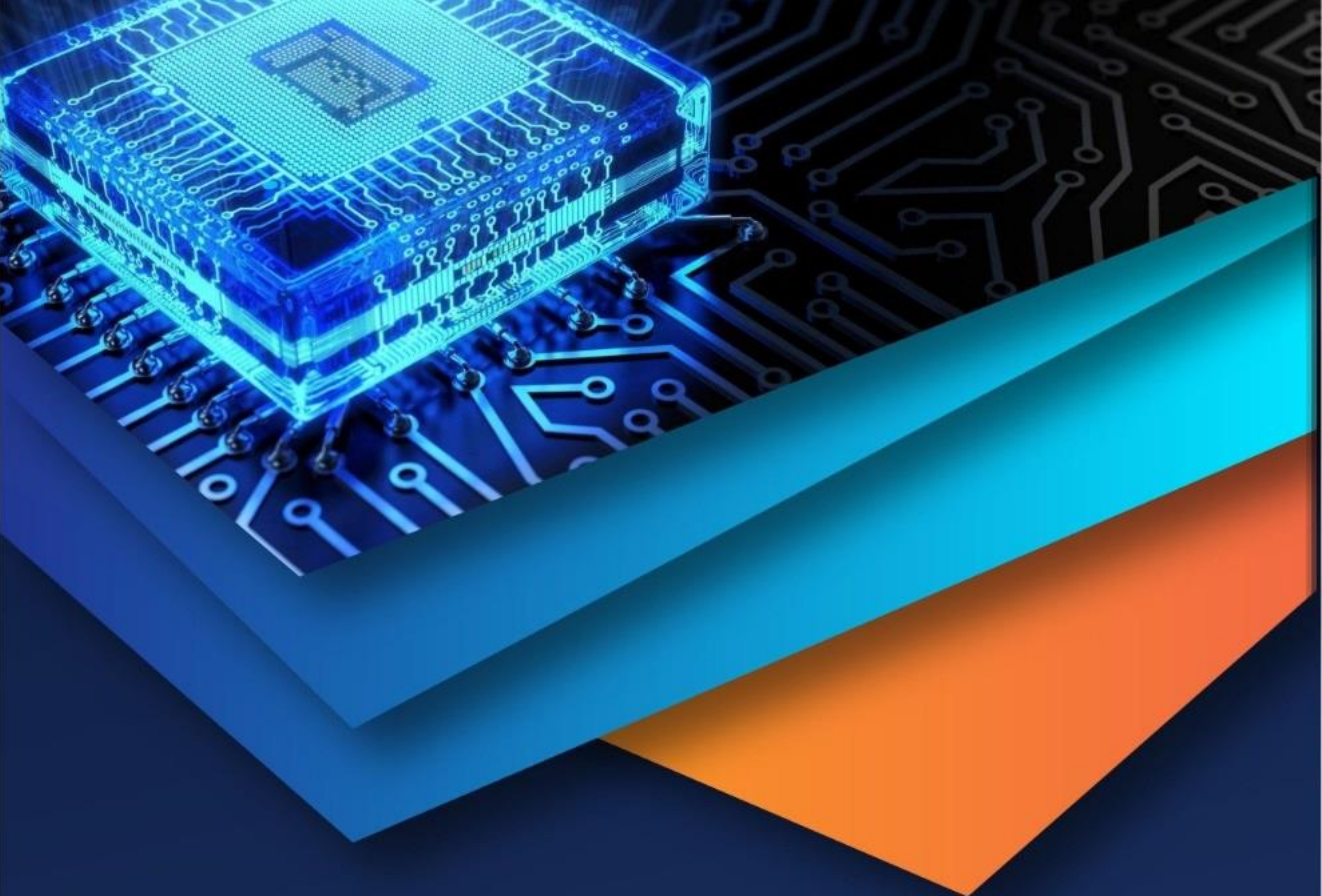

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