STRENGTH BEHAVIOR OF CONCRETE BY PARTIAL REPLACEMENT OF CERAMIC & STONE WASTE WITH COARSE AGGREGATE AND COPPER SLAG WITH FINE AGGREGATE

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ABSTRACT

All over the world, from day to day life, the large amount of concrete is being utilized in the construction field of civil engineering. But the worrying thing is that, most of the construction and demolition waste in our country are not recycled and left at industrial site as non-useable materials, which creates pollution to environment. Waste is one of the main challenges to dispose and manage but optional remedy on that is recycling of waste materials. Recycling is the most promising waste management process for disposal of materials.

Increase in industrialization and urbanization, the use of buildings also increased which results in continuous usage of construction material leads to scarcity of the concrete materials (such as sand). To overcome these issues many research were done to use many industrial waste as alternative or substantial material for concreting. In this project work, control concrete is casted for M25 and M30 grades and the partial replacement of concrete materials were decided to reuse industrial waste such as Copper Slag as fine aggregate replacement in range of 10%, 20%, 30% by weight of sand and the Ceramic Waste (Tile & Shabath Stone waste) as Coarse Aggregate replacement in 10%, 20%, 25% and 20%, 30%, 35% by weight of coarse aggregate. Totally 180-cubes (90 for M25 & 90 for M30 grades) were casted and tested for Compressive Strength at 7, 14, 28 days curing of concrete and the obtained results are compared with M25 and M30 grades of conventional concrete.

KEYWORDS*:-Ceramic Waste, Compressive Strength, Copper Slag, Shabath Stone Waste, Tile.*

I. INTRODUCTION

General:- Big attention is being focused on the environment and safeguarding of natural resources and recycling of waste materials. Actually many industries are producing a significant number of products which incorporate scrap (residues). In the last 20-25years, a lot of works concerning the use of several kinds of urban wastes in building materials industrials process have been published. Many researchers have been extended to study new kinds of wastes to investigate deeply particular aspects. The addition of wastes, apart from the environmental benefits, also produces good effects on the properties of final products.

Problem statement:-The demand of construction materials for various projects is increasing. Therefore, there is a need to explore alternative building materials from industrial waste materials that can be recycled. Ceramic tiles waste, Copper Slags, Shabath Stone waste are often discarded as waste after defined as useless. But it can be recycled and can be used as a construction material in present world which is seeking for alternative construction materials which are economical, environment friendly as well as provides same quality as that of a normal aggregate made of regular aggregates. Ceramic wastes can be used safely with no need for dramatic change in production and application process.

Objectives of project:- In this experimental study work, major sources of industrial waste which creates pollution to environment and left at industrial site as non-useable materials such as Copper slag, Shabath Stone waste and ceramic waste tiles are used as concreting materials. Copper slag is the waste of strelite industry obtained from smelting and refining process of copper at larger rate and have high density can be used as replacement for all concrete materials like sand, cement and coarse aggregate. Ceramic waste of industry is the leading industrial waste obtained in various forms like ceramic powder, broken tiles, slurry waste etc., which is disposed to landfill create pollution at larger rate.

In this project work Ceramic Waste Tiles and Shabath Stone Waste are collected and broken into 20mm aggregates for partial replacement with coarse aggregate. These replacements will reduce the cost of the project at greater percentage because aggregates are more costly than cement for concrete production.

This study was conducted to achieve the following objectives:-

- To study the strength developments of hardened concrete with use of various waste materials as aggregates in concrete.
- To determine the effects of various percentage of ceramic, stone waste and copper slag used as partial replacement of aggregates towards compressive strength of concrete.
- To determine the water absorption of ceramic aggregate concrete containing various content of ceramic waste as partial coarse aggregates replacement material.
- To reduce the concrete production cost by using waste materials having very low cost.

II. MATERIAL DESCRIPTION

In this experimental study work, major sources of industrial waste which creates pollution to environment and left at industrial site as non-useable materials such as Copper Slag, Shabath Stone Waste and Ceramic Tiles Waste are used as concreting materials. The details of materials used in this project are given below.

Materials Used In Concrete Mixes:-

The materials used in this project are Cement, Fine Aggregate, Coarse Aggregate, Water, Copper Slag, Ceramic Tiles Waste and Shabath Stone Waste which are detailed below:-

Cement:- Cement is fine powder of clay, limestone and sand burnt together at 1400^0 C. Cement is the essential ingredient to bind all other materials to form workable concrete. The Ordinary Portland Cement (OPC) 43-Grade (ACC) conforming to IS: 8112-1989 is used in this experimental project.

Aggregates:- Aggregates are the most important constituents in concrete. Nearly about 70-80% of concrete volume is composed of aggregate hence the properties of concrete are greatly affected by properties of aggregates.

Aggregates are inert materials such as Sand, gravel or crushed stone etc., which are used in concrete to produce shrinkage and cost of aggregate.

a) Fine Aggregate:- Fine Aggregate is one which passes 4.75 mm IS sieve and entirely retained on 75 micron IS sieve. These are obtained from natural sand obtained from nala beds, river beds and sea beds. Fine Aggregates are termed as “filler” which fills the voids in concrete. In this case, F.A. corresponds to grading Zone-II as per the IS code 383-1970. And the bulk density of F.A. is 1736.67 kg/m^3.

b) Coarse Aggregate:- Coarse Aggregates are the one which pass through 75 mm IS sieve and entirely retained on 4.75 mm IS sieve. It is obtained from crushed stones or rocks obtained from quarry. Aggregates fractions larger than 4.75mm are termed as Coarse Aggregates. The fraction of aggregates used in this experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone-II aggregates conforming to IS: 383-1970. And the bulk density of C.A. is 1612.67 kg/m^3.

Water:- Water is an important ingredient of concrete as it is responsible for chemical action with Cement. The strength of concrete depends on quantity and quality of water. Impure water affects setting, hardening and bond characteristics of concrete. The Specific Gravity of Water is 1. The pH value of Water should lie in between 6 to 8. In this study, portable water was used for preparing concrete mixes and curing of concrete specimens.

Copper Slag:- Copper Slag is a industrial waste obtained from smelting and refining process of Copper from Strelite Industry. The Copper Slag is a black glassy particle and granular in nature and has a similar particle size range like sand. In this project, Copper Slag is use in replacement of Fine Aggregate in various percentages. The bulk density of Copper Slag is 2200 kg/m^3.

Ceramic Tiles Waste:- In ceramic industry nearly about 15%-30% of daily production goes as waste. It is not recycled in any form at present. It can be reuse as a concreting material which helps to reduce environmental impacts. The bulk density of Ceramic Tile Waste is 1612.63 kg/m^3.

Shabath Stone Waste:-The waste of Shabath Stone can be used as the substitute for Coarse Aggregate.

Availability Of Materials:-

Copper Slag:- The Copper Slag is obtained from T.A.I. (Taj Abrasive Industries), Sikar, Jaipur, Rajasthan by on-line process of INDIA-MART. In this case, Copper Slag corresponds to grading Zone-II.

Fig No.1- Availability of Copper Slag

Ceramic Tile Waste:- Ceramic waste of industry is the leading industrial waste obtained in various forms like ceramic powder, broken tiles, slurry waste etc. Broken tiles were collected from the solid waste of ceramic manufacturing unit and crushed them into small pieces by manually. They have been cut manually into the required size of 20-25mm approximately.

Fig No.2- Ceramic Tile Waste

Shabath Stone Waste:- Shabath Stone Waste is obtained from nearly available shop in market. The wastes of Shabath Stone are used as the substitute for Coarse Aggregate. They have been cut manually into the required size of 20 -25mm approximately.



Fig No.3- Shabath Stone Waste, Manual Cutting and Preparation of Aggregate

III. MATERIAL PROPERTIES

In this experimental study work, major sources of industrial waste which creates pollution to environment and left at industrial site as non-useable materials such as Copper slag, shabath stone waste and ceramic waste tiles are used as concreting materials (with partial replacements of F.A. & C.A.). The physical properties of materials are as follows-

Properties of OPC 43-Grade Cement:-

Table No.1- Properties Of Ordinary Portland Cement (OPC) 43-Grade

Properties	Average values for OPC used in investigation
Specific Gravity	3.15
Consistency (%)	26%
Fineness by dry sieving	9%
Initial setting time	35 minutes
Final setting time	185 minutes
Soundness (mm)	7 mm

Sr. No.	For	Compressive Strength obtained(Mpa)	Standard values
1.	3-days	24.7	>23
2.	7-days	35.63	>33
3.	28-days	45.94	>43

Physical Properties Of Aggregates:- following are the physical properties of the fine and coarse aggregate which are obtained after test results.

Physical Properties Of Fine Aggregates:-

Table No.2- Physical Properties Of Fine Aggregate

Properties of F. A. (sand)	Value
Specific Gravity	2.62
Water Absorption	1.21%
Sieve Analysis	Corresponds to Zone-II
Particle Shape	Granular
Properties of F. A. (Copper Slag)	**Value**
Specific Gravity	3.56
Water Absorption	0.4 %
Sieve Analysis	Corresponds to Zone-II
Particle Shape	Granular

Physical Properties Of Coarse Aggregate:-

Table No.3- Physical Properties Of Coarse Aggregates

Properties (Natural C.A.)	Value
Specific Gravity	2.82
Water Absorption (W.A.)	1.44%
Sieve Analysis (S.A.)	Corresponds to 20mm single size
Particle Shape	Angular
Aggregate Impact Value	18.6% (Strong)
Properties (Ceramic Tile Waste)	**Value**
Specific Gravity	2.1
Water Absorption	11.68%
Sieve Analysis	Corresponds to 20mm single size
Particle Shape	Angular
Aggregate Impact Value	Less than 30% (weak)
Properties (Shabath Stone Waste)	**Value**
Specific Gravity	2.72
Water Absorption	0.72%
Sieve Analysis	Corresponds to 20mm single size
Particle Shape	Angular
Aggregate Impact Value	Less than 30% (weak)

IV. CONCRETE MIX DESIGN

Test Data Required For Concrete Mix Design Of M25 & M30 Grades:-

Table No.4- Stipulations for proportioning (for M25 Grade)

Sr. No.	Design Stipulations	Quality
1.	Characteristic compressive strength required in the field at 28 days	25 N/mm^2
2.	Maximum size of aggregates	20mm (angular)
3.	Degree of workability	0.8 (C.F.)
4.	Degree of quality of control	Good
5.	Type of exposure	Moderate

Table No.5- Stipulations for proportioning (for M30 Grade)

Sr. No.	Design Stipulations	Quality
1.	Characteristic compressive strength required in the field at 28 days	30 N/mm^2
2.	Maximum size of aggregates	20mm (angular)
3.	Degree of workability	0.8 (C.F.)
4.	Degree of quality of control	Good
5.	Type of exposure	Severe

Table No.6- Test Data for Materials

Sr. No.	Test Data For Materials
1.	Cement - OPC, 43-Grade
2.	Specific gravity of cement – 3.15
3.	Specific gravity of water - 1
4.	Specific gravity of Fine Aggregate (sand) – 2.62
5.	Specific gravity of Coarse Aggregate – 2.82
6.	Water absorption of Fine Aggregate (sand) – 1.21%
7.	Water absorption of Coarse Aggregate – 1.44%
8.	Free surface moisture of Fine Aggregate – 2.0%
9.	Free surface moisture of Coarse Aggregate – Nil
10.	Sieve analysis of Fine Aggregate corresponds to – Zone-II
11.	Sieve analysis of Coarse Aggregate corresponds to 20mm single size

CONCRETE MIX DESIGN OF M25 GRADE

Following is the step by step procedure for mix design as recommended in IS 10262–1982:-

- Target mean strength of concrete
- Selection of Water-Cement Ratio
- Selection of Water and Sand content
- Determination of Cement content
- Determination of Coarse and Fine Aggregate content
- Actual quantities required for the mix per bag of cement

1. Target mean strength of concrete:-

Ft = Fck + (**K** x **S**)

Where,

Ft = target average compressive strength at 28 days,
Fck = characteristic compressive strength of concrete at 28 days,
K = constant and is taken as 1.65
S = standard deviation, (from I.S. 456 -2000, T.N.-8, for M25 - S =4 N/mm2)

Table No.7- Values of constant (K)

Accepted proportion of low results	K
1 in 5, 20%	0.84
1 in 10, 10%	1.28
1 in 15, 6.7%	1.50
1 in 20, 5%	1.65
1 in 40, 2.5%	1.86
1 in 100, 1%	2.33

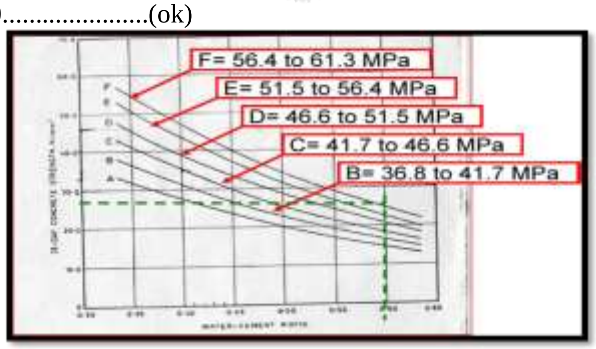
Ft = 25 + (1.65 x 4) = 31.6 =**32 Mpa- (**Target mean strength of concrete for mix design of M_{25})

2. Selection of Water-Cement Ratio:-

In this case, we have 43-grade of cement which belongs to **curve-C (**i.e. C = 41.7 to 46.6 mpa) and target mean strength is 32 mpa, match these values on given graph. (I.S.10262-1982, P.N.-8)

We get, w/c ratio = 0.43

From graph,:- **0.43 < 0.50**......................(ok)



Graph No.1- Modified graph for selection of Water Cement Ratio

IS Requirements (RCC):-Table No.8- Minimum cement content, W/C ratio and Grade selection

Exposure	Min. Cement content (kg/m^3)	Max. W/C Ratio	Min. grade of concrete
Mild	300	0.55	M20
Moderate	**300**	**0.50**	**M25**
Severe	**320**	**0.45**	**M30**
Very severe	340	0.45	M35
Extreme	360	0.40	M40

3. **Selection of Water and Sand content (up to M35 Grade):-** Approximate sand and water contents per cu.m of concrete-W/C = 0.6, Workability = 0.8 C.F. (For medium strength concrete up to M_{35})- (as per IS 10262-1982, table:4) **Table No.9- Selection of Water and Sand content (up to M35 Grade)**

M.S.A. (mm)	Water content, (kg/m^3)	Sand as per % total aggregate by absolute volume P = F_{agg}(% of total)
10	208	40
20	**186**	**35**
40	165	30

*Water content corresponding to saturated surface dry aggregate

Estimation of entrapped air:-

It is depends on nominal max size of aggregate as given in table –

Table No.10- MSA & Entrapped air as % of volume of concrete

Max. Size Of Aggregate (mm)	Entrapped air as % of volume of concrete
10	3.0
20	**2.0**
40	1.0

Hence, volume = 1-0.02 = 0.98 m^3

The values are given in the tables, based on the following conditions

(a) Crushed (Angular) Coarse Aggregate conforming to IS: 383

(b) Sand conforming to grading zone II of table 4 of IS: 383

(c) Workability corresponds to C.F. of 0.8

Water content per cubic meter of concrete with respect to nominal maximum size of aggregate of 20mm is 186 kg. Proportion of sand of total aggregate by absolute volume = 35%.

Adjustments in sand proportion:-

For w/c ratio of 0.43,

Change in w/c ratio= 0.60-0.43=0.17

Percentage reduction in sand =0.17/0.05 = 3.4%

Final sand content = (35-3.4) % = 31.6% = 0.316 = P

4. **Determination Of Cement Content:-**

Min. Cement Content = (final water content) / (w/c ratio)

= 186/0.43 = 432.56 kg/m^3

Volume of cement = 432.56 kg/m^3

5. **Determination of Coarse and Fine Aggregate content:-**

$\mathbf{V_{F.A.} = \{W + (C/S_C) + (1/p) \times (F_{agg}/S_{agg})\} \times (1/1000)}$

$(1-0.02) = \{186 + (432.56/3.15) + ((1/0.316) \times (F_{agg}/2.62))\} \times (1/1000)$

Volume of F_{agg} = 543.68 kg/m^3

$\mathbf{V_{C.A.} = \{W + (C/S_C) + (1/(1-p)) \times (C_{agg}/S_{agg})\} \times (1/1000)}$

$(1-0.02) = \{186 + (432.56/3.15) + ((1/0.684) \times (C_{agg}/2.82))\} \times (1/1000)$

Volume of C_{agg} = 1266.66 kg/m^3

6. **Actual quantities required for the mix per bag of Cement:-**

Based upon the above mix design following mix proportion has been calculated:-

Table No.11- Mix Design Ratio of M_{25} grade concrete

Mass of water (kg/m^3)	Mass of cement (kg/m^3)	Mass of F.A. (Kg/m^3)	Mass of C. A. (kg/m^3)
186	**432.56**	**543.68**	**1266.66**
(Ratio) 0.43	**1**	**1.26**	**2.93**

Hence, the obtained mix design ratio of M_{25} grade concrete is **1:1.26:2.93**

And also, as per mix design of M_{25} grade, the proportions of special materials used in concrete mix are as follows-

Table No.12- Mix Design Ratio of M_{25} grade concrete for special materials

Mass of Cement (kg/m^3)	Mass of Copper Slag (kg/m^3)	Mass of Ceramic Tile (Kg/m^3)	Mass of Shabath Stone (kg/m^3)
432.56	738.74	943.25	1221.74
(Ratio) 1	1.71	2.18	2.82

Calculation:-

1. **For Fine Aggregate:-** (sp. Gr. of Copper Slag =3.56)

$V_{F.A.}$ = {W + (C/S_C) + (1/p) x (F_{agg}/S_{agg})} x (1/1000)

(1-0.02) = **{**186 + (432.56/3.15) + ((1/0.316) x (F_{agg}/3.56))} x (1/1000)

Volume of F_{agg} = 738.74 kg/m^3

2. **For Coarse Aggregate:-** (sp. Gr. Of Ceramic Tile =2.1 & sp. Gr. of Shabath Stone =2.72)

➢ **$V_{ceramic\ tile}$ = {W + (C/S_C) + (1/(1-p)) x (C_{agg}/S_{agg})} x (1/1000)**

(1-0.02) = **{**186 + (432.56/3.15) + ((1/0.684) x (C_{agg}/2.1))} x (1/1000)

Volume of C_{agg} = 943.25 kg/m^3

➢ **$V_{shabath\ stone}$= {W + (C/S_C) + (1/(1-p)) x (C_{agg}/S_{agg})} x (1/1000)**

(1-0.02) = **{**186 + (432.56/3.15) + ((1/0.684) x (C_{agg}/2.72))} x (1/1000)

Volume of C_{agg} = 1221.74 kg/m^3

CONCRETE MIX DESIGN OF M30 GRADE

1. **Target mean strength of concrete:- Ft** = **Fck** + (**K** x **S**)

Where, **Ft** = target average compressive strength at 28 days,

Fck = characteristic compressive strength of concrete at 28 days,

K = constant and is taken as 1.65

S = standard deviation, (from I.S. 456 -2000, T.N.-8, for M_{30}- S =5 N/mm2)

Ft = 30 + (1.65 x 5) = **38.25mpa**

2. **Selection of Water Cement Ratio:-**

In this case, we have 43 grade of cement which belongs to **curve-C (**i.e. C = 41.7 to 46.6 mpa) and target mean strength is 38.3 mpa, match these values on given graph. (IS-10262-1982, P.N.-8), We get, W/C ratio = 0.37 (say as 0.4)

From graph:- **0.37 < 0.45**......................(ok)

3. **Selection of Water and Sand content (up to M35 grade):-**

M.S.A.(mm)	W (kg/m^3)	P = F_{agg}(% of total)
20	186	35

Adjustments- Approximate sand and water contents per cu.m of concrete-W/C = 0.6, Workability = 0.8 C.F. (For medium strength concrete up to M35)-

For w/c ratio of 0.37,

Change in w/c ratio= 0.60-0.37=0.23

Percentage reduction in sand =0.23/0.05 = 4.6%

Final sand content = (35-4.6) % = 30.4% = 0.304 = P

4. **Determination of Cement content:-**

Min. cement content = (final water content) / (w/c ratio)

= 186/0.37 = 502.7 kg/m^3

Volume of Cement = 502.7 kg/m^3

5. **Determination of Coarse and Fine Aggregate content:-**

$V_{F.A.}$ = {W + (C/S_C) + (1/p) x (F_{agg}/S_{agg})} x (1/1000)

(1-0.02) = **{**186 + (502.7/3.15) + ((1/0.304) x (F_{agg}/2.62))} x (1/1000)

Volume of F_{agg} = 505.3 kg/m^3

$V_{C.A.}$ = {W + (C/S_C) + (1/(1-p)) x (C_{agg}/S_{agg})} x (1/1000)

(1-0.02) = **{**186 + (502.7/3.15) + ((1/0.696) x (C_{agg}/2.82))} x (1/1000)

Volume of C_{agg} = 1245.17 kg/m^3

6. Actual quantities required for the mix per bag of Cement:-

Based upon the above mix design following mix proportion has been calculated:-

Table No.13- Mix Design Ratio of M_{30} grade concrete

Mass of Water (kg/m^3)	Mass of Cement (kg/m^3)	Mass of F.A. (Kg/m^3)	Mass of C. A. (kg/m^3)
186	502.7	505.3	1245.17
(Ratio) 0.37	1.0	1.01	2.48

Hence, the obtained mix design ratio of M_{30} grade concrete is **1:1.01:2.48**

As per mix design for M30 grade, the proportions of special materials used in concrete mix are as follows-

Table No.14- Mix Design Ratio of M_{30} grade concrete for special materials

Mass of cement (kg/m^3)	Mass of Copper Slag (kg/m^3)	Mass of Ceramic Tile (Kg/m^3)	Mass of Shabath Stone (kg/m^3)
502.7	686.59	927.26	1201.02
(Ratio) 1	1.37	1.84	2.39

Calculation:-

1. **For Fine Aggregate:-** (sp. Gr. of Copper Slag =3.56)

$V_{F.A.} = \{W + (C/S_C) + (1/p) \times (F_{agg}/S_{agg})\} \times (1/1000)$

$(1-0.02) = \{186 + (502.7/3.15) + ((1/0.304) \times (F_{agg}/3.56))\} \times (1/1000)$

Volume of $F_{agg} = 686.59\ kg/m^3$

2. **For Coarse Aggregate:-** (sp. Gr. Of Ceramic Tile =2.1 & sp. Gr. of Shabath Stone =2.72)

➢ **$V_{ceramic\ tile} = \{W + (C/S_C) + (1/(1-p)) \times (C_{agg}/S_{agg})\} \times (1/1000)$**

$(1-0.02) = \{186 + (502.7/3.15) + ((1/0.696) \times (C_{agg}/2.1))\} \times (1/1000)$

Volume of $C_{agg} = 927.26\ kg/m^3$

➢ **$V_{shabath\ stone} = \{W + (C/S_C) + (1/(1-p)) \times (C_{agg}/S_{agg})\} \times (1/1000)$**

$(1-0.02) = \{186 + (502.7/3.15) + ((1/0.696) \times (C_{agg}/2.72))\} \times (1/1000)$

Volume of $C_{agg} = 1201.02\ kg/m^3$

V. EXPERIMENTAL PROGRAM

Concrete Mix Proportioning:-

In this experimental project, the concrete grades M_{25} & M_{30} was decided to use for investigation. The normal concrete mix for both is designed in accordance with the Indian Standard Code–I.S.10262-2009 guideline assuming good degree of quality control and moderate exposure conditions. The Normal Concrete mix (N.C.) proportion for per cubic meter of concrete is calculated. For making the concrete mixes containing special materials, the amount of each special material is calculated in percentage by weight of corresponding normal materials.

The copper slag is used as partial replacement for fine aggregate varying in range of 0%, 10%, 20% & 30% in normal concrete. Similarly ceramic tile waste in range of 0%, 10%, 20%, 25% & shabath stone waste in range of 0%, 20%, 30%, 35% is used as partial replacement for coarse aggregate (as shown in Table No.15). The performance of the experimental mixes was compared with that of the normal mixes and finding out its optimum strength. In this project, as per mix design of concrete, the obtained mix design ratio of M_{25} grade concrete is **1:1.26:2.93** and mix design ratio of M_{30} grade concrete is **1:1.01:2.48.**

Table No.15- Various Percentages of Material Replacements use in concrete mixes

(The quantities of cement is constant for all replacements i.e. 100%)

Various Mixes	(F.A.)	(C.A.)	Copper Slag (By Wt. Of F.A.)	Ceramic Waste (By Wt. Of C.A.)	Stone Waste (By Wt. Of C.A.)
Control Mix	100%	100%	0%	0%	0%
Mix-1	90%	70%	10%	10%	20%
Mix-2	90%	50%	10%	20%	30%
Mix-3	90%	40%	10%	25%	35%
Mix-4	80%	70%	20%	10%	20%
Mix-5	80%	50%	20%	20%	30%
Mix-6	80%	40%	20%	25%	35%
Mix-7	70%	70%	30%	10%	20%
Mix-8	70%	50%	30%	20%	30%
Mix-9	70%	40%	30%	25%	35%

Fresh Concrete Test Results (Slump Test):-A slump of 25mm is generally provides good workability of concrete. Throughout the project, no more extra amount of water needed to get slump. Moisture content and absorption of ingredients were taken into account in mix design for calculating the amount of water needed. Table shows the measured slump and the amount of water needed to obtain the slump during the project.

Fig No.4- Measurement of Slump

Table No.16- Slump Test for M_{25} Grade Concrete

Various Mixes	W/C Ratio	Slump (mm)
Control Mix	0.43	24
mix-1	0.43	30
mix-2	0.43	27
mix-3	0.43	25
mix-4	0.43	32
mix-5	0.43	29
mix-6	0.43	26
mix-7	0.43	38
mix-8	0.43	35
mix-9	0.43	32

Table No.17- Slump Test for M_{30} Grade Concrete

Various Mixes	W/C Ratio	Slump (mm)
Control Mix	0.4	25
mix-1	0.4	28
mix-2	0.4	26
mix-3	0.4	24
mix-4	0.4	30
mix-5	0.4	28
mix-6	0.4	25
mix-7	0.4	35
mix-8	0.4	31
mix-9	0.4	29

Density Test:-The density of hardened concrete at saturated-surface dried condition was measured at the age of 28 days. From the results in the table, it can be seen that the density of hardened concrete increased with the increase of the copper slag as sand content. Also the density of harden concrete decreases with the increase of ceramic waste as coarse aggregate. This is due to the specific gravity of materials. There is a higher specific gravity of the copper slag, which were 3.56 as compared to 2.62 of the natural sand. However compared with the large difference in the specific gravity of the copper slag and the natural sand, it increased density of concrete.

Table No.18- Density of Concrete (For M25 Grade)

Various Mixes	28 days density (KN/m^3)
Control Mix (C.M.)	26.51
mix-1	26.22
mix-2	25.87
mix-3	25.58
mix-4	26.45
mix-5	26.04

mix-6	**25.93**
mix-7	**26.74**
mix-8	**26.28**
mix-9	**26.16**

Table No.19- Density of Concrete (For M_{30} Grade)

Various Mixes	28 days density (KN/m^3)
Control Mix	22.96
mix-1	22.73
mix-2	22.24
mix-3	22.15
mix-4	22.82
mix-5	22.38
mix-6	22.18
mix-7	23.02
mix-8	22.67
mix-9	22.38

Hardened Concrete Test Results-

Compressive Strength Test on Cement Concrete Cubes:-

In this investigation, for each mix 3-samples were tested and the average strength is compared with nominal mix of M25 & M30 grade. Totally 180-cubes (90 for M25 & 90 for M30 grades) of size 150mm x 150mm x 150mm were casted and tested at 7, 14, 28 days after curing. The compression test on concrete is done by applying constant load after placing concrete between plates and the failure load is note down after the load reversal occurs, cracks appears on concrete shows the compressive strength of concrete. The normal mix strength is compared with the strength obtained from various percentage of replacement in concrete mix.

$$\text{compressive strength}\left(\frac{N}{mm2}\right) = \frac{\text{ultimate compressive load}(N)}{\text{area of cross section of specimen}(mm2)}$$

Table No.20- Number of Specimens required for Mixes of M_{25} Grade

Name of test	Size of Specimen (cube)	No. of mixes	No. of Specimens for each Mixture	Total No. of Specimens
Compressive Strength Test for Mix of M_{25} Grade	(150 x150 x 150) mm	10	9	90

Table No.21- Number of Specimens required for Mixes of M_{30} Grade

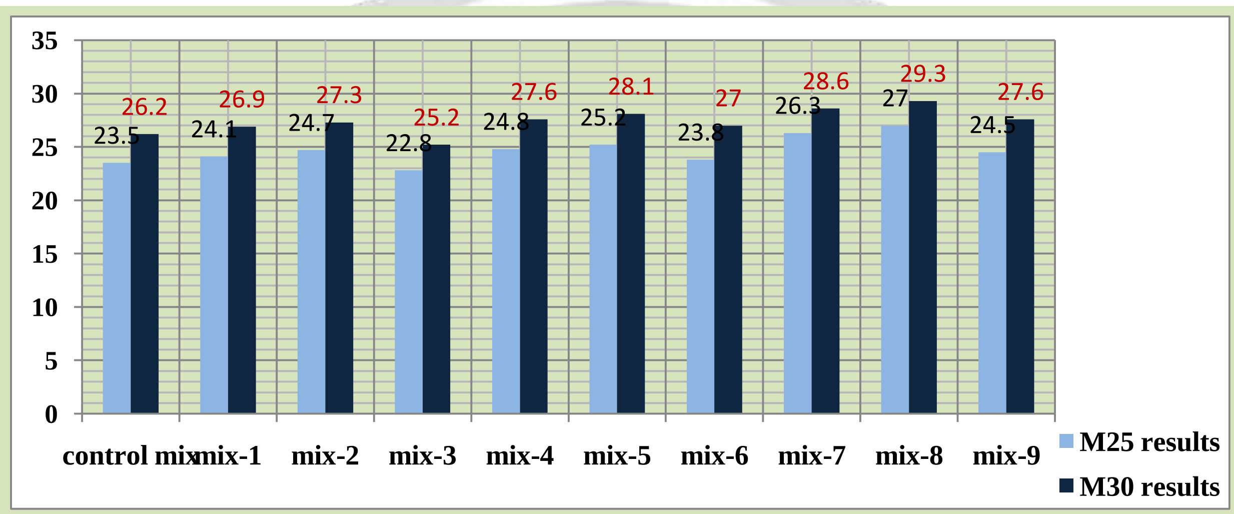
Name of test	Size of Specimen (cube)	No. of mixes	No. of Specimens for each Mixture	Total No. of Specimens
Compressive Strength Test for Mix of M_{30} Grade	(150 x150 x 150) mm	10	9	90

Table No.22- Compressive strength test results on M_{25} grade concrete cubes

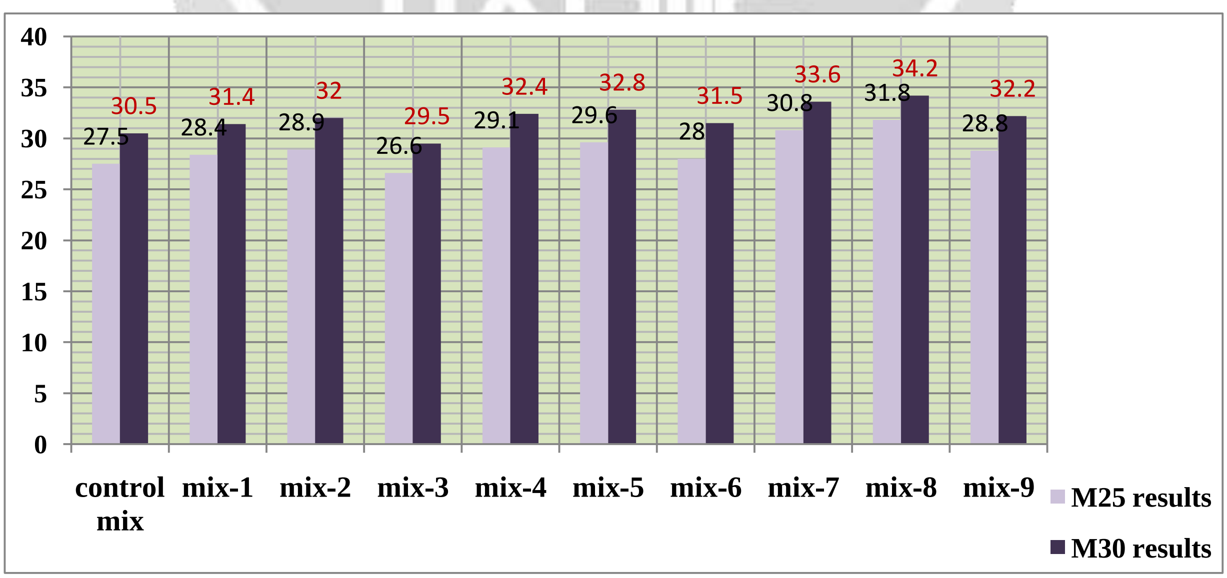
Mix No. [M_{25}]	Compressive Strength (Mpa)		
	7 days	14 days	28 days
1. Control Mix	23.5	27.5	31.6
2. Mix-1	24.1	28.4	32.2
3. Mix-2	24.7	28.9	32.8
4. Mix-3	22.8	26.6	30.8
5. Mix-4	24.8	29.1	33.0
6. Mix-5	25.2	29.6	33.7
7. Mix-6	23.8	28	31.8
8. Mix-7	26.3	30.8	35
9. Mix-8	27.0	31.8	36.1
10. Mix-9	24.5	28.8	32.7

Table No.23- Compressive strength test results on M_{30} grade concrete cubes

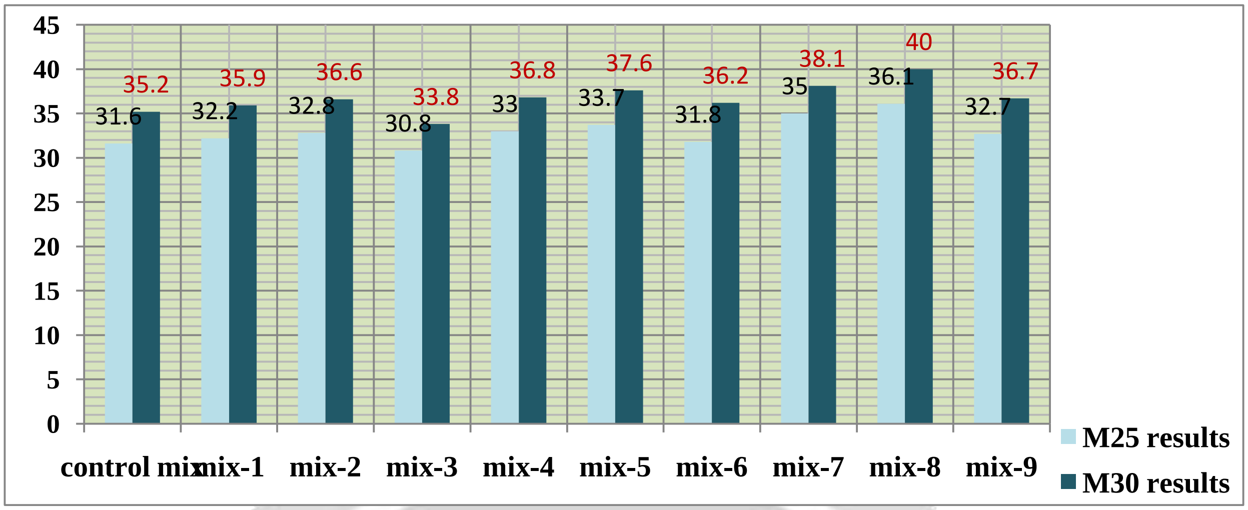
Mix No. [M_{30}]	Compressive Strength (Mpa)		
	7 days	14 days	28 days
1. Control Mix	26.2	30.5	35.2
2. Mix-1	26.9	31.4	35.9
3. Mix-2	27.3	32	36.6
4. Mix-3	25.2	29.5	33.8
5. Mix-4	27.6	32.4	36.8
6. Mix-5	28.1	32.8	37.6
7. Mix-6	27	31.5	36.2
8. Mix-7	28.6	33.6	38.1
9. Mix-8	29.3	34.2	40
10. Mix-9	27.6	32.2	36.7



Graph No.2- 7 days compressive strength test results of M25 and M30 grades



Graph No.3- 14 days compressive strength test results of M25 and M30 grades



Graph No.4- 28 days compressive strength test results of M25 and M30 grades

VI. RESULTS AND DISCUSSION

From the above test result done on 7th, 14th, 28th days curing for normal and other replaced concrete, shows the maximum strength obtained at **mix-8** of 36.1Mpa at 28th day for M25 grade and 40 mpa for M30 grade concrete. The obtained results for all other replacements also have increased strength compared to normal M25 & M30 grade of concrete.

Table No.24- Optimum Values of Compressive Strength Test for both M_{25} and M_{30} Grades of Concrete

Mix	Cement	Fine Aggregate (F.A.)	Coarse Aggregate (C.A.)	Copper Slag (By Wt. Of F.A.)	Ceramic Waste (By Wt. Of C.A.)	Stone Waste (By Wt. Of C.A.)
mix-8	100%	70%	50%	30%	20%	30%

Mix No. [M_{25}]	Compressive Strength (Mpa)		
	7 days	14 days	28 days
1. Mix-8	27.0	31.8	36.1

Mix No. [M_{30}]	Compressive Strength (Mpa)		
	7 days	14 days	28 days
1. Mix-8	29.3	34.2	40

DISCUSSION

Discussion on results of fresh concrete (slump test):-A slump of 25mm generally provides good workability of concrete. Moisture content and absorption of the ingredients were taken into account for calculating the amount of water added. In this project hand mixing was done. It may be noted that in hand mixing more cement and water is required as compared to machine mixing of concrete for obtaining the concrete of same strength. The water to cement ratio was kept at approximately 0.45.

From the slump test it was concluded that the amount of water to obtain the targeted slump in the concrete composites was the equivalent conventional concrete. As the amount of copper slag increased the amount of slump increased. And as the amount ceramic waste increased the value of slump decreased because % of Water Absorption (W.A.) of ceramic waste is more as compared to copper slag.

Density:-The density of hardened concrete at saturated-surface dried condition was measured at the age of 28 days. From the results in the table, it can be seen that the density of hardened concrete increased with the increase of the copper slag as sand content. Also the density of harden concrete decreases with the increase of ceramic waste as coarse aggregate. This is due to the specific gravity of materials. There is a higher specific gravity of the copper slag, which were 3.56 as compared to 2.62 of the natural sand. However compared with the large difference in the specific gravity of the copper slag and the natural sand, it increased density of concrete. Addition of slag in concrete increases the density thereby the self weight of the concrete.

Compressive Strength:-

From the test results of compressive strength, it is observed that the replacement of copper slag as sand attained high strength of at 30% replacement than conventional concrete, further replacements also has increased strength. As the amount of copper slag increased, strength increased. The replacement of ceramic waste alone will not have sufficient strength, so it is replaced with optimum slag content as constant also have increased strength compared to control concrete. These changes in results are same for both M25 and M30 grades of concrete.

As the amount ceramic waste increased with the amount copper slag, the strength also increased, but this is up to certain limit. The compressive strength results of mix-3, mix-6 and mix-9 is less as compared to other mixes because these mixes contained maximum amount of ceramic waste for both M25 and M30 grades (see table no.6.1). The compressive strength results for all mixes are more than the results of conventional concrete for both M25 and M30 Grades.

From the test result done on 7^{th}, 14^{th}, 28^{th} days curing for normal and other replaced concrete, shows the maximum strength obtained at **mix-8** of 36.1Mpa at 28^{th} day for M25 grade and 40 mpa for M30 grade concrete. Earlier strength is attained at7 day testing itself due to this partial replacement with economy.

CONCLUSION

From the test results of compressive strength, it is observed that the replacement of copper slag as sand attained high strength of at 30% replacement than conventional concrete, further replacements also has increased strength. (Hence, it may be said that, as the amount of Copper Slag increased, strength increased). The replacement of ceramic waste alone will not have sufficient strength, so it is replaced with optimum slag content as constant. As the amount of ceramic waste increased with the amount of copper slag, the strength also increased, but this is up to certain limit. These changes in results are same for both M25 and M30 grades of concrete.

The compressive strength results of mix-3, mix-6 and mix-9 are less as compared to other mixes because these mixes contained maximum amount of ceramic waste for both M25 and M30 grades (see table no.4). But the profitable thing is that, the compressive strength results for all mixes are more than the results of conventional concrete.

From the test result done on 7^{th}, 14^{th}, 28^{th} days curing process, it is shows that, the maximum strength obtained at **mix-8**, which is 36.1Mpa at 28^{th} day for M25 grade and 40 mpa for M30 grade concrete. Earlier strength is attained at7 day testing itself due to this partial replacement with economy.

- Copper Slag behaves like River Sand, both having same contain silica (SiO2).
- It is observed that when increasing % replacement of F.A. by Copper Slag, the unit weight of concrete is gradually increases. It is also observed that, the workability of concrete increased with the increase in Copper Slag content of Fine Aggregate.
- While using Ceramic Waste as partial replacement of C.A., workability decreased with increase in replacement level. It is also observed that, with the addition of Ceramic Waste as a C.A. up to certain percentage, the strength values are noticed to increased and later decreased with more addition of Ceramic Waste.
- It is observed that, the weights of some designed concrete Mixes are lighter than conventional concrete which helps to becomes Light Weight Concrete (LWC). And also the compressive strength values of these mixes are higher than the conventional concrete.
- The ceramic waste used for concreting having very low cost as compared to cost of normal concrete materials and it is also providing greater strength as compared to conventional concrete. As we used ceramic & stone waste replacement of 50% with coarse aggregate, it reduces the concrete production cost enormously which helps to became economical concrete.
- The value of designed M25 grade concrete for Mix-8 (30% of C.S. for F.A., 20% of ceramic tile and 30% of shabath stone waste for C.A.) shows the highest value of compressive strength (i.e. 36.1 mpa at 28^{th} day).
- The value of designed M30 grade concrete for Mix-8 (30% of C.S. for F.A., 20% of ceramic tile and 30% of shabath stone waste for C.A.) shows the highest value of compressive strength (i.e. 40 mpa at 28^{th} day).
- From above test results, it can be say that, Ceramic waste and Copper Slag can effectively be used as alternative & supplementary materials in concrete.

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