EXPERIMENTAL STUDY ON CONCRETE BY PARTIAL REPLACEMENT OF RICE HUSK ASH FOR CEMENT, COPPER SLAG WITH FINE AGGREGATE AND CERAMIC TILE WASTE WITH COARSE AGGREGATE

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ABSTRACT

*Increase in industrialization and urbanization,the use of buildings also increased which results in continuous usage of construction materials leads to scarcity of the natural concrete materials. Due to increase in industrialization, waste materials also increased by dumping. To overcome the issues many research were done to use many industrial waste as alternative or substantial material for concreting. In this project, concrete will be casted for M35 grade and the partial replacement of concrete material were decided to reuse industrial waste such as Rice husk ash (**RHA**) as cement replacement in range of 10%, 15%, 20% by weight of cement, the copper slag as fine aggregate replacement in range of 20%, 30%, 40% by weight of sand and the waste ceramic tiles as coarse aggregate replacement in range 10%, 20%, 30% by weight of aggregate. In this concrete, strength and durability properties such as Compressive Strength, Split Tensile Strength and Flexural Strength had been evaluated for mixes of concrete.*

Key Words: Rice husk ash, Copper Slag, Ceramic TileWaste, compression test, Split tensile test, Flexural test.

1. INTRODUCTION

In India, there is great demand of aggregates mainly from civil engineering industry, for road and concrete constructions. But nowadays it is a very difficult problem for availability of cement, fine aggregates and coarse aggregate. So the researchers developed waste management strategies to apply for replacement of cement or fine aggregate or coarse aggregate for specific needs. Natural resources are depleting worldwide while at the same time the generated wastes from the industry are increasing substantially. The sustainable development for construction involves the use of nonconventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment. The rapid increase in the natural aggregates consumption every year due to the increase in the construction industry worldwide means that the aggregates reserves are being depleted rapidly, particularly in desert countries.

It has come to our knowledge that, without proper alternative aggregates being utilized in the near future, the concrete industries globally consume 8-10 billion tons of natural aggregates, after some years that will be replenished.

1.1 OBJECTIVES OF STUDY

This study is conducted to achieve the following objectives:

i) To assess the feasibility of utilizing the rice husk ash for producing an economical concrete by studying the properties like Compressive Strength, Water Absorption and Slump Retention.

ii) To find the optimum proportion (10%, 15% & 20%) of Rice Husk Ash that can be used as a replacement substitute material for cement in concrete

iii) To evaluate mechanical properties by use of copper slag in concrete specimens.

iv) To determine Strength, Workability, Durability by using copper slag as partial replacement of fine aggregate using different proportion.

v) To find the optimum proportion (20%, 30% & 40%) of Copper Slag that can be used as a replacement substitute material for fine aggregate in concrete.

vi) To study the strength developments hardened concrete with waste ceramic tiles in coarse aggregate.

vii) To determine the effect of various percentage of ceramic tile waste as partial coarse aggregates replacement towards compressive strength of concrete.

viii) To determine the water absorption of ceramic aggregate concrete containing various content of ceramic tile as partial coarse aggregates replacement material.

ix) To find the optimum proportion (10%, 20% & 30%) of Ceramic tile waste that can be used as a replacement substitute material for coarse aggregate in concrete

x) To reduce the waste materials which comes from industries.

1.2 SCOPE OF STUDY

i) Flexural Strength of structural members can be improved.
ii) Proper usage of waste materials from environment can be made.
iii) Basic strength characteristics, such as Compressive strength, Flexural strength and Split Tensile strength studies of concrete are the main focuses in this project in order to study the quality and performance of concrete.

2. LITERATURE REVIEW

The usage of industrial by-products especially industrial wastes in making of concrete is an important study of worldwide interest. Many researchers have investigated the possible use of Rice Husk Ash, Copper Slag and Ceramic Tiles Waste as a concrete aggregate. For this investigation, some of the important literatures were reviewed and presented briefly.

2.1. RICE HUSK ASH

Kartini& Mahmud reported on the improvementon Mechanical Properties of Rice Husk Ash Concrete with Super plasticize. Without super plasticizer RHA concrete attained lower compressive strength than that of the control due to the higher amount of water for similar workability. RHA concrete improves the durability of concrete. It is concluded from the paper that by adding super plasticizer to the RHA mixes, higher replacement levels are possible. Concrete containing up to 30%RHA can attain strength of 30 N/mm2 at 28 days.

DaoVan&PhamDuypresented several keyproperties of high strength concrete using RHA. RHAs obtained from two sources: India and Vietnam. India RHA was much better than that of the Vietnam RHA. The acceptable content is 10% to replace for cement with an acceptance of reduction in compressive strength. It is concluded that Rice husk is an abundant waste generated from agriculture product in Vietnam. Investigations in manufacturing high quality RHA in Vietnam is necessary.

Ramezanianpour&Khaniinvestigated the effectof rice husk ash on mechanical properties and durability of sustainable concrete. RHA replaced with cement by weight are 7%, 10% and 15%. Results show that concrete incorporating RHA had higher compressive strength, splitting tensile strength and modulus of elasticity at various ages compared with that of the control cement concrete. In addition, results show that RHA as an artificial pozzolanic material has enhanced the durability of RHA concretes and reduced the chloride diffusion.

Harunur&Keramatinvestigated the durability ofcement mortar in presence of Rice Husk Ash (RHA). The strength and durability of mortar with different replacement level (0%, 10%, 15%, 20%, 25% and 30%) of Ordinary Portland Cement (OPC) by RHA is investigated.

RHA was manufactured from an uncontrolled burning process. In durability test all samples passed for 20 cycles except 25% and 30% replacement level. It is concluded from the paper that the mortar incorporating rice husk ash is more durable than OPC mortar up to 20% replacement level.

Abhilash&Arbindevaluated one type ofcommercially available RHA as supplementary cementitious material for cement. There was a significant improvement in Compressive strength of the Concrete with RHA content of 10% for M30 and M60 at 7 days and 28 days i.e. 4.23% to 10.93%. It is concluded that we can replace 10% cement with the help of RHA without any ill effect.

2.2 COPPER SLAG

MostafaKhanzadi and Ali Behnood (2009) presented the results of a study undertaken to investigate the feasibility of using copper slag as coarse aggregates in high-strength concrete. The effects of replacing limestone coarse aggregate by copper slag coarse aggregate on the compressive strength, splitting tensile strength and rebound hammer values of high-strength concretes are evaluated in this work. Concrete mixtures containing different levels of silica fume were prepared with water to cementitious materials ratios of 0.40, 0.35 and 0.30. The percentages of the cement replacements by silica fume were 0%, 6% and 10%. The use of copper slag aggregate compared to limestone aggregate resulted in a 28-day compressive strength increase of about 10–15% and a splitting tensile strength increase of 10–18%. It can be concluded from the results of this study that using copper slag as coarse aggregate in high-strength concrete is technically possible and useful.

Wei wu et al (2010) investigated the mechanicalproperties of high strength concrete replacing fine aggregate with copper slag. Micro silica was used to supplement the cementitious content in the mix for high strength requirement. They observed that when copper slag was used to replace fine aggregate, upto 40% copper slag replacement, the strength of concrete was increases while the surface water absorption decreases. They also observed that when more than 40% of copper slag is used, the microstructure of concrete contains more voids, micro cracks, and capillary channels which accelerate the damage of concrete during loading.

Najimi et al (2011) investigated the performance ofcopper slag in concrete in sulphate solution. An experimental investigation on expansion measurements, compressive strength degradation and micro structural analysis were conducted in sulphate solution on concretes by replacing 0%, 5%, 10% and 15% of cement with copper slag waste. The results of this study emphasized the effectiveness of copper slag in improving the concrete resistance against sulphate attack. Although some studies have been done to investigate the potential of using copper slag as a sand replacement material, significant knowledge gaps still exist. There is a need for more research in India in this area.

R RChavan& D B Kulkarni (2013) conductedexperimental investigations to study the effect of using copper slag as a replacement of fine aggregate on the strength properties and concluded that Maximum Compressive strength of concrete increased by 55% at 40% replacement of fine aggregate by copper slag and flexural strength increased by 14 % for 40 % replacement. Many researchers have investigated worldwide on the possible use of copper slag as a concrete aggregate. Some of the important and published works are reviewed and presented briefly below.

Brindha et al(2014) studied the strength behavior ofconcrete where sand was partially replaced with Copper Slag in the concrete manufacturing process. The strength was found to be increasing till 40% of sand replacement with copper slag after which the strength was found to be decreasing. **Binaya et al** reported that sand can be partially replaced with copper slag in concrete manufacturing process and for M20 Grade mix the maximum strength can be attained with 40 % of Copper Slag replacement. **Binaya et al** reported that when copper slag is partially replaced with sand in M30 Grade concrete, the coefficient of determination for 28 days & 90 days compressive strength found to be 0.9753 and 0.9748 which indicates that the model has a good fit.

J. Anne Mary et al (2016) reported that Worldwidethe average consumption of sand for construction increases 40 billion tons annually as sand is used as a conventional construction material. The main objective of this investigation is to compare the strength parameter and behavior of fresh and hardened concrete with conventional concrete and copper slag incorporated concrete in various percentages as replacement of fine aggregate.

2.3 CERAMIC TILES WASTE

C. Medina et al. (2012) investigated on the reuse ofwaste as recycled coarse aggregate in partial substitution of 15%, 20% and 25% in the manufacture of structural concrete. Compressive strength is found out t 7, 28 and 90 days. There is an increase in strength with increase of percentage replacement, the best results shown is at 25% with increase of 21.12%, 11.04% and 6.70% at 7, 28 and 90 days respectively.

Sudarsana et al. (2013) investigated on theinfluence of water absorption of ceramic waste aggregate on strength properties of ceramic aggregate concrete. M_{20} concrete is used with 0.48 water cement ratio. Ceramic waste water absorption is 0.08% more than conventional aggregate. Compressive strength is best at 20% replacement reaching 93.45%, 98.84% to that of conventional concrete at 7 and 28 days. There is decrease in density with increase of percentage replacement; at 100% replacement density is 4.43% less when compared to conventional concrete.

Umapathy et al. (2014) studied on Rice HuskAsh(RHA) as cement at 10%, 15% and 20% and waste tiles as coarse aggregate at 20%, 30% and 50%. Compression strength is found out and the best results is with 20% tiles and 10% RHA of 80.60% to that of conventional concrete.

M.Roobini et al. (2015) determined thedevelopment strength of concrete with ceramic tiles as coarse aggregate. 20MPa characteristic strength concrete is used with water cement ratio of 0.5. The compressive strength and split tensile strength improved by 4.84% and 13.30% respectively at 20% replacement. Whereas, flexure strength is best at 10% replacement which is 4.84% more than that of conventional concrete.

Amir Javed et al. (2015) analyzed the compressiveand flexural strength of concrete with stone dust as natural sand at 20%, 40%, 60%, 80% and 100% along with ceramic waste as stone aggregate at 20% replacement. It is found that at 40% stone dust and 20% ceramic waste compressive strength reaches upto 77.32% of that of conventional concrete whereas there is an increased in flexure strength by 25.62%.

2.4 LITERATURE SUMMARY

From all the above literature reviews, it was evident that Rice Husk Ash can be used as a cement replacement, Copper Slag can be used as a fine aggregate replacement and Ceramic Tile waste can be used as a coarse aggregate replacement, individually in a concrete mix.

The optimum percentage of replacement was also identified for all industrial waste materials individually. But there was no literature available on the utilization of all the three above mentioned replacement in the same concrete mix.

Hence it is planned to use Rice Husk Ash as cement replacement, Copper Slag and Ceramic Tile Waste as fine and coarse aggregate respectively together as an ingredient of the concrete.

3. MATERIAL USED

The materials used for the project is collected and made sun dried before as initial testing and for further usage. The amount of material to be used should be noted in advance based on the preparation of mix design. From the results of mix design the quantity of each component such as cement, FA, CA and water will be finalized, then the collection of materials to be done and to be stored in a specified place free from impurities. Based on the availability of the materials and its condition the following tests were performed.

3.1 CEMENT

Ordinary Portland cement of 53 grade having specific gravity of 3.1 and fineness modulus of 6.5% was used. The Cement used has been tested for various proportions as per IS 4031-1988 and found to be confirming to various specifications of IS 12269-1987.

3.2 FINE AGGREGATE

Fine aggregates are termed as "filler" which fills the voids in concrete. The fractions of aggregates less than 4.75mm are known as fine aggregates. The river sand is used as fine aggregate conforming to requirements of IS: 383-1970 comes under zone II.

3.3 COARSE AGGREGATE

Aggregates fractions larger than 4.75mm are termed as coarse aggregates. The fraction of aggregates used in the experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970.

3.4 RICE HUSK ASH

Rice husk Ash is an agricultural residue obtained from the outer covering of rice grains during milling process. It constitutes 20% of the 500 million tons of paddy produced in the world. Initially rice husk was converted into ash by open heap village burning method at a temperature, ranging from 300°C to 450°C. When the husk was converted to ash by uncontrolled burning below 500°C, the ignition was not completed and considerable amount of unburnt carbon was found in the resulting ash.

Fig.no.3.1: Rice Husk Ash

3.5 COPPER SLAG

Copper slag which is an industrial waste obtained from smelting and refining process of copper from Sand Blasting., Irunkadukottai, Tamilnadu. Nearly 4 tons of copper is obtained as waste is disposed to lands cause's environmental impacts. So it can be reused as concreting materials.

Fig.no.3.2: Copper Slag

3.6 CERAMIC WASTE TILES

In Ceramic industry about 15%-30% of daily production goes as waste. It is not recycled in any form at present. This cause impacts to environment, so it can be reused as construction materials.

Fig.no.3.3: Ceramic Tile Waste

Table 3.1: Physical properties of OPC & RHA

SL. NO.	PROPERTY	OPC VALUE	RHA VALUE
1	Specific Gravity	3.1	2.06
2	Initial Setting Time	45 min	40 min
3	Final Setting Time	385 min	380 min
4	Fineness Modulus	6.5 %	6%
5	Bulk density(Dense)	1.55g/ cm^3	0.49g/ cm^3

Table 3.2: Chemical Properties of OPC & RHA

Materials	OPC	RHA
SiO_2	20.25	20.2
Al_2O_3	5.04	5.02
Fe_2O_3	3.16	3.1
CaO	63.61	63.6
MgO	4.56	4.52
Na_2O	0.08	0.08
K_2O	0.51	0.5

Table 3.3: Physical Properties of Fine Aggregate and Copper Slag

Materials	Specific Gravity	Finess Modulus (%)	Bulk Density (Kg/m3)	Water Absorption (%)
Fine Aggregate	2.55	3.9	1736.67	1.69
Copper Slag	3.56	4.1	2200	0.50

Table 3.4: Physical Properties of Coarse Aggregate and Ceramic Tiles Waste

Materials	Specific Gravity	Finess Modulus (%)	Bulk Density (Kg/m3)	Water Absorption (%)
Coarse Aggregate	2.71	3.18	1612.67	0.33
Ceramic Tiles	2.30	3.42	1723.14	8.49

4. TESTING AND RESULT

Experimental Investigation comprises of test on cement, Fine aggregate and Coarse aggregate, concrete with partial replacement of Cement with RHA, Fine aggregate with Copper Slag and Coarse aggregate with Ceramic Tiles Waste.

4.1 MIX DESIGN

The mix proportion was done as per the IS 10262:2009 the target mean strength was 43.25 Mpa (35) for the OPC control mixture. Mix design is a term used for determining quantities of different constituents, which in our experiment was done with Indian standard method. The quantities of cement, fine aggregate, coarse aggregate, Rice Husk Ash, Copper Slag and Ceramic Tiles Waste were found out with help of this method. The proportions for normal mix of M35 Normal Mix were: - Cement: Sand: Coarse Aggregate: Water. After calculating the quantity, all constituents were weighed using electronic weighing machine.

First of all cement and rice husk ash were thoroughly mixed in dry state, fine aggregate and Copper Slag were later added to the mixture. To the above mixture coarse aggregate and Ceramic Tiles Waste were added. Now the whole mixture was mixed manually. Water was finally added to the dry mixture.

After mixing operation, moulding was done and as the moulds were filled tamping was done simultaneously for compaction. After 24 hours demoulding was done and the specimen was placed in curing tank for 7, 14 and 28 days

4.2 TESTING

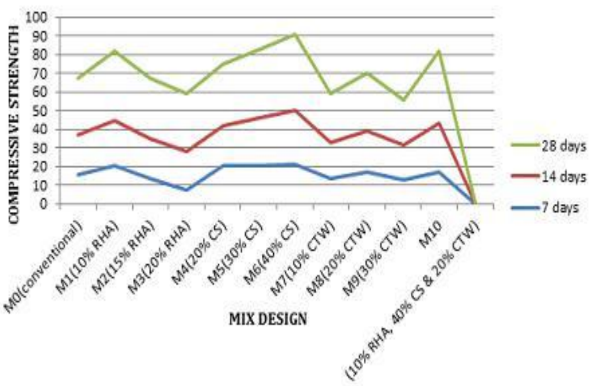
Compressive Strength: To examine the compressiveStrength Standard cubical moulds of size 150mm × 150mm×150mm made of cast iron were used.

To determine the compressive strength we casted cubes with different percentage of Rice Husk ash, Copper slag and Ceramic tiles waste in the concrete. After that the specimen are tested at 7, 14 and 28 days at compression testing machine (CTM) as per I.S. 516-1959. The optimum percentage of RHA, Copper slag and Ceramic tiles waste were again casted and tested at 7, 14 and 28 days.

Table 4.1: Compressive Strength Result

MIX DESIGN	Compressive Strength		
	7 days	14 days	28 days
M_0(conventional)	15.52	21.77	30.22
M_1(10% RHA)	20.45	24.44	36.66
M_2(15% RHA)	13.21	21.77	32.65
M_3(20% RHA)	7.55	20.53	30.8
M_4(20% CS)	20.5	21.08	33.17
M_5(30% CS)	20.72	25.12	36.63
M_6(40% CS)	21.2	29.10	40.54
M_7(10% CTW)	13.61	19.5	26.22
M_8(20% CTW)	17.05	22.07	31.11
M_9(30% CTW)	12.52	18.63	24.14
M_{10} (10% RHA, 40% CS & 20% CTW)	17.2	25.77	33.78

Fig.No 4.1: Compressive Strength Results



Split Tensile Strength: To examine the Split tensilestrength of plane mortar and mortar of various percentages of RHA, Copper Slag and Ceramic tiles waste contents in concrete has been investigated by testing cylinders of 200mm × 100mm under CTM of 2000 KN capacity.

After that the specimen were tested at 7, 14 and 28 days at compression testing machine (CTM) as per I.S. 516-1959. The optimum percentage of RHA, Copper slag and Ceramic tiles waste were again casted and tested at 7, 14 and 28 days.

Table 4.2: Split Tensile Strength Result

MIX DESIGN	Split Tensile Strength		
	7 days	14 days	28 days
M_0(conventional)	1.52	1.95	2.86
M_1(10% RHA)	1.8	2.23	3.35
M_2(15% RHA)	1.64	2.05	2.87
M_3(20% RHA)	1.3	1.62	2.42
M_4(20% CS)	2.03	2.4	3.59
M_5(30% CS)	2.04	2.54	3.81
M_6(40% CS)	2.2	2.75	4.1
M_7(10% CTW)	1.4	1.72	2.58
M_8(20% CTW)	1.68	2.1	3.14
M_9(30% CTW)	1.5	1.86	2.80
M_{10} (10% RHA, 40% CS & 20% CTW)	2.29	2.86	4.3

Fig.No 4.2: Split Tensile Strength Results

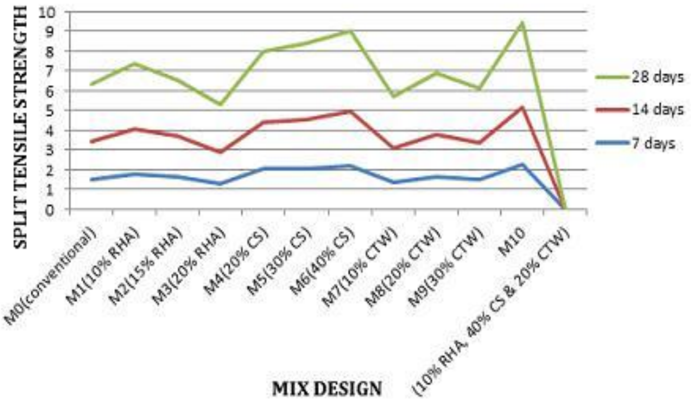
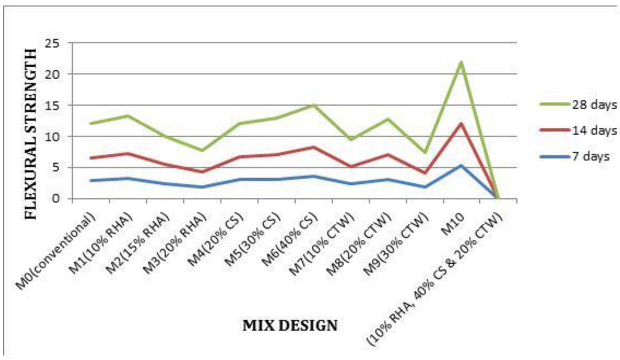


Fig.No 4.3: Flexural Strength Results



Flexural Strength: To examine the flexural strength of

planemortar and mortar with various percentages of Rice Husk Ash, Copper Slag and Ceramic tile waste content in concrete has been investigated by testing beams of 100mm × 100mm ×500mm under two-point load because of small span between the supports

Table 4.3: Flexural Strength Result

MIX DESIGN	Flexural Strength		
	7 days	14 days	28 days
M_0(conventional)	2.93	3.67	5.5
M_1(10% RHA)	3.22	4.02	6
M_2(15% RHA)	2.4	3.06	4.5
M_3(20% RHA)	1.87	2.33	3.56
M_4(20% CS)	3.01	3.61	5.5
M_5(30% CS)	3.12	3.9	5.86
M_6(40% CS)	3.63	4.53	6.8
M_7(10% CTW)	2.31	2.83	4.3
M_8(20% CTW)	3.1	3.92	5.8
M_9(30% CTW)	1.77	2.26	3.35
M_{10} (10% RHA, 40% CS & 20% CTW)	5.32	6.67	10

5. CONCLUSIONS

The following conclusions could be drawn from the present investigation.

1. As cement is very costlier and use of cement creates an environmental problems need to find alternative material. Rice husk ash is a waste material which is obtained from rice mills a, it is a suitable substitute for cement at very low cost.
2. Cost of Concrete production reduces when Copper Slag is used as a fine aggregate in concrete. Use of copper slag helps in waste management and dumping industrial wastes. Copper Slag behaves similar to River Sand as it contains Silica (SiO2) similar to sand.
3. Ceramic tile aggregate is an appreciated and appropriate concrete material for substitution into concrete composition based on its properties.
4. Tile aggregate concrete is little bit more economical as compare to conventional concrete. As an estimate for making 1 m3 of concrete by substituting 20% normal 20 mm aggregates with tile aggregates about 16% money can be saved on total amount of 20 mm aggregates.
5. By addition of Rice husk Ash, Copper Slag and ceramic tile waste into concrete, proper effective utilization of industrial waste can be achieved.
6. From the above experimental investigation rice husk ash(RHA), Copper Slag and Ceramic Tile Waste can be used as alternate material to cement upto 10%, Fine aggregate up to 40% and Ceramic Tile up to 20%.
7. Compressive strength increase with increasing the percentages of Rice husk ash (RHA), Copper slag (CS)and Ceramic Tile waste (CTW) upto replacement (10%RHA, 40%CS and 20%CTW) of cement, Fine Aggregate and Coarse Aggregate in concrete.

8. Flexural strength increase with increasing the percentages of Rice husk ash (RHA), Copper slag (CS) and Ceramic Tile waste (CTW) upto replacement (10%RHA, 40%CS and 20%CTW) of cement, Fine Aggregate and Coarse Aggregate in concrete.

9. Split Tensile strength increase with increasing the percentages of Rice husk ash (RHA), Copper slag(CS) and Ceramic Tile waste (CTW) upto replacement (10%RHA, 40%CS and 20%CTW) of cement, Fine Aggregate and Coarse Aggregate in concrete.

10. The combination of 10% rice husk ash, 40% copper slag and 20% of ceramic tile waste have increased strength compared to conventional concrete

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