Partial Replacement of Fine Aggregate & Cement in Concrete with Ceramic Rejects

Sadic Azeez [1] , Remya Raju [2], Dr. P.R Sreemahadevan Pillai [3]

[1]M Tech student, Civil Department, Ilahia College of Engineering & Technology,Kerala , India
[2]Professor, Civil Department, Ilahia College of Engineering & Technology,Kerala , India
[3]Dean, Faculty of Engineering, University of Calicut.,Kerala , India

Abstract *Research is being carried out on the utilization of waste products in concrete as a replacement of natural sand and cement. Such waste products included in this paper are the rejects from ceramic industries, mainly quartz powder and grog. Each of these waste products has significant effects on the properties of concrete. The use of waste products in concrete not only makes it economical, but also helps in reducing waste disposal problems. In this paper it is planning to replace both fine aggregate and cementitious material with the rejects from ceramic industries. After the physical and chemical analysis of quartz powder and grog, it will be able to identify its chemical and mineralogical composition. During the physical analysis like grain size analysis it is able to determine the utility size i.e. whether it can be replaced for sand or cement. In this paper both fine aggregate and cement is replaced with quartz and grog simultaneously and also fine aggregate alone is replaced with different proportions of quartz and grog . After the experimental analysis and testing an optimum replacement of 5% fine aggregate and 5% cement is possible. It is also found that compressive strength and splitting tensile strength of replaced specimens increases up to 25% replacement of fine aggregate without replacing cement .*

Keywords— Grog, quartz, ceramic rejects

I.INTRODUCTION

Concrete is the most undisputable and indispensable material being used in infrastructure development throughout the world. Umpteen varieties of concretes were researched in several laboratories and brought to the field to suit the specific needs. Numerous waste materials are generated from manufacturing processes, service industries and municipal solid wastes. The increasing awareness about the environment has tremendously contributed to the concerns related with disposal of the generated wastes. Solid waste management is one of the major environmental concerns in the world. With the scarcity of space for land filling and due to its ever increasing cost, waste utilization has become an attractive alternative to disposal. Investigations are being carried out to create an economical concrete with the utilization of waste products as substituent Ceramics is a diverse industry and contains several categories of products, including sanitary ware, cement, advanced ceramics and ceramic tiles. The ceramic industry has a long history, with the first instance of functional pottery vessels being used for storing water and food, being thought to be around since 9,000 or 10,000 BC. Clay bricks were also made around the same time. The ceramic industry has been modernising continuously, by newer innovations in product design, quality etc. Many waste products are generated from ceramic industries. Such waste products included in this paper are the rejects from ceramic industries, mainly quartz and grog. Such waste products included in this paper are the rejects from ceramic industries, mainly quartz and grog. Each of these waste products has provided a specific effect on the properties of fresh and hardened concrete. The use of waste products in concrete not only makes it economical, but also helps in reducing disposal Problem. Reuse of bulky wastes is considered the best environmental alternative for solving the problem of disposal. This paper presents a detailed review about waste and recycled materials that can be effectively used in concrete as a sand and cement replacement.

II.MATERIALS

A. Cement

53 grade Ordinary Portland cement of grade is used in the study. The properties of cement were tabulated in table 1.

TABLE I
PROPERTIES OF CEMENT

Properties	Magnitude
Specific gravity	3.07
Standard consistency	35%
Initial setting time	75 minutes
Final setting time	310 minutes

B. Fine Aggregate

M sand is used as fine aggregate in this study. The properties of fine aggregate are shown in Table II.

TABLE II
PROPERTIES OF FINE AGGREGATE

Properties	Magnitude
Specific gravity	2.6
Bulk density ,kg/m^3	1830
Porosity,%	29.67
Grading zone	Zone II
Fineness modulus	3.13
Water absorption	1.02%

C. Coarsee Aggregate

The well graded angular shaped crushed aggregates of size 20mm as per IS 383-1970 is used as coarse aggregate.

TABLE III
PROPERTIES OF COARSE AGGREGATE

Properties	Coarse aggregate
Particle shape	Angular
Particle size	20mm
Specific gravity	2.75
Bulk density	1340 kg / m^3
Fineness modulus	4.18

D. Grog

Grog is obtained as by product of ceramic industry .Grog, also known as firesand and chamotte, is a ceramic raw material. It has high percentage of silica and alumina. It can be produced by firing selected fire clays to high temperature before grinding and screening to specific particle sizes. The particle size distribution is generally coarser in size than the other raw materials used to prepare clay bodies. It tends to be porous and have low density

Fig 1. Grog

TABLE IV
PROPERTIES OF GROG

Properties	Grog
Specific gravity	2.525
Bulk density	970 kg / m^3
Percentage of voids	61.58 %
Fineness modulus	2.783

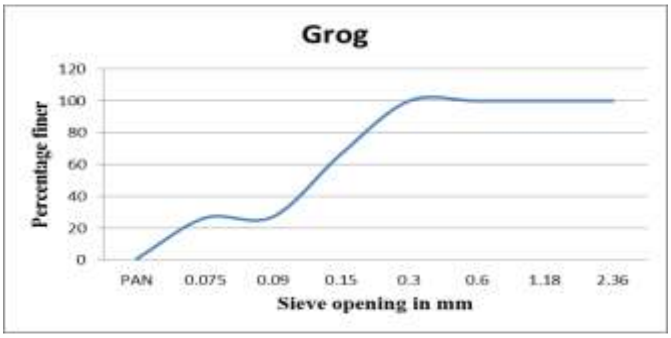

Fig 2. Grading curve for grog

TABLE V
CHEMICAL COMPOSITION OF GROG

OXIDES	%
SiO_2	55.18
Al_2O_3	21.89
Fe_2O_3	11.3
CaO	1.12
MgO	2.89
Na_2O	1.52
K_2O	1.28
SO_3	0.5

D. Quartz

Quartz, most common of all minerals is composed of silicon dioxide, or silica, SiO_2. It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute particles that sparkle in rock surfaces. The crushed quartz powder used in the experiments is in a form of white powdered quartz flour, which replaces fine aggregate from the conventional concrete. The particle size used ranges from 10 to 45µm

Fig 3. Quartz

TABLE VI
PROPERTIES OF QUARTZ

Properties	Quartz
Specific gravity	2.55
Bulk density	1340 kg / m^3
Percentage of voids	47.45 %
Fineness modulus	3.418

Fig 4. Grading curve for quartz

TABLE VII

CHEMICAL COMPOSITION OF QUARTZ

Oxides	%
SiO_2	72.4
Al_2O_3	1.44
Fe_2O_3	0.07
CaO	11.57
MgO	0.32
Na_2O	13.64
K_2O	0.35
SO_3	0.21

III. MIX PROPORTIONING

The process of determining required and specifiable characteristics of a concrete mixture is called mix design. Characteristics can include fresh concrete properties, required mechanical properties of hardened concrete such as strength and durability requirements and the inclusion, exclusion, or limits on specific ingredients. Mix design leads to the development of a concrete specification. In the present investigations a mix of M30 grade concrete was used and designed as per relevant Indian Standard specifications.

TABLE VIII
MIX DETAILS FOR M30 CONCRETE

Cement	Fine aggregate	Coarse aggregate	w/c ratio
413.3 kg	654.16 kg	1178.1 kg	0.45

Following are the mixes considered for the study

STC - Cement + MSand + CA

MO - 5%Quartz + 5% Grog + 95%cement + 95% MSand +CA

MF1 - 5%Quartz + 5% Grog + cement + 90% MSand + CA

MF2 - 10%Quartz + 5% Grog +cement + 85% MSand + CA

MF3 - 10%Quartz + 10% Grog + cement + 80% MSand + CA

MF4 - 15%Quartz + 5% Grog + cement + 80% MSand + CA

MF5 - 15%Quartz + 10% Grog + cement + 75% MSand+ CA

Weigh batching is done for all materials. All aggregates used in the mix were weighed under surface dry conditions. Laboratory mixer is used for mixing the components of concrete. Coarse aggregate, fine aggregate and cement were added to the mixer and they are mixed thoroughly. Water is then added and is mixed for 5 minutes. Standard cubes, cylinders and beams were casted for all mixes in concrete

IV. RESULTS AND DISCUSSIONS

A. Compressive Strength

Compression tests are used to determine how a product or material reacts when it is compressed, squashed, crushed or flattened by measuring fundamental parameters that determine the specimen behaviour under a compressive load. Compression test are conducted at the end of 7^{th} and 28^{th} day of casting the specimens. The load was applied without any shock and continuously until the failure of the specimens. The maximum load is applied to the specimens until failure is recorded.

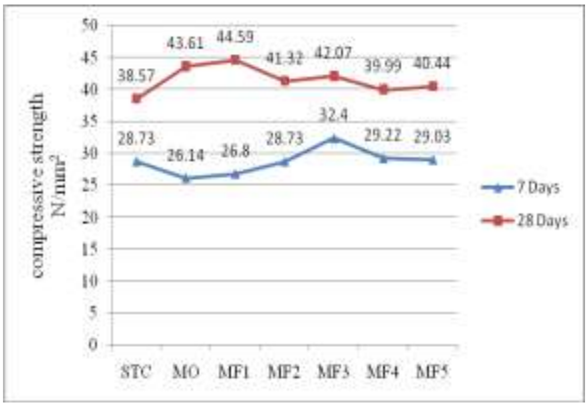

Fig. 5 7th and28th days compressive strength of concrete cube specimens replaced by both grog and quartz

B. Splitting Tensile Strength

Tensile strength is one of the basic and important properties of concrete. A knowledge of its value is required for the design of concrete structural elements subject to transverse shear, torsion, shrinkage and temperature effects. Its value is also used in the design of prestressed concrete structures, liquid retaining structures etc. The cylindrical specimen shall have diameter not less than four times the maximum size of the coarse aggregate and not less than 150 mm. The length of the specimens shall not be less than the diameter and not more than twice the diameter.

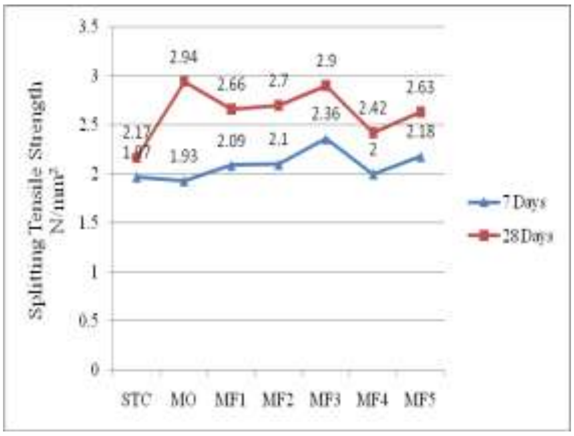

Fig. 6. 7th and28th days splitting tensile strength of specimens replaced by both grog and quartz

C. Flexural Strength

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending.

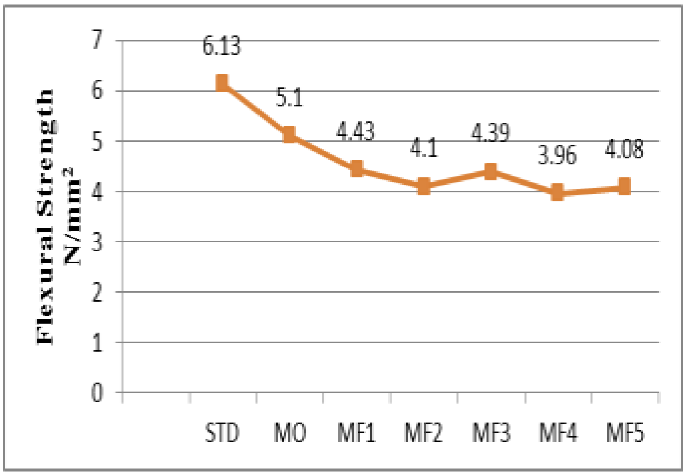

Fig.7 28th days flexural strength of specimens replaced by both grog and quartz

V. CONCLUSIONS

The objective of study is to determine the mechanical properties of concrete specimens in which fine aggregate and cement are replaced with quartz and grog. And also fine aggregate alone is replaced with different percentage of quartz and grog.

1. The optimum replacement possible for fine aggregate and cement with quartz and grog is 5%.

2. Compressive strength of concrete with optimum replacement at 7 days and 28 days of water curing is 26.14N/mm^2 and 43.61 N/mm^2.

3. Compressive strength of concrete with replacement of Msand by 5% quartz and 5% grog at 7 days and 28 days water curing is 26.8N/mm^2 and 44.59 N/mm^2.

4. Compressive strength of concrete with replacement of Msand by 10% quartz and 5% grog at 7 days and 28 days water curing is 28.73N/mm^2 and 41.32N/mm^2.

5. Compressive strength of concrete with replacement of Msand by 10% quartz and 10% grog at 7 days and 28 days water curing is 32.40N/mm^2 and 42.07 N/mm$^{2.}$

6. Compressive strength of concrete with replacement of Msand by15% quartz and 5% grog at 7 days and 28 days water curing is 29.22N/mm^2 and 39.99 N/mm^2.

7. Compressive strength of concrete with replacement of Msand by 15% quartz and 10% grog at 7 days and 28 days water curing is 29.04N/mm^2 and 40.44 N/mm^2.

8. Splitting tensile strength of specimens with optimum replacement at 7 days and 28 days water curing is 1.93N/mm^2 and 2.94 N/mm^2 which is greater than that of control specimens

9. Flexural strength of all replaced specimens is less than that of control specimens.

10. The compressive strength results suggest that 5% of both fine aggregate and cement can be simultaneously replaced with quartz and grog respectively. It also shows that up to 25% of fine aggregate alone can replaced with different percentages of grog and quartz.

ACKNOWLEDGMENTS

I wish to express my sincere gratitude to ***Mrs. Remya Raju***, *Professor, ICET, Mulavoor* and ***Dr.P.R Sreemahadevan Pillai*** *Dean, Faculty of Engineering, University of Calicut* for their willingness to share their valuable time and expertise with me. The help and support rendered by all the teachers and students of M.Tech section of Civil Engineering Department of ICET was also invaluable in making this paper.

REFERENCES

[1] Gunalaan Vasudevan,Seri Ganis Kanapathy pillay *" Performance ofUsing Waste Glass Powder In Concrete As Replacement Of Cement"*American journal of engineering research.

[2] Mr.Anjan kumar M U, Dr. Asha Udaya Rao, Dr. Narayana Sabhahit" *Reactive Powder Concrete Properties With Cement Replacement Using Waste Material"* International Journal of Scientific & Engineering Research.

[3] S.P. Gautam, Vikas Srivastava and V.C. Agarwal "*Use of glass wastes as fine aggregate in Concrete" J. Acad. Indus. Res.* Vol. 1(6) November 2012.

[4] IS 12269-1987 "*Indian Standard specification for 53 grade ordinary Portland cement" Bureau of Indian Standards* ,New Delhi,1997.

[5] IS 383-1970 "*specifications for course aggregate and fine aggregates from natural sources for concrete" Bureau of Indian Standards* ,New Delhi,1997.

[6] IS 10262-2009 "*Indian Standard recommended guidelines for concrete mix design" Bureau of Indian Standards* ,New Delhi,1997.

[7-] Is 516 -1959 "*Indian standard methods of test in concrete" Bureau of Indian Standards* ,New Delhi,1997.

[8] BIS:5816-1999 "*Indian standard splitting tensile strengthof concrete test method" Bureau of Indian Standards* ,New Delhi,1999.

[9] Works Bureau of Hong Kong, (2002) "Specifications facilitating the use of recycled aggregates." WBTC No. 12.

[10] Moriconi G, Corinaldesi V, Antonucci R (2003) "*Environmentally- friendly mortars: a way to improve bond between mortar and brick*", Material and Structure, 36(10), pp-702–708

[11] Angelim RR, Angelim SCM, Carasek H (2003) "*Influence of the addition of limestone, siliceous and clay fines in the properties of mortars and renderings*", Paper presented at the V Brazilian Symposium on Mortars Technology (SBTA), Paulo, Brazil, 11–13 June 2003.