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Volume 08, Issue 09, Pages: 746–754.

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STUDY ON COMPRESSIVE AND FLEXURAL STRENGTH OF CONCRETE WITH SUSTAINABLE INDUSTRIAL CERAMIC WASTE MATERIAL AS PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT

Concrete is a composite material consist of mainly water, aggregate, and cement. The physical properties desired for the finished material can be attained by adding additives and reinforcements to the concrete mixture. A solid mass that can be easily molded into desired shape can be formed by mixing these ingredients in certain proportions. Over the time, a hard matrix formed by cement binds the rest of the ingredients together into a single hard (rigid) durable material with many uses such as buildings, pavements etc., The technology of using concrete was adopted earlier on large-scale by the ancient Romans, and the major part of concrete technology was highly used in the Roman Empire. The coliseum in Rome was built largely of concrete and the dome of the pantheon is the World's largest unreinforced concrete structure. After the collapse of Roman Empire in the mid-18th century, the technology was re-pioneered as the usage of concrete has become rare. Today, the widely used man made material is concrete in terms of tonnage.

1.INTRODUCTION

Although high strength concrete is considered as relatively a new material, its development has been gradually increasing over years. In 1950s, USA considered the concrete with a compressive strength of 34mpa as high strength. In 1960's, the concrete with compressive strength 41mpa to 52mpa was used commercially. In the early 1970's, 62mpa concrete was been made. With in the world state of affairs, however, within the last fifteen years, concrete of terribly high strength entered into the construction sector of high-rise buildings and long span bridges. The compressive strength over 110mpa has been thought-about by IS 456-2000 for the applications in pre-stressed concrete members and cast-in-place buildings.

1.1 PROPERTIES OFCONCRETE

Generally the Concrete is a material having high compressive strength than to tensile strength. As it has lower tensile stress it is generally reinforced with some materials that are strong in tension like steel. The elastic behavior of concrete at low stress levels is relatively constant but at higher

stress levels start decreasing as matrix cracking develops. Concrete has a low coefficient of thermal expansion and its maturity leads to shrinkage.Due to the shrinkage and tension, all concrete structures crack to some extent. Concrete prone to creep when it is subjected to long-duration forces. For the applications various tests be performed to ensure the properties of concrete correspond to the specifications. Different strengths of concrete are attained by different mixes of concrete ingredients, which are measured in psi or Mpa. Different strengths of concrete are used for different purposes of constructions. If the concrete must be light weight a very low-strength concrete may be used. The Lightweight concrete is achieved by the addition of lightweight aggregates, air or foam, the side effect is that the strength of concrete will get reduced. The concrete with 3000-psi to 4000-psi is oftenly used for routine works. Although the concrete with 5000-psi is more expensive option is commercially available as a more durable one. For larger civil projects the concrete with 5000-psi is oftenly used. The concrete strength above 5000 psi was often used for specific building elements. For example, the high-rise concrete buildings composed of the lower floor columns may use 12,000 psi or more strength concrete, to keep the columns sizes small Bridges may use concrete of strength 10,000 psi in long beams to minimize the number of spans required. The other structural needs may occasionally require high- strength concrete. The concrete of very high strength may be specified if the structure must be very rigid, even much stronger than required to bear the service loads. For these commercial reasons the concrete of strength as high as 19000-psi has been used.

2. LITERATURE SURVEY

studied the replacement of 0%,20%,50% and 100 % of total natural aggregate volume with recycled aggregate (recycle brick and sanitary ware aggregate) for determination of its mechanical properties i.e. workability, Fresh density, compressive strength , split tensile strength, modulus of elasticity, abrasion resistance and influence of super plasticizers. Wioletta et al. [7] Studied about the properties of cement matrix modified with ceramic waste by the addition of ceramic filler (10%, 15% and 20% of cement mass) with Mortar and tested its consistency retention, workability retention, shrinkage test, freeze-thaw resistance test, flexural and compressive test (2,7,14,28 and 56 days) .Jiménez et al. [8] tested the replacement of natural fine aggregate with ceramic waste in masonry mortar with the replacement of fine aggregate (0%, 5%, 10%, 20% and 40%) of natural sand with ceramic recycled fine aggregate in a ratio of 1:7 volumetric cement-to-aggregate. Katzer [9] did the strength performance comparison of mortar made with waste fine aggregate and ceramic fume with exchange of cement by ceramic fume Lots of researcher has been done a research on concrete. This paper covers some of the paper based on partial replacement of cement.

Wen-Ten Kuoet al. [1] has investigate an

effect of ground granulated blast furnace slag (GGBFS). He has tested the mechanical and electricity properties to assess the correlations among flow, compressive strength, water absorption, and electricity at 50 V and 100 V. At the curing age of28 days, the compressive strength of the control group was in the range of 29.1–1.7 MPa, whereas the compressive strength of PZT was in the range of 26.8–30.0 MPa. The control group exhibited higher results (1786–2075 X) in the electricity property test under 50 V, whereas PZT exhibited lower results (1368–1562 X). The compressive strength and results of the electricity property tests demonstrated that the compressive strength and electrical resistance decreased as the replacement of GGBFS increased. The strength of the control group was higher than the strength of PZT because 5% of the fine aggregate was replaced by the piezoelectric material and the piezoelectric material was water-resistant. Thus, the piezoelectric material could not be effectively combined with fine aggregate and cement.

Wadhah M.Tawfeeq (2016) [11]: This study investigated the effects of using crushed tiles (CT) as coarse aggregates in the concrete mix. The technology of concrete recycling is well established in the U.S. Recycling of Portland cement concrete, as well as asphaltic concrete, has been shown to be a cost-effective alternative for road, street and highway construction. It includes not only the water content and tiles but also the gravel/sand ratio. They concluded that as the water- cement ratio decrease, the compressive strength increases. The paper consists of replacement of crushed tiles to 50% and 100% only. The results show that replacement of crushed tiles as coarse aggregate below 50% will have considerable properties.

3.MATERIALS AND PROPERTIES DESCRIPTION OF MATERIALS

Concrete is a composition of three raw materials. Cement, Fine aggregate and Coarse aggregate. These three raw materials play an important role in manufacturing of concrete. By varying the properties and amount of these materials, the properties of concrete will changes. The main raw materials used in this experimental work are Cement, fine aggregate, Coarse aggregate.

3.1 CEMENT

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. Cement is the main ingredient in manufacturing of concrete. The characteristics of concrete will be greatly affected by changing the Cement content. The Cement used in this project is Ordinary Portland Cement of 53 grade confirming to IS 12269 – 1987.

It developed from other types of hydraulic lime in England in mid 19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade

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OPC Cement provides consistently higher strength compared to others. As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28th day shouldn't be less than 53MPa or 530 kg/cm^2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also.

3.2 PROPERTIES OF MATERIALS:

Various tests have conducted on the Raw materials to obtain the physical and mechanical properties. The detailed test results are given below.

3.2.1 Tests on Cement:

3.2.1.1 Specific Gravity of Cement

The method used to calculate specific gravity of Cement is Le-chatlier's Flask method. In this Cement is tested by using Kerosene. The tested Cement specific gravity is of 3.15

3.2.1.2 Normal Consistency of Cement

Normal consistency test is conducted as per IS 4031 (part 4) – 1988. The main purpose of conducting Normal consistency is to find the amount of water to be added for producing Cement paste of standard consistency. Vicat apparatus is generally used for this test and is confirming to IS 5513 – 1976.

Result: The Normal consistency of Cement paste = 31.22

Fig 1 Vicat Apparatus for Normal consistency

3.2.1.3 Fineness of Cement

The Fineness of Cement is calculated by the 90 micron sieve method. In this the retained amount of Cement on the sieve should not be more than 10 % for ordinary Cement.

Observations:

Retained weight on sieve = 3gm

Result: The fineness of Cement = 97 %

3.2.2 Tests on Fine Aggregate

Tests on aggregate are confirming to IS 383 specifications. The detailed test reports are tabulated as follows

3.2.2.1 Sieve Analysis of Fine Aggregate

Natural Sand

Sieve analysis helpful in determining the particle size distribution of the aggregates gradation of fine aggregate. It is confirming to IS 2386 – 1963 part 1

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Table 1.Grading limits of fine aggregate in sieve analysis (As per IS 383 – 1970)

I.S sieve size	Percentage passing			
	Zone I	Zone II	Zone III	Zone IV
10mm	100	100	100	100
4.75mm	90 – 100	90 – 100	90 – 100	95 – 100
2.36mm	60 – 95	75 – 100	85 – 100	95 – 100
1.18mm	30 – 70	50 – 90	75 – 100	90 – 100
600 µ	15 – 34	35 – 59	60 – 79	80 – 100
300 µ	5 – 20	8 – 30	12 – 40	15 – 50
150 µ	0 - 10	0 - 10	0 - 10	0 - 15

Observations and Calculations:

Natural Sand:

Table2 .Sieve analysis of Fine Aggregate

S.NO	Sieve size	weight retained (gm)	Cumulative weight retained (gm)	Cumulative % wt retained	% of passing
1	4.75mm	10	10	1.0	99
2	2.36mm	100	110	11.0	89
3	1.18mm	72	182	18.2	81.8
4	600 µ	362	544	54.4	45.6
5	300 µ	268	812	81.2	18.8
6	150 µ	132	944	94.4	5.6
7	Pan	56	1000	100	0
Total				260.2	

Fineness modulus of sand = (Total cumulative % wt retained)/100

= 260.2/100

=2.60

3.3 CONCRETE MIX DESIGN (AS PERIS: 10262-2009)

MIX DESIGN FOR M30 GRADECONCRETE:

The steps involved in the design of concrete mix as per IS: 10262-2009 ,IS: 456-2000.

Stipulations for proportioning:

Grade designation : M30

Type of Cement : OPC 53 grade confirming to IS 12269:1987

Maximum nominal size of aggregate : 20 mm

Exposure condition : Severe (for reinforced concrete)

Degree of supervision : Good

Minimum Cement content : 320 Kg/m^3

Type of aggregate : Crushed angular aggregate

Workability : 25-50mm

Test data for Materials:

Cement used: OPC 53 grade confirming to IS 12269:1987

Specific gravity of Cement: 3.15

Specific gravity of

Coarse aggregate :2.8

Fine aggregate :2.6

Target mean strength for mix proportioning

$f_t = f_{ck} + 1.65\ S$

$f_t = 30 + 1.65(5) = 38.25 N/mm^2$

f_t = Target average Compressive strength at 28 days

f_{ck} = Character Compressive strength at 28 days

S = Standard deviation (taken from Table1 of IS:10262-2009);S=5

Selection of Water-Cement ration

From IS: 456-2000, Table 5 by taking severe exposure condition for M30 grade, the maximum water Cement ratio is 0.45

W/C = 0.45

Selection of water content

From IS: 10262-2009, Table 2 depending upon the nominal size of aggregate (20mm), the maximum water content is 186 liters.

∴ Maximum water content per cubic meter of concrete for 20mm aggregate is 186 Kg (liters)

Proportion of volume of Coarse aggregate and fine aggregate content

∴ Volume of Coarse aggregate =0.63

Volume of fine aggregate = 1-0.63 =0.37

4. EXPERIMENTAL DETAILS

This chapter deals with the various mix proportions adopted in carrying out the experiments and experimental results obtained with respect to their workability, compressive strength, split tensile strength, flexural strength and durability test.

GENERAL:

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Mix proportion for M30 grade of concrete: The design mix proportion is shown in Table6.

Table.3.Design Mix

Mix ID	Ceme-nt (kg/m^3)	Cera-mic waste(kg/m^3)	Fine aggre-gate (kg/m^3)	CoarseAg-gregate (kg/m^3)	Water/ cement ratio	Silica fume (kg/m^3)
C0	425.7	-	691.32	1110.708	0.45	-
CW1	383.13	42.57				0.425
Cw2	340.56	85.14				
Cw3	297.99	127.71				
Cw4	255.42	170.28				
Cw5	212.82	212.82				

4.1 WORKABILITY:

The property of fresh concrete which is indicated by the amount of useful internal work required to fully compact the concrete without bleeding or segregation in the finished product. Workability is one of the physical parameters of concrete which affects the strength and durability as well as the cost of labor and appearance of the finished product. Concrete is said to be workable when it is easily placed and compacted homogeneously i.e without bleeding or Segregation. Unworkable concrete needs more work or effort to be compacted in place, also honeycombs &/or pockets may also be visible in finished concrete.

4.2 DIFFERENT TEST METHODS FOR WORKABILITY MEASUREMENT:

Depending upon the water cement ratio in the concrete mix, the workability may be determined by the following three methods.

1.Slump Test

2.Compaction Factor Test

In this study, the slump-cone test and compaction factor tests were carried out to determine the workability of concrete. The test procedures are given below:

4.2.1 DETERMINATION OF WORKABILITY BY SLUMP-CONETEST:

To find the workability of concrete thoroughly mix cement, sand And coarse aggregate according to designed mix proportions to form a homogenous mix of concrete.

Equipment's Required for Concrete Slump Test:

Mould for slump test, non porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end. Clean the internal surface of the mould and apply oil. Place the mould on a smooth horizontal non-porous base plate. Fill the mould with the prepared concrete mix in 3 approximately equal layers. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer. Remove the excess concrete and level the surface with at rowel. Clean away the mortar or water leaked out between the mould and the base plate. Raise the mould from the concrete immediately and slowly in vertical direction. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

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5.TEST RESULTS

5.1 WORKABILITY RESULTS

The ideal concrete is the one which is workable in all conditions i.e, can prepared easily placed, compacted and moulded. In this chapter, the workability is assessed by two methods as follows:

Slump Cone Test:. The test was conducted for fresh concrete prepared before the Mould for slump test, non porous base plate, measuring scale, temping rod. The mould for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end. Clean the internal surface of the mould and apply oil. Place the mould on a smooth horizontal non-porous base plate. Fill the mould with the prepared concrete mix in 3 approximately equal layers. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer. Remove the excess concrete and level the surface with at rowel. Clean away the mortar or water leaked out between the mould and the base plate. Raise the mould from the concrete immediately and slowly in vertical direction. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

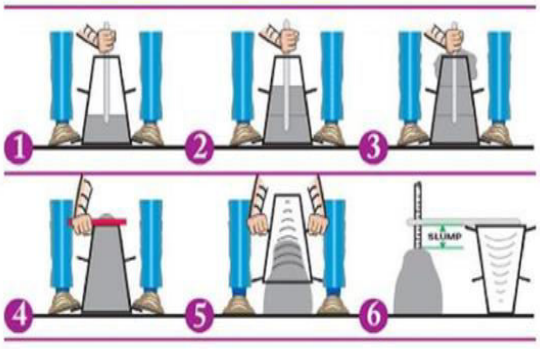
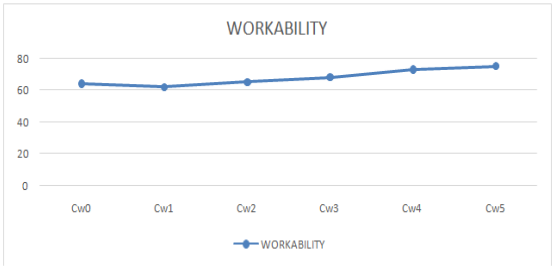


Table 4: Test results from slump cone test for workability in mm

S.No	Mix ID	cement Replacements % (CCA)	Workability (mm)
1	C0	0	64
2	CW1	10	62
3	Cw2	20	65
4	Cw3	30	68
5	Cw4	40	73
6	Cw5	50	75

Graph-01: Test results from slump cone test for workability in mm



The workability from the slump cone test is in increasing manner as the mix proportion replacement increasing. The workability range of concrete increasing as mentioned while being in medium range overall.

5.2 COMPACTION FACTORTEST:

The compaction factor test was conducted to the same mix that tested for workability by slump cone. The results obtained from the compaction factor test for the workability of

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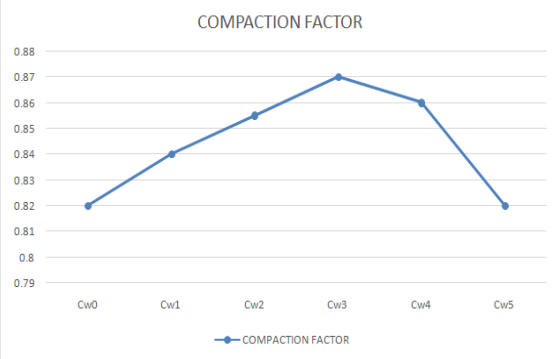
various mixes of replacements of M30 grade of concrete are tabulated as follows:

Table 5: Test results of compaction factor test for workability

S.No	Mix ID	cement Replacements % (CCA)	Compaction Factor
1	C0	0	0.82
2	CW1	10	0.84
3	Cw2	20	0.855
4	Cw3	30	0.87
5	Cw4	40	0.86
6	Cw5	50	0.82



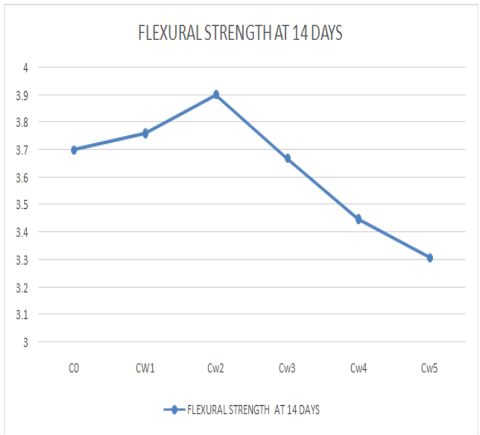
5.3 FLEXURAL STRENGTH:

The flexural test was conducted for M3 mix only since it has the highest compressive and split tensile strength to compare it with conventional i.e.,M30

Table: 6: Flexural strength results of M30 grade of concrete for 14 days

MIX ID	FLEXURAL STRENGTH 14-DAYS
C0	3.70
CW1	3.76
Cw2	3.90
Cw3	3.67
Cw4	3.45
Cw5	3.31

Graph: 03: flexural strength results of M30 grade of concrete for 14 days



6.CONCLUSION

In the elite plan of the solid blend, the water-bond proportion is received low. It is important to keep super plasticizers for the required usefulness. At the point when the level of mineral added substances in the blend builds, the level of super plasticizer additionally increments to acquire the required opposition.

On account of various mixes of level of substitution of mineral added substances, most extreme compressive quality is acquired for cement of evaluation M30 at 45.77 Mpa at 90 days with supplanting of bond with 20% ceramic waste powder. high resistance Reason The field of use of elite cement in our development exercises is wide, to be specific pre-assembled, prestressed spans, multi-story structures, scaffolds and structures in beach front zones and so forth. To impact this change, we should reactivate the plan of the structures by empowering the utilization of high-quality cement. When the smaller scale split shows up, an abrupt disappointment is seen in the high-quality solid shapes.

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Paul O. Awoyera , Julius M. Ndambuki , Joseph O. Akinmusuru , David O. Omole-4048 2016 Housing and Building National Research Center. Production and hosting by Elsevier B.V. 15 November2016)

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