© 2016 IJSRSET | Volume 2 | Issue 6 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Experimental Analysis on Properties of Concrete by Partial Replacement of Cement with Ceramic Waste

Pamula Sowjanya*[1], D. Venkata Krishna[2], V. Bala Krishna[3]

[1]Civil, JNTU Kakinada/Sri Vatsavai Krishnam Raju College of Engineering and Technology/ Bhimavaram, Andhra Pradesh, India

ABSTRACT

Industrial wastes are being produced per year by chemical process throughout the world, these by products are left largely unused and are hazardous materials to humans because they are air born and can be easily inhaled .An experimental investigation has been carried out to explore the possibility of using the ceramic waste powder. concrete is a composite material consists of cement, fine and course aggregate, water admixture.The objectives are to mix these materials traditionally to concrete workable. The proportionate quantity of each material (i.e cement, water, fine and course aggregates) effect the properties of hardened concrete. This project is about to process of using the waste product (ceramic industry) for construction purpose. Now a days they are rapid growth in urban and industrial is more and the demand is being increased day by day. The waste generated from ceramic industry is used as a partial replacement in cement. To eradicate the demand of construction material cement is being replaced in our project as CERAMIC WASTE accordingly in the range of 0% (without CERAMIC WASTE), 10%, 20%, and 30% by weight of cement for M-20 and M-30 mix. Concrete mixtures were produced, tested and compared in terms of compressive, flexural and split tensile strength with the Conventional concrete. These tests were carried out to evaluate the mechanical properties for the test results of 3, 7, 28, 56 days for compressive strength, flexural Strength and split tensile strength. In this paper the effect of ceramic waste on workability, setting time, density, air content, compressive strength, split tensile strength, flexural strength, modulus of elasticity are studied Based on this study compressive strength v/s W/C curves have been plotted so that concrete mix of grades M 20, M 30, with difference percentage of ceramic waste.

Keywords: Ceramic Waste, Compressive Strength, Split Tensile Test, Flexural Strength

I. INTRODUCTION

CEMENT:

In 2010, the world production of cement was 3,300 million tones. The top three producers were China with 1,800, India with 220 and U.S.A with 63.5 million tons for a combined total of over half the world today by the world's three most populated states. For the world capacity to produce cement in 2010, the situation was similar with the top three - China, India, and USA, accounting for just under half the world total capacity.

The cement industry in India has received a great Infrastructure projects taken up by the Government of India like road networks and housing facilities. While the Indian cement industry enjoys a phenomenal phase of growth, experts reveal that it is poised towards a highly prosperous future over the recent years. The annual demand for cement in India is consistently growing at 8-10%.

Concrete is the world's most consumed man-made material. To produce 1 ton of Portland cement, 1.5 tons of raw materials are needed. These materials include quality limestone and clay. Therefore, to manufacture 1.5 billion tons of cement annually, at least 2.3 billion tons of raw materials are needed. Over 5-million BTU of energy is needed to produce one tone of cement. In the year 1914, India Cement Company Ltd started cement production in Porbandar with an output of 10,000 tons and a production of 1000 installed capacity. At the time of independence 1947, the installed capacity of cement plants in India was approximately 4.5 million tons and actual production around 3.2 million tons per year. The partial deep control in 1982 prompted various industrial houses to set a setup new cement plants in the country, capacity was nearly 30 million tons, which has now, increase to nearly 120 million tons during a period of 20 years.

AGGREGATES:

Aggregates are defined as inert, granular, and inorganic materials that normally consist of stone or stone-like solids. Aggregates can be used alone (in road bases and various types of fill) or can be used with cementing materials (such as Portland cement or asphalt cement) to form composite materials or concrete Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However it is now known that the type of Aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. Aggregates can form up to 80% of the concrete mix so there properties are crucial to the properties of the concrete.

CLASSIFICATION OF AGGREGATE:

Aggregates can be divided into several categories according to different criteria.

In accordance with size

Coarse aggregate: Aggregates predominately retained on the No. 4 (4.75 mm) sieve. For mass concrete, the maximum size can be as large as 150 mm. Fine aggregate (sand): Aggregates passing No.4 (4.75 mm) sieve and predominately retained on the No. 200 (75 μm) sieve.

In accordance with sources

Natural aggregates: This kind of aggregate is taken from natural deposits without changing their nature during the process of production such as crushing and grinding. Some examples in this category are sand, crushed limestone, and gravel.

In accordance with unit weight

Light weight aggregate: The unit weight of aggregate is less than 1120 kg/m . The corresponding concrete has a bulk density less than 1800 kg/m.

PROPERTIES OF CERAMIC WASTE:

Physical properties of Ceramic waste

S. No.	Property	Test Result
1.	Specific Gravity	1.89
2.	Bulk density (g/cm^3)	1.26
3.	Impact Test	23.69 %
4.	Water Absorption	6.56 %

Composition	Ceramic powder %
SiO_2	63.29
Al_2O_3	18.29
Fe_2O_3	4.32
CaO	4.46
MgO	0.72
P_2O_5	0.16
K_2O	2.18
Na_2O	0.75
SO_3	0.10
CL	0.005
TiO_2	0.61
SrO_2	0.02

Applications of Ceramic Waste

The ways of CERAMIC WASTE utilization include (based on different journals, documents, research papers, approximately in order of decreasing importance):

1. Concrete production, as a substitute material for Portland cement and sand.
2. Embankments and other structural fills (usually for road construction).
3. Grout and Flow able fill production.
4. Waste stabilization and solidification.
5. Cement clinkers production - (as a substitute material for clay).
6. Mine reclamation.
7. Stabilization of soft soils.

8. Road sub base construction.
9. As Aggregate substitute material (e.g. for brick production).
10. Mineral filler in asphaltic concrete.
11. Agricultural uses: soil amendment, fertilizer, cattle feeders, soil stabilization in stock feed yards, and agricultural stakes.
12. Loose application on rivers to melt ice.
13. Loose application on roads and parking lots for ice control.

Addition of Ceramic Waste in Concrete Mixes Helps in Many Ways:

Workability of Concrete

CERAMIC WASTE particles are generally spherical in shape and reduce the water requirement for a given slump. The spherical shape helps to reduce friction between aggregates and between concrete and pump line and thus increases workability and improve pump ability of concrete. CERAMIC WASTE use in concrete increases fines volume and decreases water content and thus reduces bleeding of concrete.

Carbonation of Concrete

Carbonation phenomenon in concrete occurs when calcium hydroxides (lime) of the hydrated Portland cement react with carbon dioxide from atmospheres in the presence of moisture and form calcium carbonate. To a small extent, calcium carbonate is also formed when calcium silicate and aluminates of the hydrated Portland cement react with carbon dioxide from atmosphere. Carbonation process in concrete results in two deleterious effects (i) shrinkage may occur (ii) concrete immediately adjacent to steel reinforcement may reduce its resistance to corrosion. The rate of carbonation depends on permeability of concrete, quantity of surplus lime and environmental conditions such as moisture and temperature. When CERAMIC WASTE is available in concrete; it reduces availability of surplus lime by way of pozzolanic reaction, reduces permeability and as a result improves resistance of concrete against carbonation phenomenon.

Sulphate Attack

Sulphate attacks in concrete occur due to reaction between sulphate from external origins or from atmosphere with surplus lime leads to formation of etrringite, which causes expansion and results in volume destabilization of the concrete. Increase in sulphate resistance of CERAMIC WASTE concrete is due to continuous reaction between CERAMIC WASTE and leached out lime, which continue to form additional C-S-H gel. This C-S-H gel fills in capillary pores in the cement paste, reducing permeability and ingress of sulphate ions.

Reduced alkali aggregate reaction

Certain types of aggregates react with available alkalis and cause expansion and damage to concrete. These aggregates are termed as reactive aggregates. It has been established that use of adequate quantity of CERAMIC WASTE in concrete reduces the amount of alkali aggregate reaction and reduces/ eliminates harmful expansion of concrete. The reaction between the siliceous glass in CERAMIC WASTE and the alkali hydroxide of Portland cement paste consumes alkalis thereby reduces their availability for expansive reaction with reactive silica aggregates.

In a nutshell, it can be summarized that permeability and surplus lime liberated during the hydration of Portland cement are the root causes for deleterious effect on the concrete. Impermeability is the foremost defensive mechanism for making concrete more durable and is best achieved by using CERAMIC WASTE as above

II. METHODS AND MATERIAL

MATERIALS

Cement Type: OPC Cement of 43 Grade Was Used
Cement Brand: ANJANI CEMENT
Coarse Aggregate: Crushed granite metal with 50% passing 20 mm, retained on 10 mm sieve and 50% passing 10 mm, and retained on 4.75 mm sieve was used.
Fine Aggregate: River sand of zone – 11 was used as fine aggregate.
Water: Potable fresh water, which is free from concentration of acid or organic substances, was used for mixing the concrete

Simple Replacement Method

In this method, CERAMIC WASTE replaces a part of the OPC on a one to one basis by mass of cement. In this process, the early strength of concrete is lower and higher strength is developed after 56-90 days. At early age's CERAMIC WASTE exhibits very little cementing value. At later ages when liberated lime resulting from hydration of cement, reacts with CERAMIC WASTE and contributes considerable strength to the concrete. This method of CERAMIC WASTE use is adopted for very concrete works where initial strength of concrete has less importance compared to the reduction of temperature rise.

Addition Method

In this method, CERAMIC WASTE is added to the concrete without corresponding reduction in the quantity of OPC. This increases the effective cementations content of the concrete and exhibits increased strength at all ages of the concrete mass. This method is useful when there is a minimum cement content criterion due to some design consideration.

Modified Replacement Method

This method is useful to make strength of CERAMIC WASTE concrete equivalent to the strength of control mix (without CERAMIC WASTE concrete) at early ages i.e. between 3 and 28 days. In this method CERAMIC WASTE is used by replacing part of OPC by mass along with adjustment in quantity of fine aggregates and water. The concrete mixes designed by this method will have a total weight of OPC and CERAMIC WASTE higher than the weight of the cement used in comparable to control mix i.e. without CERAMIC WASTE mix. In this method the quantity of cementations material (OPC + CERAMIC WASTE) is kept higher than quantity of cement in control mix (without CERAMIC WASTE) to offset the reduction in early strength.

Workability

The behavior of green or fresh concrete from mixing up to compaction depends mainly on the property called "**workability of concrete**". Workability of concrete is a term that consists of the following four partial properties of concrete namely, Mutability, Transportability, Mould ability and Compatibility.

Factors Affecting Workability

Workable concrete is the one which exhibits very little internal friction between particle and particle or which overcomes the frictional resistance offered by the formwork surface or reinforcement contained in the concrete with just the amount of compacting efforts forthcoming. The factors helping concrete to have more lubricating effect to reduce internal friction for helping easy compaction are given below:

1. Water content
2. Size of aggregates
3. Surface texture of aggregate
4. Use of admixtures
5. Mix proportions
6. Shape of aggregates
7. Grading of aggregate

III. RESULTS AND DISCUSSION

Sieve analysis of Coarse Aggregate:

Sieve Analysis of Coarse Aggregate

S.NO	IS SIEVE	WEIGHT RETAINED (Kg)	% WEIGHT RETAINED	CUMULATIVE % WEIGHT RETAINED	% PASSING
1	80 Mm	0	0	0	100
2	40 Mm	0	0	0	100
3	20 Mm	0.225	0.225	4.5	95.5
4	10 Mm	3.07	3.295	65.90	34.10
5	4.75 Mm	1.435	4.73	94.6	5.4
6	2.36 Mm	0.27	5.00	100.0	0.00
7	1.18 Mm	0	5	100	0
8	600 µm	0	5	100	0
9	300 µm	0	5	100	0
10	150 µm	0	5	100	0
Fineness Modulus = 6.65			Total = 665		

Sieve Analysis of Fine Aggregate:

Sieve Analysis of Fine Aggregate

Total weight of sample taken = 1000 gm

S.NO	IS SIEVE	WEIGHT RETAINED	% WEIGHT RETAINED	CUMULATIVE % WEIGHT RETAINED	% PASSING
1	10 Mm	0	0	0	100
2	4.75 Mm	22	22	2.2	97.8
3	2.36 Mm	34	56	5.6	94.4
4	1.18 Mm	131	187	18.7	81.3
5	600 µm	216	403	40.3	59.7
6	300 µm	384	787	78.7	21.3
7	150 µm	202	988	98.8	1.2
Fineness Modulus = ——				Total = 244.3	

According to IS 383-1970 this sand confirms to Zone - II.

Workability

Workability in terms of Compaction Factor

S.NO	1	2	3	4	5	6	7	8
MIX DESIGN	M20				M30			
MIX ID	X	X1	X2	X3	XY	X4	X5	X6
% OF CERAMIC WASTE	00.00	10.00	20.00	30.00	00.00	10.00	20.00	30.00
COMPACTION FACTOR	0.87	0.88	0.88	0.90	0.90	0.91	0.92	0.92

Workability in terms of Vee-Bee Factor

S.NO	1	2	3	4	5	6	7	8
MIX DESIGN	M20				M30			
MIX ID	X	X1	X2	X3	XY	X4	X5	X6
% OF CERAMIC WASTE	00.00	10.00	20.00	30.00	00.00	10.00	20.00	30.00
VEE-BEE TIME (SECONDS)	21.00	20.50	18.40	18.15	19.55	18.00	16.29	15.58

Compressive, Split Tensile & Flexural for M20

Compressive Strength of M20 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M20C	X10M20C	X20M20C	X30M20C
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	24.03	20.86	15.12	15.25
7 DAYS	32.14	31.51	27.18	22.77
28 DAYS	39.00	44.7	41.51	36.22
60 DAYS	48.96	56.07	49.38	47.22

Split Tensile Strength of M20 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M20CY	X10M20CY	X20M20CY	X30M20CY
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	2.92	2.75	2.56	2.43
7 DAYS	3.49	3.21	3.00	2.73
28 DAYS	3.83	4.20	3.95	3.63
60 DAYS	4.15	4.76	4.55	4.29

Flexural Strength of M20 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M20P	X10M20P	X20M20P	X30M20P
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	4.97	4.37	3.74	3.41
7 DAYS	6.04	5.66	4.96	4.37
28 DAYS	7.73	7.14	6.95	6.35
60 DAYS	7.32	7.98	7.45	6.90

Compressive, split tensile& flexural for M30:

Compressive Strength of M30 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M30C	X10M30C	X20M30C	X30M30C
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	32.55	28.26	21.58	14.69
7 DAYS	37.33	36.51	27.29	25.44
28 DAYS	43.86	51.88	45.13	41.36
60 DAYS	51.88	59.92	55.44	47.66

Split tensile Strength of M30 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M30CY	X10M30CY	X20M30CY	X30M30CY
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	3.86	3.62	3.23	2.71
7 DAYS	4.06	3.78	3.46	2.94
28 DAYS	4.19	4.51	4.23	3.68
60 DAYS	4.47	4.86	4.63	4.28

Flexural Strength of M30 Grade Concrete with different proportions of CERAMIC WASTE

MIX ID	X00M30P	X10M30P	X20M30P	X30M30P
% OF CERAMIC	00.00	10.00	20.00	30.00
3 DAYS	4.84	4.46	3.91	3.60
7 DAYS	6.65	5.99	5.39	4.97
28 DAYS	7.39	8.11	7.51	6.71
60 DAYS	8.22	8.76	8.42	7.39

Graphs:

Compressive Strength:

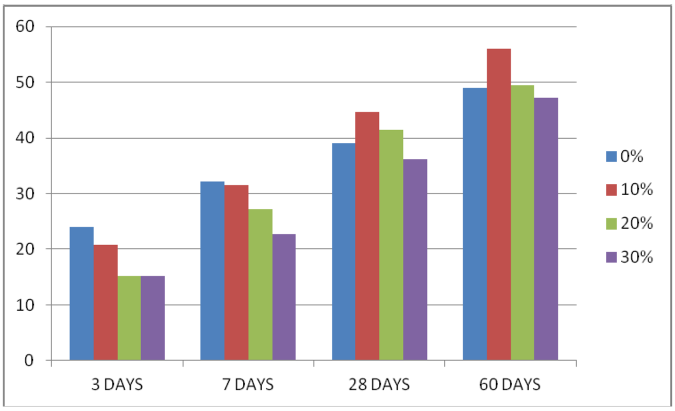

Figure 1. Variation of 28 Days Compressive Strength M20 Grade

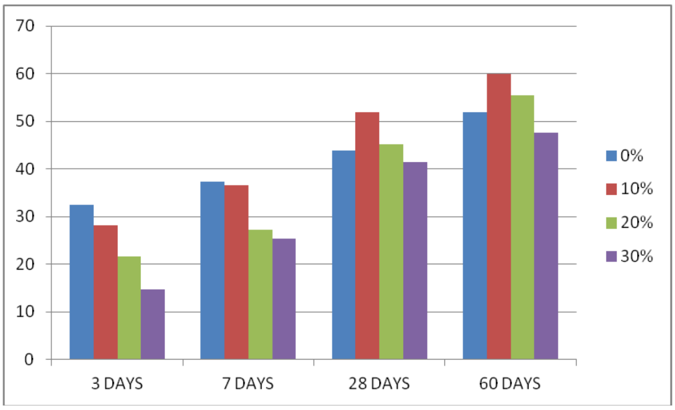

Figure 2. Variation of 28 Days Compressive Strength M30 Grade

Split Tensile:

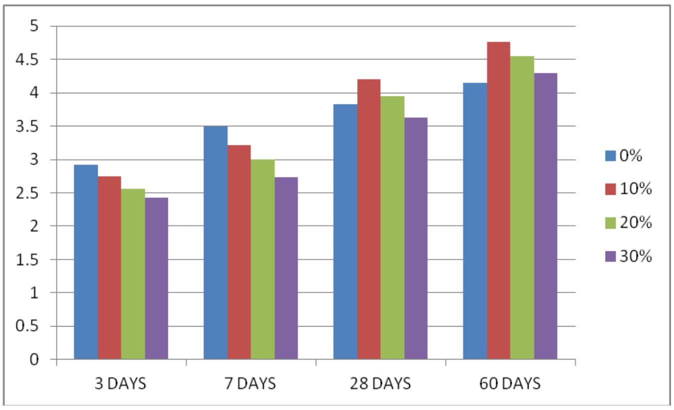

Figure 3. Variation of 28 Days Split Tensile Strength M20 Grade

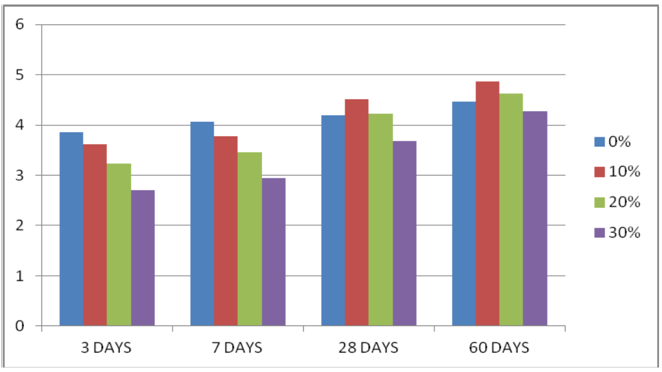

Figure 4. Variation of 28 Days Split Tensile Strength M30 Grade

Flexural Strength:

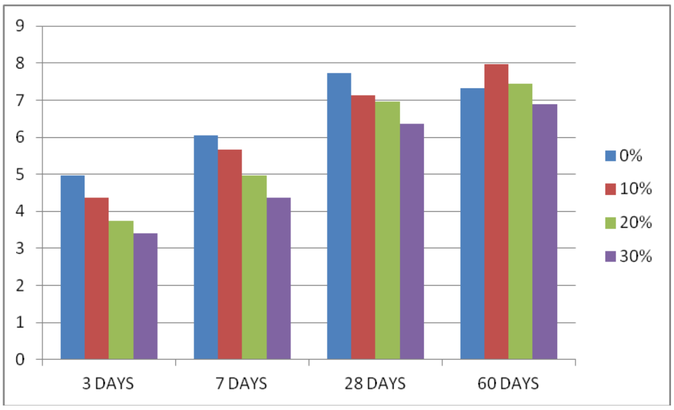

Figure 5. Variation of 28 Days Flexural Strength M20 Grade

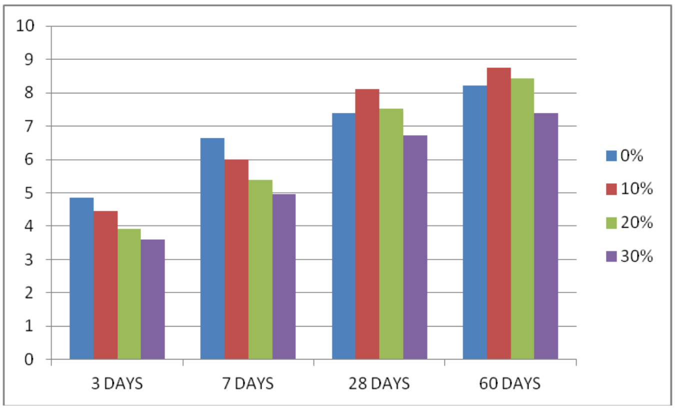

Figure 6. Variation of 28 Days Flexural Strength M30 Grade

IV. CONCLUSION

- CERAMIC WASTE is a good alternative for cement and gives more strength in order of order 8.46%, 5.90% increase for 10 %, 20% to depending on grade of concrete, type of strength, by partial replacement of CERAMIC WASTE in place of cement. Replacement of CERAMIC WASTE in place of cement by 10% has given more strength and durability. The replacement of CERAMIC WASTE in place of cement by 20% gives good result both cases of strength and economy.
- The workability of concrete measured from Slump cone, Compaction factor is increasing with increasing in CERAMIC WASTE partial replacement and Vee-bee is decreasing as the proportion of replacement of CERAMIC WASTE in place of cement increases.
- In order to make the replaced mixes workability equal to workability of reference mix. The quantity of admixture added by percentage of weight to M20 and M30 grade concrete for replacement of cement by CERAMIC WASTE in proportions of 0%, 10%, 20%, 30%, is of order 0%, 0%, 0.1%, 0.2%, 0.4%, 0.6% and 0.8% for each grade respectively.
- The compressive strength, split tensile strength and flexural strength of M20 grade concrete for replacement of cement by CERAMIC WASTE increase in proportions of 0%, 10%, 20% is of order 0%,8.46%, 5.90% and decrease by 11.95% for 30% replacements respectively for compressive strength, 0%, 13.07%, 4.24% increase for 0%, 10%, 20% and decrease by 7.06% for 30% replacements respectively for split tensile strength, 0%, 7.15%, 3.83% for 0%, 10%, 20% and decrease by 6.63%

for 30% replacements respectively for flexural strength respectively.

- The compressive strength, split tensile strength and flexural strength of M30 grade concrete for replacement of cement by CERAMIC WASTE increase in proportions of 0%, 11.26%, 2.77% for 0%, 10%, 20% and decrease by 10.64 for 30% replacements respectively for compressive strength, 0%, 10.03%, 01.25% for 0%, 10%, 20% and decrease by 15.98% for 30% replacements respectively for split tensile strength, order 0%, 11.26%, 2.77% for 0%, 10%, 20% and decrease by 10.64% for 30% replacements respectively for flexural strength respectively.

V. REFERENCES

[1] IS 3812-2003, Pulverized Fuel Ash specification, part 1 for use as pozzolana in cement, cement mortar and concrete

[2] IS: 456-2000 Plain &Reinforced Concrete Code of Practice

[3] IS: 269 -1989 - Ordinary Portland cement - 33 Grade (Reaffirmed 2004)

[4] IS: 8112-1989 - 43 Grade Ordinary Portland cement (Reaffirmed 2005)

[5] IS: 12269-1987 - 53 Grade Ordinary Portland cement (Reaffirmed 2004)

[6] IS: 1489 part-1 1991 - Portland Pozzolana Cement CERAMIC WASTE based (Reaffirmed 2005)

[7] IS: 1489 part-2 1991 - Portland Pozzolana Cement calcined clay based (Reaffirmed 2005)

[8] IS: 455-1989 - Portland Slag Cement (Reaffirmed 2005)

[9] IS:10262-2009 – Concrete Mix Proportioning(Guidelines)

[10] IS:10262-1982 – Concrete Mix Proportioning(Guidelines)