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IJIEMR Transactions, online available on 26th Aug 2017. Link :http://www.ijiemr.org/downloads.php?vol=Volume-6&issue=ISSUE-7

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Volume 06, Issue 07, Pages: 243-253.

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STUDY ON COMPRESSIVE STRENGTH OF CONCRETE WITH SUSTAINABLE INDUSTRIAL CERAMIC WASTE MATERIALS AS PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT In the contemporary existences the ceramic waste consumption have been urbanized a huge volume. Almost 15%-30% ceramic production goes as discarded. These wastes pose a challenging extent in the existing society, and it requires a proper form of management in order to accomplish the sustainable development. It is utmost important to develop a sustainable concrete from ceramic wastes. The ceramic waste is economical and it also improves the strength characteristics moreover a harmless clearance of waste material is protecting from contamination. In this research study the ordinary Portland cement has been replaced by ceramic waste powder accordingly in the range of 0%, 10%, 20%, 30%, 40%, and 50% by weight for M- 50 grade concrete and the compressive strength flexural strength, split tensile strength of conventional concrete and ceramic replaced concrete are compared and the results is been tabulated

Key words: Ceramic Waste , compressive Strength , flexural strength, split tensile strength

1.INTRODUCTION The ceramic waste management has become one of the foremost eco friendly problems in many cities. It has been a persistent problem in India since for a decade due to consecutively out of disposal sites to accomplish the massive volume of waste produced. Many people believe that sustainability takes a break during construction activities. In recent years, initiatives have been investigated on a global and national level to control and regulate waste management. The development of concrete technology can minimize the intake of natural assets. The consumption of the additional materials offers reduction of the cost, energy savings, possibly larger products, and fewer exposures in the surroundings. The additional cementing material has established the application in concrete production because of their prospective to replace a part of Portland cement in concrete. Hence, these constituents can be measured aseco-friendly cement alternatives. The manufacture of Indian ceramic is 100 Million ton per year. In the ceramic industry,15%-30% surplus material produced from the total manufacture. The ceramic waste is not reused in any form at contemporary days. Nevertheless; the ceramic discarded is hardwearing and highly impervious to organic, biochemical, and physical degradation forces. 2 The Ceramic productions are discarding the ash in any

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adjacent pit or unoccupied places, near their part even though warned zones have been noticeable for discarding. This tops to severe ecological and dust contamination and occupation of a massive zone of land, particularly after the residue become dry up so it is necessary to organize the Ceramic waste rapidly and use in the construction industry. The ceramic waste is heaping up; there is a density on ceramic industries to catch an explanation for its removal. The demolition rubbishes give the determined quantity of debris global. Furthermore, ceramic ingredients, includes block walls, ceramic tiles and all other ceramic yields, subsidize the utmost proportion of rubbishes inside the demolition wastes. 2. MATERIALS AND METHODOLOGY i) CEMENT Portland cement is the most common type of cement in general use around the world, used as a basic ingredient of concrete, mortar, stucco, and most non-specialty grout. It usually originates from limestone. It is a fine powder produced by grinding Portland cement clinker(more than 90%), a limited amount of calcium sulphate (which controls the set time) and up to 5% minor constituents as allowed by various standards such as the European Standard EN 197-1. Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates (3 CaO·SiO2and 2 CaO·SiO2), the remainder consisting of aluminum- and iron-containing clinker phases and other compounds. The ratio of CaO to SiO2 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass. The cement used for concrete is Portland cement 53 grade. The chemical properties of cement are shown in Table 3.2. Table.3.2: Chemical analysis of the Portland cement

S.No	Oxide Compounds	Weight in %
1	SiO_2	35.4
2	Al_2O_3	17.5
3	Fe_2O_3	5.3
4.	CaO	26.1
5.	MgO	4.6
6.	SO_3	2.8

Fig. 3.2 Cement

ii) 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. The most popular use of aggregates is to make Portland cement concrete. Approximately three-fourths of the volume of Portland cement concrete is occupied by aggregate. It is inevitable that a constituent occupying such a large percentage of the mass should have an important effect on the properties of both the fresh and hardened products. As another important application, aggregates are used in asphalt cement concrete in which they occupy 90% or more of the total volume. Once again,

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aggregates can largely influence the composite properties due to its large volume fraction.

Aggregates

iii) CERAMIC WASTE Around 15%-30% of ceramic industry goes as waste from the total production. The waste is not reused in any form at existing however; the ceramic waste is long-lasting, durableand highly impervious to biological, chemical, and physical degradation forces. Hence these scraps remain 4 grinded finely to the size of cement and used as an alternative material for cement in construction industry. The ceramic waste material used for the investigation came from tiles and sanitary ware.

Table 3.3 Chemical Properties of Ceramics

Chemicals	Percentage%
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	2.75
Na_2O	0.72

Ceramic Powder

3. TESTS CONDUCTED Consistency Test The basic aim of this test is to find out the water content required to produce a cement paste of standard consistency as specified by the IS: 4031 (Part 4) – 1988. The principle of standard consistency of cement is that consistency at which the Vicat plunger penetrates to a point 5- 7mm from the bottom of Vicat mould. Procedure to find consistency of cement: 300gms of cement is weighed and mixed with a weighed quantity of water the time• gauging should be between 3 to 5 minutes. The Vicat mould is filled with the paste and leveled with a trowel.• The plunger is lowered gently till it touches the cement surface.• 5 The plunger is released allowing it to sink in to the paste and the reading is noted on the• gauge. The above procedure is repeated taking fresh samples of cement and different quantities• of water until the reading on the gauge is 5 to 7mm.

Consistency of Cement

S. no	Wt of water in (gms) W_1	Wt of cement in (gms) W_2	$(W_2/W_1) \times 10$	Position in (mm)
1	75	300	40	6
2	78	300	38.4	5
3	81	300	37.03	6
4	84	300	35.7	6
5	87	300	34.48	5
6	90	300	33.3	6

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As per IS 4031 [1968] it is in a range of 5 to 7 mm hence Pn=30% is taken.

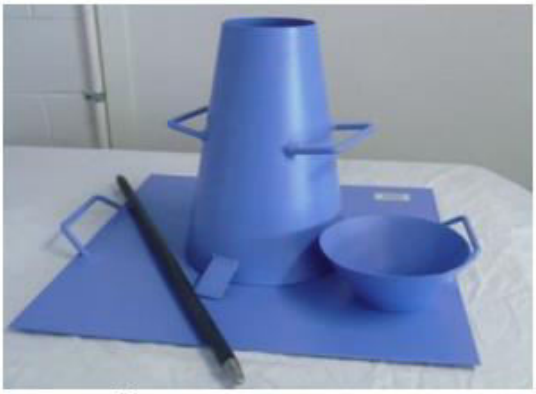
Fig. 4.2: Testing on le-Chatelier flask

SPECIFIC GRAVITY OF FINE AGGRAGATE Specific gravity of fine aggregate is found by using pycnometer. The clean and dry pycnometer is weighed along with the lid (Wp).• Pycnometer is then filled with fine aggregate up to half of it and then weighed (Wps).• The pycnometer is filled with water up to graduated mark and then weighed (Wa).• Pycnometer is then filled with water and weighed (Wb).• Specific gravity = [(Wps-Wp)/ (Wps-Wp) + (Wa-Wb)] = 2.74 SPECIFIC GRAVITY OF FLY ASH Specific gravity of fly ash is found using le-chatelier flask. A clean and dry le-chatelier flask is weighed with its stopper (w1).• A sample of fly ash is placed up to half of the flask (about 30Gms) and weighed• along with the stopper (w2). Kerosene is added to fly ash in flask till it is half full and thoroughly mixed glass• rod to remove entrapped air and stirring is continued and kerosene is added till the graduated mark and weighed as (w3). The flask is filled with kerosene up to graduated mark and weighed as (w4).• Specific gravity = [(W2-W1)/ (W2-W1)-(W3-W4) x 0.81] = 2.1

Table 4.2: Test Results on Cement

S.No	Test	Value
1	Specific gravity of cement	3.15
2	Normal consistency of cement	30%
3	Initial setting time of cement	35 minutes
4	Final setting time of cement	6 hrs. 30 min

Slump Test



Slump cone test apparatus

The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and adherence of any old set concrete before commencing the test. The mould is placed on a smooth, horizontal, rigid, and non- absorbent surface. The mould is then filled in four layers, each approximately 1/4th of the height of the mould. Each layer is tamped 25 time by tamping rod taking care to distribute the strokes evenly over the cross-section after the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod. The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside. This subsidence is referred as slump of concrete. The difference in level between the height of the mould and that of the highest point of the subsided concrete is measured. This difference in height is in mm and is taken as slump of concrete. ASTM measures the center of the slump concrete as the difference in height. Compressive Strength Test- [Test on Cubes] According to cement association of India (2003), compressive strength of concrete can be defined as the measured maximum resistance of concrete to axial loading. Compression test is the most common test used to test the hardened concrete specimens because the testing is easy to make. The specimens used in compression test were the cube of150×150×150 mm. The testing for the specimens should be carried out as soon as possible after taking out from the curing rank i.e. Saturated Surface Dry condition (SSD).The specimen need to get measurement before testing. The length and height of specimen is measured and recorded. Clean the uncapped surface of the specimen and place specimen in the testing machine .The axis of specimen is aligned with the center of thrust of the seated plate. Plate is lowered until the uniform bearing is obtained. The force is applied and increased continuously at a rate equivalent to 20 Mpa compressive stresses per minute until the specimen failed. Record the maximum force from the testing machine.


Fig 5.2: Tests on Cube

Split Tensile Test [Test on Cylinders] Normally concrete is very strong in compression but weak in tension. Indirect tensile test is used to indicate the brittle nature of specimen's apparatus and test procedure of Indirect Tensile Test. The following apparatus and equipment used in the indirect tensile test are according to IS: 5861-1970.Testing machine Testing Supplementary Bearing barer Plate Bearing strips Ruler Verniercaliper Test Procedure According to the IS: 5861-1970..Measure the diameter and length of the specimen. Record the measurements. Place the specimen on testing. Bearing strips are aligned on the top and bottom of the specimen and place the bearing plate outside the bearing strips. Apply a small initial force and the side constrain is removed. Concrete cylinders are prepared and cured in the similar manner as concrete cubes. Immediately on removing the cylinder from the water and while it is still in a wet condition, the extensometer shall be attached at the end, or on opposite sides of the specimen and parallel to its axis, in such a way, that the gauge points are symmetrical about the center of the specimen and in no case are nearer to either end of the specimen than a distance equal to half the diameter of the specimen. The specimen shall be immediately placed

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in the testing machine (CTM and UTM) and accurately centered. The load shall be applied continuously and without shock at a rate of 14 N/sq. mm/min until an average stress of (C+0.5) N/ mm2 is reached, where C is one third of the average compressive strength of the cubes calculated to the nearest 0.5 N/mm2 .The load shall be maintained at this stress for at least one minute and shall then be reduced gradually to an average stress of 0.15 N/mm2 when extensometer readings shall be taken. The load shall be applied a second time at the same rate until an average stress of (C+0.15)N/mm2 is reached. The load shall be maintained at this figure while extensometer readings are taken. The load shall again be reduced gradually and readings again taken at ±0.15N/mm2 . The load shall again be reduced gradually and readings taken at ten, approximately equal increments of stress up to average stress of (C±0.15) N/mm2 . The readings shall be taken at each stage of loading with as little delays possible. If the overall strains observed on the second and third readings differ by more than ±5%.The loading cycle shall be repeated until the difference in strains between consecutive readings at (C±0.15) N/mm2 does not exceeds 5 percent.

Fig 5.3: Split Tensile Strength of Cylinder

Durability of Concrete Durability is the ability to last a long time without significant deterioration. A durable material helps the environment by conserving resources and reducing wastes and the environmental impacts of repair and replacement. Construction and demolition waste contribute to solid waste going to landfills. The production of new building materials depletes natural resources and can produce air and water pollution The design service life of most buildings is often 30 years, although buildings often last 50 to 100 years or longer. Most concrete and masonry buildings are demolished due to obsolescence rather than deterioration. A concrete shell can be left in place if a building use or function changes or when a building interior is renovated. Concrete, as a structural material and as the building exterior skin, has the ability to withstand nature's normal deteriorating mechanisms as well as natural disasters. Chemical Resistance: Concrete is resistant to most natural environments and many chemicals. Concrete is virtually the only material used for the construction of wastewater transportation and treatment facilities because of its ability to resist corrosion caused by the highly aggressive contaminants in the wastewater stream as well as the chemicals added to treat these waste products. However concrete is sometimes exposed to substances that can attack and cause deterioration. Concrete in chemical manufacturing and storage facilities is especially prone to chemical attack. The effect of sulfates and chlorides is discussed below. Acids attack concrete by dissolving the cement paste and calcareous aggregates. In addition to using concrete with a low permeability, surface

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treatments can be used to keep aggressive substances from coming in contact with concrete. An effect of Substances on Concrete and Guide to Protective Treatments discusses the effects of hundreds of chemicals on concrete and provides a list of treatments to help control chemical attack. Resistance to Sulfate Attack: Excessive amounts of sulfates in soil or water can attack and destroy a concrete that is not properly designed. Sulfates (for example calcium sulfate, sodium sulfate, and magnesium sulfate) can attack concrete by reacting with hydrated compounds in the hardened cement paste. These reactions can induce sufficient pressure to cause disintegration of the concrete. 10 Sulfate attack and salt crystallization are more severe at locations where the concrete is exposed to wetting and drying cycles, than continuously wet cycles. For the best defense against external sulfate attack, design concrete with a low water to cementations material ratio (around 0.40) and use cements specially formulated for sulfate environments Sulfate attack can be 'external' or 'internal'. External: Due to penetration of sulfates in solution, in groundwater for example, into the concrete from outside. Internal: due to a soluble source being incorporated into the concrete at the time of mixing, gypsum in the aggregate, for example. 4. RESULTS AND DISCUSSIONS i) COMPRESSIVE STRENGTH TEST RESULTS: Compressive strength test is the most common test conducted on hardened concrete as it is easy to perform and also most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. The tests are performed in a compression testing machine using cube and cylindrical samples. The compressive strength of concrete cubes are tested at 7, 14, and 28days of curing period and compressive strength of concrete cylinders are tested at 28 days of curing period. The mean compressive strength is calculated and tabulated in Table 6.1 Table 6.1.1 Compressive Strength of Concrete Cubes (M-25)

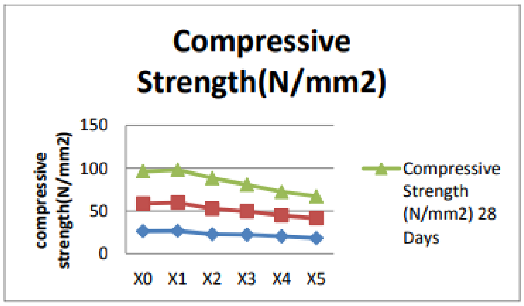
For M-25:

Concrete Mix Design	Compressive Strength (N/mm^2)		
	7 Days	14 Days	28 Days
X0	26.45	32.14	37.61
X1	26.65	33.14	38.31
X2	22.76	29.85	35.66
X3	22.19	27.32	31.16
X4	20.35	24.37	27.61
X5	18.27	23.31	25.43

In this chart %Ceramic Waste Replaced on X-axis and Compressive Strength on Y-axis.

X-axis:- %Ceramic Waste Replaced

Y-axis:-Compressive Strength in (N/mm2)



%of cement replaced with ceramic waste

For M-50:-¬

Compressive Strength of Concrete Cubes (M-50)

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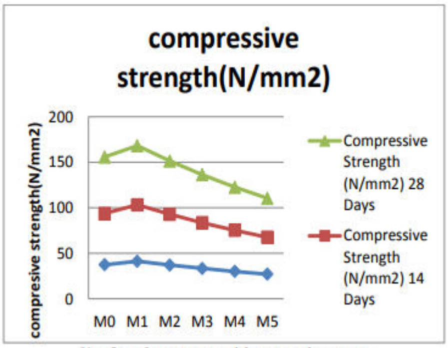
Concrete Mix Design	Compressive Strength (N/mm^2)		
	7 Days	14 Days	28 Days
M0	37.51	56.27	61.89
M1	41.26	61.89	64.99
M2	37.14	55.71	58.49
M3	33.42	50.13	52.64
M4	30.08	45.12	47.38
M5	27.07	40.61	42.64



% of replacement with ceramic waste
Compressive Strength of Concrete with Ceramic Waste Replacement

ii) SPLIT TENSILE STRENGTH Split tensile test is done by placing the cylindrical specimen horizontally between the loading surfaces of compression testing machine and the load is applied till the cylinder failed along the vertical diameter. Split tensile strength of concrete mixes is determined at the age of 28 days. The mean tensile strength is calculated and tabulated in Table 6.3. Split tensile strength = LOAD / AREA = 2P / LDπ Split Tensile Strength of Concrete (M-25)

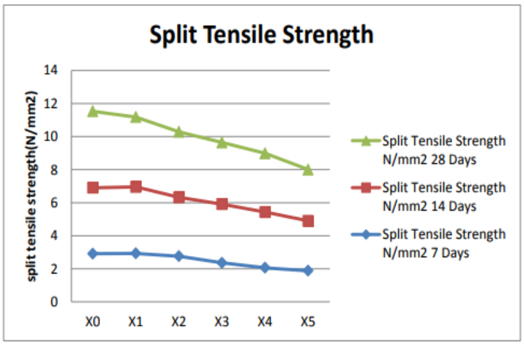
For M-25¬

Concrete Mix Design	Split Tensile Strength N/mm^2		
	7 Days	14 Days	28 Days
X0	2.91	3.99	4.63
X1	2.93	4.02	4.23
X2	2.76	3.56	3.96
X3	2.36	3.55	3.73
X4	2.06	3.37	3.55
X5	1.88	3.02	3.10

In this chart %Ceramic Waste Replaced on X-axis and Split Tensile Strength on Y-axis.

X-axis :- %Ceramic Waste Replacement

Y-axis:- Split Tensile Strength in N/mm2



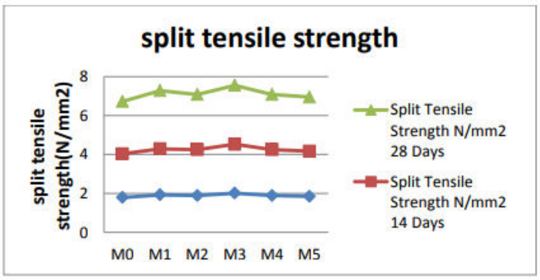
% of cement replaced with ceramic powder
Split Tensile Strength for Different Concrete Mixes

Split Tensile Strength of Concrete Mix is determined at the age of 28 Days. The above chart is for 28Days mix.

For M-50:-¬

Split Tensile Strength of Concrete (M-50)

Concrete Mix Design	Split Tensile Strength N/mm^2		
	7 Days	14 Days	28 Days
M0	1.79	2.242	2.69
M1	1.93	2.358	2.99
M2	1.89	2.358	2.83
M3	2.01	2.517	3.02
M4	1.89	2.358	2.83
M5	1.85	2.317	2.78



% of cement replaced with ceramic powder
Split Tensile Strength for Different Concrete Mixes

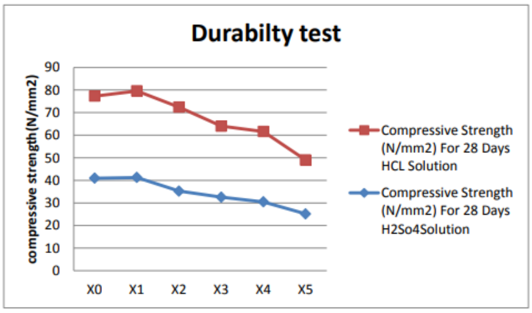
iii) DURABILITY TEST: Compressive strength when cubes immersed in acid for 28 days, after curing in normal water is measured. Strength in concrete increases when immersed in HCL and when immersed in H2So4 it decreases. As in CWP concrete strength 30% was preferable, in this durability test we get results as in decreased nature. Percentage Strength loss in durability test with compares to conventional concrete is decreased. Compressive Strength of Concrete Cubes (M-25) 0 2 4 6 8 M0 M1 M2 M3 M4 M5 split tensile strength(N/mm2) split tensile strength Split Tensile Strength N/mm2 28 Days Split Tensile Strength N/mm2 14 Days 14 For M-25:¬

Concrete Mix Design	Compressive Strength (N/mm^2) For 28 Days	
	H_2So_4Solution	HCL Solution
X0	40.96	36.33
X1	41.26	38.33
X2	35.22	37.19
X3	32.57	31.43
X4	30.46	31.13
X5	25.14	23.85

In this chart % Ceramic Waste Replaced on X-axis and Compressive Strength on Y-axis.

X-axis:- % Ceramic Waste Replaced

Y-axis:- Compressive Strength in N/mm2

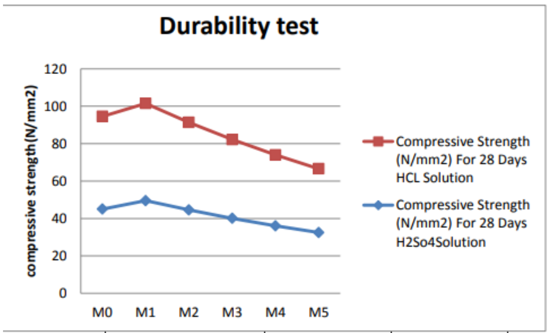


%of cement replaced with Ceramic Powder
Compressive Strength for Durable Concrete in Chemical Solution

For M-50:

Compressive Strength of Concrete Cubes (M-50)

Concrete Mix Design	Compressive Strength (N/mm^2) For 28 Days	
	H_2So_4Solution	HCL Solution
M0	45.016	49.512
M1	49.512	51.992
M2	44.568	46.792
M3	40.104	42.112
M4	36.096	37.904



5. CONCLUSION

The Compressive Strength of M25 grade concrete increases at 28 days ,increased by1.827%

The Compressive Strength of M50 grade concrete increases at 28 days ,increased• by4.769%

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Split Tensile test also at 10% of replacement of cement with ceramic waste . For M25• grade 0.746 % increased. And M50 grade was increased by 10.03%.

ACKNOWLEDGEMENT

I am grateful to my guide Dr .D. VENKATESWARLU, Professor and Head of the Department, for having given me the opportunity to carry out this project work. I feel immense pleasure to express thanks and profound sense of guidance and valuable suggestions. I would like to thank Dr .D. VENKATESWARLU, Professor and Head of the Department of CIVIL ENGINEERING, for valuable suggestions throughout my project which have helped in giving definite shape to this work. I would like to express my deep sense of gratitude to Dr.D.V. RAMA MURTHY Principal, for providing me a chance to undergo the course in the prestigious institute. I am very much obliged to Dr.L.S. GUPTA, Director and Dr.M.VARA PRASADARAO, Dean of Godavari Institute of Engineering and Technology for giving opportunity to undergo this project. The euphoria and satisfaction of completing this project will not be completed until I thank all the people who have helped me in the successful completion of this enthusiastic task. DECLARATION I, Medisetti.Veera Siva RamaLakshmi, hereby declare that the project entitled "STUDY ON COMPRESSIVE STRENGTH OF CONCRETE THE CONCRETE WITH SUSTAINABLE INDUSTRIAL CERAMIC WASTE MATERIALS AS PARTIAL REPLACEMENT OF CEMENT" under the guidance of Dr.D.VENKATESWARLU, submitted in partial fulfillment of the requirements for the award of the degree of Master of Technology in Structural Engineering is a record of bonafide work carried out by me and the results embodied in the project have not been reproduced. The results embodied in this project have not been submitted to any other university or institution for the award of any degree.

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