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Comparative Study on Ceramic Waste Powder with Coir Fibre composite concrete Using Destructive and Non Destructive Tests

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Abstract: Concrete is the most widely used construction material all over the globe next to water. The present challenge for civil engineers is to produce large volume, good performance, durable and sustainable concrete at lowest possible cost. This can be achieved by utilizing maximum possible industrial by-product in concrete .In this study, industrial by-product ceramic waste powder together with coir fibre is used for making sustainable concrete. Addition of natural fibre like coir improves the ductility, flexural and tensile strengths, fracture toughness and crack inhibiting properties of the matrix. But due to high moisture absorption by the natural fibre, compressive strength does not give desirable results. So use treated fibres that may help in modifying concrete performance.

From previous studies optimum ceramic powder obtained by replacing the cement in concrete is 15%.Here,using M_{30} grade concrete, take optimum 15% ceramic powder and adding different percentages of coir fibre that is 0%, 0.5% ,1%, 1.5%, 2% ,2.5%, by the weight of cement in concrete to conduct destructive and non-destructive test for analysing the strength of concrete specimen at 28 days. Results showed that 15% replacement of cement by ceramic waste powder and 1.5% of coir fibre makes a considerable increase in strength than conventional concrete. Use of these waste materials makes to sustainable development in construction industry.

Keywords: Ceramic waste powder, Coir fibre, Destructive test, Non-destructive test, Sustainable development

I. INTRODUCTION

The advancement of concrete technology can reduce the consumption of natural resources, which can be reused and find other alternatives. In India numbers of waste materials are produced by different manufacturing companies, thermal power plant, municipal solid wastes and other wastes. Solid as well as liquid waste management is one of the biggest problems of the whole world. Disposal of waste in to the land causes serious impact on environment. Now a day's large amount of tile powder is generated in tile industries with an impact on environment and humans. By using the replacement materials offers cost reduction, energy savings and few hazards in the environment. . Concrete is nothing but a combination of aggregates both fine and coarse, Cement and water. Comparing to all other ingredients in concrete, cement is considered to be the expensive material. This is because cement is manufactured using energy-intensive process. Cement is one of the major producers of carbon dioxide, which is the main cause of global warming. During the manufacturing process of cement the formation of clinker can be achieved only by heating the cement at very high temperature. This leads to the release of enormous amounts of carbon in the atmosphere. This was one among the major problems identified for climatic changes. Various research works has been carried out for the cost reduction in construction with some of the locally available materials that is partial or full replacement material for cement. Over the last few decades supplementary materials like fly ash, rice husk, silica fume, egg shell, groundnut shell, etc. are used as a replacing material. These supplementary materials have proven to be successful in meeting the needs of the concrete in construction. In India ceramic production is 100 million ton per year. The tile industry has about 15% to 30% waste material generated from the total production. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental pollution which is dangerous for human health. This waste is not recycled in any form at present. However, the tile waste is durable, hard and highly resistant to biological, chemical, physical degradation forces. The tile waste which is dumped in land filling and pit or vacant spaces causes the environmental and dust pollution which is dangerous for human health. As the ceramic waste is piling up every day, there is a pressure on tile industries to find a solution for its disposal. Concrete is considerably the world's largely adaptable and well-liked material produced each year in the construction.

II. SCOPE AND OBJECTIVES OF THE STUDY

A. The main Scopes of The Study Are,

1) To examine the effectiveness of using Ceramic Waste Powder (CWP) with Coir fiber (CF) for studying strength parameters.
2) To study the necessity of consumption of the waste material for manufacturing of sustainable concrete for construction. To use local available material and to reduce the cost of producing concrete.
3) To overcome the problems faced by cement industries to a little extent. The experimental investigation was proposed to work out the suitability of addition of Ceramic Waste Powder (CWP) with coir fibre, as partial replacement of ordinary Portland cement in concrete with the following are the objective.
4) To investigate the destructive and non- destructive test on concrete with ceramic-coir fiber composite concrete to that of normal concrete.
5) To prepare high strength, eco-friendly and cost effective concrete.

III.MATERIALS USED

The material used in this study included ordinary Portland cement, fine aggregate, coarse aggregate, water, chemical admixture and glass fibre.

A. Cement

Ordinary Portland cement 53 grade was used throughout the study. The standard consistency, setting time and specific gravity were tested in the laboratory. All the tests were carried out in accordance with procedure laid down in IS 12269 – 1987.

B. Fine Aggregate

Fine aggregates are basically sands. Fine aggregates are the materials that pass through 4.75 mm IS sieve. Manufactured sand (M sand) was used as fine aggregate. The tests such as specific gravity and gradation were carried out to determine the physical properties of fine aggregate.

C. Coarse Aggregate

Locally available crushed stone aggregate of 20 mm size was used throughout the experimental study. The tests such as specific gravity and gradation were carried out to determine the physical properties of coarse aggregate. The coarse aggregate is chosen by shape as per IS 2386(Part I) 1963, surface texture characteristics of aggregate is classified as in IS 383-1970.

D. Water

This is the least expensive but most important ingredient of concrete. The water which is used for making concrete should be clean and free from harmful impurities such as oil, alkali, acid, etc. Potable water was used for the experiment.

E. Ceramic Powder

The principle waste coming into ceramic industry is the ceramic powder, specifically in the powder forms. Ceramic wastes are generated as a waste during the process of dressing and polishing. It is estimated that 15 to 30% waste are produced of total raw material used, and although a portion of this waste may be utilized on-site, such as for excavation pit refill, The disposals of these waste materials acquire large land areas and remain scattered all around, spoiling the aesthetic of the entire region. It is very difficult to find a use of ceramic waste produced. Ceramic waste can be used in concrete to improve its strength and other durability factors. Ceramic waste can be used as a partial replacement of cement or as a partial replacement of fine aggregate sand as a supplementary addition to achieve different properties of concrete:-

IV.METHODOLOGY

A. Material testing

1) *Specific gravity test:* The specific gravity is normally defined as the ratio between the weight of a given volume of material and weight of an equal volume of water. Specific gravity of cement, fine aggregate and coarse aggregate are tested.
2) *Sieve analysis :* Sieve analysis is done as per IS 2386 (Part I)-1963. The first step involves arranging the IS sieves in the order of4.75mm-2.36mm-1.18mm-600µ-300µ-150µ as shown in Fig-3. 1kgs of fine aggregate is taken and placed on the top most sieves. Sieving is done for fifteen minutes and weight retained on each IS sieve is found.

3) *Fineness of cement:* Fineness test conducted on cement using 90 micron sieve. Fineness is an important property of cement which affects the rate of hydration of cement. Finer cement offers a greater surface area for hydration and hence faster the development of strength. The test was conducted by sieving 100 gm of cement through IS 90 micron sieve continuously up to 15 minutes
4) *Consistency of cement:* Ordinary Portland cement of grade 53 was used in the casting of the specimens. Consistency limit test is done to determine the standard water requirement for setting time, the test was done under standard condition as mention in IS: 4031-1988. shows consistency test.
5) *Bulk Density, Void Ratio and Porosity of Fine and Coarse Aggregate :* Bulk density is the density of dry aggregate. This is required to determine the amount of aggregate in concrete mix. Container having 3L capacity, tamping rod and weighing balance were used for determining the bulk density, void ratio and porosity of aggregate.
6) *Initial and final setting time:* Vicat apparatus with 1mm square needle was used for initial setting time test and another needle with annular attachment was used for final setting time test of Ordinary Portland cement. In this test 400 gm of cement was mixed with 0.85 times the percentage of water as determined in the consistency test. The time required to penetrate the needle to a depth of 5 mm from the bottom of the mould was noted as initial setting time and the time required to make an impression on the test block was noted as final setting time.

B. Mix Design
Mix design is calculated as per IS 10262:2009 specifications. The concrete mix of M_{30} grade concrete is adopted with a water cement ratio of 0.5.

C. Preparation of Specimen
The cube moulds of size 150mmx150mmx150mm and cylinders mould of size 150mm diameter and 300mm length were filled with the mix. The cubes were tamped by tamping rod for around 25 times and the surfaces of moulds were leveled properly. The specimens were kept for 24 hours; de- moulded and then set for curing.Fig-8 preparation of mix for specimens. The curing was allowed until the date of testing i.e., for 7th, 14th, and 28th. Then after the days of curing, the cube specimens were taken out and tested under testing machine.

D. Curing
The curing was allowed until the date of testing i.e., for 7th, 14th, and 28th. Then after the days of curing, the cube specimens were taken out and tested under testing machine.

E. Workability test
Slump test and compaction factor test were conducted on fresh concrete to determine the workability of concrete as per IS 456 – 2000.

V. DESTRUCTIVE AND NON-DESTRUCTIVE TEST

A. Destructive test
Destructive tests are widely applied to study mechanical properties and integrity of concrete structures. The crushing of the specimens is the usual destructive test to assess the strength of concrete. Destructive tests are

1) *Compressive strength test:* Compressive strength of concrete is a measure of its ability to resist static load. 7, 14 and 28 day compressive strength test were conducted on three specimens having size 150x150 mm and the average strength was taken as the cube compressive strength of concrete.Fig-10 shows the compression testing machine. The optimum percentage of ceramic powder was determined by conducting compression test on cubes. Cubes were made with partially replaced CWP at 15% and addition of CF various percentages such as0%,0. 5%, 1%, 1.5%, 2%, and 2.5%. The tests were conducted by using compression testing machine. From the results of the compression tests, the optimum percentage of CWP to be added is determined as the one which renders the maximum compressive strength. The cube specimen was taken out from the curing tank after specified curing time and were allowed for dry and the weight of each specimen as well as measure the dimension of the specimen were noted. The specimens were placed in the machine such that load shall be applied to the opposite sides of the specimen, and the specimens were aligned centrally on the base plate of the machine. The movable portion was rotated gently by hand so that it touches the top surface of the specimen. The load was applied gradually till the specimens failed and the maximum load at

failure of specimen were recorded. The compressive strength of the specimen was calculated by dividing the failure load by the cross-sectional area of the specimen.

Fig-1: Compression testing machine

B. Non-Destructive Tests

The standard method of evaluating the quality of concrete in buildings or structures is to test specimens cast simultaneously for compressive, flexural and tensile strengths. The main disadvantages are that results are not obtained immediately; that concrete in specimens may differ from that in the actual structure as a result of different curing and compaction conditions; and that strength properties of a concrete specimen depend on its size and shape. Although there can be no direct measurement of the strength properties of structural concrete for the simple reason that strength determination involves destructive stresses, several non-destructive methods of assessment have been developed. Nondestructive testing (NDT) is a wide group of analysis techniques used in science and technology industry to evaluate the properties of a material, component or system without causing damage. These depend on the fact that certain physical properties of concrete can be related to strength and can be measured by non-destructive methods. Such properties include hardness, resistance to penetration by projectiles, rebound capacity and ability to transmit ultrasonic pulses and X- and Y-rays. These non-destructive methods may be categorized as penetration tests, rebound tests, pull-out techniques, dynamic tests, radioactive tests, maturity concept.

1) *Ultrasonic Pulse Velocity Test :* An ultrasonic pulse velocity test is an in-situ, nondestructive test to check the quality of concrete and natural rocks. In this test, the strength and quality of concrete or rock is assessed by measuring the velocity of an ultrasonic pulse passing through a concrete structure or natural rock formation. This test is conducted by passing a pulse of ultrasonic wave through concrete to be tested and measuring the time taken by pulse to get through the structure. Higher velocities indicate good quality and continuity of the material, while slower velocities may indicate concrete with many cracks or voids. This test is done to assess the quality of concrete by ultrasonic pulse velocity method as per IS: 13311 (Part 1) – 1992. The UPV apparatus and UPV test on cube specimen is shown in Fig-4

Figure 2: Ultrasonic pulse velocity test

2) *Rebound Hammer Test:* Rebound hammer test (Schmidt hammer) is used to provide a convenient and rapid indication of the compressive strength of concrete. It consists of a spring controlled mass that slides on a plunger within a tubular housing. The operation of rebound hammer is shown in the Fig 3. When the plunger of rebound hammer is pressed against the surface of concrete, a spring controlled mass with a constant energy is made to hit concrete surface to rebound back. The extent of rebound, which is a measure of surface hardness, is measured on a graduated scale. This measured value is designated as

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rebound number (rebound index). A concrete with low strength and low stiffness will absorb more energy to yield in a lower rebound value.

Figure 3: Rebound hammer test

VI. RESULTS AND DISSCUSSION

A. Material Testing

The tests were carried out to find out the physical properties of cement and aggregates used are tabulated in Table I and Table II respectively.

Table i: Properties of Cement

Test	Results
Fineness Test	2.6%
Specific Gravity	3.12
Standard Consistency test	32%

Table ii: Properties of Aggregate

Test	Results
Fineness modulus	3.17
Specific gravity	2.78
Water absorption	0.69%
Bulk density	1574kg/m^3
Void ratio of coarse aggregate	0.8
Porosity of coarse aggregate	0.445

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B. Workability test results

Table iii Mix Designation

Mix	Description
A3	15% CWP+ 85% Cement
A7	15% CWP+ 85% Cement+0.5% Fiber
A8	15% CWP+ 85% Cement+1 % Fiber
A9	15% CWP+ 85% Cement+1.5% Fiber
A10	15% CWP+ 85% Cement+2 % Fiber
A11	15% CWP+ 85% Cement+2.5 % Fiber

Table Iv Workability Test Result of Optimum Percentage Of Ceramic Powder By Replacement Of Cement And Different Percentage Of Coir Fibre

Sl.No	Grade	Mix	Percentage of super plasticizer Used	Workability test	
				Slump value(mm)	Compaction factor value
1	M_{30}	A3	0.2 %	107	0.91
2		A7	0.2 %	103	0.89
3		A8	0.2 %	100	0.87
4		A9	0.2 %	97	0.87
5		A10	0.2 %	94	0.85
6		A11	0.2 %	89	0.83

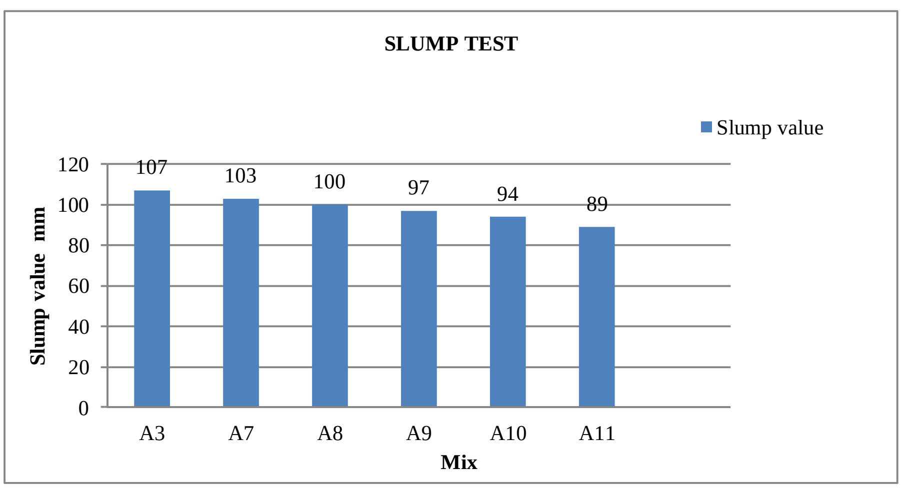

Figure 4: Relationship between slump value and optimum ceramic powder (15%) with different percentage of coir fibre

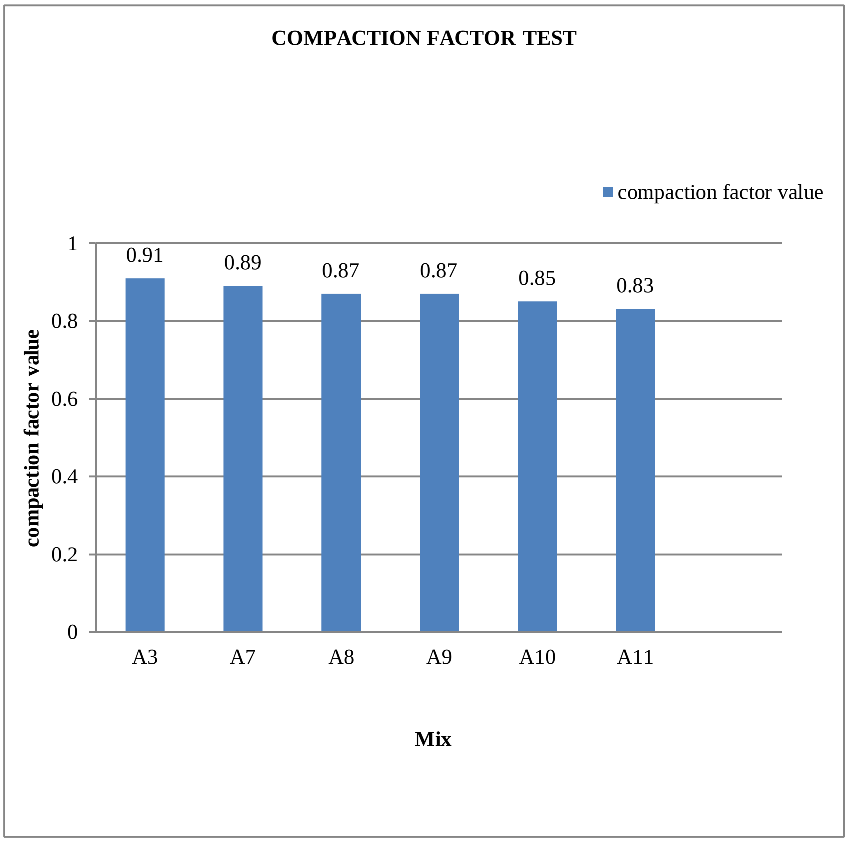

Figure 7: Relationship between compaction factor value and optimum ceramic powder (15%) with different percentage of coir fibre

C. Destructive test Results

1) Compressive strength test results

Table V: Compressive Strength of Different Percentage Of Ceramic Powder By Replacement Of Cement

Sl.No	Mix	Compressive strength after 7 days (N/mm^2)	Compressive strength after 14 days (N/mm^2)	Compressive strength after 28 days (N/mm^2)
1	A3	28.6	33.42	38.56
2	A7	30.6	33.7	37.18
3	A8	31.7	35.1	40.4
4	A9	33.67	37.7	42.9
5	A10	27.5	32.7	38.13
6	A11	26.5	29.26	34.5

2) Non-destructive test results

Table vi : Non-Destructive Test Result On Concrete With Optimum Percentage Of Ceramic Powder And Different Percentage of Coir Fibre

Sl.No	Mix	Rebound Rebound number	Compressive Strength after 28th day (N/mm^2) from graph	Concrete quality (Grading)	Pulse velocity (km/s)	Concrete quality (Grading)
		Obtained value			Obtained value	
1	A3	35.6	38.35	Good layer	4.698	Excellent
2	A7	36.4	39.75	Good layer	4.692	Excellent
3	A8	37.5	40.64	Good layer	4.587	Excellent
4	A9	40	43.12	Very good hard layer	4.571	Excellent
5	A10	36.8	38.16	Good layer	4.486	Good
6	A11	34.2	34.18	Good layer	2.8	Good

VII. CONCLUSIONS

A. The workability of concrete had been found to decrease with increase of CWP and coir fibre.
B. The use of a super plasticizer can achieve the desired workability.
C. Maximum compressive strength is attained at 15% CWP and 1.5% of Coir fibre and further replacement of Cement with Ceramic Powder decreases the compressive strength of concrete.
D. 15% Replacement of cement with CWP and 1.5% coir fiber addition gives an excellent result in strength, as compared to the normal concrete.
E. Coconut fibre played substantial role to limit crack formation.
F. Destructive and Non- Destructive tests values are almost same.
G. Use of these waste materials leads to sustainable development in construction industry.

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