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Experimental Investigation on Strength Properties of Sand by Partial Replacement of Ceramic Waste and Quarry Dust in Concrete

S.Priyadarshika[1], M.Rajkannan[2]
[1]*PG student (structural Engineering), Civil Department, Paavai Engineering College, Pachal*
[2]*Assistant Professor, Civil Department, Paavai Engineering College, Pachal*

***Abstract*- Concrete is generally composed of sand, cement, aggregate and water. The demand of natural sand in the construction industry has increased a lot resulting in the reduction of sources and an increase in price. Thus an increased need to identify a suitable substitute that is eco-friendly and inexpensive material being extensively used as an alternative to the sand in the production of concrete. In our project sand is replaced by both mixture of ceramic waste and quarry dust. Ceramic waste and quarry dust are waste material. These material are comes from various industries. The compressive strength of concrete can be compared with the ordinary concrete. Before that, various workability tests and strength tests were conducted. Sand is replaced with 25 percentage of ceramic waste and 25 percentage of quarry dust mixture that which compared with conventional concrete. No additional catalyst or plasticizers have been used. Based on the test results, our concrete with showed better results when compared to conventional concrete. The compressive strength has been tested for 7 days, 14 days and 28 days strength after casting the moulds.**

INTRODUCTION

In the present scenario the civil engineering construction industry is the biggest industry in the world, which is flourishing and giving more opportunities for employment. We know that civil engineering industry provides one of the basis amenities namely shelter which is essential for every mankind to survive on this plant. The utilization of industrial waste or secondary material has encouraged the production of cement and concrete in construction field. New by-product and waste materials are being generated by various industries. Dumping or disposal of waste material is a great potential in concrete industry. The waste materials such as ceramic waste and quarry dust comes from various industries are powered and introduced in concrete mix to check whether the strength increases.

AIM OF THE PROJECT

This project presents the feasibility of the usage of ceramic waste and quarry dust as partially substitutes for concrete. Testes were conducted on cubes to study the compressive strength of concrete made of ceramic waste and quarry dust. Workability and strength studies were done for concrete with ceramic waste and quarry dust and compared with the conventional concrete.

SOURCES OF CERAMIC WASTE

The sources of ceramic waste are obtained from the industrial in Malaysia. Presently in ceramics industries the production goes as waste, which is not undergoing the recycle process yet. The ceramic industry inevitably generates wastes, irrespective of the improvement introduced in manufacturing processes. In the ceramic industry, about 15%-30% production goes as waste. These wastes pose a problems in present-day society, requiring a suitable form of management in order to achieve sustainable development. The waste employed came from ceramic industry which had been deemed unfit for sale due to a variety of reasons, including dimensional or mechanical defects, or defects in the firing process. In the research study the sand has been replaced by ceramic waste powder accordingly in the range of 50% by weight for M-20 grade concrete.

ADVANTAGES OF CERAMIC WASTE

The results demonstrate that the use ceramic masonry rubble as active addition endows sand with positive characteristics as major mechanical strength and the economic advantages. Reuse of this kind of waste has advantages economic and environmental, reduction in the number of natural spaces employed as refuse dumps. Indirectly, all the above contributes to a better quality of life for citizens and to introduces the concept of sustainability in the construction sector.

SOURCES OF QUARRY DUST

From the quarry industry, the quarry dust production goes as waste. The sources of quarry dust from the pan industries Sdn Bhd Batu Pahat, perlis. The quarry dusts are sieved until the fine aggregates was achieved is close to sand fine aggregates. The sizes of the quarry dust fine aggregate are between 4.75mm to 2.36mm.

ADVANTAGES OF QUARRY DUST

- It is also very cheap material.
- It gives good durability in partial replacement.
- It is also easy available.
- The property of quarry dust is almost same with the fine aggregate.

LITERATURE REVIEW

Ganesha Mogaveera. G. Sarangapani and Anand V.R. (2011) have studied the effect of partial replacement of sand by quarry dust in plain cement concrete for different mix proportions. They have concluded that sand can be replaced effectively by means of quarry dust up to 20% to 25%.

Shahul Hameed and Sekar (2009) deliberated the properties of green concrete containing quarry rock dust and marble sludhe powder as fine aggregate. They concluded that the compressive strength, split tensile strength and the durability properties of concrete made of quarry rock dust are nearly 14% more than the conventional concrete.

Safiuddin et al (2007) inferred the quarry waste fine aggregate enhanced the slump and slump flow of the fresh concrete. The weight and air content of the concrete were not affected. In hardened concrete, the compressive strength was decreased. The dynamic modulus of elasticity was marginally increased. But the Ultrasonic pulse velocity was not affected. They also concluded that the initial surface absorption was marginally increased.

M. Shukla and A K Sachan (2000) studied environmental hazardous stone dust utilization in building construction. It is found that partial replacement will not affect the strength and also slove the problems of disposal of stone dust. The workability of concrete reduces with the increase in stone dust and this can be improved by adding suitable admixtures.

Chandana Sukesh et al. They have studied about the partial replacement of cement in concrete by use of waste material like cement kiln dust, ceramic waste, palm oil fuel ash and plastic. All of these materials are industrial waste material and termed as hazardous waste to environment. They have found that the addition of up to 15% cement kiln dust as a cement replacement has a negligible effect on the strength of the block. Several concrete mixes possessing a target mean compressive strength of 30 Mpa were prepared with 20% cement replacement by ceramic powder. A concrete mix with ceramic sand and granite aggregates had also prepared as well as a concrete mix with natural sand and coarse ceramic aggregates. Results show the concrete with partial cement replacement by ceramic powder although it has minor strength loss possess increase durability performance. Experiments have been conducted by replacing 10%, 20%, 30%, 40% and 50% of POFA by weight of ordinary Portland cement. The properties of concrete, such as setting time, compressive strength, and expansion due to magnesium sulfate attack were investigated. The result revealed that the use of POFA in concretes caused delay in both initial and final setting times, depended on the fineness and degree of replacement of POFA. They have observed that they have added 5% plastic by weight, the strength and found to be two times greater than the plain cement concrete. With these results it is very clear that we can effectively use these eco-friendly materials in partial replacement of cement.

A.V.S. Sai. Kumar and Krishna Rao B. They have investigated the effect of strength of concrete with partial replacement of cement with quarry dust and Metakaolin. They have stated that concrete is a composite materials made from cement, water, fine aggregate and coarse aggregate. But present researchers are in interest of finding new cement material by waste material or waste products produced from industries which are harmful to environments. The paper is deals with partial replacement of cement with quarry dust and metalaolin which are having silica used as admixtures for making concrete. They have investigated first quarry dust is made partial replacement of cement and found that 25% of partial replacement is beneficial to concrete without loss of standard strength of cement. They have made 25% partial replacement of cement with quarry dust as constant, 2.5%, 5.0%, 7.5%, 10.0%, 12.5% metakaolin was made in partial replacement of cement and they had founded that quarry dust and metakaolin can be used as a partial replacement of cement.

A.M. Mustafa Al Bakril et al. They have investigated the strength of concrete with ceramic waste as replacement of coarse aggregates in concrete. The sources of cermic waste are obtained from the industrial in Malaysia. Presently, in ceramics industries the production goes as waste, which is not undergoing the recycle process yet. The potential of recycled ceramic waste as a substitute for coarse aggregates in concrete has been investigated. The recycle ceramic waste aggregate was used. Concrete mixes with a 28 days characteristic strength of 20 Mpa had prepared using water/cement ratio of 0.4, 0.5, and 0.7. The strength development of the concrete mixes containing recycled ceramic waste aggregates was compared to that of conventional concrete. They have resulted that the concrete mixes containing recycled ceramic waste aggregates achieve strength levels between 80 to 95% compared to the conventional concrete. They have concluded that ceramic waste can be effectively replaced partially by cement in concrete.

MATERIALS USED

Cement:It is the important binding material for the production of concrete. For using cement in important and major works it is incumbent on the part of the user to test the cement to confirm the requirements of the Indian standards specification with respect to its physical and chemical properties.

Fine Aggregate: It shall consist of natural sand. The specification require that it should consists of hand, dense, uncoated rock fragment and shall be free from injurious amounts of dust, clay, silt, mica and organic matter, soft and flaky practices. Fine aggregates should be selected so as to reduce the water demand hence rounded particles are thus preferred to crush rock fines where possible.

Coarse aggregate: It is the strongest and least porous component of concrete. Presence of coarse aggregate reduces the drying shrinkage and other dimensional change occurring on account of movement and moisture. Coarse aggregate contributes to impermeability of concrete, provided that it is properly graded and mix is suitably designed.

Water: It is an important ingredient of concrete as it activity participates in the chemical reaction with cement. The strength of cements comes mainly from the binding action of the hydrated cement gel. The requirement of water should be reduced to that required for chemical reaction of unhydrated cement as the excess water would end up in only formation of undesirable voids in the hardened cement paste concrete.

Ceramic waste: It is made from fired clay. They are a popular mosaic material. It can be brittle in nature. Ceramic wastes have suitable properties for construction like sand. Every ceramic companies should have 10% to 15% waste during the manufacturing process. But these waste can not be recycled that why we are choosing the material. Due to our project environmental effects also reduced.

Quarry Dust: It is defined as residue like waste material after the extraction and processing of rocks to form fine particles less than 4.75mm. Quarry dust can be an economic alternative to the sand.

TESTING PROCEDURE

TEST ON CEMENT

Fineness test: The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate on evolution of heat. Different cements are ground to different fineness. The disadvantages of fine grinding are that it is susceptible to early deterioration of concrete. Maximum number of particles in a sample of cement should have a size less than about 100 microns. The smallest particles may have a size of about 1.5 microns. By and large an average size of the cement particles may be taken as about 10 microns. The particles size fraction below 3 microns has been found to have the predominant affect on the strength at one day while 3-25 microns fraction has a major influence on the 28 days strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete.

Consistency test: For finding out initial setting time, final setting time and soundness of cement, and strength a parameters known as standard consistency has to be used. The standard consistency of a cement paste is defined as that consistency with will permit a vicat plunger having 10mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould. The apparatus is used to find out the percentage of water required to produce a cement paste of standard consistency. The standard consistency of the cement paste is some time called normal consistency.

Setting time test: An atbitraary division has been made for the setting time of cement as initial setting time and final setting time. For convenience, initial setting time is regarded as the time elapsed between the moments that the water is added to the cement to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.

Specific Gravity Test: Specific gravity of aggregates is made use of in design calculations of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solids volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required in calculating the compacting factor in connection with workability measurements.

Properties of cement

S.NO	Property	Value
1.	Sieve Analysis	2.2%
2.	Normal Consistency	30%
3.	Initial Setting Time	36 min
4.	Specific Gravity	3.15

TEST ON THE FINE AGGREGATE

Sieve Analysis: The aggregates used for making concrete are normally of the maximum size 80mm, 40mm, 10mm, 4.75mm, 2.36mm, 600microns, 300microns, 150microns are termed as fine aggregate. The aggregate fraction from 80mm to 4.75mm is termed as coarse aggregate and those fraction from 4.74mm to 150microns are termed as fine aggregates. Grading pattern of a sample of coarse aggregate or fine aggregate is assessed by sieving a sample successively through all the sieves mounted one over the other in the order of size, with large sieve on the top. The material retained on each sieve after shaking, represents the fraction of aggregates coarser than the sieve in question and finer than the sieve above. Sieving can be done either manually or mechanically.

Properties of Sand

S.NO	Properties	Sand
1.	Specific Gravity	2.67
2.	Density	1.83g/cm^3
3.	Sieve Analysis	9%

Properties of ceramic waste

S.NO	Properties	Ceramic Waste
1.	Specific Gravity	2.55
2.	Density	1.69g/cm^3
3.	Sieve Analysis	8.6%

Properties of quarry dust

S.NO	Properties	Ceramic Waste
1.	Specific Gravity	2.6
2.	Density	1.78g/cm^3
3.	Sieve Analysis	9.2%

TEST ON COARSE AGGREGATE

Sieve Analysis: The aggregate used for making concrete are normally of the maximum size 20mm, 16mm, 12.5mm, 10mm, 4.75mm, 2.36mm, are termed as fine aggregate. The aggregates fraction from 80mm to 4.75mm is termed as coarse aggregate and those fraction from 4.75mm to 15mm are termed aggregates. Grading pattern of a sample of coarse aggregate or fine aggregate is assessed by sieving a sample successively through all the sieve mounded one over the other in the order of size after shaking, represent the fraction of aggregates coarser than the sieve in question and finer than the sieve above, sieving can be done either manually or mechanically.

Water Absorption Test: Absorption values are used to calculate the change in the mass of an aggregate due to water absorbed in the pore spaces within the constituent particles, compared to the dry condition, when it is deemed that the aggregate has been in contact with water long enough to satisfy most of the absorption potential. The laboratory standard for absorption is that obtained after submerging dry aggregates for a prescribed period of time. Aggregate mined from below the water table commonly have a moisture content greater than the absorption determined by this test method.

Properties of Coarse Aggregate

S.NO	Properties	Coarse Aggregate
1.	Specific Gravity	2.64
2.	Water Absorption	0.13%
3.	Density	855.47kg/m^3
4.	Elongation	66.5%
5.	Flakiness	75.5%
6.	Impact	21.5%

TEST ON FRESH CONCRETE

It is important to appreciate that none of the test method for SCC has yet been standardized and the test described are not yet perfected or definitive. The methods presented here test procedures are description rather than fully detailed procedures.

Slump Flow Test:It is one of the most commonly used SCC tests at the current time. This test involves the use of slump cone used with conventional concrete as described in the main difference between the slump flow test and ASTM 143 is that the slump flow test measures the spread or flow of the concrete sample once the cone is lifted rather than the traditional slump of the concrete sample. It is simply the amount of time the concrete takes to flow to a diameter of 50 centimeters. Typically slump flow values of approximately 24 to 30 inches are within the acceptable range acceptable T50 times range from 2 to 5 sec.

HARDENED CONCRETE

Compressive Strength Test: It is one of most important of concrete and influences many other describable properties of the hardened concrete. The mean compressive strength required at a specific age, usually 28 days, determines the nominal water-cement ratio of the mix. Compressive strength of concrete is usually found by testing cubes and cylinder cube size 100mm*100mm*100mm and cylinder of size 150mm*300mm concrete specimen were casting using M25 grade concrete. Specimens with conventional concrete and SCC of two different percentages were casted. After 24 hours, the specimens were removed from the mould and subjected to water curing for 7, 14, 28 days.

Compressive Strength (fc) = P/A (N/mm2)
Where,
P= Load at which the specimen fails in Newton
A= Area over which the load is applied in mm2
fc= Compressive stress in N/mm2

Split tensile strength test: It is usually found by testing plain concrete cylinder. Cylinders of size 150mm*300mm were casting using M25 grade concrete. Specimens with conventional concrete and SCC of two different percentages were casted. During casting the conventional concrete cubes were manually compacted using tamping rod. After 24 hours, the specimens were removed from the mould and subjected to water curing for 7, 14, 28 days. After curing, the specimens were tested for compressive of 2000KN capacity.
Tensile strength of concrete (ft)= 2P/3.14(d*l)
Where,
P= Maximum load in N applied to the specimen
L = Measured length in cm of the specimen
D = Measured diameter in cm of the specimen

Flexural Strength of test: It is one of the measures of tensile strength of concrete. It is the ability of a beam to resist failure in bending. It is measured by loading un-reinforced 100mm*100mm with a span 500. Beam of size 100mm*100mm*500mm were casting using M25 grade concrete. Specimen with conventional concrete and SCC of two different percentages were casted. During casting the conventional concrete cube were manually compacted using tamping rods. After 24 hours, the specimen were removed from the mould and subjected to water curing for 28 days. The bed of testing machine should be supported and these rollers should be mounded that the distance from center is 50mm for 100mm specimen. The beam is simply supported and subjected to one third points loading flexure failure. The flexure strength is expressed as modulus of rupture in N/mm2.

Flexural Strength = pl/bd2 (N/mm2)

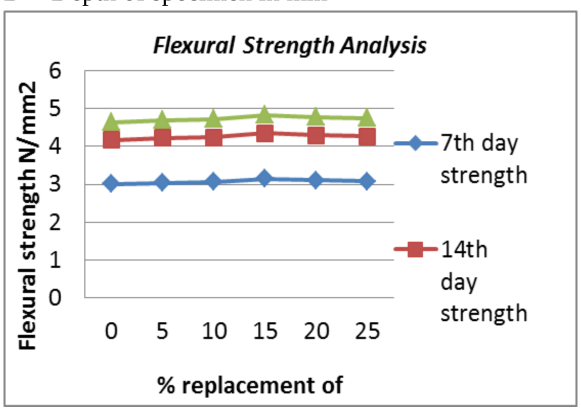
Where,

P = Load at which specimen fails in N

L = Effective span in mm

B = Breadth of the specimen in mm

D = Depth of specimen in mm



RESULT AND DISCUSSIONS

This chapter deals with the presentation of test results and discussion on compressive strength of ceramic waste and quarry dust concrete for 28 days curing. The present investigation is based on the IS method for conventional concrete. In this present investigation compression test is carried out of ceramic waste and quarry dust concrete.

TEST RESULT

Compressive strength of concrete: The compressive strength of hardened concrete is considered one of the most important properties and is often used as an index of the overall quality of concrete. The 2.5% and 5% replacement of cement with silica fume increases the compressive strength of concrete. This is due to the excessive fineness content and in appropriable content of 12.5mm coarse aggregate and fineness of silica fume. In case of concrete with silica fume there is a significant improvement in strength of concrete because of the high pozzolanic nature of silica fume and its voids filling ability.

7 days Results- Compressive strength of Conventional concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	198.8	10000	19.88
2	100*100*100	196.4	10000	19.64
3	100*100*100	199.0	10000	19.90
Average compressive strength 19.90				

7 days Results- Compressive strength of Conventional concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	145.6	10000	14.56
2	100*100*100	147.2	10000	14.72
3	100*100*100	146.8	10000	14.68
Average compressive strength 14.65				

28 days Results- Compressive strength of Conventional concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	198.8	10000	19.88
2	100*100*100	196.4	10000	19.64
3	100*100*100	199.0	10000	19.90
Average compressive strength 19.80				

7 days Results- Compressive strength of 50% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	53.2	10000	5.32
2	100*100*100	57.4	10000	5.74
3	100*100*100	55.8	10000	5.58
Average compressive strength 5.54				

14 days Results- Compressive strength of 50% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	103.3	10000	10.33
2	100*100*100	104.5	10000	10.45
3	100*100*100	102.5	10000	10.25
Average compressive strength 10.34				

28 days Results- Compressive strength of 50% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	181.5	10000	18.15
2	100*100*100	182.0	10000	18.20
3	100*100*100	187.5	10000	18.75
Average compressive strength 18.36				

7 days Results- Compressive strength of 50% Quarry Dust concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	85.5	10000	8.55
2	100*100*100	87.2	10000	8.72
3	100*100*100	86.5	10000	8.65
Average compressive strength 8.64				

14 days Results- Compressive strength of 50% Quarry Dust concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	138.7	10000	13.87
2	100*100*100	139.8	10000	13.98
3	100*100*100	139.6	10000	13.96
Average compressive strength 13.93				

28 days Results- Compressive strength of 50% Quarry Dust concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	190.5	10000	19.05
2	100*100*100	188.0	10000	18.80
3	100*100*100	191.0	10000	19.10
Average compressive strength 18.98				

7 days Results- Compressive strength of 25% Quarry Dust and 25% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	104.6	10000	10.46
2	100*100*100	102.4	10000	10.24
3	100*100*100	106.8	10000	10.68
Average compressive strength 10.46				

7 days Results- Compressive strength of 25% Quarry Dust and 25% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	104.6	10000	10.46
2	100*100*100	102.4	10000	10.24
3	100*100*100	106.8	10000	10.68
Average compressive strength 10.46				

14 days Results- Compressive strength of 25% Quarry Dust and 25% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	138.9	10000	13.89
2	100*100*100	139.7	10000	13.97
3	100*100*100	138.5	10000	13.85
Average compressive strength 13.90				

28 days Results- Compressive strength of 25% Quarry Dust and 25% ceramic waste concrete specimen

S. NO	Size of specimen (mm^2)	Ultimate load (KN)	Cross sectional area (mm^2)	Ultimate compressive strength (N/mm^2)
1	100*100*100	191.2	10000	19.12
2	100*100*100	199.0	10000	19.90
3	100*100*100	192.4	10000	19.24
Average compressive strength 19.42				

Cumulative Results for 7 days

S.NO	Specimen	Ultimate compressive strength (N/mm^2)
1.	CC	11.3
2.	CW	5.54
3.	QD	8.64
4.	CW and QD	10.46

Cumulative Results for 14 days

S.NO	Specimen	Ultimate compressive strength (N/mm^2)
1.	CC	14.65
2.	CW	10.34
3.	QD	13.93
4.	CW and QD	13.90

Cumulative Results for 28 days

S.NO	Specimen	Ultimate compressive strength (N/mm^2)
1.	CC	19.80
2.	CW	18.36
3.	QD	18.98
4.	CW and QD	19.42

CONCLUSION

In the present experimental study on concrete using ceramic waste and quarry dust, specimens were tested and the following conclusions are formed from the experimental investigation. The specific gravity is almost same both for the natural river sand, ceramic waste and quarry dust. The variation of physical properties like particle size distribution and bulking is much varying parameter that which effect of the concrete. Increase the percentage of ceramic waste and quarry dust reduce the flow of concrete. It gives better properties when compared to other concrete. However, on a more rational basis of total cost, including the labour charges, formwork and making good finished surfaces, it can be more advantageous. Ceramic waste and quarry dust are very cheap, it can be used successfully in place of sand, it gives good results at very low concrete. This is also a eco-friendly concrete and it can be avoid the environmental effects.

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