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EXPERIMENTAL INVESTIGATION ON HIGH PERFORMANCE CONCRETE WITH PARTIAL REPLACEMENT OF CEMENT WITH QUARTZ POWDER

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Abstract - The growth of concrete technology during the last decade has been mainly based on finding a substituent for cement. There is a needed to replace a part of cement by some pozzolanic material to reduce the consumption of cement and the environmental pollution can be checked to some extent. Industrial waste like fly ash, silica fume, blast furnace slag etc., have already established their usage in concrete. It is a cheaper and more easily available in the field. But maintenance repair and rehabilitation of the cement concrete structure involves lot of problem causing significant expenditures. Hence there is a need to pay more attention for improving the properties of the concrete with respected to the Strength and durability. The aim of the study is to determine strength properties of concrete with quartz powder as partial replacement of cement. The five variant concrete mixture were made by partially replacing quartz powder (up to 30%) to cement and added super plaster (0.8%). The mix proportion adopted was 1:1.35:0.29:0.8. Compressive and flexural strength test was carried out to evaluate the strength properties of concrete at age of 7 days.

***Key Words*: Quartz Powder, Cement, Fine Aggregate, Coarse Aggregate.**

1. INTRODUCTION

Cement is a binder substance used in construction that set and can bind other material together. The total production of cement world-wide is of 2000MT. India is the second largest cement producer in the world. The installed production capacity at present is nearly 165million tones (MT) annually. Cement is becoming a scare resources all over the world because of demand day by day. The construction activities have increased in almost all the developing countries of the world. There always has been great effort in improving the quality and standard of the properties of concrete as a construction material. Traditionally fly ash is added to concrete as a Pozzolanic material to enhance the properties of concrete. The use of quartz powder as a pozzolana material has increase in recent year because when mixed in certain proportion. It enhances the properties of both fresh and hard concrete like durability, strength, permeability, and compressive strength, flexural strength and tensile strength. Quartz powder is a very fine crystalline material.

1.1 Admixture

Quartz is the most abundant silica minerals. Pure Quartz is colorless and transparent. It occurs in most igneous, metamorphic and sedimentary rocks. It is mainly made up of silica. The chemical formula for quartz is Sio2. Quartz dust is a fine rock particle. Pozzolanic materials are generally able to combine with the hydrate calcium hydroxide (CA(OH)2) forming the hydrate calcium silicate (C-S-H), which is the principal responsible for the strength of hydration of cement. Quartz sand is used for traction in the rail board and mining industries. These sands are also used in the recreation on golf courses, volleyball court, baseball fields, children, s sand boxes and beaches, it is also used in glass manufacturing, petroleum industry as an abrasive. Quartz sand is used as filler in the manufactures of rubber, paint and putty. It has very good resistance to both chemical and heat. It is used as a foundry sand with a melting temperature higher than most metals. Refractory brick is often made of Quartz powder because of its high heat resistance.

On the basis of practical experience, it is seen that for concrete strength up to 100 Mpa maximum size of 20 mm aggregate could be used. However, for concrete in excess of 100 Mpa the maximum size of coarse aggregate should be limited to 10 to 12 mm.

1.2 Literature Review

A brief review of available studies related to the present strength properties of concrete materials is as follows:

Pauslon josph et al. (2017) In this studies attempt has been made to compare the mechanical strength of concrete of M30 grade by replacing cement by quartz powder. Specimen were cast by replacing cement by quartz powder 0%,5%,10%,15%,20%,30% percentage by weight cement. When 5%, 10% 15% percentage of quartz powder is added the compressive strength is increases by 9 6% At 10% than the normal concrete. The cement can be partially with 10% so that the required quantity for cement can be replaced by 134gms than 150*150*150 cubes. When the cement is replaced by textile sludge alone by 5%, 10%, 15% the maximum compressive strength is attained 5% and the value decreases as the percentage increases.

Run-sheng lin xiao-young wang et al. (2018) The paper compares the effects of the water to-binding (w/b) ratio and quartz contents on the properties of cement-quartz paste. The w/b ratio of the paste mixtures specimens are 0.5 and 0.2, and the quartz powder content are 0,10and 20%. At the age of 1, 3, 7 and 28 days, compressive strength, (SEM) XRF, XRD MIP and TG analysis were performed. When the w/b is 0 5 the compressive strength of the paste with quartz powder significantly decreases. from MIP and SEM test, the porosity of the paste is increases significantly due to the incorporation of the quartz powder. How were when the w/b ratio is 0.2 the strength of the paste mixed with quartz powder show no significant differences from that of the control paste and porosity is almost the same,

R.L. Ramesh et al. (2013) The experimental investigation was carried out to study the cube compressive strength of fibre reinforced concrete cube incorporating silica fume and metakaolin with and without steel fibers of grade M70. Using different combination of materials were casted. The cube was cured and tested under a direct compression testing machine at time period of 3, 7, 14, and 28 days. They use different mix proportion tested for 3, 7, 14and 28 days compression strength test found to gain more strength than any other.

1.3 Objective

1. Design mix of high strength concrete above M60 grade using manufactured sand.
2. Durability properties for HSC of M60 grade using manufactured sand.

2. Material Used

2.1 Cement

Ordinary Portland cement is composed of calcium silicates and aluminate and alumina ferrite. It is obtained by blending predetermined proportions limestone, clay and other minerals in small quantities which is pulverized and heated at high temperature–around 1500 deg centigrade to produce “clinker”. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland Cement (OPC). When mixed with water, sand and stone, it combines slowly with the water to form a hard mass called concrete. Cement is a hygroscopic material meaning that it absorbs moisture in presence of moisture it undergoes chemical reaction termed as hydration. Therefore, cement remains in good condition as long as it does not come in contact with moisture. If cement is more than three months old then it should be tested for its strength before being taken into use.

2.2 Coarse aggregate

Coarse aggregate for the works should be river gravel or crushed stone. It should be hard, strong, dense, durable, clean, and free from clay or loamy admixtures or quarry refuse or vegetable matter. The pieces of aggregates should be cubical, or rounded shaped and should have granular or crystalline or smooth (but not glossy) non-powdery surfaces. Aggregates should be 10 properly screened and if necessary washed clean before use. Coarse aggregates containing flat, elongated or flaky pieces or mica should be rejected. The grading of coarse aggregates should be as per specifications after 24-hrs immersion in water, a previously dried sample of the coarse aggregate should not gain in weight more than 5%. Aggregates should be stored in such a way as to prevent segregation of sizes and avoid contamination with fines.

2.3 Fine aggregate

Aggregate which is passed through 4.75 IS Sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability and to bring uniformity in mixture. Usually, the natural river sand is used as fine aggregate. Important thing to be considered is that fine aggregates should be free from coagulated lumps. Grading of natural sand or crushed stone i.e. fine aggregates shall be such that not more than 5 percent shall exceed 5 mm in size, not more than 10% shall IS sieve No. 150 not less than 45% or more than 85% shall pass IS sieve No. 1.18 mm and not less than 25% or more than 60% shall pass IS sieve No. 600 micron.

2.4 Quartz Powder

Pozzolanic material are generally able to combine with the hydrated calcium hydroxide (Ca (OH) 2 forming the hydrate calcium silicate (c-s-c), which is the principal responsible for the strength of hydrate cement pastes. It also increases in the bulk density of concrete result as the mixture voids are filled with very small admixture particles. It can produce both chemical and physical effects, which cause meaningful changes in the microstructures of concrete, diminishing its permeability and improving strength. The most important region in the micro-structure of concrete is around aggregate. The addition of quartz powder in concrete leads to reduction in porosity of the transition zone between matrix and aggregate in the fresh concrete and provided the micro-structures needed for a strong transition zone. Hence Quartz powder is replaced 0, 5%,10%,15%,20%,30% by the weight of cement. The fineness of the quartz powder is 200 mesh which is equivalent to 74 micron which is finer than cement. It is a very reactive due to. It’s finer than cement. It is a very reactive due to its fine size and high purity of silica content.

2.5 Chemical Admixture

The use of super plasticizer is practiced for production of flowing, self levelling, And Self-compacting and for the production of high strength and high-performance concrete. The mechanism of action of super plasticizer are more or less same as explained earlier in case of ordinary plasticizer. The use of super plasticizer made possible to use w/c as low as 0.29 or even lower and yet to make flowing

concrete to obtain strength of the order 120 Mpa or more. To use fly ash, slag and particularly silica fume to make high performance concrete super plasticizer is used.

3. Material Testing

3.1 Test on Cement

Table -1: Sample Table format

S. No	Property	Value
1	Specific gravity	3.15
2	Fineness	22.5
3	Initial setting time	30 mins
4	Final setting time	132 min

3.2 Specific Gravity Test

Table -2: Test on specific gravity

Material	Values
Cement	3.15
M.sand	2.74
Coarse aggregate	2.6
Quartz powder	2.55

3.3 Specific Gravity Test

From the sieve analysis test of fine aggregate values obtained are conforming to Zone II as per IS 383:1970

Fineness modulus **=*Sum of cumulative* % *weight retained*/100 =** 2.73

Fineness Modulus = 2.73

3.4 Water Absorption Test

Table -3: Test on Water Absorption

Materials	Water Absorption (%)
Coarse aggregate	0.5
Fine aggregate	0.5

4. Mix Design

1. The mix design procedure is done with IS 10262-2019.

2. Grade of concrete is taken as **M60** for high performance concrete.

3. Degree of workability is taken as high based on slump value **150 to 200.**

Table-4: Mix proportion

Cement: fine aggregate (kg/m^3): Coarse aggregate (kg/m^3): water (l/m^3): Super plasticizer (l/m^3)	1:1.35:2.19:0.29:0.8

Table-5: Cement + Quartz Powder

S.NO	CEMENT+QUARTZ POWDER	REPLACEMENT %	MIX PROPORTION
1	CQ	0	CSA
2	CQ	5	CSB
3	CQ	10	CSC
4	CQ	15	CSD
5	CQ	20	CSE
6	CQ	30	CSF

5. Casting and Curing of Specimens

The specimens were in the moulds undisturbed at room temperature for about 24 hours after casting. The specimens after removing from the moulds were immediately transferred to curing ponds containing clean and portable water. The specimens are then tested accordingly at the end of 1 days, 3days, and 7days.

Fig -1: Casting of Specimens

Fig -2: Curing of Specimens

6. Result and Discussion

6.1 Compression Strength:

Compression strength test was conducted at 1, 3, 7 and 28 days on 150mm cubes as per IS 516:1959.82

Table -6: Compression Strength of Cube on (0%) Quartz Powder

AREA mm²	LOAD (KN)	COMPERSSION STRENGTH (N/mm²)
150*150*150	674.3	58
150*150*150	665.9	60
150*150*150	645.6	59.5
Average		59

Table -7: Compression Strength of Cube on 10% Quartz Powder

AREA mm²	LOAD (KN)	COMPERSSION STRENGTH (N/mm²)
150*150*150	638.3	60
150*150*150	665.9	62
150*150*150	645.6	61
Average		61.5

Table -8: Compression Strength of Cube on 30% Quartz Powder

AREA mm²	LOAD (KN)	COMPERSSION STRENGTH (N/mm²)
150*150*150	1074.9	46.99
150*150*150	998.1	44.84
150*150*150	995.3	44.22
Average		45.35

Fig -3: Compressive Strength Test

7. Conclusions

1. From the compressive strength result it is seen that the strength of concrete Increase on addition of quartz powder as replacement of cement.
2. When the replaced by quartz powder alone 0%, 5% ,10%, 20%, 30% percentage Compressive strength value Increase.
3. The compressive strength obtained is 60N/mm² while replacing 10% Quartz powder which shows that strength obtained is 10% higher than the characteristic strength of concrete that is M60.

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