AN EXPERIMENTAL INVESTIGATION ON MECHANICAL PROPERTIES OF CONCRETE BY PARTIAL REPLACEMENT OF QUARTZ POWDER AND CRIMPED FIBERS.

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Abstract *: The purpose of experimental study is to find the effect of quartz powder and crimped fibers on strength properties of concrete. A partial substitution of cement by an quartz powder are utilized as a replacement of cement. It is proposed to study the cement is partially replaced the material of 10%,20%&30% of quartz powder and crimped fibers with constant ratio 1.5.The impact shared utilization of quartz powder and fibers on compressive strength, split tensile strength of* M_{25} *grade of concrete is studied. To tackle it, we chose quartz; a mineral commonly found in cement-based matrices and supposed to be chemically inert because of its crystalline structure. The pozzolanic reaction of quartz is a complex dissolution precipitation reaction influenced by numerous parameters. It is only barely perceptible for the particle diameters exceeding a certain critical size. The XRD analysis is carried out to know the bond characteristics in the concrete specimens.*

Key words: OPC, Crimped fibers, Quartz powder, Coarse aggregate, Fine aggregate.

I. INTRODUCTION

Concrete is the most important materials among the building materials. The characteristics of concrete as a building material to develop the strength, durability and economy have made it the world's most widely used construction material.

The production of one ton of cement consumes about 1.5 tons of raw materials, 80 units of electric power apart from 400Kg of CO_2 released into the atmosphere. Out of the total CO_2 emissions (from various sources) worldwide, cement industry alone contributes about 7% of CO_2 emissions .Annual cement production rate of the world is increasing very much year by year. This environmental problem will most likely be increased due to exponential demand of Portland cement: By 2050, demand is expected to rise by 200% from 2010 levels, reaching 6000 million tons/year.

Demand can be reduced by using supplementary cementing materials and other material which reduce Portland cement content of concrete. The properties of concrete can also be improved by using by-products and natural wastes as supplementary cementing material. Lot of energy and cost can also be saved by using these natural wastes and industrial by-products as partial replacements to OPC .Concrete is certainly the one of the most important construction material in the world. It use is over 10 billion tons per year and, when done well, concrete can present good mechanical strength, and also, acceptable durability performance. The one of the most important components of concrete is the binder and in normal concretes. It is in some cases, the presence of mineral additions, such as fly ash or silica fume etc…. are also be can be observed in its composition Quartz, most common of all minerals is composed of silicon dioxide, or silica, sio_2. It is an essential component of igneous and metamorphic rocks. The size varies from specimens weighing a metric ton to minute part
icles that sparkle in rock surfaces. The luster in some specimens is vitreous; in others it is greasy or glossy. Some specimens are transparent; others are translucent. In pure form, quartz is colorless from of quartz occurring in distinct crystals Rose quartz is coarsely crystalline and colored rose red or pink. Smoky yellow to dark brown. Amethyst, a semiprecious variety of quartz, is purple or violet.

II. MATERIALS AND METHODS

In present investigation the collected materials are 53 grade OPC cement, Quartz powder, Natural sand, crushed granite aggregate were used in concrete.

Cement:
Cement is a binder material, which is used in construction that sets and binds to another material together. In the present investigation, commercially available 53 grade ordinary Portland cement was supplied by Zuari cement with specific gravity of 3.12 and fineness modulus of 225m^2/kg . The cement confirming to IS 12269-1987 is used in this investigation.

Fig: 1 cement

Quartz powder:

Quartz powder was obtained from Kajavalli minerals near Gudur(M). Devipalam(V). The Specific gravity of quartz powder is 2.55 and the Quartz powder particle Size is calculated by using XRD test analysis for the samples. XRD of quartz is shown in Fig. 1

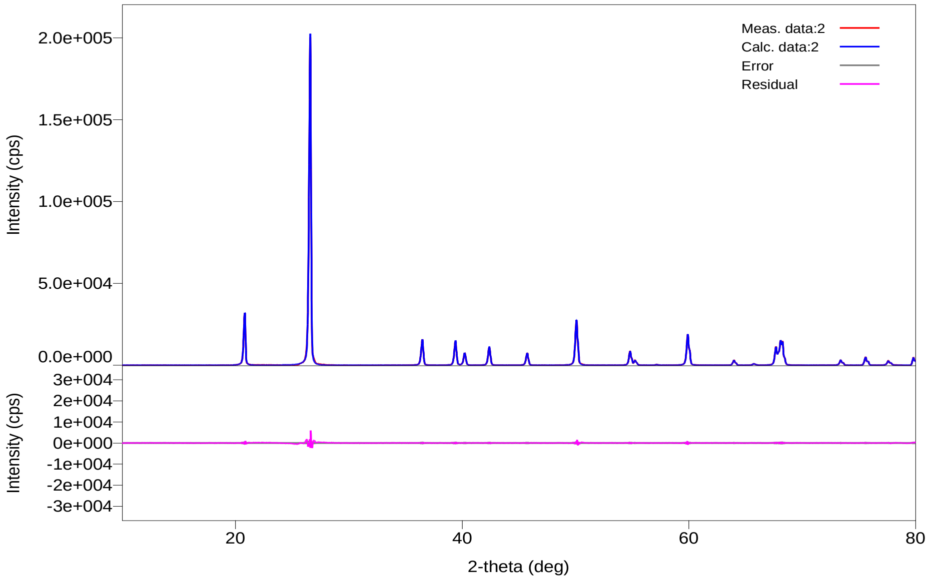


Figure: 2 XRD analysis for Quartz powder.

Fig:3 Quartz powder

Table: 1 Chemical properties of Quartz powder in physical properties.

Property	Amount
SiO_2 content	99 %
$MgCO_3$ content	0.01 %
Fe_2O_3 content	0.03 %
CaO content	0.03 %
Al_2O_3 content	0.05 %
SO_3 content	3.03 %
Specific gravity	2.55

Crimped steel fibers

Crimper steel fibers are low carbon, cold drawn steel wire fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete. Crimped steel fibers compiles with ASTM C116, standard specification for fiber reinforced concrete. Steel fiber (SF) with two values of aspect ratios (50 mm length and 1mm diameter). 1.5 % constant dosages of fibers are used by weight of cement. These steel macro-fibers will also improve impact, shatter, fatigue and abrasion resistance while increasing toughness of concrete. Dosage rates will vary depending upon the reinforcing requirements and can range from 25 to 60 kg/m^3.

Fig: 4 Crimped fibers

Coarse aggregate:

In the present investigation, crushed granite aggregate of 20 mm size was used. The specific gravity of coarse aggregate is 2.7. The physical requirements of coarse aggregate such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS 2386-1963 and IS 383-1970. Fineness modulus is obtained by using sieve analysis. Coarse aggregate was obtained from localized Quarry near Rajampet in Kadapa district.

Fig: 5 Coarse aggregate

Fine aggregate:

The amount of the fine aggregate usage is important to fill the voids present in coarse aggregate. In this investigation, natural sand was used as fine aggregate passing through 4.75mm sieve and retained on 600µ sieve conforming zone-2 as per IS 383-1970. The specific gravity of sand is found to be 2.65. The aggregate was tested for its physical properties such as gradation, fineness modulus, specific gravity ,bulk density in accordance with IS 2386-1963. Sand was obtained from Bahuda River near nandalur in Kadapa district

Fig:6 Fine aggregate

III. MIX PROPORTIONING

In present investigation M_{25} grade of concrete is used with water – cement ratio is 0.50. The M_{25} grade of concrete mix design is done as per IS 10262: 2009 with mix proportions 1:1.95:3.16 concrete mixtures were prepared by varying percentage of replacement with Quartz powder by 10%, 20%, 30%.

IV. EXPERIMENTAL INVESTIGATION

Compressive Strength Test:

The compressive strength of concrete (150mm×150mm×150 mm) are tested by means of compressive testing machine according to IS 516-1959. The specimens are tested after 7, 28,56 and 90 days. The cube was tested by using compression testing machine with 40tonnes capacity which is available in concrete technology laboratory at AITS, Rajampet. The experimental arrangement is shown in figure. The cube compressive strength can be calculated as follows. If f_c is compressive strength of cube,

Then $F_c = \frac{P}{A}$ N/mm^2

Where P is an ultimate load in newtons.
A is a cross sectional area of cube in mm^2.

Fig:7 Compressive Strength test

Split Tensile Test:

Split tensile strength on concrete cylinder is a method to determine the tensile strength of concrete .Split tensile strength of concrete is as prescribed by IS 5816- 1999 is conducted. Specimens of 150mm diameter × 300mm height were used for this test. The specimens were tested for 7, 28, 56 and 90 days. The cylinder specimen was placed in horizontal direction on the testing machine. The load was applied uniformly at a constant rate of 1.4 N/m^2/s until the failure by splitting along the vertical axis tool place. The following relation is used to find out the split tensile strength of cylinder Ft = $\frac{2p}{\pi DL}$.

Where Ft is split tensile strength
P = Ultimate load in newton.
L = length of the cylinder in mm.
D = diameter of the cylinder in mm.

Fig:8 Split tensile strength

Rapid Chloride ion penetration test:

According to ASTM C 1202 test, 50mm thick, 100mm diameter concrete specimen is subjected to a 60v applied DC voltage for 6 hours using the RCPT apparatus. In one reservoir is a 3.0% NaCl solution and in the other reservoir is a 0.3 NaOH solution. The total charge passed is determined and this is used to rate the concrete according to the criteria included. Average current flowing through one cell is calculated by,

$I= 900[I_0+2(I_{30} + I_{60} + I_{90} + I_{120} + I_{150} + I_{180} + I_{210} + I_{240} + I_{270} + I_{300} + I_{330}) + I_{360}]$

Where

I_0 = Initial reading in mA and I_{30} to I_{360} are readings taken at every 30 min interval 'I' is measured in coulombs.

Charge passed (coulombs)	Chloride ion permeability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

Table 2 RCPT ratings (per ASTM C1202)

Fig:9 Rapid chloride penetration test setup

Water permeability:

The determination of water penetration depth is specified by BS EN- 12390-8:2000. In this test, water was applied on the face of the 150mm concrete specimen under a pressure of 5 to 10 kg/cm^2. The constant pressure maintained for a period of 72 h. After the period, the specimen were taken out and split into halves. The water penetration contour in the concrete surface was marked and then maximum depth of penetration value has to be recorded as water penetration. This test will be conducted after all curing days of concrete cubes. Generally, tests of penetration of liquids through concrete due to a pressure gradient provide the means of measuring the intrinsic permeability as defined by Darcy's law. The basic requirement of this test is that the specimen should be sealed on all sides other than two opposite parallel faces between which the flow of liquid can be promoted by an applied pressure head. In the present investigation a new rapid water permeability method is adopted. As the conventional water permeability method takes a long time (up to several months). If the depth of penetration of water is d, then the coefficient of permeability of concrete is calculated by using the following formula.

$$K = \frac{D^2 V}{2HT}$$

Where, k = coefficient of permeability.
D = depth of penetration of concrete (m).
V = the fraction of volume of water\concrete occupied by pores
H = hydraulic head (m) and
T = time under pressure (seconds).
V is calculated using the expression.

$$V = \frac{1000M}{A.D}$$

Where M = gain in mass (g).
A = c/s area of concrete (mm^2).
D = depth of penetration (mm)
M = water penetrated in 'g'.
H = height of head (m)

Fig:10 Test set up for water permeability of concrete

V. RESULTS AND DISCUSSION

The M_{25} grade of OPC result with various proportions of Quartz powder was tested for compressive strength, Split tensile strength, Chloride ion penetration and water permeability test.

Table 3 shows the percentages of Quartz powder for M_{25} grade concrete

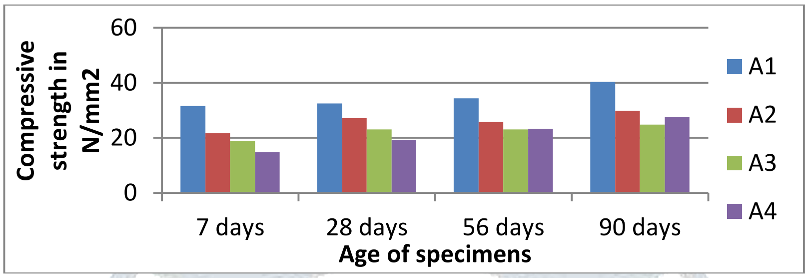
Mix Designation	Binding materials
A1	100% cement
A2	10% quartz powder+ 1.5 ratio crimped fibers + 90% cement
A3	20% quartz powder+ 1.5 ratio crimped fibers + 90% cement
A4	30% quartz powder+ 1.5 ratio crimped fibers + 90% cement

Effect of quartz powder and crimped fibers on compressive strength

The concrete specimens with partial replacement of cement by quartz powder were tested by using CTM and the test results are shown in table no: 4, Graph 1 gives the graph shown in compressive strength of different concrete mixtures at 7, 28, 56 and 90 days.

Table 4 shows compressive strength of concrete

Mix Designations	Compressive strength (N/mm^2)			
	7days	28days	56days	90days
A1	31.66	32.53	34.46	40.3
A2	21.7	27.26	25.83	29.8
A3	18.9	23.13	23.06	24.8
A4	14.8	19.26	23.33	27.46

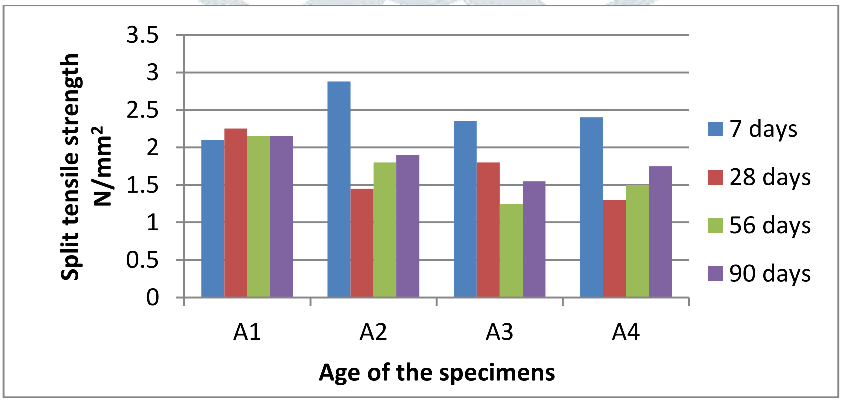


Graph 1.Effect of quartz powder on concrete

At 7 days curing age, it was observed that the compressive strength showed an increase as the Quartz powder content increased up to 20%.

Table 5: Split tensile strength results for concrete cylinder specimens

Mix Designation	Tensile strength(N/mm^2)			
	7days	28days	56days	90days
A1	2.1	2.25	2.15	2.15
A2	2.88	1.45	1.8	1.9
A3	2.35	1.1	1.25	1.55
A4	2.4	1.3	1.5	1.75



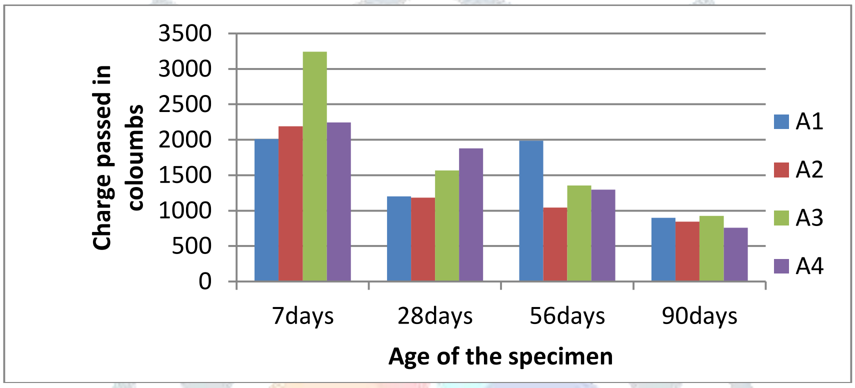
Graph 2.Effect of Quartz powder on Split tensile concrete.

At 7days curing age, it was observed that the split tensile strength showed an increase as the Quartz powder content increased up to 15%.

The RCPT of M_{25} grade concrete mixes replacing OPC by Quartz powder at 10%, 20%, 30% is investigated. The results of RCPT of A1,A2,A3 and A4 concrete mixtures tested at all curing days are represented in table-5. A graphical representation age versus RCPT is represented in table.7

Table 6: Rapid Chloride ion permeability test results.

Mix no.	Proportion of binding materials	Rapid chloride permeability test, mAh			
		7days	28days	56days	90days
A1	Conventional mix	2010.43	2189.68	3242.32	2245
A2	90% Cement+10% quartz powder+1.5 ratio crimped fibers	1200.08	1184.90	1567.32	1876.98
A3	80% Cement+20% quartz powder+1.5 ratio crimped fibers	1984.90	1045.00	1354.78	1298.0
A4	70% Cement+30% quartz powder+1.5 ratio crimped fibers	900.6	845.56	927.3	756.6



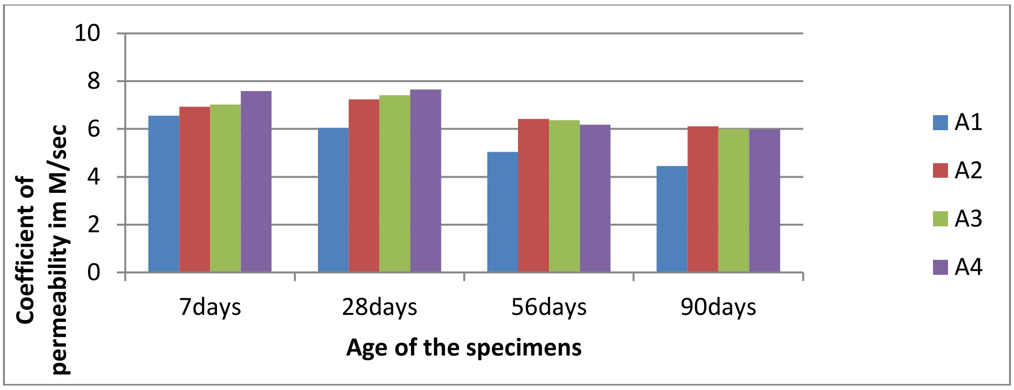
Graph 3: chloride penetration Vs percentage of Quartz powder

Effect of quartz powder on water permeability test of concrete:

The Water penetration test M_{25}grade concrete mixes replacing OPC by Quartz powder at 10%, 20% and 30% were investigated. The results of water penetration of A1,A2,A3 and A4 concrete mixtures tested at all curing days are represented.

Table 7. shows depth of penetration in mm

S.NO	Mix Notation	Depth of Penetration in m/sec			
		7days	28days	56days	90days
A1	Conventional concrete	6.56×10^{-13}	6.93×10^{-13}	7.02×10^{-13}	7.58×10^{-13}
A2	90% cement+10%quartz powder+1.5 constant ratio of fibers	6.05×10^{-13}	7.23×10^{-13}	7.41×10^{-13}	7.65×10^{-13}
A3	80%cement+20% quartz powder+1.5constant ratio of fibers	5.04×10^{-13}	6.418×10^{-13}	6.36×10^{-13}	6.18×10^{-13}
A4	70% cement+30%quartz powder+1.5 constant ratio of fibers	4.45×10^{-13}	6.106×10^{-13}	6.08×10^{-13}	5.98×10^{-13}



Graph 4: Water penetration Vs percentage of Quartz powder

Many researchers have observed that there was increase in compressive strength and tensile strength of concrete on using Quartz powder and crimped fibers.

VI. CONCLUSION

The result of the present investigation show that Quartz powder and crimped fibers can be used as a Pozzolanic material in concrete.

1. The Compressive strength of M_{25} grade concrete increases with increase in replacement of cement by Quartz powder up to 30%.
2. The compressive strength of M_{25} grade concrete with quartz powder increase with age.
3. Maximum compressive strength is obtained at 10% replacement of OPC by quartz powder at 90 days which is about 26% higher than the strength of conventional concrete.
4. At split tensile strength concrete increases with replacement of OPC by quartz powder up to 10%.After 10% of replacement the split tensile strength decreases the maximum tensile strength of concrete with 10% replacement of quartz powder is about 16.5% more than the Standard concrete.
5. The chloride permeability of concrete decrease with increase in replacement of OPC by quartz powder. At 20% replacement, the total charges passed through the specimen indicate that the chloride permeability is very low.
6. The water permeability of concrete decreases with increase in replacement of OPC by quartz powder. At M_{25} concrete with replacement of OPC by 30% of quartz powder shows the least water permeability.
7. The depth of water penetration of M_{25} concrete with quartz powder (at 10 bar pressure) decreases with increase in the percentage of replacement of OPC by quartz powder. The depth of penetration of conventional concrete is 60mm at 90 days. The depth of penetration of water for concrete with 30% of quartz powder is 50mm.

   From the result, the comparison between quartz powder & crimped fibers shows that the concrete had significantly higher compressive strength compare to that of the conventional concrete. It is found that the cement could be advantageously replaced with quartz powder up to limit 30%. Although, the partial replacement of cement by quartz powder increases workability of fresh concrete then compared to quartz powder.

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