International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 4, Issue 11, November-2018

STUDY OF THE EFFECT OF QUARTZ POWDER ON COMPRESSIVE STRENGTH IN ULTRA HIGH PERFORMANCE CONCRETE

S. M. AMANI[1] & T. CHANDRA SEKHARA REDDY[2]

[1]*M .Tech in Civil engineering Department, GPREC, Kurnool, Andhra Pradesh, India*
[2]*Professor of civil engineering department, GPREC, Kurnool, Andhra Pradesh, India*

ABSRACT:- Concrete is the most predominantly used engineering material in construction industry because of its strength, durability and less cost when compared to other construction materials. During the past few years Ultra high performance concrete (UHPC) is one of the emerging high tech building material which exhibit excellent performance and generate economic benefit. UHPC varies from the traditional concrete due to no coarse aggregate present in it , contains only the fine materials like quartz powder, quartz sand, silica fume. The present study focuses on UHPC with compressive strength greater than 170Mpa by varying the percentage of quartz powder by the weight of cement.. To improve the micro structural properties of UHPC and to accelerate the pozzolanic reaction between silica fume and quartz powder thermal curing was done. Cube specimens of 70.6mm×70.6mm×70.6mm size were casted and at the age of third day exposed to a temperature of 200℃ in oven curing for a time period of 24, 48 and 72 hours followed with water curing up to 28 days. The percentage changing of quartz powder in UHPC results the compressive strength ranges from 140MPa to 175MPa . From these study it was observed that the variation of quartz powder and the time span of temperature curing affects the compressive strength. Finally, the compressive strength of UHPC with175MPa was achieved at 40% of quartz powder by the weight of cement was used with 48 hours thermally cured at 200◦c.

Keywords: ultra high performance concrete, silica fume, quartz sand, quartz powder, compressive strength, thermal curing.

1. INTRODUCTION

Ultra high performance concrete was a composite cement based material with higher mechanical properties which includes more compressive strength, excellent toughness , superior bending resistance, high durability, and more resistance towards impact. The less porous nature exists in it results better durable compare to traditional concrete. Pierre Richard and marcel cheyrezy[1] developed the first UHPC in the 1900's at Bouygues laboratory in France. The first UHPC structure was Sherbrooke bridge constructed in Canada.
UHPC has very less porosity, predominantly under the heat treatment. In UHPC, portlandite consumed was more than the traditional concrete. The secondary hydration is promoted by the thermal curing between the mineral admixtures and $Ca(OH)2$ in concrete.(Dehui Wang, Caijun Shi et al)[2]. M.K.Maroliya et al [3] In UHPC micro structural analysis noticed that good bond strength is present at the interfacial zone of UHPC between the hydrated cement matrix and steel fiber . Microscopic images of UHPC conformed that the presence of hydrated cement on side surface of steel fiber in SEM images . The variation of the microstructure was due to the disposition of C-S-H compounds . Microstructure with the specimen cured at high tempetrature has much compressive strength than that of normal water cured sample. Doo-Yeol Yoo, Nemkumar Banitha et [4] investigated the UHPC mechanical properties , considering the different influential characteristics. In UHPC the mechanical properties are developed with the effect of the curing conditions, mineral admixtures fiber properties, specimen size was precisely investigated. While it was obvious that twisted steel fibers provides better tensile or flexural rate when compared to straight steel fibers. Sung-Hung Kang, Ji-Hyung Lee et al [5] stated that the heat treatment promotes the both cement hydration and pozzolanic reaction , the increased amount of pozzolanic reaction in UHPC clearly improves the compressive strength . Microstructural investigation recommended that in UHPC the amount of portlandite can be a good indicator for mechanical performance . Halit yazici et al [6] presented on compressive strength in UHPC with more volume of mineral admixtures. With more volume of fly ash or granulated blast furnace slag under autoclave or steam curing can improve the mechanical properties. Muhammad Abid et al[7] stated that compressive strength, tensile strength and modulus of elasticity deteriorate with excess temperature curing range. Initially compressive strength increases up to 350℃ and the sharp strength decrease from 350◦c to 800◦c, finally at above 800◦c UHPC losses its complete strength. Pu Zhang et al [8] investigated that at standard curing conditions UHPC with high compressive strength and good workability was achieved. The compressive strength and the slump of UHPC was greatly influenced by W/B ratio. Based on compressive strength and the fluidity the optimal W/B ratio is 0.194.Tinaoertal et al [9] stated that hydration of UHPC was influenced by amorphous silica in it. Amorphous silica plays an important role in the UHPC to solidify the micro structure and promotes the clinker hydration . T.ZBED et al[10] the UHPC properties were compared with the traditional concrete and stated that the components which have colloidal size particles (super plasticizer or silica fume) influences directly the structure and properties of C-S-H phase which acts as the main leading factor for achieving such outstanding UHPC mechanical

properties. Zhiming ma ea al [11]investigated the impact of loads applied on the permeability behavior of UHPC by steel fibers addition. Self healing treatment can predominantly lowers the damage caused with the applied loads which was benefited to improve the permeability resistance and durability of UHPC..Janis Just et al [12] presented micro structural investigations of UHPC by pressure application. By the application of pressure of 50Mpa the specimens have significantly very low pore volume and overall pore sizes was reduced. SEM images displays that at 6month age sample much denser micro structure was observed than that of 28 day aged sample.

So the objective of the present investigation is to experience the production of the UHPC. The worth issue of the study is to get the compressive strength of UHPC more than 170Mpa. By changing the amount of quartz powder, UHPC samples were casted to study the effect of the quartz powder on compressive strength by thermal curing, followed by water curing.

2. MATERIALS AND THEIR PROPERTIES

2.1 Cement

53grade ordinary Portland cement of ultra tech brand confirming to IS 12269-1987 is used in the present investigation.

2.2 Silica Fume

Silica fume was confirmed to ASTM 1240 and IS 15388:2003. It was brought from the Astra chemicals Ltd, Chennai .It was an amorphous polymorph of $SiO2$. silica fume is recognized by pozzolanic material which enhances mechanical properties to concrete. It fill up the voids between the larger particles of cement and filler grains, thus gives the packing density.

TABLE 1
PROPERTIES OF SILICA FUME

S No.	**Properties**	
1.	Form	Ultra fine amorphous powder
2.	Color	White
3.	Specific gravity	2.63
4.	Pack density	0.76 gm/cc
5.	Specific surface	$20m^2$/g
6.	Particle size	15um
7.	SiO2	99.89%

2.3Quartz powder

Less than 150μm sized crushed Quartz powder was used. The quartz powder was taken from Pudicherla, near orvakal , Kurnool. It increases the packing density of the mix by consuming portlandite through pozzolanic activity. The quartz powder has specific gravity 2.6.

2.4 Quartz sand

Quartz sand is yellowish white high purity silica sand. It was brought from pudicherla near orvakal in Kurnool. The quartz sand taken comprises of Grade1 (particle sizes ranges from 1180 μm -600 μm), Grade 2 (particle size ranges from 600 μm -300 μm), Grade3 (particle size ranges from 300 μm -150 μm) and the quartz sand has 2.62 specific gravity.

2.5 Steel fibers

Micro steel fibers with aspect ratio of 38 was choosen having the length of 13mm,diameter 0.35mm and the tensile strength of 2000Mpa and brought from Fiber zone, Ahmadabad, India.

2.6 super plasticizer

In UHPC, due to usage of less W/C in order to improve its strength high range water reducing admixture was used in the present study Super plasticizer of Master Glenium sky 8233 formly B-233 which is a poly carboxylic ether based is taken. It was brought from BASF India Ltd construction chemicals – Secunderabad.

TABLE 2
PROPERTIES OF SUPERPLASTICIZER

S.No	**Properties**	**Glenium B-233**
1.	Type of SP	Polycarboxylic ether
2.	Appearance	Light brown
3.	PH value	≥6
4.	Specific gravity	1.08
5.	Solid content	Less than 30% by weight
6.	Chloride content	<0.2%

3. EXPERIMENTAL PROGRAMME

3.1 Mix proportion

As there was no mix design for UHPC, the mix design for present study is taken by referring various literatures. From the past papers it was noticed that 0.25 is the ratio of silica fume/cement content and 0.4 is the ratio taken for quartz powder/cement content respectively to get good mechanical properties. The 2% by volume or about 155 kg/$m^3$is the optimal dosage for steel fibers .Quartz sand and super plasticizer are used in the mix for better workability. The mix proportion of UHPC with the variation of quartz powder was mentioned in table 3.

3.2Mixing procedure

- To mix all the ingredients of UHPC a 40 kg capacity pan mixer machine was used.
- All the dry ingredients like cement, silica fume, quartz sand and quartz powder are mixed well about 3 minutes. While the mixer was rotating at slow speed add water and 40% of SP to the premix slowly over a course of 2 minutes.
- After 1 minute remaining SP was poured into the premix and mixing was done at slow speed about 2 to 3 minutes
- Additional mixing was done at these speed for 20 to 25 minutes until a uniform mix was attained .
- When the flowable consistency was observed then add steel fibers slowly and continued mixing about 2 minutes.

TABLE 3
PROPORTION OF UHPC MIXES

Mix	**QP-1 35% QP**	**QP-2 40% QP**	**QP-3 45% QP**
Material	**Kg/m^3**	**Kg/m^3**	**Kg/m^3**
Cement	750	750	750
Silica Fume	187.5	187.5	187.5
Quartz powder	262.2	300	337.5
Quartz sand	970.1	932.4	894.69
Steel fiber	156.2	156.2	156.2
Super Plasticizer	11.25	11.25	11.25
Water	187.5	187.5	187.5
W/B ratio	0.2	0.2	0.2

3.3 sample preparation and curing

Each mix contains 3 sample sets were casted, in which each set contains 3 cubes(70.6mm×70.6mm×70.6mm) and after completion of 24 hours they are demoulded then allowed to normal water curing for one day. At the age of third day 3 sets of sample were exposed to thermal curing in oven at a temperature of 200°C. After 24 hours completion one set of sample was taken outside and those set were enable to cool till thermal equilibrium was attained with atmospheric temperature and then they were kept in the water till the age of 28 days. Similarly second set and third set of samples were taken outside of the oven after 48hrs and 72hrs respectively, after which they were allowed to attain the thermal equilibrium an then placed in the water till the date of testing.

3.4 Testing

Compressive strength test on UHPC cube specimens were done having the size of 70.6mm×70.6mm×70.6mm after completion of 28 days curing. The tests were carried out using a compression testing machine of 2000KN capacity.

4. RESULTS AND DISCUSSION

It is important to get high compressive strength greater than170MPa by using locally available materials. The several parameters influences on the compressive strength were investigated with varying percentages of quartz powder and the time period of the thermal curing regimes. At the mixing time it was observed that the mixes are very sensitive towards change in quartz powder.

4.1Effect of quartz powder on compressive strength of UHPC

Hydrated cement itself can't develop the more compressive strength in UHPC. The pozzolanic activity is promoted by quartz powder which acts as a filler material and it further depends on heat treatment duration. Quartz powder used decreases the initial pores in the mix, it fills the possible voids between cement, sand and other hydration products results a stiffer mix. This increases the mechanical properties of the mix and decreases permeability.the results shows the higher compressive strength of 175MPa is obtained at a quartz powder of 40% with thermally cured for 48hrs. This is possible at high temperatures, the pozzolanic activity of quartz powder resulted in an increase in substitution of Al for Si in C-S-H chains resulting a denser structure and an increase in compressive strength.

TABLE 4
COMPRESSIVE STRENGTH OF UHPC IN MPa

Mix	**QP-1**	**QP-2**	**QP-3**
Percentage of the quartz powder by weight of cement	35	40	45
24 Hr Thermal Curing	138	146	141
48 Hr Thermal curing	152	175	160
72 Hr Thermal Curing	142	162	153

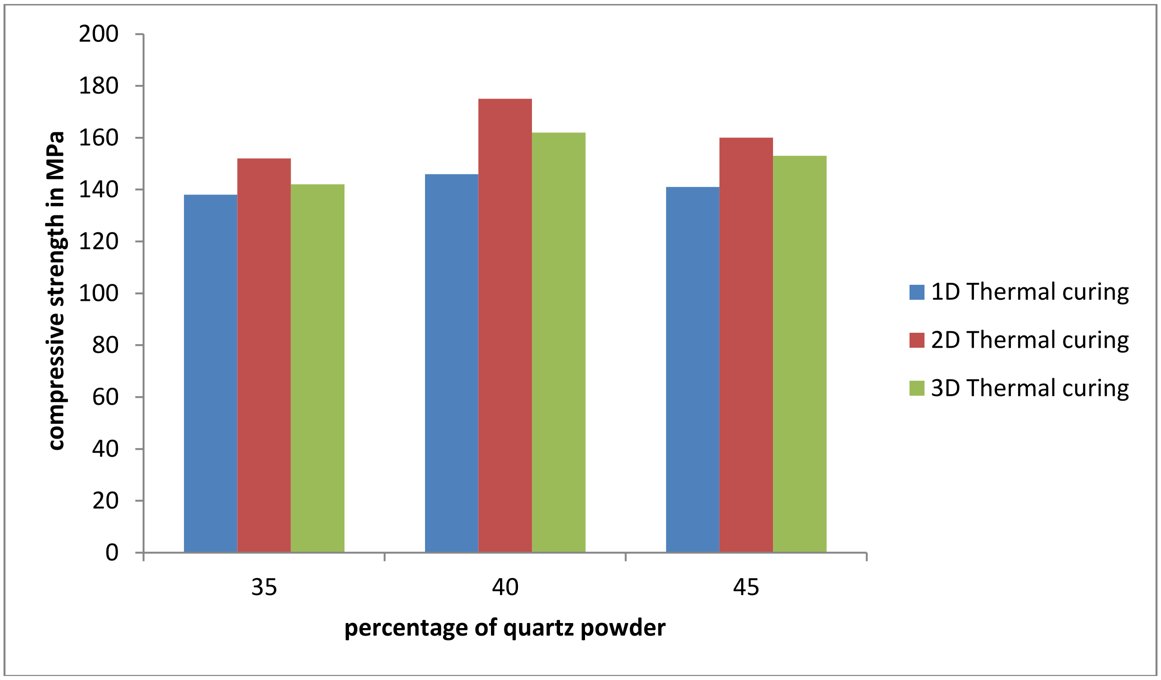

Fig.1 The variation of compressive strength versus % of Quartz Powder to the weight of Cement

4.2 EFFECT OF THERMAL CURING DURATION ON COMPRESSIVE STRENGTH OF UHPC

The compressive strength with changing percentages of quartz powder and different thermal curing regimes are presented in the table 4. The variation of compressive strength versus curing regimes are presented in Fig-2. From Fig-2 it was noticed that for the same mixes of one day and three day thermal cured samples at 200℃ gets less compressive strength, where as two day duration thermal cured sample yields more compressive strength. Hence it is suggested that two day thermal curing is benificial and economical.

The increase in compressive strength was due to, at high temperatures un hydrated cementious materials will undergo rehydration process thus yields more strength. The strength recovery was also observed after cooling due to rehydration process.

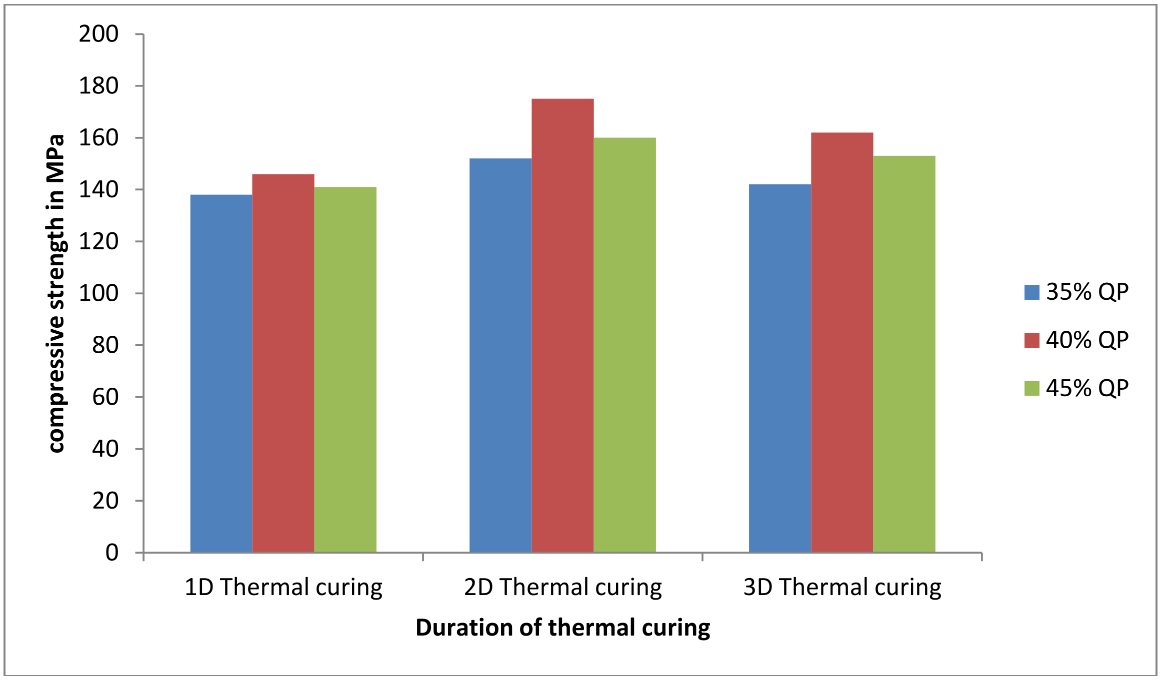

Fig.2The variation of compressive strength versus duration of thermal curing

5. CONCLUSION

Based on the above study the following conclusions can be drawn

- The maximum compressive strength of 175MPa is attained for the mix with 40% quartz powder by the weight of cement for 48 hrs of thermal curing at 200℃.
- It is noticed that quartz powder having the particle size less than 150µm is more efficient in filling the voids between the cement, sand, and other hydration products resulting the more compressive strength.
- The quartz powder used in UHPC involves in pozzolanic activity which depends on heat treatment duration.
- The addition of fillers like quartz improves the packing density of the mix.
- Quartz powder by providing dissolved silica leads to formation of further C-S-H gel; like wise to change the (Cao)/(SiO_2) ratio and support the formation of tobermorite and xonotlite when UHPC is subjected to thermal curing

REFERENCES

[1] Pierre Richard, Marcel Cheyrezy, "composition of the Reactive powder concrete", Cement and Concrete Research journal, pp 1501-1511.1995

[2] Dehui Wang, Caijun Shi, "A review on ultra high performance concrete concrete: part II. Hydration, microstructure and properties", Construction and Building materials 96(2015) 368-377

[3] M.K Maroliya, "Micro Structure Analysis of Reactive Powder Concrete", International Journal of Engineering Research and Development volume 4, Issue 2 (October 2012), PP. 68-77

[4] Doo-Yeol Yoo, Nemkumar Banitha "Mechanical properties of ultra high performance fiber-reinforced concrete: A review", Cement and Concrete Composites 73(2016) 267-280

[5] Sung-Hoon Kang, Ji-Hyung Lee,"MIcrostuctural Investigation of Heat treated Ultra-High Performance Concrete for Optimum Production",materials (September 2017)

[6] Halit Yazici, "The effect of curing conditions on compressive strength of ultra high strength concrete with high volume of mineral admixture", Building and Environment 42 (2007) 2083-2089

[7]Muhammad Abid, Xiaomeng Hou," High temperature and residual properties of reactivepowder concrete- A review", Construction and Building Materials 47((2017) 339-351

[8] Pu Zhang, Yiiliang Huang," Influence Factors on the properties of f iber-Reinforced Concrete Cured under the condition of Room Temperature", Advances in civil Engineering Volume 2018, Article Id 2754735

[9]Tina Oertel, Uta Helbig,"Influence of amorphous silica on the hydration in ultra-high performance concrete",Cement and Concrete Research 58(2014)121-130

[10] T.ZDEB, " Ultra-high performance concrete-properties and technology", BULLETIN OF THE POLISH ACADEMY OF SCIENCES TECHNICAL SCIENCES, vol 61, No 1,2013

[11]J.C.Benezet, A. Benhassaine, " The influence of particle size on the pozzaolanic reactivity of quartz powder", Powder Technology 103(1999)26-29

[12] Janis Locs ,"Microstructural Investigation of Ultra- High performance Concrete Obtained by Pressure Application within the First 24 Hours of Hardening",construction science 10.2478/cons-2013-0008