# EFFECT OF NANO SILICA AND NANO ALUMINA IN ULTRA HIGH PERFORMANCE CONCRETE

A THESIS

*Submitted in partial fulfillment of the requirements for the award of the degree of*

**MASTER OF TECHNOLOGY**

**IN**

**CIVIL ENGINEERING**

**(STRUCTURAL ENGINEERING)**

Under the supervision

*of*

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**MAY-2019**

# STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitled **"EFFECT OF NANO SILICA AND NANO ALUMINA IN ULTRA HIGH PERFORMANCE CONCRETE"** submitted for partial fulfillment of the requirements for the degree of Master of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Mr. Abhilash Shukla Assistant Professor**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

Signature of Student

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-May- 2019

# CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"EFFECT OF NANO SILICA AND NANO ALUMINA IN ULTRA HIGH PERFORMANCE CONCRETE"** in partial fulfillment of the requirements for the award of the degree of Master of Technology in Civil Engineering with specialization in "Structural Engineering" and submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Dixit Gupta(172657)** during a period from July, 2018 to May, 2019 under the supervision of **Mr. Abhilash Shukla,** Assistant Professor, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of my knowledge.

Date: - ………………………

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# ACKNOWLEDGEMENTS

The completion of any project depends upon cooperation, co-ordination and combined efforts of several sources of knowledge. I am grateful to my project guide **Mr. Abhilash Shukla, Assistant Professor** for his even willingness to give me valuable advice and direction whenever I approached him with any problem. I am thankful to him for providing immense guidance for this project.

I, Dixit Gupta would like to acknowledge my work on **“EFFECT OF NANO SILICA AND NANO ALUMINA IN ULTRA HIGH PERFORMANCE CONCRETE”.**

I am also thankful to **Dr. Ashok Kumar Gupta** (Professor & Head, Department of Civil Engineering) and all the faculty members for their immense cooperation and motivation for the research of my project.

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# ABSTRACT

Ultra-High Performance Concrete (UHPC) has been study for a considerable amount of time now. Past pains of improving the concrete performance products that mineral spices can greatly change the characteristics of concrete and give high strength and durable results. Many researchers have also give in to good strength. To take Ultra-High Performance Concrete with better performance introduced nanosilica and nanoalumina into Uhpc. The prosperous output of Ultra-High Performance concrete (UHPC) depends upon its material components and mixing proportion which leads to dense and Comparatively extra homogeneous particles pairing. The main objective of this study is to prepare the Ultra-high performance concrete having good mechanical properties by applying the concept of particle packing. The particle packing has a great influence on the properties of concrete by improving the density of structure. More is the packing of the materials lesser will be the voids. In this study mineral spices like nano silica, nano alumina, silica fume, quartz powder and steel fiber will be used and concrete will be evaluate for its various properties and ideal mix proportion will be figured out. Nanosilica and Nano alumina is used as a filler material. The consistency of cement paste with nano silica is higher than that of silica fume. With the addition of Nanosilica into the concrete mix the compressive strength of concrete can be increased and it has a high durability. The rises of Nano alumina indicate average increases into the compressive strength and sufficient increase on fire resistance properties of cement mortar. The water to binder ratio is also required to be lowered by the use of superplasticizer because higher water content leads to decrease in the strength of concrete. With the correct method and combining the above discussed factors the concrete with Ultra high strengths can be achieved.

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| | |
|---|---|
| UHPC | Ultra high performance concrete |
| NS | Nano silica |
| NA | Nano alumina |
| SP | Super plasticizer |
| SF | Silica fume |
| QP | Quartz powder |
| QS | Quartz sand |
| MS | Manufactured sand |
| CTM | Compression testing machine |
| TCM | Total cementitious materials |

# CHAPTER 1

# INTRODUCTION

## 1.1 General

### 1.1.1 Ultra High Performance Concrete

Advances in the investigation of strong materials have inflame the improvement of another class of cementitious composites called Uhpc. The mechanical and solidness properties of UHPC make it an ideal opponent for use in de-veloping new responses for crushing stresses over expressway establishment rot, re-pair, and substitution. Since 2000, when UHPC ended up being monetarily it is available in the United States a movement of research adventures has displayed the capacities of the material. A hand-ful of State divisions of transportation have sent Uhpc parts inside their infrastructure, and much more are successfully considering the usage of Uhpc.

UHPC is a cementitious material made out of upgraded level by granulated constituents, water to cementitious materials and an abnormal state of radiate inner fiber fortress. The mechanical properties of UHPC fuse compression quality more positive and proceeded with post breaking flexibility. Ultra popular concrete is an uncontrollable consider structure that diminishes liquid passageway, sufficiently redesigning strength diverged from ordinary and first class bonds.

UHPC is also inquired about use in the combination of other application. These use combines the selected strong stores, seismic retrofit, lacking platform substructures, pitiful sustained covering on rotted augmentation roof, and safety and effect extinguishing use. In general, UHPC has ended up being in particular noteworthy appli-cations where normal game plans are insufficient. Field cast UHPC considers an update and improvement of the system while all the while progressing whole deal strength.

UHPC is another type of strong that is depicted by its high compressive quality and fantastic durability. The points of interest of using UHPC in a structure consolidate reducing the proportion of bond required, specifically, spreading the columns, segments, and pieces, which in this manner constructs the general net space, diminishes work and apparatus required for creation, and subtract the improvement term. Regardless the given apparent preferences, is to wondering the UHPC is not used broadly. The low use may be credited to surprising the cost and phenomenal environment influence per cubical meter of the concrete. Particularly, inferable from the nonattendance of coarse aggregate the proportioning of the cement used in

UHPC is generally improved. Generally the making of solid records for over 5% of anthropogenic carbon dioxide transmissions consistently. In that limit much thought has done to making UHPC with lesser bond and less environmental effect while giving proportionate character.

### 1.1.2 Nanoparticles

The particles size is critical component at same time to the proportion of the atoms on the surface increases proportional to increase is known as nanoeffect. Nano equipments affected the experience of macro scale, macro properties of nano scale are developed the new process. Nano sized powdered are used for the production of gas tight materials. Nano particles can improve the microstructures and mechanical performance of material in ordinary concrete and high performance concrete. Nano silica is not yet used in concrete regularly silica fume which is known as micro silica has been used in bond for many years to make high strength concrete. Due to its fine particles it has been believed in hydration system at early ages. Micro silica fills the voids between solid particles.

The compressive and flexural characteristics of bond can be updated by nano silica and nano alumina. It was contemplated that strong with this ternary mix has a predominant demonstration to the extent both quality and quality moreover found that a choice of nano silica achieved a development of both early age quality and long term quality. Moreover, the solidification of Nano materials ahead more exhibited to improve the quality. The upgraded atom squeezing can be overcome an about faultless grain gauge allocation by intertwining the homogeneous slant of coarse and fine particles in the mix.

The degree usage of nanomaterials for some growths has significantly convincing. Believe it or not in view of their fantastically minimal size, nanomaterials are used to filled the voids between cement and silica fumes particles, stimulating highest squeezing measurement besides delivering the compact confining system with extra calcium silicate hydration. This causes the correction for both the quality and mechanical characters for the bond. In the going with segment, closes from past examinations in regards to this issue are presented. Uncovered the pozzolanic development of nanosilica is more than that of silica fume. The bond nature of paste is to add up the interface combining nano silica is more than the models with silica fume.

Supplementary cementitious materials for instance, fly powder, sway warmer slag and silica fumes are mechanical outcomes which are extensively used in the bond stands for several purposes. In the zone of UHPC more thought were committed by lessening the solid substance. Ultra performance concrete (UHPC) is a champion among the most promising sorts of strong which has been made in the latest decade. The capability of UHPC is particularly subject to its thickness. This can be intensified by improving the atom squeezing, thusly realizing ultra-high blend of the strong system.

The most important nano materials used in the construction are as follows

- Carbon nanotubes
- Titanium dioxide nano particles
- Silicon dioxide nano particles(Nano silica)
- Zinc oxide nano particles
- Nano silver particles
- Nano particles of aluminium oxide(Nano alumina)
- Nanoparticles Zirconium oxide
- Tungsten oxide nanoparticles

On my work there are two types of nano particles are considered. They are:

- Silicon dioxide nanoparticles(Nano silica)
- Aluminium oxide nanoparticles(Nano alumina)

### 1.1.3 Why so much interest in nano materials

- Nano phase ceramics are specifically interest because they are more ductile at raised temperature as compared to the coarse grained ceramics.
- Nanostructure semiconductor knows to display indirect optical properties.
- Nanostructure semiconductor used like window layer in solar cells.
- Nano metallic powder is used for manufacture of gas tight materials, dense part and accessible shell.
- Nanostructured oxides are accepting the growing attention in order to recovery the gas sensors with improved sensitivity and selectivity.

### 1.1.4 Applications

- High compressive strength concretes
- High workability with reduced water/content ratio
- Cement saving upto 35 to 40%
- Use of super plasticizer admixtures
- Fills all the micro spaces and micro pores
- An additives for plastics and rubber

- Strengthening filler for concrete and construction composites

### 1.1.5 Advantages

- Low maintenance cost
- Improve segregation resistance
- Fix micro cracking
- Low life cycle cost
- Corrosion resistance

### 1.1.6 Disadvantages

- Impurities: Nano particles are high reactionary and interact by mixing. Alteration of nano particles occurs due to nonreactive species. These impurities become a part of nano particles and pure nano particles become highly difficult.
- Fluctuation of particles: Nano particles are higly testing like energy related fast nanomaterials. Nano materials lies at the areas of advanced energy and the Fine particles have high surface area when they are coming in contact with oxygen.
- Recycle and disposal: Hard and fast secure transfer policies are developed in order to nanomaterials. Numbers of their properties are constant below problems and results of the tests could not common.
- Biological bad: Nanomaterials considered harmful because they get transparent for skin. Poisonous quality to materials also takes attributable to their high surface zone and improved surface action. Nano materials have shown to cause irritation and have indicated to be cancer causing. Their interaction with liver or blood could turn out to be harmful.

### 1.1.7 Need/Demand

- Concrete most widely used materials
- Need for desired properties such as
- Mechanical properties
- Durability
- Strength
- Minimizing cost
- Environmental concern and green building concept

# CHAPTER 2

## LITERATURE REVIEW

### 2.1 General

This examination is about nano particles. Nano particles are used as filler materials in the mix ratio, mechanical character of Ultra high performance concrete. The following literature review debate the mix ratio, character, design and use of Ultra high performance concrete. Materials like silica fume, sand with cement, steel fiber, and superplasticizer were optimized and experimental results were compared. This examination paper shows the effect of nano particles on the properties of Ultra high performance concrete.

### 2.2 Literature Survey

**T. M. Mendes et al. [1]** The utilization of nano particles in ultra high performance concretes may outcome in certain impact at machical performance by these cementitious equipment. It study estimates mixing checking 15 and 20wt% of silicafume the quantity of nanosilica resulted on the best strength. The specific surface area was finished the raw material of particle size. The Chemical compositions of equipment were got through fluorescent and Xray diffusion and the machical performance had estimated by compressive, flexural and dynamic flexible module size. In this nano particles may used as a extender to gain the strength.

**P Jai Shankar and C Karthikeyan [2]** In this examination an undertaking has been had to consider the effect of nano alumina on the properties of strong composite. The test results exhibited that extension of nano alumina redesigned the compressive quality and diminished the hidden setting time of strong composite. Subtract scale examination was finished by Scanning Electron Microscope (SEM) and Energy Dispersive Spectroscopy (EDS). The compressive quality expands through the split changeability expanded hardly. The rate voids if there should be an occasion of 1% nano alumina content safety is respectably lesser than that of 0% Nano alumina concrete.

**Haruehansapong et al. [3]** In this examination the effect of nano silica particle sizes on sturdiness properties and fix work properties of bond mortar containing nano silica. Bond mortar containing 40nm of nano silica gave the most diminished drying shrinkage, the least break number and the most amazing concrete quality. The particle size of nano silica impacted the strength properties just as the fix work properties of solid mortar. The scratched spot restriction and water vulnerability of bond mortar were improved by the extension of all particle sizes. The atom sizes of nano silica in like manner affected the drying shrinkage of bond mortar. The particle size of nano silica impacts quality properties just as the fix work properties of solid mortar.

**Yu Su et al. [4]** Fibers are used as an impaction on the design of high performance concrete materials. Steel fibers can greatly improve the growth of concrete for its flexibility and durability as well as impact and polishing opposition. Performances of steel fibers can changes with reinforced concrete, densities and its guidelines distribution. An innovative of Uhpc with nano material addition has developed. The mix design of this UHPC steel fiber is used as an important compounded. Compressive and tensile strength had been acquired with the increases of steel fibers. There are different forms of steel fibers which are used in the mix of uhpc. Mostly micro steel fibers are used in the uhpc mix.

**Mo Alkaysi et al. [5]** Ultra high performance concrete (UHPC) makes remarkable quality features via upgrade of particle filling thickness of cementitious network. A solid concrete structures to last more, diminishes the cost of upkeep and achieves a basically dynamically practical system. To define the robustness of uhpc the execution of a couple misrestrictive mixture are check out by studying the article security from stop defrost cycles, passageway of chlorides similarly like closeness also apportionment of air vacancy. Basic exploratory transient are solid sort at the measure of silica dust who shifts from 1% to 26% by the bond impact. The test shows the silica dust case take small effect at execution.

**Shah et al. [6]** Engineers are improving the performance of concrete with the help of innovatory chemical mix and complementary cementations materials. Use of nano materials in concrete has new revolutionary movement in construction industry. Which are now used in concrete to convert its strength parts. Replacement of nano-silica was increased gradually upto a certain percentage of NS and then decreased, the compressive strength of the nano silica concrete is 1.5, 1.5 & 1.3 times greater than conventional concrete for 3, 7 and 28 days. With the addition of nanosilica the error crack counterpart changed from a single large crack into the set of limited cracks. Nano silica has high figureless silicon dioxide case and is very reactionary pozzolanic material.

**R. Yu et al. [7]** In this study the rising of an ecofriendly concrete(UHPC) with masterful cement and mineral mixes were used. The deforming consolidation cost of UHPC are minor and near at every variant notified so each the formation mixes are sentient at water item. A slightly increase of the force has been observed when the water/binder ratio increases. The mechanical and porosity of the concrete increases the flexural strength of UHPC, the flexural strength of uhpc for extra growth the water porousness is larger than 10% to its overestimate and the water permeable porousness of less than about 8% is used for less recharge the flexural strength of Uhpc.

**Yuliarti Kusumawardaningsiha et al. [8]** In the recent age of concrete processing a new cement based material is developed known as UHPC. In UHPC design use of fibers are important to increase the strength and durability leads the name of material ultrahigh performance fiberreinforced concrete. Completion of uhpc and uhpfrc had pretend to there high compressionstrength. The series of practical programs were operated at check out the compressive strength of uhpc and uhpfrc using cube samples and to define its entertaining causes. Materials shows that the compressive strength bond between samples has different from conventional concrete.

**Yuliarti Kusumawardaningsiha et al. [9]** Ultra high performance concrete and Ultra High Performance Fiber Reinforced Concrete are doing special materials exhibit many growth when weigh to the parts of conventional concrete. High the value of tensile strength in UHPC and UHPFRC direction to much elastic experience. The result signalize that nevertheless the victorious use searching the term cracking tensile bahaviour of major conventional concrete like results of UHPC and UHPFRC. Tensile strength cost has high by the capacity of fibers.

**Saba Jahangir and Seyed Kazemi [10]** In this study nanosilica and nanoalumina is used as a combination on concrete investigated compressive strength of the concrete setting time, oxygen permeability, porosity. When the nano alumina and nano silica had compiled to samples the setting time had enhanced as from usage only nano silica. compressive strength experiment were taken out on concrete. 10% nano silica and 5% nano alumina may reform the compressive strength on each period. On initial setting time and setting time by these models are highest than check sample upon curing by these models till the setting time need lots of consideration.

**Ehsan Ghafari et al. [11]** In this study it had directed to estimate the impact of nano silica combination at parts of ultra high performance concrete. Thermogravimetric dissection effects suggested that the nano silica destroys more Calcium hydroxide as compare than silica fume broadly at short days. Mercury infraction porosimetry measurements entire the increase of nano silica particle leads at the lack of capillary holes. The meeting of nano silica may repair as well relating to transition zone between the binding paste and aggregates which can be visible by scanning electron microscope. In transport character of UHPC the addition of nano silica increases the compressive strength. The substitution of nano silica in cement to obtain the best performance of 3%wt in cement paste. UHPC containing nano silica has compact and extra homogeneous than that of mixture. The scope of flow table reduces the additioning of nano silica mixture. The rise on nano silica increases the compressive strength of UHPC mix.

**R. yu et al. [12]** In this study the impact on the hydration of nanosilica and fine particles growth by UHPC with lower binding quantity. Ultra high performance concrete may be procured by less lower binder quantity. Additional because of the advanced amount of super plasticizer spend to making UHPC the inactive duration of the cement hydration has detailed. The obstruction impact to super plasticizer may be seriously compensated. By the rise of nano silica the viscosity of UHPC seriously rises. An percentage use of nano silica corresponds to the highest mechanical properties of UHPC. The rise of nano silica may seriously make this opposition impact.

**Ehsan Ghafari et al. [13]** The study mentioned at evolving a statistic prototype utilizing reaction surface methodology forecast the execution of self compacting ultra high performanceconcrete reinforced by mixture steel fiber. An numerical accounts optimization had performed to receive a selfcompacting mixing by highest flexural strength by the least contents of steel fiber 1.85%vol. mixture thin steel fiber may consider as the major suitable percentage rates be posted on UHPC mixing to obtain the gateway cost of self compacting measuring rod.

**Doo Yeol Yoo et al. [14]** The mixed impact of shrinkage reducing admixture and expansive admixture into the compression and cracking quality of the rechecked ultra high performance concrete slab has been described. Expansive admixture presented a surface crack with very little most crack width under 0.04mm. Inattentive of shrinkage reducing admixture and expansive admixture matter the slabs by the lower most fattening of 40mm showed compression cracking through early period as the slabs with highest thickness of 60mm and 80mm demonstrate no cracking till testing.

**Kiachehr Behfarni and Niloofar Salemi [15]** In this paper the reduction in compressive strength, loss of mass variation in length and water soaking had studied after specified number by steady and liquate wheel. The pozzolanic response of nanosilica by calcium hydroxide rise the mass of calcium silicate hydrates who impoves the strength and tolerance of material. Nanoalumina reacts with calcium hydroxide produce hydration of calcium aluminates. Nano alumina improves the compressive strength and tensile strength. In this the size of cubes are 70 mm. The highest frost resistance containing 5% of nano silica and 3% of nano alumina.Compressive strength of concrete enhanced by progress of nano alumina content. Nano alumina is better than nano silica for frost resistance of concrete. In this nano materials also used to improves the pore structure of concrete.

**Sayed Abd El Baky et al. [16]** In this study the character of hard cement paste may be high when the nano silica is added in small amount. Cube of size 50 mm is used for testing in compressive and flexural. When we used 10% of nano silica particles the flow starts increase due to excess nano silica particles so it absorbs amount of mixing Water to reduce workability. The nano particles has assembled like a substitution by cement contented through various rates the amount by correction of flexural strength of mortar may be changed. Feasibility of cement mortar reduced by rising the amount of nano silica. The strength of the cement mortar proceed with growing of nano silica. Cement mortar checking nano silica is much adhesion, short holes, more homogenity binder which is clarified in SEM analysis.

**L.P. Singh et al. [17]** Nano particles are persuading winning idea to be associated being developed office look like to show increase execution of articles with respect to splendid social affair and prudent features. The latest multi decade different nanomaterials for example of nanosilica, nanotitanium, carbon nanotubes and nanoalumina have been investigated and among them nanosilica has been used generally. The nano atomic measurements of this basic science are focusing on the researchers. Ahead, authorities are continuing to improve the strength and sustainability of bond and they realized the significant increase in the mechanical properties of cementitious materials by containing of nano silica.

**Chong Wang et al. [18]** With the improvement of Ultra high performance concrete gives speed for great improvement rupture for the concrete of improvement headway. Current Uhpc course of action requires method over the top material improvement. This Paper focused on the ordinary raw materials and the arranging of Uhpc with important improvement. The effect of binder, water content and ground granulated effect furnace slag substance and compressive nature of the concrete and the fluidity on limestone powder were researched. The addition of superplasticizer and fine mineral additives disperse the test results of uhpc to be produced at extremely low water/binder ratio of 0.15-0.19 achieves extra workability with a biggest slump of 270 mm and compressive strengths of 165.4 MPa in 90days and 184.7MPa in 365days.

**Luca Sorelli et al. [19]** The improvement of ultra high performance concrete with the composite cementitious of microstructure. The extent of this paper is twice to describe the nano compressive properties of the stage governing the uhpc thin structure by device of nano space procedure then to upscale those nanoscale properties. Specifically, a consolidated examination of nano space, filtering electron magnifying instrument and XrayDiffraction demonstrates that the zone of transition is moderately deformity in fiber matrix. The stiffening effect of remaining clinker and calcium silicates of high thickness suggested the model based on engineering composites may role the useful result in the uhpc. For upgrading engineering bond based composites the may turn into valuable tool gives the dominant role for high thickness hydrates of calcium silicates.

**Ali Nazari et al. [20]** The nano particles with cement substitutes that partial increase in compressive and workability of concrete. With average estimation of alumina nano particles of 15nm were used with the kind of four substances of 1.5%, 2.0%, 0.5% and 1% by weight. The result shows the use of alumina nano particles upto maximum replacing of measurement of 2.0% produces concrete with improved quality. The ultimate nature of concrete was gained at 1.5wt% of the cement substitution. The workability of fresh bond was decreased by increasing the substance of alumina nanoparticles. With the partial substitution of the cement improves the compressive strength of the concrete by the addition of nanoalumina particles. With rise of nanoalumina decreases its importance.

**Ghafari et al. [21]** Ultra high performance concrete is depicted by a thick microstructure which presents both ultrahigh compressive quality and ultra high durability. In light of the creating excitement for using nano sized materials, the test consider in this showed was guided importance to survey the effect of nano silica development on both mechanical and fluid transport properties of UHPC. The porosity and distinctive parameters were assessed through assorted transport segments and techniques the littler scale structures of the precedents were some where near scanning electron microscope.

**Rattan et al. [22]** In this study macro material is concrete which can be strongly influenced by their nano properties. With the combination of nanosilica in cement rooted articles that control the degression of calcium silicate hydrated response achieved by the separation of water in calcium, with the blockage of water passage it leads to progress in durability. For quality control and checking nano sensors to be used in strong structures to take up of its great potential. The mix trial of Portland cement and water may improve its mechanical characteristics with the little proportions of nanotubes of carbon. Both compressive and flexural quality shows overhauling best oxidized multi walled nanotubes which appears differently to reference tests.

**Pang Jinchang, Liu Ronggui [23]** It has a wide applications prospect in planning practices. With high toughness and high quality notch of ultra top characterized by composite materials of ultrahigh compressive strength. In any case, there is few loss in the concrete. The aim of the researchers has to improve the quality of uhpc. This experiment proposed addition of nanosilica and nanocalcium in uhpc to get better performance in uhpc. For research of hydration process and microstructure the tests were used they were X Ray Diffraction, mercury intrusion porosimetry and nano indentation. To improves the execution of uhpc structure which provides a deal to combined action of the two composite denser structure. Nano calcium on a very basic level expect the activity of crystal core impact and packing impact.

## 2.3 Research Gap

1. With the increase in the number of nano materials added in the uhpc, the compressive strength of uhpc increases but the effects of nano silica with nano alumina have not been studies yet.
2. In jobsite situation not more researchers considering like working on concrete at low temperatures.

## 2.4 Research Objective

1. To examine the influence of Nano silica and Nano alumina addition on concrete.
2. To study the effect on strength of concrete at low curing temperature.
3. Compressive tests will performed at the end of the curing period.

# CHAPTER 3

# METHODOLOGY

## 3.1 General

The project has started with reading some journals and deciding the topic. After deciding the topic we did the problem identification by reading several related research papers and review studies. After identifying what should be done, collection of materials has started. After collecting all the materials we need to perform all the related testing. The testing done should be appropriate and must follow proper and accurate procedures.

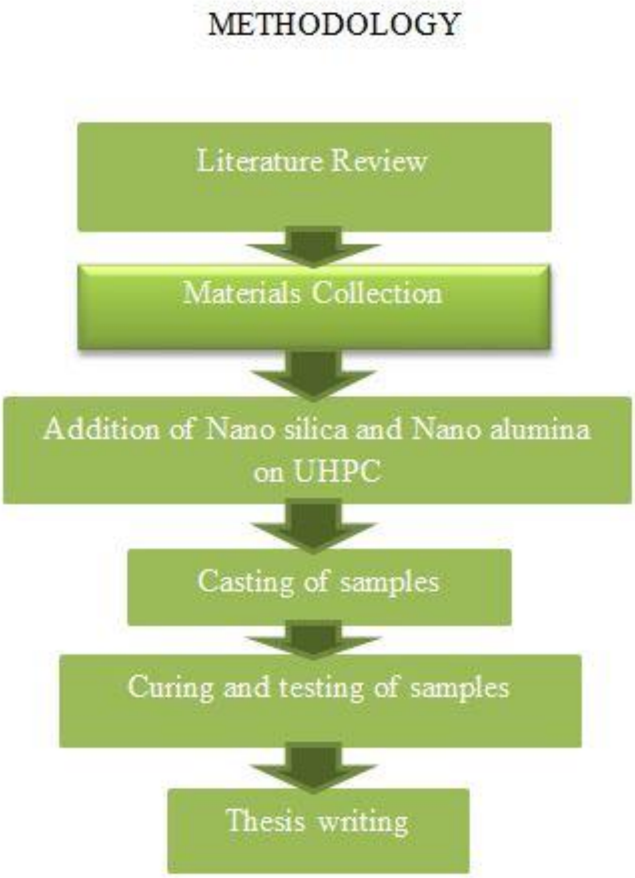


**Fig. 3.1** Methodology of the project

## 3.2 MATERIALS

### 3.2.1 CEMENT

Grade 43 ordinary Portland cement having 28days minimum Compressive strength of 43Mpa, (conforming to IS 8112:2013)

**Fig. 3.2** Cement

### 3.2.2 QUARTZ SAND (QS)

Quartz sand was procured from A.B. enterprises Zirakpur Punjab. The particle size of quartz sand required for our work lied in the range of 150-300 microns, therefore the material was passed from the 300-micron sieve and the material retained on the 150micron sieve was used.

**Fig. 3.3** Quartz sand

### 3.2.3 QUARTZ POWDER (QP)

Quartz powder was procured from A.B. enterprises Zirakpur Punjab.

**Fig. 3.4** Quartz powder

### 3.2.4 MANUFACTURED SAND (MS)

The manufactured sand was procured locally from Waknaghat, Solan. The particle size of manufactured sand required for our work lied in the range of 150-600 microns, therefore the material was passed from 600-micron sieve and the material retained on the 150-micron and 300-micron sieve was used.

**Fig. 3.5** Manufactured sand

### 3.2.5 SILICA FUME (SF)

Silica fume has been procured from KGR agro fusions Pvt. Limited Ludhiana, Punjab.

**Fig. 3.6** Silica fume

### 3.2.6 STEEL FIBER

Steel fiber was procured from fiber zone. The particle size of steel fiber required for our work was 13mm length and 0.22mm dia.

**Fig. 3.7** Steel fibers

### 3.2.7 SUPERPLASTICIZER (SP)

The superplasticizer used was polycarboxylate based. The polycarboxylate based superplasticizers works on the principle that it gets adsorbed on to the surface of material grains initially and then disperses them, thereby preventing their collection.

### 3.2.8 NANO SILICA (NS)

Nano silica was procured from Rajasthan. The particle size of Nano silica for our work was 20Nm to 60Nm.

**Fig. 3.8** Nano silica

### 3.2.9 NANO ALUMINA (NA)

Nano alumina was procured from intelligent materials private ltd. Derabassi mubarakpur. The particle size of Nano alumina for our work was 20Nm to 60Nm.

**Fig. 3.9** Nano alumina

## 3.3 EXPERIMENTAL PARAMETERS

The experiments to be carried out for this project work should be rigidly done with proper procedure and accurate parameters. List of Materials or Experiments IS Codes:

1. OPC 43 - IS 8112:1989
2. Compression test – IS 14858:2000
3. Flexural test – IS 9399:1979
4. Tensile test – IS 5816:1999
5. Chemical admixture – IS 9103:1999
6. Basic thinking– IS 456:2007

## 3.4 TESTING

1. Testing of Cement.
2. Testing of fine aggregate test.
3. Measure the property of UHPC without Nano materials.
4. Measure the property of Nano Silica in UHPC.
5. Measure the property of Nano Alumina in UHPC.
6. Measure the property of Nano silica with Nano alumina in UHPC.

## 3.5 TEST PERFORMED

Certain tests were carried out on cement they are given below

### 3.5.1 CEMENT

Following test were performed on the cement are:

#### 3.5.1.1 Normal Consistency

Normal Consistency of the cement is that percentage of the water by weight of cement added by which the plunger of 10mm dia penetrates up to depth of 5to7mm from the base of the plate.

Apparatus used: balance and measuring cylinder, vicat apparatus with 10mm plunger

Procedure:

1. Cement of 100gms was taken in a tray and initially 30% of water by the weight of cement was added and mixed thoroughly to for about 3to 5 min to obtain the paste
2. Vicat mould kept on the glass plate then filled with the prepared paste and levelled the surface properly.
3. Then the mould was placed under the plunger the plunger is then lowered the surface of paste and then released directly to penetrate the paste.

4. Depth of penetration was measured and noted down.
5. Similarly the test was performed for other percentages until the depth of penetration lies between 5to7mm from the base of the plate.

**3.5.1.2 Initial Setting Time**

The initial setting time is the time period from the penetration of paste of cement by adding 0.85p of water to the time when the paste resists the penetration of $1mm^2$ cross section needle to do so here p is the normal consistency of the cement.

Apparatus: vicat apparatus ($1mm^2$ cross section needle), balance and measuring cylinder

Procedure:

1. 100gms of cement was taken and 0.85p of water was used to make the paste.
2. The water was added quickly the time noted down.
3. Further the prepared paste is added to the mould with the surface levelled and placed below the needle of apparatus.
4. The needle is then lowered the surface of the paste and quickly liberated.
5. Initially the needle pierces the paste completely to the surface therefore this procedure is repeated until the needle stops penetrating at 5 mm from the base of the plate.
6. The time is noted again and the total time taken is calculated.

**3.5.1.3 Final Setting Time**

The final setting time is the time period from the preparation of cement paste by adding 0.85p of water to the time when 1mm dia of needles makes an impression on the surface until the 5mm attachment fails to do so here p is the normal consistency of the cement.

Apparatus: vicat apparatus (with 1mm dia needle and outer 5mm dia attachment), measuring cylinder and balance.

Procedure:

1. 100gms of cement was taken and 0.85p of water was added to make the paste.
2. The water was added quickly the time noted down.
3. Further the prepared paste is added to the mould with surface levelled and placed below the needle of the instrument.
4. The needle is then lowered to the level of the paste and quickly released.
5. Initially both 1mm needle and 5mm dia attachment makes an impression therefore this step is repeated until 1mmdia needle makes an impression on the surface until the 5mm attachment fails to do so.
6. The time is noted down and the time taken is calculated.

#### 3.5.1.4 Fineness of the cement

Fineness of the cement was measured by passing through the 90micron sieve. The weight of the cement was retained on sieve represented at percentage by the initial weight taken as the fineness of the cement.

Apparatus: balance and 90micron sieve

Procedure:

1. 10gms of cement was weighed and poured on to the sieve which had a pan attached at the bottom and was covered with the lid.
2. The cement in the pan was shaken in various motions until no more material passed through the sieve.
3. The materials retained on the sieve was weighed and calculation for the percentage retained on the sieve was carried out

### 3.6 CASTING

The mix design for the combinations was first prepared as presented in the chapter 4 and then further the casting of the combinations was carried out. The procedure for mixing of the materials followed was as follows.

1. The materials were weighed according to the mix design prepared .
2. The water required for the mix was measured in the graduated cylinder along with the super plasticizer.
3. The materials were poured into the plate (hand mixing) and the materials were dry mixed for 2 minutes.
4. Then about 70 % of the water and superplasticizer was poured into the plate and the mixing was done for about 3 minutes.
5. Then the remaining water and super plasticizer was added to mix and combination was done for 3 min.
6. The molds used for the casting were 7.07*7.07*7.07 cm. the nuts in the molds were properly tightened in order to ensure the correct dimensions. The molds were then properly oiled on the inner sides. Three cubes for the single mix were casted.
7. The molds were placed on the vibration table and while vibrating the material were added gradually into the molds up till they are full of their brims. The total vibration time was kept at 4-5 minutes.

After all the cubes were casted, they were kept to set at the room temperature for 24 hours and then demolded to be kept in the curing tank for the curing of cubes for 28 days.

**3.7 Compressive strength test**

Casting of 8 mix designs was carried out and 3 cubes were casted for each combination in order to get the average of three. Therefore the total number of 24 cubes were tested for the compressive strength. The compressive testing was performed on compression testing machine (CTM) with the loading rate of 1.8kN/mm²/min. before carrying out the compression test the cubes were displaced by the curing tank and placed it in the open until they get surface dried. After drying the top and bottom dimensions of the cubes were taken. In order to get the area the average top and bottom surface was considered. The cubes were placed one by one on the bearing of CTM and the load application was continued till the cubes failed.

The compressive strength was calculated like:

Compressive strength = Load/Average area (MPa)

*Fig. 3.9 Compression testing on CTM*

# CHAPTER 4

## 4.1 MIX DESIGN

### 4.1.1 Cement content fixed at 700kg/m³ with 4% of Nano silica

Conditions:

1. Quantity of cement = 700kg/m³
2. Water to binder ratio = 0.19
3. Content of superplasticizer = 3%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]
   = 0.001132 mm³
2. Weight of cement = 700*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]
   = 792.5 gm
3. Weight of nano silica = 700/96*4 = 29.16 kg/m³
   = 29.16*0.001132*1000 = 33.01 gm
4. Weight of silica fume = 700/75*25 = 233.33 kg/m³
   = 233.33*0.001132*1000 = 264.13 gm
5. Total cementitious materials (TCM) = 792.4 + 33.01 + 264.13 = 1089.54 gm
6. Quantity of superplasticizer = 3%*1089.54/100 = 32.67
   = 32.67*0.001132*1000 = 36.98 gm
7. Weight of water = 0.19*1089.54 = 207.013 kg/m³
8. Total volume of fine aggregates = 1 – (((700/3.15) + (29.17/1.03) + (233.33/2.25)/1000) = 0.6458m³ [1m³ - volume of TCM]
9. Weight of quartz powder = 5/100*0.6458*2.65*1000 = 85.57 kg/m³
   [5% QP of tot. vol.* Sp. gr. of QP*1000]
   = 85.57*0.001132*1000 = 96.87 gm
10. Weight of QS + MS = 0.6458-(85.57/(2.65*1000)) = 0.6135 m³
11. Weight of QS (50%) = 50/100*0.6135*2.34*1000 = 717.8 kg/m³
    [50% QS*vol. in 10*Sp. gr. of QS*1000]
    = 717.8*0.001132*1000 = 812.55 gm
12. Weight of MS (50%) = 50/100*0.6135*2.65*1000 = 812.89 kg/m³
    [50% MS*vol. in 10*Sp. gr. of MS*1000]
    = 812.89*0.001132*1000 = 920.19 gm

13. Volume of concrete = 812.55 + 920.19 + 96.87 + 792.4 + 33.01 + 264.13

= 2919.15 gm

14. Weight of Steel fiber = 2.5% of total volume = 72.98 gm

= 2.5/100*1*7089 = 0.177225

2.5% of total vol. *1*density of steel

Total weight of steel fiber = 72.98*0.177225 = 12.93 gm

15. Corrected weight of water = 207.013 – (32.67*(60/100) + 0.004*717.8 + (0.01*812.89)) = 176.4098 kg/m³

[Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

= 176.4098*0.001132*1000 = 199.75 ml

### 4.1.2 Cement content fixed at 400kg/m³ with 4% of Nano silica

Conditions:

1. Quantity of cement = 400 kg/m³
2. Water to binder ratio = 0.19
3. Content of super plasticizer = 3.5%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]

   = 0.001132 mm³
2. Weight of cement = 400*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]

   = 452.8 gm
3. Weight of nano silica = 400/96*4 = 16.67 kg/m³

   = 16.67*0.001132*1000 = 18.87 gm
4. Weight of silica fume = 400/75*25 = 133.33 kg/m³

   = 133.33*0.001132*1000 = 150.93 gm
5. Total cementitious materials (TCM) = 452.8 + 18.87 + 150.93 = 622.6 gm
6. Quantity of superplasticizer = 3.5%*622.6/100 = 21.791

   = 21.791*0.001132*1000 = 24 gm
7. Weight of water = 0.19*622.6 = 118.3 kg/m³
8. Total volume of fine aggregates = 1 – (((400/3.15) + (16.67/1.03) + (133.33/2.25)/1000) = 0.7975 m³ [1m³ - volume of TCM]

9. Weight of quartz powder = 5/100*0.7975*2.65*1000 = 105.67 kg/m³

   [5% QP of tot. vol.* Sp. gr. of QP*1000]

   = 105.67*0.001132*1000 = 120.25 gm

10. Weight of QS + MS = 0.7975-(105.67/(2.65*1000)) = 0.7576 m³

11. Weight of QS (50%) = 50/100*0.7576*2.34*1000 = 886.392 kg/m³

   [50% QS*vol. in 10*Sp. gr. of QS*1000]

   = 886.392*0.001132*1000 = 1003.396 gm

12. Weight of MS (50%) = 50/100*0.7576*2.65*1000 = 1003.82 kg/m³

   [50% MS*vol. in 10*Sp. gr. of MS*1000]

   = 1003.82*0.001132*1000 = 1136.324 gm

13. Volume of concrete = 1003.396 +1136.324 + 452.5 + 18.87 + 150.93

   = 2882.57 gm

14. Weight of Steel fiber = 2.5% of total volume = 72.06 gm

   = 2.5/100*1*7089 = 0.177225

   2.5% of total vol. *1*density of steel

   Total weight of steel fiber = 72.06*0.177225 = 12.77 gm

15. Corrected weight of water = 118.3 – (21.791*(60/100) + 0.004*886.39 + (0.01*1003.82)) = 91.636 kg/m³

   [Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

   = 91.636*0.001132*1000 = 103.732 ml

### 4.1.3 Cement content fixed at 700kg/m³ conventional

<u>Conditions:</u>

1. Quantity of cement = 700kg/m³
2. Water to binder ratio = 0.19
3. Content of superplasticizer = 3%

<u>Mix calculations:</u>

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]

   = 0.001132 mm³

2. Weight of cement = 700*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]

   = 792.4 gm

3. Weight of silica fume = 700/75*25 = 233.33 kg/m³

= 233.33*0.001132*1000 = 264.13 gm

4. Total cementitious materials (TCM) = 792.4 + 264.13 = 1056.53 gm
5. Quantity of superplasticizer = 3%*1056.53/100 = 31.7gm

   = 31.7*0.001132*1000 = 35.88 gm
6. Weight of water = 0.19*1056.53 = 200.7407 kg/m³
7. Total volume of fine aggregates = 1 – ((700/3.15) + (233.33/2.25)/1000) = 0.6741m³

   [1m³ - volume of TCM]
8. Weight of quartz powder = 5/100*0.6741*2.65*1000 = 89.32 kg/m³

   [5% QP of tot. vol.* Sp. gr. of QP*1000]

   = 89.32*0.001132*1000 = 101.1102 gm
9. Weight of QS + MS = 0.6741-(89.32/(2.65*1000)) = 0.6404 m³
10. Weight of QS (50%) = 50/100*0.6404*2.34*1000 = 749.27 kg/m³

[50% QS*vol. in 10*Sp. gr. of QS*1000]

= 749.27*0.001132*1000 = 848.17 gm

11. Weight of MS (50%) = 50/100*0.6404*2.65*1000 = 848.53 kg/m³

    [50% MS*vol. in 10*Sp. gr. of MS*1000]

    = 848.53*0.001132*1000 = 960.53gm
12. Volume of concrete = 848.17 + 960.53 + 101.11 + 792.4 + 264.13

    = 2966.34 gm
13. Weight of Steel fiber = 2.5% of total volume = 74.15 gm

    = 2.5/100*1*7089 = 0.177225

2.5% of total vol. *1*density of steel

Total weight of steel fiber = 74.15*0.177225 = 13.14 gm

14. Corrected weight of water = 200.7407 – (31.7*(60/100) + 0.004*749.27 + (0.01*848.53)) = 170.2407 kg/m³

    [Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

    = 170.2407*0.001132*1000 = 192.71 ml

## 4.1.4 Cement content fixed at 400kg/m³ conventional

<u>Conditions:</u>

1. Quantity of cement = 400 kg/m³
2. Water to binder ratio = 0.19
3. Content of super plasticizer = 3.5%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]

   = 0.001132 $mm^3$
2. Weight of cement = 400*0.001132*1000 [cement per $m^3$ * volume of 3 cubes * 1000]

   = 452.8 gm
3. Weight of silica fume = 400/75*25 = 133.33 kg/$m^3$

   = 133.33*0.001132*1000 = 150.93 gm
4. Total cementitious materials (TCM) = 452.8 + 150.93 = 603.73 gm
5. Quantity of superplasticizer = 3.5%*603.73/100 = 21.13gm

   = 21.13*0.001132*1000 = 23.92 gm
6. Weight of water = 0.19*603.73 = 114.71 kg/$m^3$
7. Total volume of fine aggregates = 1 – (((400/3.15) + (133.33/2.25)/1000) = 0.8138 $m^3$

   [1$m^3$ - volume of TCM]
8. Weight of quartz powder = 5/100*0.8138*2.65*1000 = 107.83 kg/$m^3$

   [5% QP of tot. vol.* Sp. gr. of QP*1000]

   = 107.83*0.001132*1000 = 122.064 gm
9. Weight of QS + MS = 0.8138-(107.83/(2.65*1000)) = 0.7728 $m^3$
10. Weight of QS (50%) = 50/100*0.7728*2.34*1000 = 904.176 kg/$m^3$

    [50% QS*vol. in 10*Sp. gr. of QS*1000]

    = 904.176*0.001132*1000 = 1023.53 gm
11. Weight of MS (50%) = 50/100*0.8138*2.65*1000 = 1023.96 kg/$m^3$

    [50% MS*vol. in 10*Sp. gr. of MS*1000]

    = 1023.96*0.001132*1000 = 1159.12 gm
12. Volume of concrete = 1023.53 +1159.12 + 452.8 + 150.93 + 122.064

    = 2908.44gm
13. Weight of Steel fiber = 2.5% of total volume = 72.71 gm

    = 2.5/100*1*7089 = 0.177225

    2.5% of total vol. *1*density of steel

Total weight of steel fiber = 72.71*0.177225 = 12.886 gm

14. Corrected weight of water = 114.71 – (21.13*(60/100) + 0.004*904.176 + (0.01*1023.53)) = 88.18 kg/$m^3$

[Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

= 88.18*0.001132*1000 = 99.82 ml

## 4.1.5 Cement content fixed at 700kg/m³ with 3% of Nano alumina

Conditions:

1. Quantity of cement = 700kg/m³
2. Water to binder ratio = 0.19
3. Content of superplasticizer = 3%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]

   = 0.001132 mm³
2. Weight of cement = 700*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]

   = 792.5 gm
3. Weight of nano alumina = 700/97*3 = 21.65 kg/m³

   = 21.65*0.001132*1000 = 24.51 gm
4. Weight of silica fume = 700/75*25 = 233.33 kg/m³

   = 233.33*0.001132*1000 = 264.13 gm
5. Total cementitious materials (TCM) = 792.4 + 24.51 + 264.13 = 1081.04 gm
6. Quantity of superplasticizer = 3%*1081.04/100 = 32.43

   = 32.43*0.001132*1000 = 36.71 gm
7. Weight of water = 0.19*1081.04 = 205.39 kg/m³
8. Total volume of fine aggregates = 1 – (((700/3.15) + (21.65/3.8) + (233.33/2.25)/1000) = 0.6684m³ [1m³ - volume of TCM]
9. Weight of quartz powder = 5/100*0.6684*2.65*1000 = 88.56 kg/m³

   [5% QP of tot. vol.* Sp. gr. of QP*1000]

   = 88.56*0.001132*1000 = 100.25 gm
10. Weight of QS + MS = 0.6684-(88.56/(2.65*1000)) = 0.6355m³
11. Weight of QS (50%) = 50/100*0.6355*2.34*1000 = 743.53 kg/m³

    [50% QS*vol. in 10*Sp. gr. of QS*1000]

    = 743.53*0.001132*1000 = 841.67 gm
12. Weight of MS (50%) = 50/100*0.6355*2.65*1000 = 842.037 kg/m³

    [50% MS*vol. in 10*Sp. gr. of MS*1000]

    = 842.037*0.001132*1000 = 953.18 gm
13. Volume of concrete = 841.67 + 953.18 + 100.25 + 792.5 + 24.51 + 264.13

    = 2976.24 gm

14. Weight of Steel fiber = 2.5% of total volume = 74.40 gm

= 2.5/100*1*7089 = 0.177225

2.5% of total vol. *1*density of steel

Total weight of steel fiber = 74.40*0.177225 = 13.18 gm

15. Corrected weight of water = 205.39 – (32.43*(60/100) + 0.004*743.53 + (0.01*842.037)) = 174.54 kg/m³

[Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

= 174.54*0.001132*1000 = 197.58 ml

### 4.1.6 Cement content fixed at 400kg/m³ with 3% of Nano alumina

Conditions:

1. Quantity of cement = 400 kg/m³
2. Water to binder ratio = 0.19
3. Content of super plasticizer = 3.5%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]
   i. = 0.001132 mm³
2. Weight of cement = 400*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]
   i. = 452.8 gm
3. Weight of nano alumina = 400/97*3 = 12.37 kg/m³
   i. = 12.37*0.001132*1000 = 14.003 gm
4. Weight of silica fume = 400/75*25 = 133.33 kg/m³

   = 133.33*0.001132*1000 = 150.93 gm
5. Total cementitious materials (TCM) = 452.8 + 14.003 + 150.93 = 617.73 gm
6. Quantity of superplasticizer = 3.5%*617.73/100 = 21.62

   = 21.62*0.001132*1000 = 24.47 gm
7. Weight of water = 0.19*617.73 = 117.37 kg/m³
8. Total volume of fine aggregates = 1 – (((400/3.15) + (12.37/3.8) + (133.33/2.25)/1000) = 0.81052 m³ [1m³ - volume of TCM]
9. Weight of quartz powder = 5/100*0.81052*2.65*1000 = 107.39 kg/m³

   [5% QP of tot. vol.* Sp. gr. of QP*1000]

   = 107.39*0.001132*1000 = 121.56 gm
10. Weight of QS + MS = 0.8105-(107.39/(2.65*1000)) = 0.77002 m³

11. Weight of QS (50%) = 50/100*0.77002*2.34*1000 = 900.92 kg/m³

[50% QS*vol. in 10*Sp. gr. of QS*1000]

= 900.92*0.001132*1000 = 1019.84 gm

12. Weight of MS (50%) = 50/100*0.77002*2.65*1000 = 1020.27 kg/m³

[50% MS*vol. in 10*Sp. gr. of MS*1000]

= 1020.27*0.001132*1000 = 1154.94 gm

13. Volume of concrete = 1019.84 +1154.94 + 452.5 + 14.003 + 121.56 + 150.93

i. = 2913.77 gm

14. Weight of Steel fiber = 2.5% of total volume = 72.84 gm

i. = 2.5/100*1*7089 = 0.177225

2.5% of total vol. *1*density of steel

Total weight of steel fiber = 72.84*0.177225 = 12.90 gm

15. Corrected weight of water = 117.37 – (21.62*(60/100) + 0.004*900.92+ (0.01*1020.27)) = 90.6 kg/m³

[Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

= 90.6*0.001132*1000 = 102.56 ml

### 4.1.7 Cement content fixed at 700kg/m³ with 2.5% of Nano silica and 1.5% of Nano alumina

Conditions:

1. Quantity of cement = 700kg/m³
2. Water to binder ratio = 0.19
3. Content of superplasticizer = 3%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]

   = 0.001132 mm³

2. Weight of cement = 700*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]

   = 792.5 gm

3. Weight of nano silica = 700/96*3.5 = 18.23 kg/m³

   = 21.65*0.001132*1000 = 20.64 gm

4. Weight of nano alumina = 700/96*1.5=10.94 kg/m³

= 10.94*0.001132*1000 = 12.38 gm

5. Weight of silica fume = 700/75*25 = 233.33 kg/m³

   = 233.33*0.001132*1000 = 264.13 gm

6. Total cementitious materials (TCM) = 792.4 + 20.64 + 12.38 + 264.13 = 1089.55 gm

7. Quantity of superplasticizer = 3%*1089.55/100 = 32.68

   = 32.68*0.001132*1000 = 36.99 gm

8. Weight of water = 0.19*1089.55 = 207.01 kg/m³

9. Total volume of fine aggregates = 1 - (((700/3.15) + (18.23/1.03) + (10.94/3.8) + (233.33/2.25)/1000) = 0.6535m³ [1m³ - volume of TCM]

10. Weight of quartz powder = 5/100*0.6535*2.65*1000 = 86.59 kg/m³

    [5% QP of tot. vol.* Sp. gr. of QP*1000]

    = 86.59*0.001132*1000 = 98.01 gm

11. Weight of QS + MS = 0.6535-(86.59/(2.65*1000)) = 0.6208m³

12. Weight of QS (50%) = 50/100*0.6208*2.34*1000 = 726.34 kg/m³

    [50% QS*vol. in 10*Sp. gr. of QS*1000]

    = 726.34*0.001132*1000 = 822.22 gm

13. Weight of MS (50%) = 50/100*0.6208*2.65*1000 = 822.56 kg/m³

    [50% MS*vol. in 10*Sp. gr. of MS*1000]

    = 822.56*0.001132*1000 = 931.14 gm

14. Volume of concrete = 822.22 + 931.14 + 98.01 + 792.5 + 20.64 + 12.38 + 264.13

    = 2941.02 gm

15. Weight of Steel fiber = 2.5% of total volume = 73.53 gm

    = 2.5/100*1*7089 = 0.177225

    2.5% of total vol. *1*density of steel

    Total weight of steel fiber = 73.53*0.177225 = 13.03 gm

16. Corrected weight of water = 205.39 – (36.99*(60/100) + (0.004*726.34) + (0.01*822.56)) = 172.16 kg/m³

    [Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

    = 172.16*0.001132*1000 = 194.88 ml

### 4.1.8 Cement content fixed at 400kg/m³ with 2.5% of Nano silica and 1.5% of Nano alumina

Conditions:

1. Quantity of cement = 400 kg/m³
2. Water to binder ratio = 0.19
3. Content of super plasticizer = 3.5%

Mix calculations:

1. Volume of 3 cubes = (0.07*0.07*0.07)*3*1.1 [considering 10% extra]
   = 0.001132 mm³
2. Weight of cement = 400*0.001132*1000 [cement per m³ * volume of 3 cubes * 1000]
   = 452.8 gm
3. Weight of nano silica = 400/96*2.5 = 10.41kg/m³
   = 10.41*0.001132*1000 = 11.78 gm
4. Weight of nano alumina = 400/96*1.5 = 6.25 kg/m³
   = 6.25*0.001132*1000 = 7.075 gm
5. Weight of silica fume = 400/75*25 = 133.33 kg/m³
   = 133.33*0.001132*1000 = 150.93 gm
6. Total cementitious materials (TCM) = 452.8 + 11.78 + 7.075 + 150.93 = 622.58 gm
7. Quantity of superplasticizer = 3.5%*622.58/100 = 21.79
   = 21.79*0.001132*1000 = 24.67 gm
8. Weight of water = 0.19*622.58 = 118.29 kg/m³
9. Total volume of fine aggregates = 1 – (((400/3.15) + (10.41/1.03) + (6.25/3.8) + (133.33/2.25)/1000)= 0.8020 m³ [1m³ - volume of TCM]
10. Weight of quartz powder = 5/100*0.8020*2.65*1000 = 106.26 kg/m³
    [5% QP of tot. vol.* Sp. gr. of QP*1000]
    = 106.26*0.001132*1000 = 120.29 gm
11. Weight of QS + MS = 0.8020-(106.26/(2.65*1000)) = 0.762 m³
12. Weight of QS (50%) = 50/100*0.762*2.34*1000 = 891.54 kg/m³
    [50% QS*vol. in 10*Sp. gr. of QS*1000]
    = 891.54*0.001132*1000 = 1009.22 gm
13. Weight of MS (50%) = 50/100*0.762*2.65*1000 = 1009.65 kg/m³
    [50% MS*vol. in 10*Sp. gr. of MS*1000]
    = 1009.65*0.001132*1000 = 1142.92 gm

14. Volume of concrete = 1009.22 +1142.92 + 120.29 + 11.78 + 7.075 + 452.8 + 150.93

= 2895.01 gm

15. Weight of Steel fiber = 2.5% of total volume = 72.37 gm

= 2.5/100*1*7089 = 0.177225

2.5% of total vol. *1*density of steel

Total weight of steel fiber = 72.37*0.177225 = 12.82 gm

16. Corrected weight of water =118.29-(21.79*(60/100) + 0.004*891.54 + (0.01*1009.65)) = 91.59kg/m³

[Wt. of water – (water content of SP + water absorption of QS + water absorption of MS)]

= 91.59*0.001132*1000 = 103.68 ml

# CHAPTER 5

# RESULT AND DISCUSSION

## 5.1 OPC (Grade 43)

Various test results performed on OPC 43 grade.

| Sr. No. | Experiment Name | Test Results | | As Per IS code | |
|---|---|---|---|---|---|
| 1. | Fineness | 2.5% | | 4031(part1)-1996 | 99.8% |
| 2. | Consistency | 30% | | 4031(part 4)-1988 | 26% to 33% |
| 3. | Initial setting time | 115 min | | 4031 (part 5)-1988 | Not less than 30 min |
| 4. | Final setting time | 240 min | | 4031(part 5)-1988 | Not more than 600 min |
| 5. | Specificgravity | 3.02 | | 4031(part11)-1988 | 3.15 |
| 6. | Compressive strength | 7 days 27Mpa | 28 days 39Mpa | 8112-1989 | 43Mpa |
| 7. | Tensile strength | 3 days 2.5Mpa | 7days 3.2Mpa | 4031(part 8)-1988 | 3.5mpa |

## 5.2 QUARTZ SAND AND MANUFACTURED SAND COMPRESSIVE STRENGTH

Compressive strength results for quartz sand(QS) and manufactured sand(MS)

| Quantity of sand (%) | | Rate of load-ing(kN/mm²/min) | Test results | |
|---|---|---|---|---|
| QS | MS | | 7 days | 28 days |

| | | | | |
|---|---|---|---|---|
| 40 | 60 | 1.8 | 21.39Mpa | 26.91Mpa |
| 30 | 70 | 1.8 | 23.45Mpa | 30.79Mpa |
| 50 | 50 | 1.8 | 25.49Mpa | 34.85Mpa |
| 60 | 40 | 1.8 | 24.47Mpa | 31.20Mpa |
| 70 | 30 | 1.8 | 25.08Mpa | 33.22Mpa |

## 5.3 COMPRESSIVE STRENGTH TEST

The casting was carried out for same mix combinations in 2 sets, one with the mix design having 700 kg/m³ of cement and other with the 400 kg/m³. The compressive strength results for same are presented below.

**Table 5.3** Mix design for OPC 43 content 700 kg/m³ with 4% Nano silica

| TCM | OPC 43 (g) | Nano silica (g) | Silica fume (g) | QP(5%) (g) | QS(50%) (g) | MS(50%) (g) | SP | Steel fiber | Corrected water |
|---|---|---|---|---|---|---|---|---|---|
| 1089.54 | 792.40 | 33.01 | 264.13 | 96.87 | 812.55 | 920.19 | 36.98 | 12.93 | 199.75 |

**Table 5.4** Compressive strength results for cement with 700 kg/m³

| Sr. No. | Rate of loading (kN/mm²/min) | Compressive Strength for 3 cubes (N/mm²) | Average Compressive Strength (N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 71.02 | 74.14 |
| 2. | 1.8 | 74.48 | |
| 3. | 1.8 | 76.93 | |

**Table 5.5** Mix design for OPC 43 content 400 kg/m³ with 4% Nano silica

| TCM | OPC 43(g) | Nano silica(g) | Silica fume (g) | QP(5%)(g) | QS(50%)(g) | MS(50%)(g) | SP | Steel fiber | Corrected water |
|---|---|---|---|---|---|---|---|---|---|
| 622.60 | 452.80 | 18.87 | 150.93 | 120.25 | 1003.39 | 1136.32 | 21.79 | 12.77 | 103.73 |

**Table 5.6** Compressive strength results for cement with 400 kg/m³

| Sr. No. | Rate of loading (kN/mm²/min) | Compressive Strength for 3 cubes (N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 61.22 | 64.62 |
| 2. | 1.8 | 64.89 | |
| 3. | 1.8 | 67.75 | |

**Table 5.7** Mix design for OPC 43 content 700 kg/m³ conventional

| TCM | OPC 43(g) | Silica fume(g) | QP (5%) (g) | QS(50%)(g) | MS(50%)(g) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|
| 1056.53 | 792.40 | 264.13 | 101.11 | 848.17 | 960.53 | 35.88 | 13.14 | 192.71 |

**Table 5.8** Compressive strength result for cement with 700kg/m³

| Sr. No. | Rate of loading (kN/mm²/min) | Compressive Strength for 3 cubes (N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 66.73 | 69.59 |
| 2. | 1.8 | 70 | |
| 3. | 1.8 | 72.04 | |

**Table 5.9** Mix design for OPC 43 content 400kg/m³ conventional

| TCM(g) | OPC 43(g) | Silica fume(g) | QP(5%)(g) | QS(50%)(g) | MS(50%)(g) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|
| 603.73 | 452.80 | 150.93 | 122.06 | 1023.53 | 1159.12 | 23.92 | 12.88 | 99.82 |

**Table 5.10** Compressive strength result for cement with 400kg/m³

| Sr. No. | Rate of loading(kN/mm²/min) | Compressive Strength for 3 cubes(N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 62.04 | 61.97 |
| 2. | 1.8 | 63.67 | |
| 3. | 1.8 | 60.20 | |

**Table 5.11** Mix design for OPC 43 content 700kg/m³ with 3% Nano alumina

| TCM | OPC43(g) | Silica fume | Nano alumina(g) | QP(5%) | QS(50%) | MS(50%) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|---|
| 1081.04 | 792.50 | 264.13 | 24.51 | 100.25 | 841.67 | 953.18 | 36.71 | 13.18 | 197.58 |

**Table 5.12** Compressive strength result for cement 700kg/m³

| Sr. No. | Rate of loading(kN/mm²/min) | Compressive Strength for 3 cubes(N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 68.57 | 70.47 |
| 2. | 1.8 | 70 | |
| 3. | 1.8 | 72.85 | |

**Table 5.13** Mix design for OPC 43 content 400kg/m³ with 3% Nano alumina

| TCM | OPC43(g) | Silica fume | Nano alumina(g) | QP(5%)(g) | QS(50%)(g) | MS(50%)(g) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|---|
| 617.73 | 452.80 | 150.93 | 14.00 | 121.56 | 1019.84 | 1154.94 | 24.47 | 12.90 | 102.56 |

**Table 5.14** Compressive strength result for cement 400kg/m³

| Sr. No. | Rate of loading (kN/mm²/min) | Compressive Strength for 3 cubes(N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 59.79 | 61.97 |
| 2. | 1.8 | 62.04 | |
| 3. | 1.8 | 64.08 | |

**Table 5.15** Mix design for OPC 43 content 700kg/m³ with 2.5% Nano silica + 1.5% Nano alumina

| TCM | OPC 43(g) | Silica fume | Nano silica(g) | Nano alumina(g) | QP(5 %)(g) | QS(50 %)(g) | MS(50 %)(g) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1089.55 | 792.50 | 264.13 | 20.64 | 12.38 | 98.01 | 822.22 | 931.14 | 36.99 | 13.03 | 194.88 |

**Table 5.16** Compressive strength result for cement 700kg/m³

| Sr. No. | Rate of loading(kN/mm²/min) | Compressive Strength for 3 cubes(N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 74.08 | 77.41 |
| 2. | 1.8 | 77.96 | |
| 3. | 1.8 | 80.20 | |

**Table 5.17** Mix design for OPC 43 content 400kg/m³ with 2.5% Nano silica + 1.5% Nano alumina

| TCM | OPC 43(g) | Silica fume(g) | Nano silica(g) | Nano alumina(g) | QP(5 %)(g) | QS(50 %)(g) | MS(50%)(g) | SP | Steel fiber | Corrected water(ml) |
|---|---|---|---|---|---|---|---|---|---|---|
| 622.58 | 452.80 | 150.93 | 11.78 | 7.07 | 120.29 | 1009.22 | 1142.92 | 24.67 | 12.82 | 103.68 |

**Table 5.18** Compressive strength result for cement 400kg/m³

| Sr. No. | Rate of loading(kN/mm²/min) | Compressive Strength for 3 cubes(N/mm²) | Average Compressive Strength(N/mm²) |
|---|---|---|---|
| 1. | 1.8 | 64.69 | 68.36 |
| 2. | 1.8 | 68.97 | |
| 3. | 1.8 | 71.42 | |

Maximum compressive strength of 80.20MPa was achieved by the addition of 2.5% nano silica and 1.5% nano alumina with 700kg/m³ of cement. The strength obtained was good considering few causes which impressed the strength of concrete. Firstly the temperature of water was below 24˚C about 7 to 12% resulting in unfinished hydration and secondly the moulds available in lab were not perfectly in the shape for deformed shape. The surface of the cubes was not parallel which effected in short rise of cracks. With these cause the strength of 80MPa obtained is necessarily good.

*Fig.5.1. Failure of concrete*

# CHAPTER 6

# CONCLUSIONS

The literature review carried out concluded that increase with the quantity of fine materials as a substitution to the cement and the results of the tests justification this conclusion to great extent.

- The cement had replaced by certain amount of Nanosilica and Nano alumina.
- The strength increased with the increase in the replacement of the cement up to 30% and it includes that 30% fines materials added to the mix are sufficient to fill the voids and further increase or decrease results in the lower strength.
- As the amount of fine materials kept on increasing the water demand increased gradually to the fact that the surface area at the materials extended.
- With use of superplasticizer the water to binder ratio was brought down to 0.19 with the optimum value of the superplasticizer being 3% for the cement content of 700kg/m$^3$ and 3.5% for the cement content of 400kg/m$^3$. It was observed that the superplasticizer give way to amazing workability at the lower values of water to binder ratios.
- The compressive strength results give way to the strength up to 80 MPa, which is quite satisfactory owing to certain reasons like hand mixing, deformed shapes of the cubes casted due to the defected molds and the curing of the cubes at low temperatures ranging from 7-12ºC which is quite lower than room temperature of 24ºC.
- Further if the curing of the specimens is carried out at high temperatures, these UHPC mixes are expected to provide higher strengths.

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