COMBINED USE OF NANO SILICA AND MICROSILICA TO IMPROVE DURABILITY PROPERTIES OF CONCRETE

A PROJECT REPORT

Submitted in fulfillment of the partial requirement for the Degree of

BACHELOR OF TECHNOLOGY
IN
CIVIL ENGINEERING

Under the supervision of

Mr. ANIRBAN DHULIA

(Assistant Professor)

Under the Co-guidance of

Mr. ABHILASH SHUKLA

(Assistant Professor)

By

XITIZ SEN [161642]

to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

WAKNAGHAT SOLAN-173234

HIMACHAL PRADESH, INDIA

June- 2020

STUDENT'S DECLARATION

I hereby declare that the work presented in the Project report entitles **"COMBINED USE OF NANO-SILICA AND MICRO SILICA TO IMPROVE DURABILITY PROPERTIES OF CONCRETE"** submitted for partial fulfillment of the requirements for the Bachelor 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. Anirban Dhulia** and under the co-guidance of **Mr. Abhilash Shukla.** 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.

XITIZ SEN
(161642)
Department of Civil Engineering
Jaypee University of Information Technology, Waknaghat
June, 2020

CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"COMBINED USE OF MICRO SILICA AND NANO SILICA IN ORDER TO IMPROVE DURABILITY PROPERTIES OF CONCRETE"**in the partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Xitiz Sen (161642)** during the period from July 2019 to June 2020 under the supervision of **Mr. Anirban Dhulia** and co-guidance of **Mr. Abhilash Shukla**, Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

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

Date- 1/06/2020

Abhilash	Anirban Dhulia 07/06/2020	15/7/2020 HOD CE DEPT
Mr. Abhilash Shukla	Mr. Anirban Dhulia	Dr. Ashok Kumar Gupta
Assistant Professor	Assistant Professor	Professor and head of Department
Department of Civil Engineering	Department of Civil Engineering	Department of Civil Engineering
JUIT Waknaghat	JUIT Waknaghat	JUIT Waknaghat

ACKNOWLEDGEMENT

First of all, I would like to express our deep gratitude to my project guide **Mr. Abhilash Shukla**, *(Assistant Professor, Department of Civil Engineering) and* **Mr. Anirban Dhulia**, *(Assistant Professor, Department of Civil Engineering)* for providing me an opportunity to work under their supervision and guidance. They have always been my motivation for carrying out the project. Their constant encouragement at every step was a precious asset to us during my work.

I express my deep appreciation and sincere thanks to **Dr. Ashok Kumar Gupta**, Head of the Civil Engineering Department for providing all kinds of possible help and encouragement during my project work.

I would like to thank my parents for their continuous support and motivation. Finally, I would like to thank to all who directly or indirectly helped us in completing this project.

ABSTRACT

Concrete is the most flexible material because of the persevering and nonstop requests made on solid, Engineers are ceaselessly pushing the cutoff points to improve its presentation with the assistance of imaginative synthetic admixtures and beneficial cementitious materials like fly ash, silica seethe, granulated impact heater slag and steel slag and so forth… The utilization of enormous amount of concrete produces expanding co_2 outflows and outcome the green house impact. A strategy to decrease the concrete substance in concrete blends is the utilization of silica rage which is a formless (non-crystalline) polymorph of silicon dioxide, silica. It is a ultra-fine powder gathered as a result of the silicon and ferrosilicon amalgam creation with a normal molecule breadth of 0.1 to 0.5 µ. Nano innovation is encouraging regions of science. The nano materials utilization is new transformation in concrete.

Concrete is the most generally utilized development material on the planet. As of late, specialists have concentrated on improvement of the solid quality in regards to its strength and mechanical properties. The accomplishment can be achieved by the use of the beneficial cementitious materials.

Out of all these beneficial materials, silica seethe is being created in tones of mechanical waste every year. The greatest challenge to investigate the properties of silica seethe was the absence of material to explore different areas. Earlier research involved a costly added substance called smoldered silica, an undefined type of silica made by ignition of silicon tetrachloride in a hydrogen-oxygen fire. Silica is a fine pozzolanic material and a reactant. It is a side-effect of delivering silicon metal or ferrosilicon amalgams. One of the most useful employments of silica rage is in concrete. On account of its compound and physical properties; it is a responsive pozzolanic material. Highly durable concrete quality can be achieved with silica additives in it.

Keywords: Fly ash, Micro silica, Nanosilica, Nano materials, Pozzolanic materials.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND THEIR FULL FORM

A.C.V.	Aggregate Crushing Value
C.T.M.	Compression Testing Machine.
C.M.	Cementitious
MS	Micro Silica
NS	Nano Silica
OPC	Ordinary Portland Cement
ITZ	Interfacial Transition Zone
RCPT	Rapid Chloride Penetration Test

CHAPTER 1

INTRODUCTION

1.1 General

The basic concrete properties are presented along with its history. Furthermore, nanotechnology is discussed along with its advancement in the field of enhancing the properties of concrete in a gigantic manner. The reason of usage of *MS* and *NS* in a concrete mix is tried to be found along with the respective advantages and challenges.

1.1.1 Concrete

A composition which is solid is flexible and malleable material is termed as concrete. It comprises of concrete, sand and total (e.g., rock or squashed stone) blended in with water. The concrete and water structure a glue or gel which covers the sand and total. As the hydration mechanism proceeds, the concrete forms bond with water and the setting of the materials begin. Around a month is taken for cement to arrive at full hardness and quality. Cement can take many years to achieve strength and quality over time.

Shockingly, concrete has an extremely long if fairly rambling history. It is believed to be the soonest utilization of cement. The sections of an oven were found on the site - the lime to make the solid may have been signed in it. The lime had been blended in with stone and laid 30-80mm profound and given a smooth completion. Egyptian wall paintings from the subsequent thousand years BC delineate the creation of mortar and cement. Around 500 BC, at Camiros on Rhodes, the antiquated Greeks assembled a 600,000 liters' limit underground storage fixed with fine concrete.

Long haul sturdiness of cement has been of enthusiasm for scientists in past decades, and all through their various research attempts, they have attempted to improve solidness with the use of various strategies. One procedure is the mix of another material into the solid.

1.1.2 Nanotechnology

The nanoscience and nano-designing, here and there called Nano modification, of cement are terms that have come into regular utilization and its application is quickly developing. Nanoscience manages the estimation and portrayal of the nano and small scope structure of concrete based materials to all the more likely see how this structure influences large scale properties and execution using propelled portrayal procedures and atomistic or sub-atomic

level demonstrating. Nano-building envelops the procedures of control of the structure at the nanometer scale to build up another age of custom-made, multifunctional, and cementitious.
Composites with unrivaled mechanical execution and solidness conceivably scopes of novel properties, for example, low electrical resistivity, self-detecting abilities, self-cleaning, self-recuperating, high pliability, and poise of splits. Cement can be nano-designed by the fuse of nano sized fabricating squares or articles (e.g., nanoparticles and nanotubes) to control material conduct and include novel properties, or by the joining of atoms onto concrete particles, concrete stages, totals, and added substances (counting nano sized added substances) to give surface usefulness, which can be changed in accordance with advance explicit interfacial connections.

For centuries, nanoparticles have been added to the creation of earthenware production; in any case, it is their cognizant, logical use that establishes nanotechnology. Nano sized particles have a high surface territory to volume proportion, giving the possibility to enormous concoction reactivity. There are a couple of studies on consolidating nano-iron (nano-Fe_2O_3), nano-alumina (nano-Al_2O_3) , and nanoclay particles. Also, a predetermined number of examinations are managing the assembling of nanosized concrete particles and the advancement of nanobinders. Nanoparticles can go about as cores for concrete stages, further elevating concrete hydration because of the reactivity pace, as Nano reinforcements and fillers, microstructure densifying and the *ITZ* porosity decreasing is seen. The most noteworthy issue for all nanoparticles is that of powerful scattering. In spite of the fact that it is especially critical at high loadings, even low loadings experience issues with self-conglomeration, which decreases the advantages of their little size and makes unreacted pockets prompting a potential for grouping of worries in the material.

The most vital nano materials used for the construction purposes are as follows

- Use of Carbon- nanotubes.
- Nano particles usage of Titanium dioxide.
- Nano silica, the most widely used one.
- Nano particles usage of Zinc oxide.
- Particlesof nano silver are used.
- Nanoparticles usage of Zirconium oxide.
- Tungsten oxide nanoparticles.

1.1.3 Why so much interest in nano materials

- Nano stage earthenware production is explicitly intrigued since the increasingly pliable at high temperature when contrasted with the grained pottery.
- Nanostructure semiconductor is known to show backhanded properties related to optical sector.
- The Nanostructure semiconductor is utilized likewise a window layer, in a sun powered cells.
- Nano metallic powder is utilized for production of materials of gas tight.
- Oxides related to nano-structured are tolerating the developing consideration so as to recuperation the improved affectability and selectivity in respect to gas sensors.

1.1.4 Applications

- For the manufacturing of High compressive quality mixes.
- High usefulness with less w/c demand.
- Cement setting aside to 35 to 40%.
- Super plasticizer usage as an admixture.
- Filling of all the smaller scale voids and miniaturized scale pores.
- An added substance for plastics and elastic.

1.1.5 Advantages

- Less expenses on maintenance cost.
- Improvement in the segregation resistance.
- Micro-cracking is highly fixed.
- Low expenses on the life time applications.
- Corrosion resistance

1.1.6 Disadvantages

- Impurities: Reactionary ability of nano materials is quite high and associated by blending. Change at nano particles happens because of pozzolanic species. The contaminations become a piece of nano particles, and unadulterated nano particles come out to be exceptionally troublesome.
- Fluctuation of particles: Profoundly the nano admixtures are trying to be like vitality related quick nanomaterials. Nano materials at the zones of cutting edge vitality and the Fine particles are having high surface territory when they are reacting with oxygen.

- Recycle and removal: Quantities of their properties are steady beneath issues and aftereffects of the tests are not normal.
- Biological awful: Unsafe consideration on the grounds that they get highly reactive for skin. Harmful quality materials, additionally takes owing to their high surface area and improved surface reactivity. Nano materials demonstrated to cause aggravation and have shown to be disease causing. Association of these materials with liver or blood could end up being unsafe.

1.1.7 Need/Demand

- Most generally utilized materials for concrete.
- Necessary for respective properties, for example,
- In enhancement of Mechanical properties,
- In the improvement of Durability Parameters.
- To upgrade the Strength.
- In order to reduce the cost conditions.
- Concern related to the environment and green structure idea

CHAPTER 2

LITERATURE REVIEW

2.1 General

This study constitutes about nano-particles and smaller scale particles. Nano particles and smaller scale particles are utilized as a reactant so as to upgrade toughness properties of cement. The accompanying writing survey banter the blend proportion, character, and plan and joined utilization of miniaturized scale silica and nano silica in concrete. Materials like *MS, NS,* sand, coarse totals with concrete, and super plasticizer were advanced and trial results were looked at. This assessment paper shows the impact of joined utilization of *MS* and *NS* on the strength properties of cement.

2.2 Literature survey

Barbhuiya et al. [1] In their examination 10% concrete was supplanted with *MS* and *NS* (9%*MS*+1%*NS*, 8%*MS*+2%*NS* and 7%*MS*+3%*NS*). The impacts of *MS* and *NS* were assessed on the sturdiness properties of cement. Compressive quality, electrical resistivity, chloride entrance obstruction and sorptivity of cement were considered. They discovered best blend to accomplish greatest compressive solidarity to be 9%*MS*+1%*NS*. The resistivity of cement containing a mix of *NS* and *MS* was higher than that of cement containing *MS* just and the solid containing 9%*MS*+1%*NS* was best in opposing chloride entrance in cement and this mix had the most minimal sorptivity.

Sharkawi et al. [2] In this examination the effectiveness of utilizing *MS* and *NS* blend, as concrete halfway substitution, on consumption assurance and sulfate obstruction of cementious materials was explored. What's more, the impact of this silica multi-sized blend was likewise concentrated on some solidness qualities identified with erosion and sulfate assurance. Concrete incompletely supplanted with 10% *MS* and 2%*NS* just as 8%*MS* + 2%*NS* blend separately. They found that joined utilization of MS and NS surprisingly improved the cementitious material's strength execution, as opposed to the different utilization of either a similar all out silica substitution proportion of *MS* (for example 10%) or the ideal *NS* proportion (for example 2%).Micro-nano blend substitution proportion deferred the erosion inception time of inserted steel bar in solid example by 16% just as improved the sulfate opposition. Moreover, they expressed that in further examination for the synergistic solidness productivity of miniaturized scale nano silica blend, the proposed 2%*NS* + 8%*MS* blend can be viewed as an underlying blending proportions of 10% absolute silica substitution proportion. Be that as it may, various parameters affecting the effectiveness of nano proportion (for example scattering of nano particles) ought to likewise be thought of, to acquire the ideal blending proportion of *MS/NS* just as the ideal absolute concrete substitution proportion of the blend.

Behfarnia et al. [3] This examination researched the impact of halfway substitution of the slag utilized in salt enacted slag concrete with *NS* and *MS* on its penetrability. The impact of NS and MS, both separately and in blend, on porousness of soluble base enacted slag concrete was inspected through water impermeability test, rapid chloride penetrability test, carbonation test, present moment and all out water assimilation tests, and compressive quality. They discovered examples containing small scale silica accomplished more compressive quality than that containing nano silica. The aftereffects of water impermeability test demonstrated replacement of 10% small scale silica diminished the water infiltration profundity by 49% and in *RCPT* and carbonation tests, *MS* had a constructive outcome and *NS* negatively affected obstruction of Concrete.

Li et al. [4] To research the joined impacts of *MS* and *NS* on the sturdiness of concrete, a trial program was propelled, mortar blends speaking to mortar bits of cement with different water, *MS* and *NS* substance yet a consistent usefulness were made for quality, sulfate assault, carbonation, quick chloride penetrability and water retention tests. It was discovered that the expansion of *MS* or potentially *NS* was powerful in improving the sturdiness of mortar. In addition, for improving the quality, sulfate opposition and carbonation obstruction, 1% *NS* was nearly tantamount to 10% *MS* and the joined expansion of *MS* and *NS* demonstrated certain synergistic impacts as in the consolidated impacts were bigger than the separate wholes of the individual impacts. In particular, they expressed that the establishing productivity factor of *NS* is at unsurpassed higher within the sight of *MS*. The expansion in the establishing proficiency factor of *NS* with the *MS* content expert vides strong proof of the synergistic impact of consolidated expansion of *MS* and *NS*.

Massana et al. [5] The primary motivation behind the exploration was to analyze the impacts of *NS* and *MS* on the solidness of a superior self-compacting concrete (*HPSCC*). Ten mixes were fabricated: one without augmentations as control, three with 2.5%, 5% and 7.5% of *NS*, three more with 2.5%, 5% and 7.5% of *MS* and three utilizing the two admixtures, with 2.5%/2.5%, 5%/2.5% and 2.5%/5%, of *NS* and *MS*, separately. The blend of *NS* and *MS* in the blends contemplated created cements with a high compressive quality, minimization and, in this manner, improved toughness properties. Ultimately, in ternary blends the pores arrange got is a consequence of the mix of the two impacts, creating cements with a little normal pore size, corresponding to the measure of nSi, and with a littler complete porosity relative to the measure of mSi.

Shaikh et al. [6] The impacts of nano silica (*NS*), small scale silica (*MS*) and consolidated NS and MS on bond conduct of steel and polypropylene (*PP)* filaments in raised volume fly debris (*HVFA*) mortar is presented in the study. *NS* and the *MS* were included as 2% and 10% (by wt), individually as fractional substitution in *HVFA* mortar, with 40% fly debris. On account of consolidated *NS* and *MS*, 2% NS and 10% *MS* was utilized as fractional substitution of *OPC* in *HVFA* mortar. The expansion of 2% *NS* and 10% *MS* demonstrated practically comparative improvement in the most extreme draw out power of steel and PP filaments at the two ages in *HVFA* mortar containing 40% fly debris. The joined utilization of 2%*NS* + 10%*MS* likewise improved the greatest draw out power and higher than 2% *NS* and 10% *MS*.

Senff et al. [7] In this paper the impacts of nano silica (nS), smaller scale (silica smoke, *SF*) and their synchronous use (nS and *SF*) on "both" the microstructure of concrete glues and the mechanical properties of mortars were researched. Results demonstrated that synergistic impact among nS and SF upgraded the glue carbonation obstruction. The concoction activity advanced by nS along with the physical impact because of the little molecule size dissemination given by SF brought about higher compressive quality and better solidified properties, proposing the synergistic activity of nS and SF contrasted and single augmentations. X-beam diffraction uncovered that the expansion of nS and SF didn't prompt the development of unmistakable hydration stages when contrasted with the glue without mineral expansion. The main perceptible contrast related to the portlandite top power, which would in general reduce for all restoring ages with expansion of nS, SF and nSzSF.

Sanchez et al. [8] The paper surveys the field of nanotechnology with the condition of concrete. Meanings of nanotechnology, including nanoscience and nano-designing in concrete, are given. The effect of ongoing advancements in instrumentation, computational materials sciences and the utilization in solid research is examined and late advancement in nano-designing and nano-change of concrete based materials is introduced. In their decision, they expressed that this data is pivotal for foreseeing the administration life of cement and for giving new in-sights on how it very well may be improved.

Rossen et al. [9] This investigation presents new outcomes on the microstructure and *C–S–H* organization of PC-silica seethe mixes hydrated at 10, 20 and 38 °C and with low to high replacement levels. Results show that the microstructure advancement of concrete silica smolder mixes is totally different from plain concrete. The development morphology of *CH* is unequivocally influenced by the nearness of silica smolder and the loss of calcium from the *C–S–H* is driven by the utilization of calcium by the response of silica seethe. It was seen that two edges of IP *C–S–H* exist in such mixes. There was an external edge framing first, trailed by a darker dim edge shaping at a later stage when the *CH* was exhausted.

Puentes et al. (10) A similar report evaluated the impact of silica-put together miniaturized scale and nano increments with respect to Self-Compacting Concretes with respect to solidified porosity and porousness. A few standards were observed during 24 h: water dissipation, slim weight, free drying shrinkage, temperature and ultrasonic heartbeat speed (*UPV*). All the silica based increases (*SBA*) utilized in this examination altered the water relocations during *EA*, quickened the concrete hydration process. In spite of the fact that the quality came out to be low and the porosity was higher at 7 days, the pozzolanic impact of *SBA* enhanced the material execution at 28 days. Further he found that the utilization of *SBA* presented the production of an underlying strong interconnected structure (PSS or purpose of zero slender pres-sure) albeit no molecule size impact was recorded. The pozzolanic impact mutually with the nucleating impact of the *SBA* particles influenced the response advancement, expanding the temperature sufficiency of the material at *EA*.The improvement of negative fine weight at *EA* relied upon the improvement of interior worries by water utilization because of both dissipation and hydration, while *EA* drying shrink-age likewise relied upon the strong structure combination. In the solidified state, *SBA* improved the mechanical exhibition of the material and the pore arranges development and fume porousness. In spite of the fact that the quality was lower and the open porosity was bigger at 7 days, the pozzolanic impact of *SBA* improved the material execution at 28 days.

Ghafoori et al. [11] In this paper, the impact of joined nano silica (*NS)* and small scale silica (*MS*) on sulfate obstruction of Portland concrete (*PC*) mortars was assessed. Mortars containing silica had 6% concrete substitution of *NS*, *MS*, or 3% of each and an extra blend with 3% *MS* was additionally tried. The mortars tried were estimated for extension and compressive quality. The development estimations showed that *MS* substitution mortars beat both *NS,* and *NS+MS* mix substitution blends. The *NS+MS* blend mortar blends for the concrete sorts gave results better than those with *NS* just yet worse than the *MS* just mortars.

Kong et al. [12] Influence of nano-silica on microstructure and the solidified concrete materials were researched by utilizing hastened silica (*PS)* with exceptionally enormous agglomerates and seethed silica (*FS)* with lot littler ones as nano-scale added substances. The outcomes indicated that the expansion of either *PS* or *FS* refined the porosity of the solidified concrete glue. Through *PS* expansion, compressive quality of the mortars and their protection from calcium draining and chloride entrance were upgraded.

Khan et al. [13] This paper covers the physical, synthetic properties of silica smoke, and its response component. It manages the impact of silica smolder on the porousness, freezing and defrosting obstruction, consumption, sulfate opposition, carbonation, and soluble base total opposition of cement. Results indicated that expansion of silica seethe quickens the hydration of concrete at all phases of hydration. The pozzolanic activity of silica rage is by all accounts dynamic at early long stretches of hydration, Silica seethe improves the drawn out consumption obstruction, soluble base silica extension, however builds the carbonation profundity.

Jalal et al. [14] this study investigated, mechanical, rheological, toughness and micro-structure properties of superior self-compacting concrete (*HPSCC*) fusing SiO_2 miniaturized scale and exploration of nanoparticles. For this reason, a small amount of Portland concrete was supplanted by various measures of *MS*, *NS* and mix of miniaturized scale and nano silica as 10%, 2% and 10% + 2% separately. Compressive and parting elastic qualities improved rather essentially in the blends containing SiO_2 small scale and nanoparticles, water retention and hair like assimilation results indicated rather huge abatement.

Hendi et al. [15] In this examination, Combination of *MS* and *NS* were considered to structure a high quality self-merging cement to oppose in the sulfuric corrosive medium. Thermo gravimetric investigation (*TGA)* was likewise used to discover the calcium hydroxide run while utilizing these two pozzolans. *TGA* uncovered that colloidal silica didn't add to solidify hydration inside seven days of restoring while a blend of them helped calcium hydroxide utilization. Blend of smaller scale silica and nano silica was more powerful than when they utilized independently. The outcomes additionally uncovered that 7 percent replacement of miniaturized scale silica indicated a similar impact as 2 percent nano silica substitution.

Gesoglu et al. [16] This study constituted the impact of utilizing parallel and ternary mixes of *NS*, smaller scale silica *MS*, with the direct impact on the mechanical properties of low folio ultra-elite cementitious composites (*UHPCs*). For the investigation, two solid gatherings were structured having silica seethe and the other one missing it, by weight of concrete. Economically accessible *NS* was utilized in halfway replacement of concrete at 0%, 0.5%, 1%, 2% and 3% by weight. The outcomes showed that among various *NS* substance, *UHPC* containing 2% *NS* displayed the best consequences of compressive quality, parting rigidity, modulus of versatility, flexural qualities, load–dislodging conduct and break vitality at 90 days. The examples of *UHPC* containing paired cementitious materials (*NS* and *SF)* gave preferred outcomes over cements containing just *NS*. Moreover, the impact of 1% *NS* is practically equivalent to that 10% of *SF*.

Balapour et al. [17] In this paper, significant solidness qualities of cement with *NS*, including the chloride particle infiltration, electrical resistivity, water entrance, water ingestion, the pore size appropriation, the carbonation, the sulfate obstruction, ice opposition, shrinkage, and warm parameters were investigated. The expansion of *NS* to concrete adds to the improvement of compressive quality, Tensile and flexural quality and the consolidation of *NS* lead to the decrease of chloride particles infiltration. The expansion of *NS* to solidify grid can enhance the electrical resistivity of cement and decline water entrance profundity, all things considered, in contrast with control blend. *NS* was essentially successful in improving sulfate opposition and causes prominent development decrease in the examples and carbonation profundity additionally diminished.

Arel et al. [18] In this examination, the impacts of miniaturized scale *MS*, *NS*, class C fly ash *(FA*), and met kaolin (*MK*) on the toughness and on the mechanical properties of mortars presented to inside and outer sulfate assaults were researched. At the point, outcomes of all the parameters were assessed together, the hugest commitment to toughness and quality among the admixtures was seen to be from *NS*, which showed a normal improvement of 2%–10% over *MS*, which showed the second most critical commitment for mortar tests presented to the most extreme inward and outside sulfate assaults.

Singh et al. [19] This examination worries with the utilization of nano silica and small scale silica to improve the compressive quality of cement. An exploratory examination was done by incompletely supplanting the concrete with Nano Silica in differing rate (for example 1%,2%,3%,4% and 5%) and smaller scale silica in shifting rate (for example 5%,7%,9%,11%,13% &15%). In test result it was discovered that even exceptionally little of measure of *NS* (for example 2 to 3%) has generous beneficial outcomes on the compressive quality of cement, however there was appeal of super plasticizer. In addition, joined option of *MS* and *NS* has noteworthy synergistic consequences for the compressive quality (*CS*) of cement and based on results got it tends to be prompted that *NS* and *MS* ought to be included to accomplish the most extreme quality of the solid anyway the impact of these material on functionality of cement can be repaid utilizing high range water diminishing super plasticizer.

2.3 Research gap

- The cement replacement percentage varied only between 8-10%.
- Very few researchers have done individual replacements and combined replacements of nano silica and micro silica along with normal mix.
- Results of concrete mix and mortar mix cannot be assessed and compared to evaluate *MS* and *NS* improvement abilities.
- W/c ratio and super plasticizer dosages are not varied alot.

2.4 Research objective

- To evaluate the effects of nano silica (*NS*) and micro silica (*MS*) on the durability properties of concrete as shown in **Fig 2.1**.
- To study consolidated impacts of micro silica and nano-silica on solidness of concrete.
- To observe property change in concrete after increasing w/c ratio and super plasticizer dosages.
- To evaluate compressive strength alterations by increasing MS content.

2.5 Scope of study

- *MS* and *NS* can be replaced to a higher proportion of about 20-30% with cement in concrete mix, with proper water reducers, air entrainers and super plasticizer dosages and Durability as well as strength parameters of the concrete can be enhanced to a remarkable level.
- If proper environment for *MS* and *NS* replacement is generated then it can be used in extreme environment as well as with *SCC, UHPC* etc.
- In coming time due to growing industrialization in our country, the production of *MS* and *NS* will increase and their usage will be economical and an advantage for the infrastructure of the country.
- With the help of heavy duty mixers, the high dosages of super plasticizers can be incorporated for *MS* and *NS* replacements at high scale and durability as well as strength parameters can be enhanced at an exceptional level.

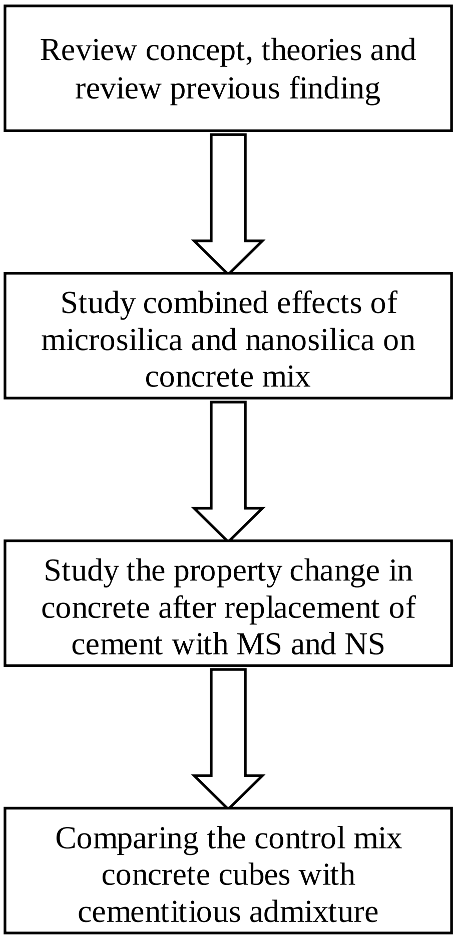

Figure 2.1 Flowchart for research objective

CHAPTER 3

METHODOLOGY

3.1 General

The task has begun with perusing a few diaries and choosing the subject as shown in **Fig 3.1**. In the wake of choosing the point we did the difficulty distinguishing proof by perusing a few related research papers and audit contemplates. In the wake of distinguishing what ought to be done, assortment of materials has begun. In the wake of gathering of the respective materials, we had to carry out all the standardized testing. Testing done ought to be fitting and should follow legitimate and exact strategies.

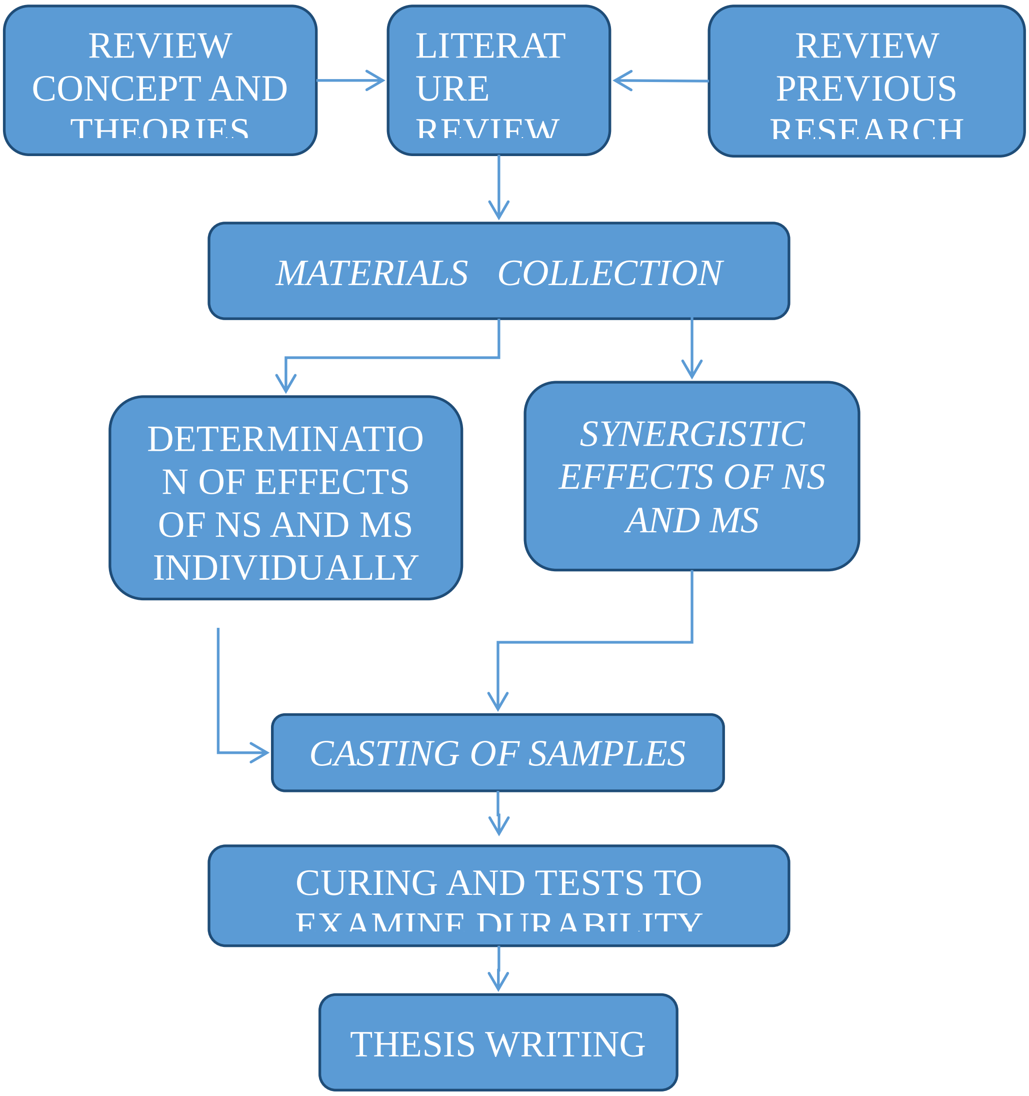

Figure 3.1 Project methodology

3.2 MATERIALS USED

Table 3.1 Ingredients used to prepare concrete mix

Components	Function	Particle size	Type
Cement	Binds the constituents	10-90 micrometer	OPC 43 grade
and	Inert material	150-600 micrometer	Crushed at crushers/Naturally
Nano silica	Pores reducing ability and improves rheology.	20-25 micrometer	Powder
Micro silica	Fills the voids and enhance rhelogy	8-10 micrometer	Powder
Coarse Aggregates	Inert material	10-25 micrometer	Aggregates

3.2.1 OPC 43 GRADE

It was obtained within the university, reffering to IS: 8112-1989 as shown in **Fig 3.2.**

Figure 3.2 OPC 43

3.2.2 SAND

The gathering of Fine aggregates as shown in **Fig 3.3** and **Fig 3.4** is gotten in the wake of smashing of hard stone. Size of squashed sand is under 4.75mm. It is secured locally from Solan, Himachal Pradesh. Scope of fine total is 150µm To 600 µm.

Figure 3.3 Sand zone iv

Figure 3.4 Sand zone ii

3.2.3 NANO SILICA

Silicon dioxide nanoparticles or nano-silica, are the areas for a vast biomedical research due to their soundness, low poisonousness and capability to be functional with reference of particles and polymers. It very well may be gathered from argillaceous stone. Adequate measure of silica in solid assists with giving quality. Some respective properties of *NS* are:

1. Builds quality
2. Usefulness
3. Adaptability
4. Builds thickness of liquid stage
5. Strength

Nano silica is acquired from Trimex businesses Ltd. from Hyderabad as shown in **Fig 3.5**. Nano molecule size extents from 0.21μm to 0.35μm.

Figure 3.5 Nano silica

3.2.4 MICRO SILICA

Micro silica, otherwise called silica seethe or consolidated silica rage, is a mineral admixture made out of fine strong lustrous circles of silicon dioxide. It is generally found as a result in the modern assembling of ferrosilicon and metallic silicon in high-temperature electric curve heaters. Added to that, Micro silica diminishes the pace of carbonation and diminishes penetrability to chloride. Subsequently, smaller scale silica concrete can unequivocally shield support and installation from forceful operators.

3.2.4.1 Micro silica comes in three forms which are:

- Powdered micro silica
- Condensed micro silica
- Slurry micro silica

3.2.4.2 Effects of Micro silica on Concrete

- It decreases isolation prospects, so it very well may be utilized as siphoning help.
- It nearly disposes of dying; subsequently completing work will start early.
- Workability and consistency of solid reductions.
- Compressive quality, subsequently flexural and rigidity are improved too.
- Abrasion obstruction
- Impact and cavitations opposition.
- Sulphate Resistance
- Heat Reduction
- Chemical Resistance

Figure 3.6 Micro silica

Micro silica is procured from Trimex industries Ltd. from Hyderabad as shown in **Fig 3.6.**

3.2.5 COARSE AGGREGATES

These are bigger size filler material utilized in solid blend. They go about as an idle material in concrete. The surface zone of coarse aggregates is not exactly fine totals. Dolomite totals, squashed rock or stone, regular breaking down of rock are significant wellsprings of coarse totals. Coarse aggregates utilized as shown in **Fig 3.7 and Fig 3.8** was secured locally from solan. Scope of coarse total utilized are 10mm To 20 mm.

Figure 3.7 20mm Coarse aggregates

Figure 3.8 10mm Coarse aggregates

3.2.6 SUPERPLASTICIZER (SP)

The super plasticizer as shown in **Fig 3.9** utilized was a poly-carboxylate based. The super plasticizer put together works with respect to the rule that, the super plasticizer is adsorbed onto the outside of material particles at first and afterward scatters them, subsequently forestalling their assortment.

Figure 3.9 Super plasticizer

3.3 Oxide composition and particle size distribution of materials

The oxide structures are shows the rates of various mixes in the materials as shown in **Table 3.2**. Oxide pieces of *OPC 43, NS* and *MS* were analyzed with the help of *XRD*. Molecule size of the considerable number of materials is a significant component for the development of High Strength concrete. Appropriate molecule size of the considerable number of materials ought to be known for ideal blend proportioning.

Table 3.2 Oxide composition

Materials %	CaO %	SiO_2 %	Al_2O_2 %	Fe_2O_3 %	MgO %	SO_2 %	K_2O+ Na_2O %
OPC 43	61.8	19.4	5.98	3.1	2.21	1.48	1.04
NS	<0.002	99.8	<0.0041	<0.0013	<0.0019	-	-
MS	<0.003	99.54	<0.056	<0.016	<0.003	-	<0.005

3.4 Indian standards used to conduct this study:

To conduct the tests and experiments for this research work, all the below mentioned IS codes in **Table 3.3** were accounted.

Table 3.3 List of IS code used during experimental study of research work.

Code No.	Description
IS-1989	Ordinary Portland Cement 43 Grade
IS 4031-1988 (part- 4)	Normal Consistency
IS 4031-1988 (part- 5)	IST & FST of cement
IS 4041-1988 (part-1)	Fineness
IS 4041-1988 (part-11)	Specific gravity of cement
IS 516-1959	Compressive strength of concrete
IS 1458-2000	CTM
IS 383-1970	Zoning of sand
IS 2386-1963 (part-1)	Specification of aggregate
IS 15388-2003	MS & NS
IS 9103-1999	Specification for concrete admixture
IS 12330-1988	Sulphate resisting test
IS 6925-1973	RCPT
IS 456-2000 & IS 10262-2019	Mix design considerations

3.5 Specific Gravity of materials

The specific gravity of various materials are shown in **Table 3.4.**

Table 3.4 Specific Gravity of materials

Material	**Specific Gravity**
MS	2.17
NS	1.03
Cement – OPC Grade 43	3.15
Coarse Aggregates	2.74
Fine Aggregates	2.65
Chemical Admixture	1.14

3.6 Testing

The experimental work plan was divided in four stages. Experimental works of every stage included the preparation of samples.

Stage 1 Cement, workability of concrete, fine aggregate test and coarse aggregate tests.

Stage 2 Casting samples of control mix

Stage3 Casting samples of different proportions of *MS* and *NS*.

Stage 4 Tests on control mix samples and *MS* & *NS* samples.

Stage I: - Basic cement, concrete, fine and coarse aggregate tests

3.6.1 Normal consistency

It is utilized to ascertain precise amount of water it is utilized, and for complete hydration which to get ideal quality. Water requirement of Ideal amounts yields for the best outcome. Vicat's apparatus as shown in **Fig 3.10** is accustomed to evaluate the ideal measure of water. The needle utilized vicat's hardware is 10mm breadth and 50mm in the length. To discover the typical steadiness of concrete the needle ought to be entering 5mm to 7mm.

Figure 3.10 Vicat Apparatus

To determine the possible consistency of concrete, at first 400g of dry cement is taken. The typical consistency of concrete reaches from 25% to 34% by its weight.

3.6.2 Fineness of cement

Fineness of the cement is the estimation of molecule grain of concrete powder. Fineness is communicated in the details of the particular surface of the concrete. Significant factor i.e. the fineness is essential for finding the size of addition of solidarity and normalized of amount. The fineness of the concrete determined with the assistance of 90µm sieve as shown in **Fig 3.11**.

Figure 3.11 Sieve 90 micron

3.6.3 Specific gravity of cement

Specific gravity of strong materials is the proportion of the volumetric mass of strong to the mass of equivalent water, by volume. We utilized Kerosene oil, Kerosene fuel oil not responds with concrete. Using Lechatleir Flask as shown in **Fig 3.12** the specific gravity was evaluated for cement.

Figure 3.12 Le-chatlier flask

3.6.4 Initial Setting Time

The time span from the infiltration of glue of concrete after adding the 0.85p of water to when the glue opposes the entrance of $1mm^2$ cross area needle to do is the initial setting time. As such, p is the ordinary consistency of the concrete.

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

Procedure:

1. Concrete of amount 100gms was taken and water of the 0.85p was utilized to make the paste.
2. The time was noted as soon as the water was added.
3. Then the readied glue was added to the mold with the top surface leveled and was put under device needle.
4. The needle was immediately freed as soon as the mold is placed back in the apparatus.
5. At first the needle punctures the glue totally to the surface, and along these lines this system is rehashed until the needle prevents entering at 5 mm from the base of the plate.
6. After the penetration, the time is noted again and the cumulative time is noted down.

3.6.5 Final Setting Time

The time span from the planning of concrete paste after the addition of 0.85p of water, till the 1mm dia of needles develop a mark onto the surface and the needle of 5mm neglects to do the same, then this time is called final setting time. As such here p is the normal consistency of the concrete.

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

Procedure:

1. Concrete of amount 100gms was taken and water of the 0.85p was utilized to make the paste.
2. The time was noted as soon as the water was added.
3. Then the readied glue was added to the mold with the top surface leveled and was put under device needle.
4. After the placement of the mold, the needle was brought down and immediately discharged.
5. At first both needles of dia 1mm and 5mm connection establishes a connection in this manner this progression is rehashed until 1mmdia needle establishes a connection with the surface until the 5mm connection neglects to do as such.

6. After the penetration, the time is noted again and the cumulative time is noted down.

3.6.6 Water absorption test on Coarse and fine aggregates

1. Coarse aggregates of about 2kg were washed altogether, depleted and after that put in the density basket as shown in **Fig 3.13** and inundated in clean water at the recommended temperature between 22-32º C.

2. After the aggregates were submerged, immediately the ensnared air was removed from the submerged aggregates by raising the crate containing it 25 mm over the tank and permitting the drop of it at the pace of around, in one second one drop fall. For about 24 hrs the aggregates were immersed in the container subsequently.

3. The crate and the aggregates were gauged by keeping the aggregates suspended in the water of temperature of 22° – 32°C. This weight of the aggregates while being suspended in water was taken = W1g.

4. The bushel and aggregates were expelled from water and permitted to deplete for a couple of moments, after that the totals are moved to the dry spongy garments. The vacant basket was then taken to the tank of water, washed multiple times and the weight recorded was said to be= W2 g.

5. The aggregates were set on the respective permeable garments and were dried properly at the surface till most of the moisture was removed. After the aggregates were moved to the secondary spread of fabric and was left to dry for at any rate 10 minutes, till the aggregates were totally surface dry. After this, the weight of the dried aggregates was noted and = W3 g

6. Aggregates were transferred onto a plate and were kept in an oven for 24 hrs at a temperature of 110°C.The aggregates were taken out of the oven and were cooled down progressively. After that the weight of the aggregates was noted down as=W4 g.

7. Water Absorption was calculated by using the **Equation 1**.

$$((W3 - W4)/W4) \times 100 \qquad \text{Equation 1}$$

Figure 3.13 Density basket

3.6.7 Aggregate Crushing value

An overall proportion of the opposition of an aggregate smashing under steadily applied compressive load renders the aggregate crushing value. The rate of the load and the weight of the aggregates when test totals are exposed to a predetermined load under normalized conditions give the coarse aggregates crushing value. Method for total pounding esteem test is:

1. On the base plate the cylinder was placed and gauged it, the weight was taken (W).
2. The aggregates were set in three of the layers; every single layer was being exposed to 25 strokes utilizing the packing bar. Proper care was taken to maintain the geometry of the aggregates and after gauging, the weight was taken as (W1).
3. Leveled the outside of total cautiously and embedded the plunger with the goal that it lays on a level plane on a superficial level. Work was done with care to guarantee that the plunger doesn't stick inside the chamber.
4. Placed the chamber with plunger as in order of stacking base of the compressive testing machine.
5. After that the load was applied at a rate of uniformity with the goal that an all-out heap of 40T is applied quickly.
6. Released the heap and expelled the aggregates from the respective chamber.
7. Material was sieved with the help of a 2.36mm IS sifter; care was being assumed to maintain a strategic distance from loss of fines.
8. Weighed the division, which passed from the sieve was weighed as (W2).
9. Aggregate crushing value was calculated using **Equation 2**.

$$(W2 \times 100)/(W1-W) \quad \text{——— Equation 2}$$

3.6.8 Workability of Concrete

Slump cone test was performed to decide the usefulness or consistency of solid blend. The Most basic usefulness test for concrete is the slump cone test, as it includes the minimum of efforts and gives brisk and suitable results. Technique for slump cone test is:

1. Cleaned the inside of the shape and applied oil.
2. Placed shape on an even and smooth base plate which was non permeable.
3. Filled the shape with the prepared mix in a round of four equivalent layers.
4. Tamping of 25 strokes to each layer was given in order to ensure the firm packing of the mix.
5. The excessive mix was chopped off from the top of the shape with the help of a trowel.
6. The mortar and the excessive water which came from the form, was cleaned off from over the base plate.
7. The form was raised quickly in a vertical direction as shown in **Fig 3.14**.
8. After the slump was measured with the help of a measuring tape and the observed value was noted down.

Figure 3.14 Slump cone apparatus

Stage 2 Casting samples of control mix

3.7 Casting

Mix design of control mix was prepared as introduced in the part 4 and after that the procedure of casting of control mix was completed. The system for blending of the materials was done as:

1. Gauging of the constituents was done according to the prepared mix design.
2. For the blend, water requirement was estimated in the plate (hand mixing).

3. The plate was filled with the materials (hand blending) and dry blending was carried out for 2 minutes.
4. As the dry mixing proceeded as, around 70-75% of the calculated water was added in the prepared dry mix and the blending was continued for around 2-3 mins.
5. The remaining water was then added subsequently added and the blending was then continued for about 3 mins.
6. The dimensions of the molds were 15x15x15cm.The nuts in the molds were appropriately fixed so as to guarantee the right measurements. After this, the molds were oiled properly from the inside surface and the prepared mix was added in the molds with a fraction of three layer packing and tamping each layer with a tamping rod for 25 tamps.
7. The prepared molds were placed on the vibration table and keeping in mind that vibrating the material were included step by step and the molds were filled up with the mix to their edges. For tenure of 4-5 mins the molds were placed on the vibration table.

Figure 3.15 15*15*15cm molds

Figure 3.16 Dry mixing of components

Figure 3.17 Filling mold with concrete

Figure 3.18 Prepared molds

3.7.1 Mixing

The concrete dry mix was thoroughly mixed using Hobart N-50 and mechanical mixer as shown in **Fig 3.19** and **Fig3.20**

For little volume of blend Hobart N-50 was utilized and for enormous volume of the blend mechanical blender was utilized. The blending term changed from 5-7 min’s and around 70% of the water was included alongside the dry blend in the blender. After 2-3 min’s of the blending, staying 30% of the water was included.

Diverse Hobart speeds as shown in **Table 3.4** were utilized to blend the segments completely as indicated by the necessary consistency and usefulness. Moreover, as the speed of the blending expanded then at the same time the blending length was diminished so as to decrease the chance of draining and isolation in the blend.

Table 3.4 Rotation speed and state of rotation

State of rotation	Rotation Speed (RRM)
Low	65
Intermediate	125
High	250

Figure 3.19 Hobart N-50 mixer

Figure 3.20 Mechanical mixer

3.7.2 Curing

Curing acts as a significant job to the advancement of strength and quality of concrete mortar. The hydration procedure is expanded by the curing, builds the sturdiness and splits improvement is controlled. As the samples were demoulded after 24 hours, they were kept in a curing tank for tenure of 28 days as shown in **Fig 3.21**.

Figure 3.21 Curing of Prepared samples

Stage3 Casting samples of different proportions of MS and NS.

3.8 Casting

Mix design of the addition of *MS* and *NS* was prepared as introduced in the part 4 and after that the procedure of casting was completed. The system for blending of the materials was done as:

1. Gauging of the constituents was done according to the prepared mix design.
2. For the blend, water requirement and the super plasticizer was estimated in the plate (hand mixing).
3. The plate was filled with the materials as shown in **Fig 3.22** (hand blending) and dry blending was carried out for 2 minutes.
4. As the dry mixing proceeded, around 70-75% of the calculated water was added in the prepared dry mix and the blending was continued for around 2-3 mins.
5. The remaining water was then added subsequently added and the blending was then continued for about 3 mins.
6. The dimensions of the molds were 15*15*15cm.The nuts in the molds were appropriately fixed so as to guarantee the right measurements. After this, the molds were oiled properly from the inside surface and the prepared mix was added in the molds with a fraction of three layer packing and tamping each layer with a tamping rod for 25 tamps.
7. The prepared molds were placed on the vibration table and keeping in mind that vibrating the material were included step by step and the molds were filled up with the mix to their edges. For tenure of 4-5 mins the molds were placed on the vibration table

Figure 3.22 Dry mix of concrete with NS and MS

3.8.1 Curing

Curing acts as a significant job to the advancement of strength and quality of concrete mortar. The hydration procedure is expanded by the curing, builds the sturdiness and splits improvement is controlled. As the samples were demoulded after 24 hours, they were kept in a curing tank for tenure of 28 day.

Stage 4 Tests on control mix samples and MS & NS samples

3.9 Tests to measure durability properties of concrete

3.9.1 Compressive strength test

For the prepared two mix designs casting was done as discussed in the above sections. As around three cubes were prepared for every consistency, so a total number of 15 cubes were casted for the evaluation of compressive strength. With the loading rate of 1.8kN/mm²/min, the respective test was performed on the *CTM* as shown in **Fig 3.23** and **Fig 3.24**. The cubes were taken out of the curing tank and were dried out for a day in open environment before the conduction of this test. In respect to the drying surfaces, the top and bottom surfaces of the samples were taken into account. After this, the samples were individually placed on the *CTM* and the reading was observed on the display of *CTM*, till the samples failed.

The compressive strength calculation:

Compressive strength = Load/Average area (MPa)

Figure 3.23 Compression testing machine

Figure 3.24 Cube after being tested in CTM

3.9.2 Sulphate resistance test

Cubical Specimens of size 150mm x 150mm x150mm were used to perform this test. The casted samples were demolded after 24 hours. For curing purpose, the samples were kept in curing tank for 28 days. After that the samples were dried at room temperature for around 24 hours. Then the samples were weighed before their exposure to sulphate attack as well as the compressive strength were also taken for all the compositions i.e. control mix, 10% *MS*, 10% *MS* + 1% *NS*, 10% *MS* +2% *NS*. Then the samples were immersed in 5% Sodium sulphate solution for standard period of 60 days. Finally, the samples were taken out as shown in **Fig 3.25**, dried for 24 hours and again the weight of the respective samples were taken along with the compressive strength.

Figure 3.25 Samples after sulphate attack

3.9.3 Acid Resistance Test

Cubical Specimens of size 150mm x 150mm x150mm were used to perform this test. The casted samples were demolded after 24 hours. For curing purpose, the samples were kept in curing tank for 28 days. After that the samples were dried at room temperature for around 24 hours. Then the samples were weighed before their exposure to acid attack as well as the compressive strength were also taken for all the compositions i.e. control mix, 10% *MS*, 10% *MS* + 1% *NS*, 10% *MS* +2% *NS*. After that these samples were immersed in 5% solution of sulphuric acid with pH ranging from 1.4-2.3. The samples were exposed to the solution for 60 days. The pH was measured at regular intervals with the help of pH meter. Finally, the samples were taken out as shown in **Fig 3.26**, dried for 24 hours and again the weight of the respective samples were taken along with the compressive strength.

Figure 3.26 Sample after Acid attack

3.9.4 Chloride Resistance Test

Cubical Specimens of size 150mm x 150mm x150mm were used to perform this test.For curing purpose, the samples were kept in curing tank for 28 days. After that the samples were dried at room temperature for around 24 hours. Then the samples were weighed before their exposure to Chloride attack as well as the compressive strength were also taken for all the compositions i.e. control mix, 10% *MS*, 10% *MS* + 1% *NS*, 10% *MS* +2% *NS*. After that these samples were immersed in 5% solution of Sodium chloride. The samples were exposed to the solution for 60 days. Finally, the samples were taken out, dried for 24 hours and again the weight of the respective samples were taken along with the compressive strength.

CHAPTER 4

MIX DESIGN

4.1 General

In this chapter, mix design was prepared according to IS 456-2000 and IS 10262-2019 to evaluate the respective quantities of the various materials which are to be added in the concrete mix of M-40.

4.1.1 Conditions

a) Grade designation: M40

b) Type of cement: OPC conforming to IS 1489 (Part 1)

c) Maximum nominal size of aggregate: 20 mm

d) Minimum cement content and maximum water-cement ratio to be adapted to exposure conditions as per Table 3 and Table 5 of IS 456.

e) Workability: 100 mm (slump)

f) Method of concrete placing: Chute (Non pump able)

g) Degree of site control: Good

h) Type of aggregate: Crushed angular aggregate

Test Data for Materials

a) Cement used: PPC conforming to IS 1489 (Part 1)

b) Specific gravity of cement: 3.15

c) Chemical admixture: Super plasticizer conforming to IS 9103

d) Specific gravity of Materials:

1) Coarse aggregate [at saturated surface dry(SSD) Condition] : 2.74
2) Fine aggregate [at saturated surface dry (SSD) Condition] : 2.65
3) Chemical admixture: 1.145

e) Water absorption :

1) Coarse aggregate: 0.5 percent
2) Fine aggregate: 1.0 percent

f) Moisture content of aggregate [As per IS 2386 (Part 3)]:

1) Coarse aggregate: Nil

2) Fine aggregate: Nil

4.1.2 Target Strength for Mix Proportioning

f'ck = fck+1.65 S Or on the other hand,

f'ck = fck + X

Whichever is higher.

Where,

f'ck = target normal compressive strength at 28 days,

fck =characteristic compressive strength at 28 days,

S = standard deviation, and

X = factor dependent on evaluation of cement.

From Table 2 IS 10262-2019, standard deviation, S = 5 N/mm^2.

From Table 1 IS 10262-2019, X = 6.5.

Consequently, target quality utilizing the two conditions, that is,

a) f'ck = fck+1.65 S

= 40+1.65 × 5 = 48.25 N/mm^2

b) f'ck = fck + 6.5

= 40 + 6.5 = 46.5 N/mm^2

The higher worth is to be received. Along these lines, target quality will be 48.25 N/mm^2 as 48.25 N/mm^2 > 46.5 N/mm^2.

4.1.3 Approximate Air Content

From Table 3 IS 10262-2019, the inexact measure of entrained air not out of the ordinary in typical (non-air-entrained) concrete is 1.0 percent for 20 mm nominal greatest size of total.

4.1.4 Selection of Water-Cement Ratio

The free water-concrete proportion required for the objective quality of 48.25 N/mm^2 is 0.36 for OPC 43, Evaluation bends. This is lower than the greatest estimation of 0.45 recommended for 'extreme' presentation for fortified concrete according to Table 5 of IS 456. Subsequently, 0.36< 0.45, henceforth O.K.

4.1.5 Selection Of Water Content

From Table 4, water content = 186 kg (for 50 mm slump) for 20 mm total.

Assessed water content for 100 mm slump

= 186 +6*186/100

= 197.16 kg

4.1.6 Calculation of Cement Content

Water-cement ratio = 0.36

Concrete substance =197.16/0.36 = 547.6 kg/m^3

From Table 5 of IS 456, least concrete content for

Severe exposure condition = 320 kg/m^3

547.6 kg/m^3> 320 kg/m^3, thus, O.K.

4.1.7 Proportion Of Volume Of Coarse Aggregate And Fine Aggregate Content

From Table 5 IS 10262-2019, the proportionate volume of coarse total relating to 20 mm size total and fine total (Zone II) for water-concrete proportion of 0.50 = 0.62. In the current case water-concrete proportion is 0.36. Along these lines, volume of coarse total is required to be expanded to diminish the fine total substance. As the water-concrete proportion is lower by 0.14, the extent of volume of coarse, total is expanded by 0.028 (at the pace of 0.01 for each ± 0.05 change in water concrete proportion). Along these lines, adjusted extent of volume of coarse total for the water-concrete proportion of 0.36 = 0.62 + 0.028 = 0.648. Volume of fine total substance = 1 – 0.648 = 0.352.

4.1.8 Mix Calculations

a) Total volume = 1 m^3

b) Volume of captured air in wet cement = 0.01 m^3

c) Volume of concrete

= (Mass of concrete/Specific gravity of concrete) *(1/1 000)

= (547.6/2.88)*(1/1000)

= 0.190 m^3

d) Volume of water

= (Mass of water/Specific gravity of water) * (1/1000) (197.16/1)*(1/1000)

= 0.197 m^3

e) Volume of all in total = [(a-b)- (c+d+e)]

= [(1-0.01) – (0.190 + 0.197)]

= 0.603 m^3

f) Mass of coarse total

= e) × Volume of coarse total × Specific gravity of coarse total × 1 000

= 0.603 × 0.648 × 2.74 × 1 000

= 1070.6 Kg

g) Mass of fine total

= e) × Volume of fine total × Specific gravity of fine total × 1 000

= 0.603 × 0.352 × 2.65 × 1 000

= 562.4 Kg

4.1.9 Adjustment on Water, Fine Aggregate and Coarse Aggregate (If The Coarse And Fine Aggregate Is In Dry Condition)

a) Fine Aggregate (Dry)

= Mass of fine total in SSD condition/(1+ (water ingestion)/100))

= 562.4/(1+ (1/100))

= 556.8 kg/m^3

b) Coarse Aggregate (Dry)

= Mass of coarse total in SSD condition/(1+Water retention/100))

= 1070.6/(1+ (0.5/100))

= 1064.6 Kg/m^3

The additional water to be included for retention by coarse and fine total,

1) For coarse total

= Mass of coarse total in SSD condition – mass of coarse total in dry condition

= 1070.6 – 1 064.6

= 6 kg

2) For fine total

= Mass of fine total in SSD condition – mass of fine total in dry condition

= 562.4 – 556.8

= 6 kg

The assessed necessity for included water, thusly, becomes

= 197.16+ 6 + 6

= 208.76 kg/m^3

Table 4.1 Mix design considerations

Material	**Quantity**
Cement	545.8 kg/m^3
Water	209.16 kg/m^3
Fine aggregate (Dry)	557kg/m^3
Coarse aggregate (Dry)	1066.5 kg/m^3
Free water-cement ratio	0.36

Table 4.2 Mix design considerations for combined use of MS & NS along with SP

Mix ID	**Mix proportions (Kg/m^3)**						**SP%**
	OPC	**MS**	**NS**	**Water**	**F.A.**	**C.A.**	
CM	547.6	0	0	208.76	557	1064.6	0
10MS	475.98	71.18	0	208.76	557	1064.6	1
10MS+1NS	475.98	65.71	5.47	208.76	557	1064.6	1.2
10MS+2NS	475.98	60.26	10.95	208.76	557	1064.6	1.5

The calculated quantities for respective constituents of the concrete mix are shown in **Table 4.1** and the *MS* and *NS* considerations along with their respective quantities are shown in **Table 4.2.**

CHAPTER 5

RESULTS AND DISCUSSIONS

5.1 General

The final results were evaluated along with the standard results of the materials used in the study. The progressive effects of combined use of *NS* and *MS* were evaluated analytically and the final patterns followed by the outcomes were discussed closely.

Table5.1 Various test results performed on OPC 43 grade.

Sr. No.	Experiment Name	Test Results		As Per IS code	
1.	Fineness of cement	2.48%		IS 4031(part1)-1996	99.8%
2.	Consistency of cement	31.7%		IS 4031(part 4)-1988	26% to 33%
3.	IST of cement	107 min		IS 4031 (part 5)-1988	Not less than 30 min
4.	FST of cement	238 min		IS 4031(part 5)-1988	Not more than 600 min
5.	Specific gravity	3.13		IS 4031(part11)-1988	3.15
6.	Compressive strength	7 days 23.67Mpa	28 days 37.43Mpa	IS 8112-1989	43Mpa

5.2 Workability of concrete

Workability of cement is the property of freshly blended concrete which decides the straightforwardness and homogeneity with which it very well may be blended, put, combined and wrapped up. By the slump cone test the slump estimated was 98mm, concerning M40 the w/c proportion chose was kept 0.36 and fitting functionality turned out so as to work easily with the prepared mix.

5.3 Compressive strength

Compressive strength of cement is the Strength of solidified cement estimated by the pressure test. The compressive strength of cement is a proportion of the concrete capacity to oppose loads which will in general pack it.

In my case, the first three samples failed as shown in **Fig 5.1** just after demoulding them from the molds. The possible reasons for the failure can be:

- Calculation error in mix design.
- Improper compaction.
- Loosened molds
- Less water content.
- Improper aggregate selection and gradeation.
- Less cement content.

Figure 5.1 Failed samples

After proper analysis of mix design and proper aggregate selection, the samples came out of proper consistency and compaction. But, the compressive strength of 28 days came out to be **23.67mpa**. The target strength for control mix was not achieved. The possible reasons can be that the coarse aggregate and fine aggregate proportion might not be appropriate and cement was not fined properly. As well as, proper mixing might not have been done.

After further evaluation and study, again the samples were casted and then the 28 days compressive strength came out to be **36.43mpa**. The evaluated compressive strength was appropriate and as desired. After this further cubes were casted with the successful mix design with combined use of MS and NS.

Figure 5.2 Tested sample

The compressive strengths of different combinations of *MS* and *NS* along with control mix are along with strength comparison of all the proportions at different days are shown in the **Fig 5.2**.As for the control mix after 28 days highest strength attained is **36.43Mpa** as shown in **Table 5.3**, and the highest strength for *MS* and *NS* combination was attained by **10% *MS*+2% *NS*** i.e. **46.17 Mpa** after 28 days. For this combination of *MS* and *NS* **26.47%** of strength increase was noticed as compared to the control mix. For other combinations, **10 %*MS* +1% *NS*** gave a strength increase of **21.47%** and **10% *MS*** gave a strength increase of **5%** after 28 days respectively.

For the result comparison of compressive strengths of 7 days and 14 days **10% *MS*+2%*NS*** showed the highest strength gain of **21.88%** and **24.11%** respectively as compared to the control mix. For the other combinations, **10% *MS*** showed a decrease of **3.4%** and **3.9%** respectively for compressive strength of 7 days and 14 days as compared to control mix, and for **10% *MS*+1% *NS*** strength increase of 17.74**%** and **11.9%** was noticed for compressive strength of 7 days and 14 days respectively.

Table 5.3 Compressive strength of different proportions at respective days

Strength (Mpa)	7 Days	14 Days	28 Days
Control mix	23.67	32.81	36.43
10MS	22.86	31.51	38.25
10MS+1NS	27.87	36.72	44.25
10MS+2NS	28.85	40.72	46.17

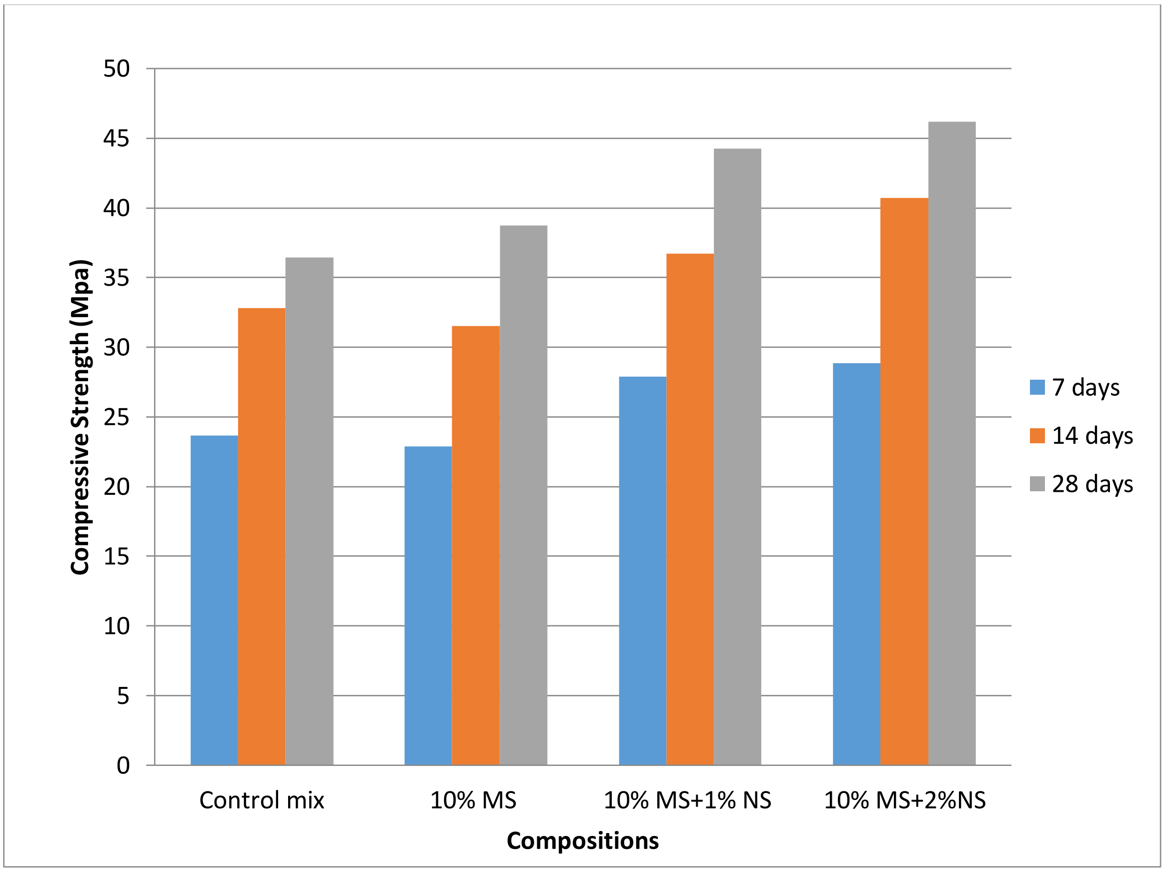

Figure 5.3 % variation of compressive strength of various combinations at different days

5.4 Sulphate Attack Test

For this test, the % weight loss for control mix and different proportions of *MS* and *NS* and % loss in strength after the sulphate attack on respective specimens are shown in the **Fig 5.4 and Fig 5.5.**

Lowest % weight loss after 60 days of sulphate attack was observed in **10%*MS*+2%*NS*** i.e. **2.17%.** Whereas the highest % weight loss was observed in control mix i.e. **9.2%.** For the other combinations **4.49%** weight loss was observed in **10% *MS*+1% *NS*** and **6.91%** weight loss was observed in **10% *MS***.

For % loss in strength, the lowest loss of **8.32%** was observed in **10% *MS*+2% *NS***. The highest % loss in strength was observed in control mix i.e. **21.8%.** For other combinations **9.97%** strength loss was observed for **10% *MS*+1% *NS*** and **14.69%** for **10 *MS***.

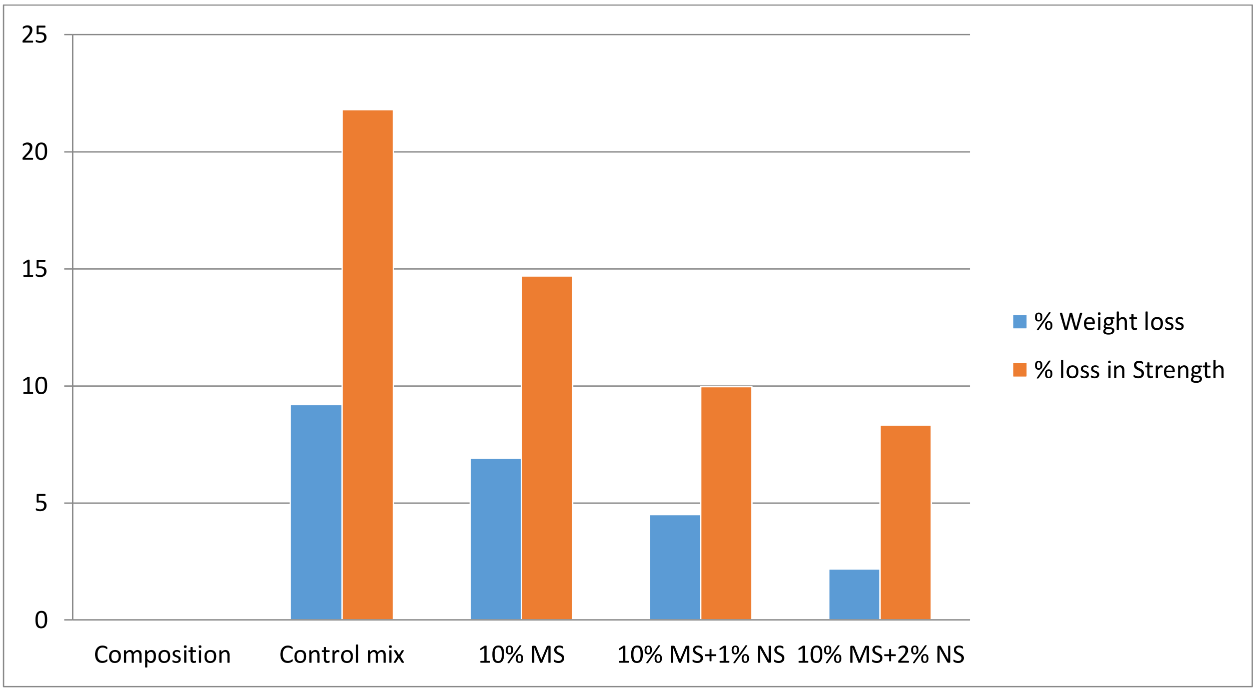

Figure 5.4 Comparison of % loss in strength and % loss in weight due to sulphate attack.

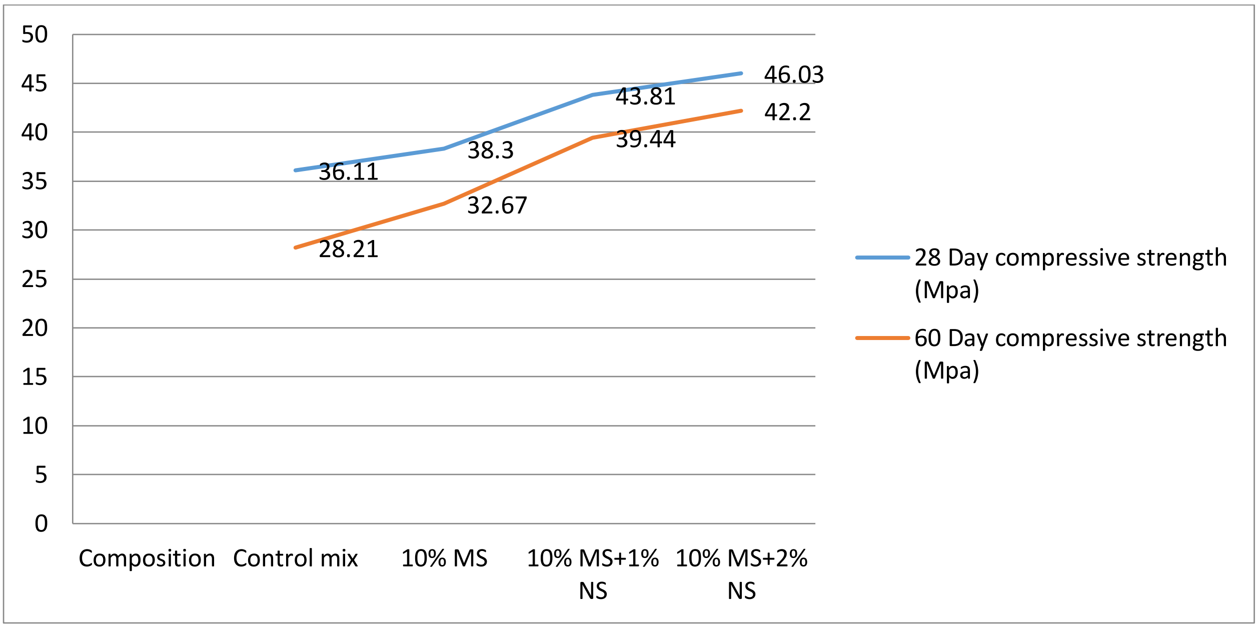

Figure 5.5 Compressive strength comparison before and after sulphate attack.

5.5 Acid Resistance Test

For this test % Weight loss and % loss in strength after 60 days of acid attack on control mix and different combinations are shown in figure in **Fig 5.6** and **Fig 5.7**.

Lowest % weight loss after 60 days of acid attack was observed in **10%*MS*+2%*NS*** i.e. **3.14%.** Whereas the highest % weight loss was observed in control mix i.e. **10.48.** For the other combinations **6.73%** weight loss was observed in **10% *MS*+1% *NS*** and **8.59%** weight loss was observed in **10% *MS***.

For % loss in strength, the lowest loss of **9.74%** was observed in **10% *MS*+2% *NS***. The highest % loss in strength was observed in control mix i.e. **27.19%.** For other combinations **11.7%** strength loss was observed for **10% *MS*+1% *NS*** and **16.26%** for **10% *MS***.

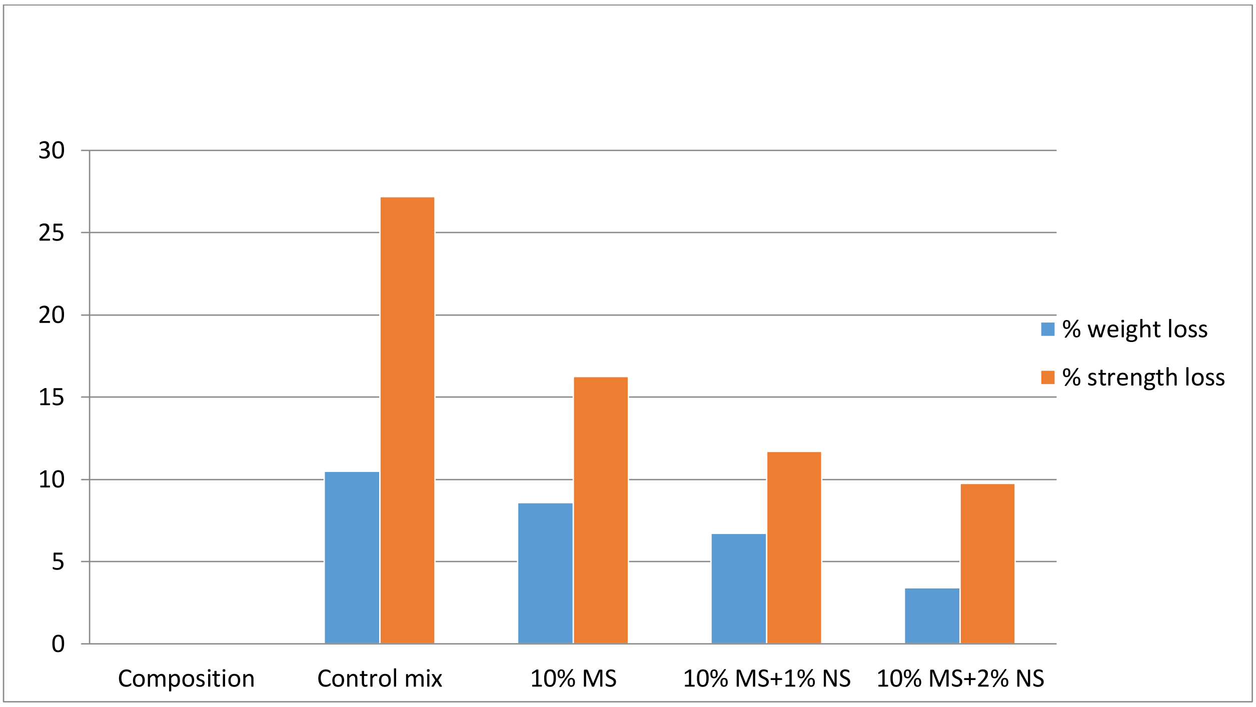

Figure 5.6 Comparison of % loss in strength and % loss in weight due to acid attack

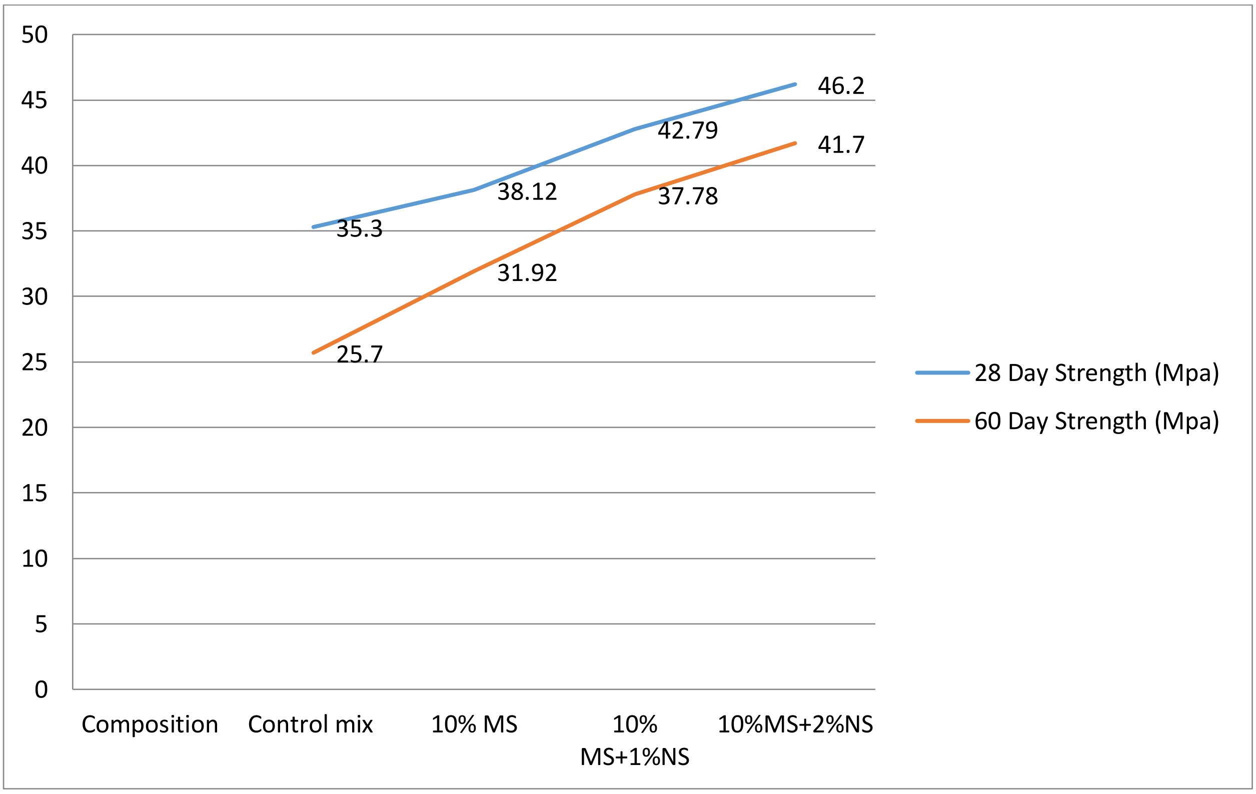

Figure 5.7 Compressive strength comparison before and after acid attack.

5.6 Chloride Resistance Test

For this test % Weight loss and % loss in strength after 60 days of Chloride attack on control mix and different combinations are shown in figure in **Fig 5.8** and **Fig 5.9**.

Lowest % weight loss after 60 days of acid attack was observed in **10%*MS*+2%*NS*** i.e. **2.4%.** Whereas the highest % weight loss was observed in control mix i.e. **5.16%.** For the other combinations **3.53%** weight loss was observed in **10% *MS*+1% *NS*** and **3.61%** weight loss was observed in **10% *MS***.

For % loss in strength, the lowest loss of **6.21%** was observed in **10% *MS*+2% *NS***. The highest % loss in strength was observed in control mix i.e. **15.14%.** For other combinations **8.1%** strength loss was observed for **10% *MS*+1% *NS*** and **6.21%** for **10 *MS***.

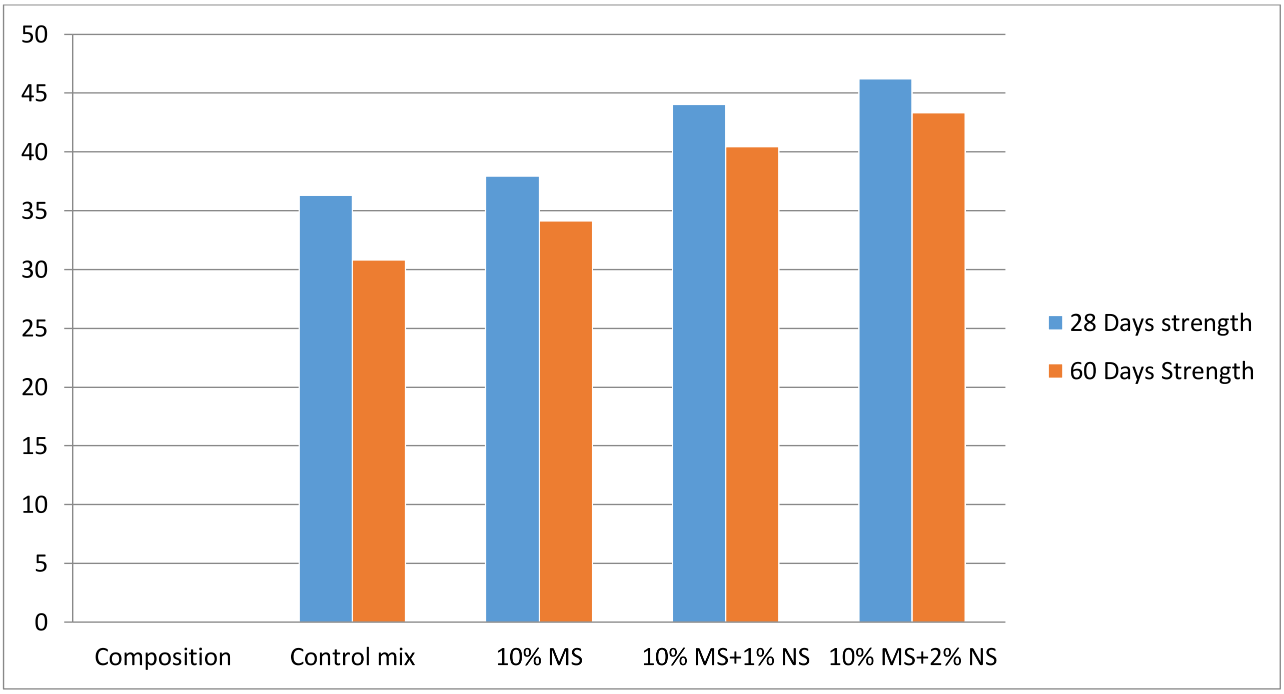

Figure 5.8 Comparison of % loss in strength and % loss in weight due to Chloride attack

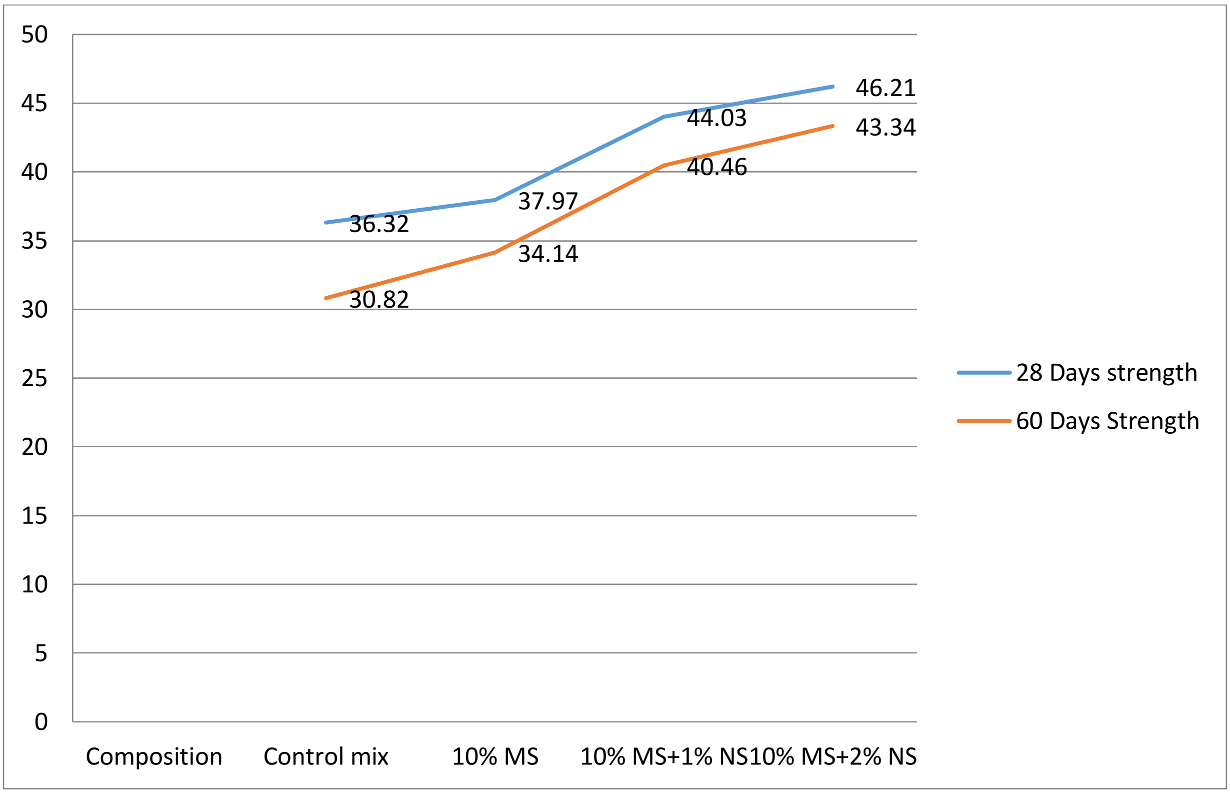

Figure 5.9 Compressive strength comparison before and after Chloride attack.

5.7 Water absorption test

The water absorption of coarse aggregates came out to be 0.5% and for fine aggregates 1%. The values were according to the standard mentioned in IS 10262-2019. Hence, the aggregates were appropriate to be used in the concrete mix in order to give desired durability properties.

CHAPTER 6

CONCLUSIONS

6.1 General

The final conclusions were made on the basis of the results and impacts of *MS* and *NS* on the durability properties of concrete. The overall hydration mechanism changes after addition of these constituents are also discussed. All the possible limitations as well as future scope of *MS* and *NS* usage is also presented.

6.2 Conclusions

The combined and individual effect of micro-silica (*MS*) and nano-silica (*NS*) to replace 10-12% of *OPC* on durability properties of concrete was evaluated in this study. The best combination to achieve the maximum compressive strength was found to be 10%*MS*+2%*NS*. The resistance of concrete containing a combination of *MS* and *NS* was higher towards acid attack, sulphate attack and Chloride attack than the concrete containing only *MS*.

As the *NS* was introduced along with *MS*, the durability properties of the concrete were enhanced largely. The combination of 10% *MS*+2% *NS* performed the best in every exposure condition as compared to any other combination or control mix. The reason can be accounted as the pozzolanic reaction of *MS* with calcium hydroxide forms additional calcium silicate hydrate gel. The density of concrete is increased by the void filling of *MS* particles in fresh and partially hydrated cement [1].

Furthermore, *NS* improves properties not only by pozzolanic reaction, but also their use accelerates the hydration of cement by creating additional surfaces for early precipitation of hydration products [3]. Therefore, even small dosages of *NS* brought gigantic difference in the behavior of concrete containing it.

6.3 Limitations

- The maximum replacement of cement with *NS* is up to 3%, because above this proportion the compressive strength decreases vigorously due to high heat of hydration.
- The high dosage of super plasticizers makes it difficult to work with the concrete containing *MS* and *NS* as water demand is reduced and hydration of cement starts at very brisk rate.

- The results of *MS* and *NS* in concrete are highly temperature and climate dependent.
- *MS* and *NS* are however prepared from the silica left as a byproduct in glass industry, but still on large scale usage of *MS* and *NS* is quite difficult and expensive.

6.4 Scope

- *MS* and *NS* can be replaced to a higher proportion of about 20-30% with cement in concrete mix, with proper water reducers, air entrainers and super plasticizer dosages and Durability as well as strength parameters of the concrete can be enhanced to a remarkable level.
- If proper environment for *MS* and *NS* replacement is generated then it can be used in extreme environment as well as with *SCC*, *UHPC* etc.
- In coming time due to growing industrialization in our country, the production of *MS* and *NS* will increase and their usage will be economical and an advantage for the infrastructure of the country.
- With the help of heavy duty mixers, the high dosages of super plasticizers can be incorporated for *MS* and *NS* replacements at high scale and durability as well as strength parameters can be enhanced at an exceptional level.

REFRENCES

[1] Hussain, S.T. and Sastry, G.K., (2014) “Study of Strength Properties of Concrete by Using Micro Silica and Nano Silica”. International Journal of Research in Engineering and Technology, 3(10), pp.2321-7308.

[2] Sharkawi, A.M., Abd-Elaty, M.A. and Khalifa, O.H., (2018)” Synergistic influence of micro-nano silica mixture on durability performance of cementious materials”. Construction and Building Materials, 164, pp.579-588.

[3] Shaikh, F.U.A., Shafaei, Y. and Sarker, P.K., (2016) “Effect of nano and micro-silica on bond behavior of steel and polypropylene fibers in high volume fly ash mortar”. Construction and Building Materials, 115, pp.690-698.

[4] Senff, L., Hotza, D., Repette, W.L., Ferreira, V.M. and Labrincha, J.A., (2010) “Effect of nano silica and micro silica on microstructure and hardened properties of cement pastes and mortars”. Advances in applied ceramics, 109(2), pp.104-110.

[5] Sanchez, F. and Sobolev, K., (2010) “Nanotechnology in concrete–a review”. Construction and building materials, 24(11), pp.2060-2071.

[6] Rossen, J.E., Lothenbach, B. and Scrivener, K.L., (2015) “Composition of C–S–H in pastes with increasing levels of silica fume addition”. Cement and Concrete Research, 75, pp.14-22.

[7] Puentes, J., Barluenga, G. and Palomar, I., (2015) “Effect of silica-based nano and micro additions on SCC at early age and on hardened porosity and permeability”. Construction and Building Materials, 81, pp.154-161.

[8] Ghafoori1a, N., Batilov1b, I., Najimi1c, M. and Sharbaf1d, M., (2016) “Effect of combined nano silica and micro silica on resistance to sulfate attack”.

[9] Massana, J., Reyes, E., Bernal, J., León, N. and Sánchez-Espinosa, E., (2018) “Influence of nano-and micro-silica additions on the durability of a high-performance self-compacting concrete”. Construction and Building Materials, 165, pp.93-103.

[10] Li, L.G., Zheng, J.Y., Zhu, J. and Kwan, A.K.H., (2018) “Combined usage of micro-silica and nano-silica in concrete: SP demand, cementing efficiencies and synergistic effect”. Construction and Building Materials, 168, pp.622-632.

[11] Kong, D., Du, X., Wei, S., Zhang, H., Yang, Y. and Shah, S.P., (2012) “Influence of nano-silica agglomeration on microstructure and properties of the hardened cement-based materials”. Construction and Building Materials, 37, pp.707-715.

[12] Khan, M.I. and Siddique, R., (2011) "Utilization of silica fume in concrete: Review of durability properties". Resources, Conservation and Recycling, 57, pp.30-35.
[13] Jalal, M., Mansouri, E., Sharifipour, M. and Pouladkhan, A.R., (2012) "Mechanical, rheological, durability and micro structural properties of high performance self-compacting concrete containing SiO2 micro and nanoparticles". Materials & Design, 34, pp.389-400.
[14] Hendi, A., Rahmani, H., Mostofinejad, D., Tavakolinia, A. and Khosravi, M., (2017) "Simultaneous effects of microsilica and nano silica on self-consolidating concrete in a sulfuric acid medium". Construction and Building Materials, 152, pp.192-205.
[15] Gesoglu, M., Güneyisi, E., Asaad, D.S. and Muhyaddin, G.F., (2016) "Properties of low binder ultra-high performance cementitious composites: Comparison of nano silica and microsilica". Construction and Building Materials, 102, pp.706-713.
[16] Behfarnia, K. and Rostami, M., (2017). "Effects of micro and nanoparticles of SiO2 on the permeability of alkali activated slag concrete". Construction and building materials, 131, pp.205-213.
[17] Balapour, M., Joshaghani, A. and Althoey, F., (2018) "Nano-SiO2 contribution to mechanical, durability, fresh and micro structural characteristics of concrete: A review". Construction and Building Materials, 181, pp.27-41.
[18] Arel, H.Ş. and Thomas, B.S., (2017.)"The effects of nano-and micro-particle additives on the durability and mechanical properties of mortars exposed to internal and external sulfate attacks". Results in physics, 7, pp.843-851.
[19] Singh, A. and Dhillon, R.S., (2017). "Experimental Investigation on Effect of Micro silica and Nano silica on Compressive Strength of High Strength Concrete". Int. J. Eng. Technol. Sci. Res. (IJETSR), 4(6).

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY, WAKNAGHAT

PLAGIARISM VERIFICATION REPORT

Date: ...1/06/2020..........

Type of Document (Tick): PhD Thesis | M.Tech Dissertation/ Report | B.Tech Project Report ✓ | Paper

Name: Xitiz Sen **Department:** CIVIL **Enrolment No** 161642

Contact No. 9418405397 **E-mail.** xitiz7797@gmail.com

Name of the Supervisor: Mr. Anirban Dhulia, Mr. Abhilash Shukla

Title of the Thesis/Dissertation/Project Report/Paper (In Capital letters): COMBINED USE OF NANO SILICA AND MICRO SILICA TO IMPROVE DURABILITY PROPERTIES OF CONCRETE

UNDERTAKING

I undertake that I am aware of the plagiarism related norms/ regulations, if I found guilty of any plagiarism and copyright violations in the above thesis/report even after award of degree, the University reserves the rights to withdraw/revoke my degree/report. Kindly allow me to avail Plagiarism verification report for the document mentioned above.

Complete Thesis/Report Pages Detail:

- Total No. of Pages = 60
- Total No. of Preliminary pages = 9
- Total No. of pages accommodate bibliography/references = 2

(Signature of Student)

FOR DEPARTMENT USE

We have checked the thesis/report as per norms and found **Similarity Index** at .....25.......(%). Therefore, we are forwarding the complete thesis/report for final plagiarism check. The plagiarism verification report may be handed over to the candidate.

Anirban Dhulia
07/06/2020 07/2020

(Signature of Guide/Supervisor) (Signature of Co-Supervisor) **Signature of HOD**
HOD CE DEPT

FOR LRC USE

The above document was scanned for plagiarism check. The outcome of the same is reported below:

Copy Received on	Excluded	Similarity Index (%)	Generated Plagiarism Report Details (Title, Abstract & Chapters)	
	• All Preliminary Pages • Bibliography/Images/Quotes • 14 Words String		Word Counts	
Report Generated on			Character Counts	
		Submission ID	Total Pages Scanned	
			File Size	

Checked by
Name & Signature **Librarian**

Please send your complete thesis/report in (PDF) with Title Page, Abstract and Chapters in (Word File) through the supervisor at plagcheck.juit@gmail.com