Determining the properties of high strength concrete by using micro silica and nano silica

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ABSTRACT

Concrete is the most versatile material. Due to the persistent and continuous demands made on concrete to meet the various difficult requirements, extensive and wide spread research work is being carried out in the area of concrete technology. Engineers are continually pushing the limits to improve its performance with the help of innovative chemical admixtures and supplementary cementitious materials like fly ash, silica fume, and granulated blast furnace slag, steel slag etc…

Researchers have developed variants of concrete composites like Admixture Concrete, Fiber Reinforced Concrete (FRC), Polymer Impregnated Concrete (PIC), High Performance Concrete (HPC), Self Compacting Concrete (SCC), Geopolymer Concrete etc. Presently, Nano Technology being applied to concrete includes the use of nano materials like nano silica, nano fibers etc. By adding the nano materials smart concrete composites with superior properties can be produced.

The use of large quantity of cement produces increasing co_2 emissions, and consequence the green house effect. A method to reduce the cement content in concrete mixes is the use of silica fume which is an amorphous (+non-crystalline) polymorph of silicon dioxide, silica. It is an ultra fine powder collected as a byproduct of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 0.1 to 0.5 µ. The past investigations reveled that silica fume was an excellent pozzolanic material in producing HPC.

Nano material concrete is new generation concrete; the composition of nano material concrete consists of cement, nano silica grain of the size of 10 nm - 140 nm, water, fine aggregate and coarse aggregate. Nano materials like nano silica, nano titanium oxide, carbon nano tubes, nano alumina etc… which are presently used in concrete to modify its strength properties. Nano materials have properties or functions different from similar materials of large size. Nano materials have a larger value of the ratio between surface area and volume than other similar particles in larger size, making the nano materials more reactive. Nano silica will react with C_3S and C_2S in the cement and produce CSH-2 that will form a strong and solid bond of gel.

In the present study strength properties such as Compressive strength, split tensile strength and flexural strength of M_{40} and M_{50} grades of concrete with the use of micro silica (5%, 7.5%, 10%, 15%) and nano silica (1%, 1.5%, 2%, 2.5%) as partial replacement of cement were studied. It was found from the

experimental study that concrete composites with superior properties can be produced using micro silica, nano silica and combination of micro silica and nano silica.

CHAPTER-I

1. INTRODUCTION:

1.1 GENERAL

Concrete will be stuff composed primarily of cement, combination and water. It is a wide used construction material for varied types of structures ascribable to its structural stability and strength. Increasing the event challenges in combos with the new innovations in materials and production techniques have give new basis for manufacturing high performance concrete structures. Presently concrete is obtaining used for wide styles of functions to make it applicable in varied conditions. In these conditions commonplace concrete could fail to exhibit the desired quality performance or strength. In such cases, pozzolanic or mineral admixtures ar accustomed modify the properties of traditional concrete.

The word 'Pozzolana' was derived from pozzuolu, a city in Italy, some of miles from metropolis and mount vacuous. The materials are of volcanic region containing varied fragments of stone, obsidian, feldspars, and quartz etc. The name 'Pozzolana' was initial applied only to the current material. However the term has been extended later to earth, terribly chemical compound rocks and varied artificial merchandise. Thus, the pozzolanic materials are natural or artificial having nearly identical composition as that of volcanic tuffs or ash found at pozzuolu.

Pozzolanic materials are chemical compound or chemical compound and aluminous material, that in themselves possess very little or no whole price, but will, in finely divided kind and inside the presence of wet, with chemicals react with hydroxide liberated on association, at degree Centigrade, to make compounds, possessing artefact properties. On the association of tri-calcium salt and di-calcium salt, hydroxide is created joined of the merchandise of association. This compound has no whole price and it's soluble in water and will be leached out by the percolating water. The substance or aluminous compound throughout a finely divided kind react with the hydroxide to make terribly stable whole substances of subtle composition involving water, range twenty and compound. Generally amorphous salt reacts much more quickly than the crystalline kind. It's known that hydrated oxide is regenerate in to insoluble artefact material by the reaction of pozzolanic materials.

The reaction unit of measurement typically shown as

Pozzolanic + hydroxide + Water C-S-H (Gel)

This reaction is termed pozzolanic reaction. The reaction involves the consumption of $Ca(OH)_2$ and not production $Ca(OH)_2$. The reduction of $Ca(OH)_2$ improves the sturdiness of cement paste by creating the paste dense and greaseproof.

Concrete can be a artificial material throughout that the aggregates each fine and coarse are secure on by the cement once mixed with water. Concrete has unlimited opportunities for innovative applications, vogue and construction techniques. It exhibits nice state and relative economy in filling good selection of wishes that by various means has been created itself as competitive object.

With the advancement of technology and enlarged field of applications of concrete and mortars, the strength, workability, strength and varied characteristics of the standard concrete would like modifications to make it applicable for difficult desires for construction environment(Added to the current is that the requirement to combat the increasing price and inadequacy of cement). Beneath these circumstances the utilization of admixtures is found to be an important completely different answer.

Increasing the usage of cement is that the foremost cringe that inflicting more emission of acid gas (co2). So, researchers area unit learning to reinforce the mechanical properties of concrete by incorporation of mineral admixture.

The use of pozzolanic materials in cement concrete sealed an answer for

- Modifying the properties of the concrete
- Controlling the concrete price
- To overcome the inadequacy of cement
- The economic advantageous disposal of economic wastes

Pozzolanic materials unit of measurement typically divided in to 2 teams

1. **Natural Pozzolans**

- Clay and Shale's
- Opalinc Cherts(A mineral of hydrated silica)
- Diatomaceous Earth
- Volcanic Tuffs and Pumicites.

2. **Artificial Pozzolans**

- Fly ash
- Blast chamber scum

- Silica fume
- Rice Husk ash
- Metakaolin
- Surkhi.

Out of these mineral admixtures, compound fume is that the one in every of the material that created tones of economic waste p.a. in our country. The primary testing of oxide fume in Portland-cement-based concretes was applied in 1952. The biggest draw back to investigate the properties of oxide fume was a scarceness of material to experiment with. Early analysis used treated oxide a stylish additive, that is degree amorphous reasonably compound created by combustion of matter throughout a hydrogen-oxygen flame.

Silica fume may be a fine pozzolanic material that will be a byproduct of constructing matter metal. The foremost serviceable uses of compound fume in concrete are ascribable to its physical and chemical properties; it is a notably fine and terribly reactive pozzolanic material. Incorporation of compound fume in to the concrete can have high strength and strength. The assembly of waste materials is awfully giant so the strain for selling house to dispose this material are high. By this reference of compound Fume, it unit of measurement typically tested that the number of compound fume is increasing once a year because of actively for several functions like in construction, off shore, machine motives, piping and etc... To travel searching the selling house for these materials can increase the price within the steel industries, as a result of they want to obtain for the planet for this purpose. The worth of land presently will be quite valuable notably at urban and industrial house. So, by pattern oxide Fume (waste materials) from the trade as a mineral admixture replacement or more in preparation of concrete will save our earth for a property setting.

Recently Nano Technology has been introduced in technology applications. Nano technology is one in every of the foremost promising areas of science. The utilization of nano materials in concrete is new revolution. Researchers are taking the prospect to achieve advantage on technology to introduce a replacement generation of concrete materials that overcome the higher than drawbacks and creating an endeavor to appreciate the property concrete structures. Evolution of materials is would very like of the day for improved or higher performance for special engineering applications and modifying the bulk state of materials in terms of composition or microstructure or nanostructure has been the established route for synthesizing new materials.

With the advancement of nano technology, nano materials space unit developed to see the improved physical, chemical and mechanical properties of concrete. Among the many developed or factory-made nano materials like nano compound (NS), nano Ti compound, carbon nano tubes (CNT), nano corundum, nano Fe2O3 etc… that are presently utilized in concrete to vary its strength properties.

1.2 NANOTECHNOLOGY

Nanotechnology is that the employment of really little things of fabric by themselves or their manipulation to make new large scale materials. The particle size may be a big issue. At the nano scale (anything from 100 or more right all the method all the way down to some of nano meters, or 10-9 nm) material properties ar altered from that of larger scales. There's a sudden modification in state of affairs and this might be what happens at the dimensions of technology. As particles become nano-sized, the proportion of atoms on the surface will increase and this ends up in modification among the properties. Knowledge at the nano scale of the structure and characteristics of materials (otherwise referred to as characterization) will promote the event of latest applications and new merchandise to repair or improve the properties of construction materials. as associate example, the structure of the essential Calcium-silicate-hydrate (C-S-H) gel that is in charge of the mechanical and post-selfing physical properties of cement pastes, like shrinkage, creep, porosity, consistence unit of measurement typically improved to urge higher strength characteristics of concrete.

1.3 NANO TECHNOLOGY IN CONCRETE

One of the foremost and extremely important helpful uses of technology in technology is to use in concrete. It's utilized in regarding of all construction fields like roads, bridges, buildings and varied construction works. Concrete unit of measurement typically changed in varied ways; one in every of that is to feature nano particles to that. Researchers are aiming for how higher understanding of the delicate structure of cement- based materials at nano levels. This could ends up in new generation of stronger and additional sturdy concrete with desired behaviors and properties. Association of cement produces a rigid, heterogeneous microstructure. As water is introduced to cement to make a paste that hardens over time the foremost little structural phases within the hydrous cement paste are

- Calcium salt hydrate gel (C-S-H)
- Calcium hydroxide (C-H)
- Ettringite (a Sulfo matter hydrate)
- Monosulphate
- Unhydrated cement particles and
- Air voids

These tiny structural phases govern the gross properties of artefact materials like strength, durability, physical property and flow ability. Determination of the behavior of megascopic properties provides a radical data of the structure of these phases at the tiniest size level. Among the varied phases, the primary one, C-S-H, is that the most vital product of association and accounts for fifty to seventieth of the full paste volume. This main binding part governs the microscopic properties of the cement paste, however the small and nano scale structure of C-S-H continues to be not well established.

The pozzolanic supplementary building material materials like atomic number 14 oxide fume, ash react with CH at intervals the presence of wet to build C-S-H. Researchers have taken this to the nano scale by mistreatment mixture silicon oxide within the concrete combine to achieve identical properties in handiest manner. It is additionally being used to management the cracks in concrete due to alkalis in cement.

Most of the researchers have done with nano particles with nano-silica, nano clay, nano-titanium oxide, nano-alumina and nano-iron. These “nano particles will act as nuclei for cement phases, further promoting cement hydration owing to their high reactivity, as nano reinforcement, and as filler, densifying the microstructure”.

1.4 TYPES OF NANO MATERIALS

1. Nano silicon dioxide (NS)
2. Nano Metakolin
3. Carbon nano tubes (CNT’s)
4. Polycarboxilates

1.5 Nano silicon dioxide

One of the most used nano material is Nano Silica (NS). This is often the primary Nano product that has replaced the small silicon dioxide. The advancement created by the study of concrete at nano scale has proved nano silicon dioxide far better than silicon dioxide that is employed in typical concrete. Nano-silica possess a lot of pozzolanic nature, has the aptitude to react with the free lime throughout the cement association and forms extra C-S-H gel provides strength, non porous and sturdiness to concrete

1.5.1 Uses of nano silicon dioxide Concrete

- Nano silicon dioxide has extreme fineness and high silicon dioxide content than silicon dioxide fume
- It provides high workability with reduced water/cement magnitude relation.
- By incorporation of nano silicon dioxide, it fills all the small pores and small areas in concrete.
- Using the nano silicon dioxide, cement will saves up to 35-45%.
- By adding Nano silicon dioxide within the hydraulic cement concrete, mechanical properties are improved compare to silicon dioxide fume.
- Using Nano silicon dioxide, it reacts with free metallic element hydroxide in the paste that result the pozzolanic reactions in the cement paste.
- Addition of nano silica also reduces the permeability of concrete to chloride ions that protects the reinforcing steel of concrete from corrosion, particularly in chloride-rich environments.

1.5.2 Effects of Nano silicon dioxide on contemporary and Hardened Properties of Concrete

Workability:

With the addition of nano silicon dioxide, the slump price decreases with time is directly proportional to extend within the nano silicon dioxide content owing to the introduction of enormous expanse within the concrete combine.

Segregation and bleeding:

Nano silicon dioxide reduces harm considerably as a result of free water is consumed in wetting of enormous expanse of nano silicon dioxide and thence the free water left within the combine for harm additionally decreases. Nano silicon dioxide additionally blocks the pores within the contemporary concrete, thus water at intervals the concrete isn't allowed to return to the surface.

1.6 NEED FOR PRESENT WORK

Mortar and concrete are composite materials whose over all mechanical properties are suffering from properties and arrangement of every constituent (cement, aggregate) in it. By incorporating nano materials in to matrix to enhance mechanical properties, emerged as a promising analysis field of nano composite. When put next with dense structure matrix like polymer, the case is kind of different within the area of cement matrix composites. As a result of cement matrix has relative loose structure. Between the cement and mixture there are nano sized air voids which can have vital impact on the nano composite's chemical properties. There exists a lot of space for improvement of cement composites by incorporating nano materials in to the cement matrix.

The requirement of gift work is to check the standard of nano construction materials and to seek out the mechanical properties of nano silicon dioxide concrete i.e. compressive strength, flexural strength and split tensile strength.

CHAPTER-II

2. LITERATURE REVIEW

2.1 Literature Review on silicon dioxide Fume

Yogendran et al, 1987[1] investigated on silicon dioxide fume on high strength concrete at a relentless water binder quantitative relation (w/b) of zero.34 and that they replaced the silicon dioxide fume by weight of cement with percentages of zero to twenty fifth, with variable dosages of High vary Water Reducer Admixtures (HRWRA). From their results, the most twenty eight day compressive strength was obtained at 15 August 1945 replacement of silicon dioxide fume.

ACI Committee 234 (1995) [2] has according that concrete containing silicon dioxide fume can reduces haemorrhage considerably. This result is caused primarily by the high extent of the silicon dioxide fume to be wetted, there's little free water left within the mixture for haemorrhage. The static modulus of physical property of silicon dioxide fume concrete is seemingly just like that of cement concrete of comparable strength. Committee additionally according that the most contribution of silicon dioxide fume to concrete strength development at traditional solidification temperatures takes place from regarding three to twenty-eight days. At twenty eight days the compressive strength of silicon dioxide fume concrete is often higher.

Shannag (2000) [3] Studied the behaviour of high strength concrete containing natural Pozzolana and silicon dioxide fume. He terminated that sure natural Pozzolana – silicon dioxide fume combination will improve the strength of mortar over natural Pozzolana or silicon dioxide fume alone. additional he instructed that the employment of silicon dioxide fume at 15 August 1945 of the load of cement was ready to turn out comparatively the best strength increase within the presence of regarding 15 August 1945 Pozzolana than while not Pozzolana.

Joshi (2001) [4] ascertained that reduction in cement content at fastened water cement quantitative relation wasn't prejudicial to contemporary and hardened concrete properties and will truly improve performance once silicon dioxide fume was supplementary as 100 percent by weight of cement content. Basu (2001) [5] developed High Performance Concrete (HPC) with SF. He according that by victimization silicon dioxide fume in (HPC) will scale back micro-cracks that tends to develop round the interface between bulk hydrous cement paste and anhydrous cement particles or United Nations reacted pozzolanas. A study has been administrated by Thomas (2001) [6] on dominant alkali-silica reaction (ASR) in concrete with explicit stress on development of a replacement customary practices in North American country. He terminated that use of emulsified cement containing low alkali cement mixed with SF would be a viable suggests that of dominant enlargement in concrete. From the analysis work done by Lewis (2001) [7] it's been ascertained that there's a substantial reduction in rebound from (35-15)% by addition of SF that additionally enlarged the pumpability of high workability combine having slump price on top of 250mm.

Kanstad et al (2001) [8] created a investigation work to assess the crack sensivity of HPC with totally different SF contents and that they found that result of variation of SF content was of minor importance compared to alternative factors viz degree of insulation and condition.

Roncero et al (2002) [9] explicit that incorporation of SF and alternative admixtures may be necessary within the production of HPC so as to get superior mechanical and sturdiness properties. They found that water demand of cement SF system in an exceedingly paste of traditional consistency will increase with temperature and reduces with incorporation of super plasticizers till an explicit indefinite quantity. throughout the intensive analysis work administrated by Vishnoi (2003) [10] and he terminated that SF concrete features a capability to face up to abrasion erosion with higher construction practicability, workability and surface end.

S. Bhanja and B. Sengupta (2004) [11] studied the influence of silicon dioxide fume on the strength of concrete. They found that the optimum strength has obtained within the vary of 5-10% silicon dioxide fume replacement level and for flexural strength is 15 August 1945 to twenty fifth.

K.Perumal (2004) [12] studied the result of partial replacement of cement with silicon dioxide fume on the strength and sturdiness characteristics of high performance concrete. He found that most strength of compressive, split tensile strengths at 100 percent silicon dioxide fume by partial replacement of cement and additionally disclosed that strength and sturdiness connected tests have incontestible superior strength and sturdiness characteristics of HPC mixes containing silicon dioxide fume. This can be thanks to the advance within the small structure thanks to pozzolanic action and filling effects of silicon dioxide fume.

Palanisamay T et al (2008) [13] have investigated on result of GGBS and silicon dioxide Fume on mechanical Properties of Concrete Composites. They administrated on seventy Mpa concrete with partial replacement of silicon dioxide fume of five, 10, 15, and 20%. The compressive strength, split tensile and Flexural Strength were administrated on twenty five concrete mixes at the age of twenty eight days and compared with typical concrete. From their results, the optimum replacement of silicon dioxide fume was at ten only if showed compressive, split tensile and Flexural Strength enlarged by V-E Day, 22% and 4.1% than management concrete.

V. Bhiksham et al (2009) [14] have investigated on mechanical properties of high strength silicon dioxide fume concrete of grades M40 and M50 at twenty eight days characteristic strength with totally different replacement levels of cement with silicon dioxide fume. They found that increasing in young's modulus of concrete as a silicon dioxide fume content will increase. From their results, the rise in strength was found up to twelve-tone music replacement of silicon dioxide fume by weight of cement that is over the standard concrete. AN experimental program has been administrated by K.C. Biswal and Suresh Chandra Sadangi (2011) [15] to review the result of super softener alone and in conjugation with silicon dioxide fume on a number of the properties of contemporary and hardened concrete. From the investigation of their studies, it had been found that the water cement quantitative relation reduces by twenty third in concrete by victimization super softener (1% by weight of cement) for a relentless vary of slump 80mm to 85mm. The compressive strength of concrete is enlarged by use of silicon dioxide fume up to twenty replacement of cement. The flexural strength of concrete is enlarged by use of silicon dioxide fume up to fifteen replacement of cement.

Verma ajay et al (2012) [16] have studied the result of small silicon dioxide and also the strength of concrete with normal cement. They ascertained that silicon dioxide fume will increase the strength of concrete and reduces capillary pores. Dilip Kumar Singha Roy and Amitava Sil (2012) [17] have investigated on the strength parameters of concrete created with partial replacement of cement by SF. They terminated that use of silicon dioxide fume may be a necessity in production of high strength concrete, however for low/medium strength concrete this material facilitate the adoption of lower water - cement quantitative relation and higher association of cement particles as well as robust bonding amongst the particles. From their study, it's been ascertained that most compressive strength (both cube and cylinder) is noted for 100 percent replacement of cement with silicon dioxide fume and also the values ar higher (by nineteen.6% and 16.82% respectively) than those of the conventional concrete (for cube and cylinder) wherever as split strength and flexural strength of the SF concrete (3.61N/mm2 and four.93N/mm2 respectively) are enlarged by regarding thirty eight.58% and 21.13% severally over those (2.6 N/mm2 and four.07 N/mm2 respectively) of the conventional concrete once 100 percent of cement is replaced by SF.

Faseyemi Victor Ajileye (2012) [18] has investigated the chance of utilizing a broad vary of materials as partial replacement materials for cement within the production of concrete. He found that between five to ten vitreous silica fume by replacement of cement can increase the strength from sixteen.15% to 29.24%.

N.K. Amudhavalli and Jeena Mathew (2012) [19] studied the result of silicon dioxide fume on strength and sturdiness parameters of concrete. They according that consistency of cement depend upon its fineness. Silicon dioxide fume has bigger fineness than cement and bigger extent therefore the consistency will increase once silicon dioxide fume proportion will increase. The conventional consistency will increase regarding four-hundredth once silicon dioxide fume proportion will increase from 1/3 to twenty. From their experimental study, the optimum seven and 28-day compressive strength and flexural strength are obtained within the vary of 10-15 vitreous silica fume replacement level. Increase in split strength on the far side ten vitreous silica fume replacement is nearly insignificant whereas gain in flexural strength have occurred even up to fifteen the concerns replacements. Silicon dioxide fume looks to own a a lot of pronounced result on the flexural strength than the split strength. in comparison to alternative combine the loss in weight and compressive strength proportion was found to be reduced by a pair of.23 and 7.69 once the cement was replaced by 100 percent of silicon dioxide fume.

T.Shanmugapriya (2013) [20] studied the influence of silicon dioxide fume on M60 concrete and located that seven.5% of silicon dioxide fume replacement will increase the most compressive, split tensile and flexural strengths of concrete. a trial have created by Debabrata Pradhan and D.Dutta (2013) [21] to research the various mechanical properties like compressive strength, compacting issue, slump of concrete by incorporating silicon dioxide fume as a thought of single water building material material quantitative relation of zero.40. From their studies it had been found that there's scope of skyrocketing slump price by increasing dosages of super plasticizers while not hampering the strength for additional investigation, but 0.814 compacting issue is additionally smart for victimization concrete within the field au fait system. Higher compressive strength resembles the concrete incorporating silicon dioxide fume is high strength concrete as per IS code recommendations. Improved pore structures at transition zone for silicon dioxide fume concrete resembles that it should be LED to as high performance concrete.

2.2 Literature Review on Nano silicon dioxide

Bjornstrom et al (2004) [21] have investigated the association method of tricalcium salt (C3S) cement and established the fast effects of mixture silicon dioxide and role of water throughout association. They ascertained that CNS accelerate dissolution of C3S section, thereby renders the speedy formation of C-S-H section. If the nano particles are integrated with cement based mostly materials, the new materials may possess some outstanding properties. The pozzolanic activity of NS is a lot of obvious than that of silicon dioxide fume. NS will react with CH crystals that are clad within the surface transition zone (ITZ) between hardened cement paste and aggregates and turn out C-S-H gel. Thus, the dimensions and quantity of CH crystals ar considerably bated and also the early age strength of hardened cement paste in enlarged.

Li(2004) [22] exhibit the result of addition of NS in high volume ash concrete (more of CaO content) and also the results compared and according that the pozzolanic activity of ash based mostly concrete with NS were enlarged significantly and located that decrements in porousness of concrete gained high strength within the early and later stage. Foreign terrorist organization (2005) [23] studied the water porousness resistant behavior and small structure of concrete with NS and ascertained that NS concrete features a higher water-resistant porousness than normal concrete. Ye Manchu dynasty et al (2007) [24] have studied the influence of silicon dioxide fume and nano silicon dioxide singly on contemporary concrete and hardened concrete and located that consistency and setting times were totally different for NS and SF. NS makes cement paste thicker and accelerated the association method that improves the bond strength and compressive strength in comparison therewith of SF in concrete. Jo et al (2007) [25] compared the SF concrete and NS concrete. They explicit that NS Shows improved compressive strength and bond strength too. They additionally studied the properties of cement mortar with NS particles and according the importance of NS addition towards strength characteristics. carver et al (2008) [26] have ascertained the result of NS addition on porousness and compressive strength of ash cement mortar. From the pore analysis study, it had been according that the relative porousness and pore sizes of concrete were bated, whereas the compressive strength enlarged by adding a lot of NS. Gaitero et al (2008) [27] have according that the Ca {leaching|leach|natural method natural action|action|activity} was a degradation process that gift within the progressive dissolution of the cement paste as a consequence of the migration of Ca2+ ions to the aggressive resolution.

Yazdi et al (2009) [28] have investigated the result of NS on high volume ash concrete [HFC], and located that thanks to the low pozzolanic reactions of ash, early strength of hydro fluorocarbon reduced significantly, however with the addition of NS promoted the pozzolanic activity reaction that enabled the improvement of strength of hydro fluorocarbon, particularly within the early ages. Sololev et al (2009) [29] studied the roles of nano particles of silicon dioxide that act as fillers within the voids or empty areas. They according that, the well distributed NS act as a nucleation or crystallization centers' of the hydrous product, thereby increasing the association rate, that is, NS helps towards the formation of smaller size CH crystals and solid clusters of C-S-H composition. Moreover, they found that NS improved the structure of the transition zone between aggregates and paste.

Sadrmontazi Barzegar (2010) [30] terminated that the properties of self compacting concrete with and while not Rice Husk Ash [RHA], AN agro-industry waste, and exhibited improvement within the physical and mechanical properties of concrete with addition of NS. Khanzadi et al (2010) [31] according the influence of NS particles on the mechanical properties and sturdiness of concrete through activity of compressive and strength, water absorption and also the depth of chloride penetration. it had been discovered that the compressive and strength doubled in presence of nano SiO2 that indicates the pozzolanic activity of NS. Improvement in surface transition zone was found and collectively water absorption, capillary absorption and distribution of chloride particle results indicate the nano-silica concrete has higher porousness resistance than the quality concrete.

With the prevalence of supplementary building material materials and alternative silicious and aluminous materials, today's concrete technology has achieved monumental potential applications, by the means of reduction in cement consumption, increased properties and reduced carbon foot print. In concrete, for instance, the small silicon dioxide fume works within the style of chemical process with caustic lime [CH] kind a lot of C-S-H gel at end and additionally fill the voids and pores within the contemporary and hardened cement paste, thereby increasing the concrete's density. Some researchers found that the addition of one metric weight unit of silicon dioxide fume [SF] permits a discount of four metric weight unit of cement, and this will be a lot of if NS is employed.

The cacophonic strength assessments, thermal behavior and microstructure of concrete containing totally different amounts of ground coarse furnace scum and SiO2 nano particles as binder were investigated by Nazari and Riahia(2011)[32]. The cement replaced with forty fifth of ground coarse furnace scum and up to three.0 twin towers SiO2 nano particles enlarged compressive strength thanks to the presence of enlarged crystalline Ca(OH)2 by formation of dense C-S-H at early stage and improvement in resistance of water porousness was mentioned. it had been stressed that on the far side the proportion level of three SiO2 replacement would cause reduction in cacophonic strength. The character of pores gift within the concrete was additionally mentioned.

The compressive strength analysis of cement mortar with nano SiO_2 and with silicon dioxide fume was mentioned for various w/c quantitative relations. The experimental results make sure that the compressive strength of mortars with NS was over those of mortars containing silicon dioxide fume at seven and twenty eight days. it had been proven from this study that the improvement of strength in the main depends on NS addition instead of addition of silicon dioxide fume. The association progress was perpetually monitored from SEM observation, residual amount check for $Ca\ (OH)_2$ a pair of and rate of heat evolution it had been confirmed supported the on top of conducted tests, the SiO2 in nano scale behave not solely as a filler to boost the microstructure, however additionally AN activity to will increase the pozzolanic reactions. The influences and importance of super softener whereas mixture cement with nano particles for mortar or concrete preparation were addressed. The reaction mechanism of NS with cement supported their offered high extent towards the strength improvement by strengthening the C-S-H gel was additionally mentioned.

Min-Hang Zhang et al (2012) [33] found that the incorporation of NS by regarding a pair of weight of cement with five hundredth GGBS cement mixture, not solely altered the setting time, however additionally enlarged the compressive strength by regarding twenty second and eighteen for third and seventh days severally compared to the reference scum concrete. They additionally found that the big capillary porousness bated and medium porousness enlarged within the scum cement pastes at twenty eight days. However, the incorporation of twenty-two NS by mass of building material materials density the pastes-aggregates interface compared with scum concrete while not NS addition. Additional reduction of size of NS perceived to be more practical in increasing the speed of cement association and reaction compared with SF. In another study, an equivalent authors used NS to cut back setting times and increase early strength of concrete with high volumes of ash or scum. supported the experimental results by victimization NS in pastes, mortars and concretes with regarding five hundredth of ash or scum, the incorporation of twenty-two NS by weight of building material materials reduced initial and final setting times and enlarged 3- and 7- days compressive strengths of high volume ash by half-hour and twenty fifth severally compared to the reference concrete with five hundredth ash and also the similar trends were ascertained in high volume scum concrete too. it had been found that later strength for NS with ash enlarged, however not within the case of GGBS cement. Same quite action of chloride porousness of the NS with scum and ash concrete were according compared with management concrete.

Another study was according by Mastafa Jalal et al (2012) [34] for the natural philosophy, small structure particles, mechanical and sturdiness of high performance self compacting concrete [HPSCC] containing silicon dioxide of small and nano size and with emulsified NS and SF. The addition of NS alone up to twenty weight of cement increased each the compressive and split strengths by regarding sixty two and twenty fifth severally, whereas a pair of NS emulsified with 100 percent SF with management concrete, there was a further strength improvement of Sep 11 and eight severally. They delineated that the improvement of strength wasn't solely due to pour filling result, however additionally by the accelerated cement association thanks to their higher reactivity of NS. Moreover, the water and capillary absorption results disclosed important decrease by the addition of emulsified NS and SF for the binder content. in line with SEM microstructure studies, pure microstructure and smaller pores were achieved by the addition of NS and SF, which may LED to improvement of mechanical, sturdiness and small structural properties of HPSCC.

The result of mixture NS [CNS] on the cement association method compared with SF, similarly as its influence on the gel structure and nano scale mechanical properties of cement paste were studied by Hou et al (2012) [35] and showed that the pozzolanic activity of mixture NS (instead of NS powder) was over that of SF and its association acceleration result was additionally over SF within the early age, however this result was admire that of SF within the later stage. The strength enhancing result of CNS and SF mixture of regarding five-hitter disclosed that there was regarding Sixteen Personality Factor Questionnaire and forty fifth improvements in strength for third and seventh day severally, whereas SF showed but 100 percent improvement. At an equivalent time, they found that there have been significant reduction is that the CH content within the cement paste with CNS addition, however not the case in SF addition.

The influence of NS with totally different dosages were studied by Stefanidou, and Papayannis (2012) [36] and according that the addition of NS tends to primarily increase the mechanical response and caused twenty -25% strength improvement. At an equivalent time, with the addition of super plasticizers in a hundred and twenty fifth w/w of cement reduced the water demand and also the strength increase varied from half-hour to thirty fifth. Spectacular changes were additionally recorded within the structure of nano-modified samples because the Ca salt crystal size is larger in samples with high NS content and small structure observation additionally recorded a denser structure in nano-modified samples. in an exceedingly similar line, the result of NS addition with cement pastes on the workability and compressive strength were studied by Lawrence Peter Berra, et al (2012) [37] they found that thanks to the instant interactions between NS and also the liquid section of the building material mixes (mainly dissolved alkalis), the formation of gels characterized by high water retention capacities made a motivating reduction of the combo workability, while not dynamical water / binder quantitative relation and /or addition of super plasticizers.

A.Siva Sai, B.L.P. Swami, B.Sai Kiran (2013) [38] have ascertained the mechanical properties of M60 and M70 grade concrete with small silicon dioxide and together with mixture nano-silica. They found that concrete composites with superior properties will be made with the mixture of micro-silica and nano-silica. prophet Reza Zamani Abyaneh et al (2013) [39] have found that the concrete made with Micro-SiO_2 and Nano-SiO_2 show higher degrees of quality in their compressive strength than the concrete that solely have Micro-SiO_2 in their mixtures. Specimens with a pair of Nano-SiO_2 and 100 percent Micro-SiO_2 had less water absorption and a lot of resistivity.

CHAPTER -III

3.1 OBJECTIVES AND SCOPE OF PRESENT INVESTIGATION:

Concrete is the most wide used construction material in the world. In recent years, researchers have targeted on the development of concrete quality concerning its mechanical and sturdiness properties.

A reaction between the cement and water turn out metal salt hydrate, which provides strength to the concrete and alternative mechanical properties. The most important disadvantage within the concrete at the recent and hardened state is that the crack formation and its ensuing issues. The cracks in the concrete structures and early degradation are primarily due to the alkali silicon dioxide reaction, that is a chemical reaction that causes cracks in the concrete. Except the higher than, permeableness of gases through pores and micro-cracks within the concrete, that results in corrosion downside within the reinforcement of concrete causes any failure. Moreover, the enlargement and shrinkage within the concrete happen, which cause cracks in concrete at later ages; these are mainly due to the sulphate attack, that are chargeable for the loss of strength in concrete, the chemical leach attributable to the surplus of hydroxide [CH]. The subsequent chemical equation provides the association method in cement

$$2C3S + 6H\ C3S2H3 + 3CH$$

$$2C2S + 4H\ C3S2H3 + CH$$

[Cement chemistry notation: C = CaO; S = SiO2; H = H2O]. With relevance the higher than equations, the C-S-H is that the strength section, whereas the by-product, the CH is not having any building material properties, so it will easily leached out and leads prone to chemical attack. With the addition of appropriate building material materials, mostly siliceous or aluminous, with cement which can react with excess CH and produce additional C-S-H with the replacement of porous CH and refines the pore structure and reduces permeability of gases and water in concrete. The reduction of the CH content throughout cement association related to the chances of sulfate attack and chemical leach will be reduced any, which can tackle to remediate the concrete cracking to some extent. These will be achieved by the application of the supplementary building material materials like silicon dioxide fume, fly ash, Ground Granulated Ballast Slag (G.G.B.S) and etc.

Recently Nano Technology has been introduced in engineering applications. One among the foremost used nano material is Nano Silica (NS). This is often the primary Nano product that has replaced the small silicon dioxide. The advancement created by the study of concrete at nano scale has well-tried that nano silicon dioxide is a lot of higher than silicon dioxide fume used in standard concrete. Nano silicon dioxide possess a lot of pozzolanic nature, it has the capability to react with the free lime during the cement hydration and forms additional C-S-H gel which gives strength, impermeability and sturdiness to concrete.

3.2 OBJECTIVES OF STUDY:

The main objectives of this study is

- To study the mechanical properties of concrete by victimization small silicon dioxide and nano silicon dioxide
- To verify the feasibleness of victimization small silicon dioxide and nano silicon dioxide as a replacement of cement in concrete
- To verify the feasibleness of victimization small silicon dioxide and nano silicon dioxide as a replacement of cement in concrete
- To fulfill safe atmosphere and strength properties by victimization small silicon dioxide and nano silicon dioxide.
- To investigate the various basic properties like compressive strength, split durability and flexural strength of nano silicon dioxide concrete compared with plain concrete.

- In this experimental work, study of strength properties of concrete by victimization nano silicon dioxide and silicon dioxide fume as partial replacement of cement with relevance M40 and M50 grade concretes is created. Strength properties of concrete such as compressive strength, split tensile strength, and flexural strength of concrete are created with completely different replacement levels of normal Portland cement with silicon dioxide fume (5%, 7.5%, 100% and 15%) and nano silicon dioxide (1%, 1.5%, 2% and 2.5%). Strength properties of M40 and M50 grade concretes were additionally studied for a combination of optimum replacement levels of SF (7.5%) and NS (2%).

CHAPTER –IV

4.1 EXPERIMENTAL INVESTIGATION

The experimental programme was administrated to check the mechanical properties like. compressive strength, split durability, and flexural strength of high strength concrete with relevance M40 and M50 grade of concrete, with different replacement levels of ordinary hydraulic cement (ultra tech cement 53 grade) with silica fume (5%, 7.5%, 100 percent and 15%) and nano oxide (1%, 1.5%, 2% and 2.5%). Strength properties of M40 and M50 grade concretes were additionally studied for combination of optimum replacement levels of SF (7.5%) and NS (2%).

4.2 MATERIALS USED AND THEIR PROPERTIES

The materials used in the present investigation are as fallows

1. Cement
2. Aggregates
3. Water

4. Super plasticizer

5. Silica Fume

6. Nano silica

4.2.1 CEMENT

In this gift investigation radical school cement of standard hydraulic cement (OPC) of fifty three Grades was used that satisfies the wants of IS: 12269-1987. The subsequent tests area unit conducted on cement.

4.2.1.1 TESTS ON CEMENT

Following tests area unit conducted to grasp the physical properties of cement

1. Fineness
2. Consistency
3. Initial and Final Setting Time
4. Soundness
5. Specific gravity
6. Compressive strength

TABLE: 1 Physical Properties of Ultra Tech 53 grade (OPC) cement

S.No	Physical Tests	Obtained Results	Requirements as per IS CODES
1	Fineness	4%	Not>10% as per IS 4031 part 1
2	Standard Consistency	31%	IS 4031 part 4
2	Initial Setting time	120 min	Not less than 30 minutes as per IS 4031 part 5
3	Final setting time	250 min	Not more than 600 minutes as per IS 4031 part 5
4	Soundness	3mm	Not>10mm as per IS 4031 part 3
5	Specific gravity	3.11	IS 2720 part 3 (3.15)

4.2.2 AGGREGATE

Aggregates are the important ingredient materials in concrete. They impart bulk volume to the concrete and scale back the shrinkage result. They occupy seventy to eighty % of the overall volume of concrete.

Fine Aggregate: Domestically out there sand collected from watercourse Tungabhadra was used. The subsequent tests area unit conducted on fine mixture per IS: 383-1987

4.2.1.1 Test on fine Aggregate

- Sieve Analysis of Fine Aggregate
- Specific Gravity of Fine Aggregate
-

Sieve analysis of Fine Aggregate (FA): The sieve analysis of fine mixture is as shown within the Table-2. And from this take a look at the sand utilized in gift study was conformed to zone-II Semi log graph premeditated for sieve analysis of fine mixture is shown in Figure-1

The fineness modulus of fine aggregate is 2.81

Table: 2 Sieve Analysis of Fine Aggregate

S.NO	Sieve size in mm	Weight retained in gm	% weight retained	Cumulative % weight retained (f)	% passing (100-f)
1	4.75	25	2.5	0.25	99.75
2	2.36	20	2	2.25	97.75
3	1.18	130	13	15.25	84.75
4	0.60	570	57	72.25	27.75
5	0.35	225	22.5	94.75	5.25
6	0.15	15	1.5	96.25	3.75
	PAN	15	1.5		100
	Total	1000	100	281	

Fineness modulus = Sum of cumulative percentage retained on standard sieves/100

= 281/100

= 2.81

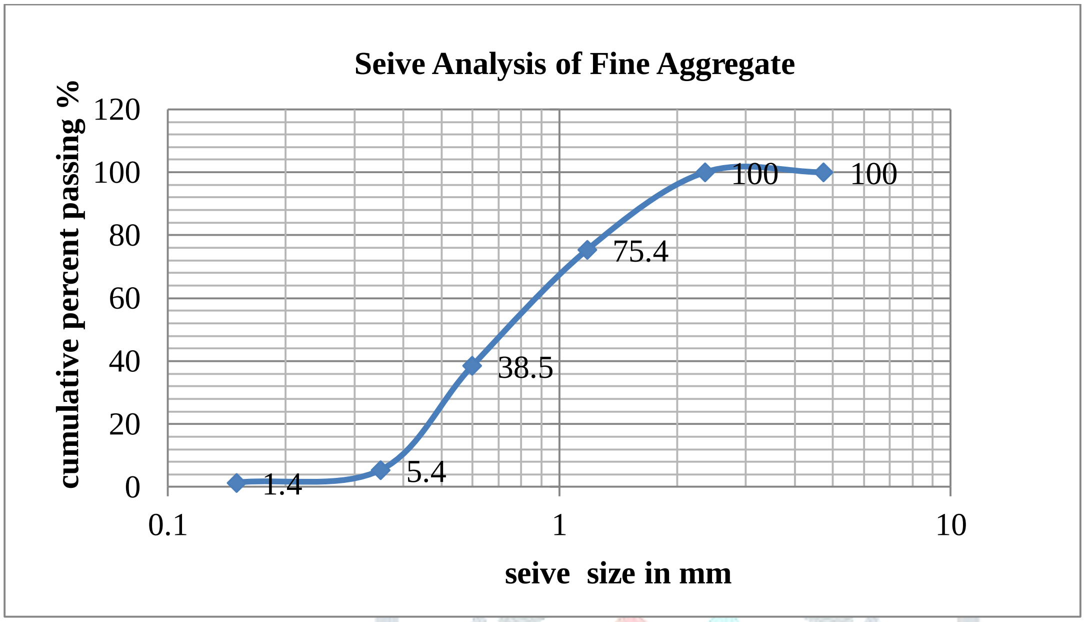

Figure: 1 Sieve Analyses of Fine Aggregate

Specific Gravity of Fine Aggregate:

The specific gravity for fine mixture is set as shown in Table-3

Table: 3 Specific Gravity of Fine Aggregate

SPECIFIC GRAVITY OF FINE AGGREGATE (FA)			
S.No	**Sample Description**		
1	Weight of Dry and Empty pycnometer	W1 = 596	Gm
2	weight of pycnometer + Sand	W2 =1097	Gm
3	weight of pycnometer + Sand + Water	W3 =1800	Gm
4	weight of pycnometer + water	W4 =1485	Gm
5	weight of Oven Dry Aggregate Sample	W5 = 500	Gm

$$\text{Specific Gravity of Fine Aggregate} = \frac{W_5}{((W_2 - W_1) \quad (W_3 - W_4))}$$

$$\text{Specific Gravity of Fine Aggregate} = \frac{500}{((1097\text{-}596)\quad(1800\text{-}1485))}$$

The Specific Gravity of Fine Aggregate is 2.68

The physical properties of fine aggregate are shown in Table-4

Table: 4 Physical Properties of Fine Aggregates

S.No	Properties	Results
1	Bulk density, kg/m^3	1650
2	Specific gravity	2.68
3	Fineness modulus	2.81

Coarse Aggregate: The crushed aggregate was used from the local quarry. In this experiment the aggregate was used of 20mm down and tested as per IS: 2386-1963(I, II, III) specification. The subsequent tests area unit conducted on coarse mixture**.**

4.2.1.2 Test on Coarse Aggregate

- Sieve Analysis of Coarse Aggregate
- Specific Gravity of Coarse Aggregate

Sieve analysis of Coarse Aggregate:

The sieve analysis of coarse mixture is shown within the Table-5 and Semi log graph is premeditated for sieve analysis of coarse mixture is shown in Figure-2

Table: 5 Sieve Analysis of Coarse Aggregate

s.no	Sieve size in mm	Weight retained in gm	% weight retained	Cumulative % weight retained (f)	% passing (100-f)
1	80	0	0	0	100
2	63	0	0	0	100
3	50	0	0	0	100
4	40	0	0	0	100
5	31.5	30	0.3	0.2	99.8
6	25	1120	11.2	11.5	88.5
7	20	4170	41.7	53.2	46.8
8	12.5	4360	43.6	96.8	3.2
9	10	220	2.2	99	1
10	6.3	90	0.9	99.9	0.1
11	4.75	10	0.1	100	0
				460.6	

Fineness modulus = Sum of cumulative percentage retained on standard sieves /100

= 460.6/100

The fineness modulus of coarse mixture is 4.60

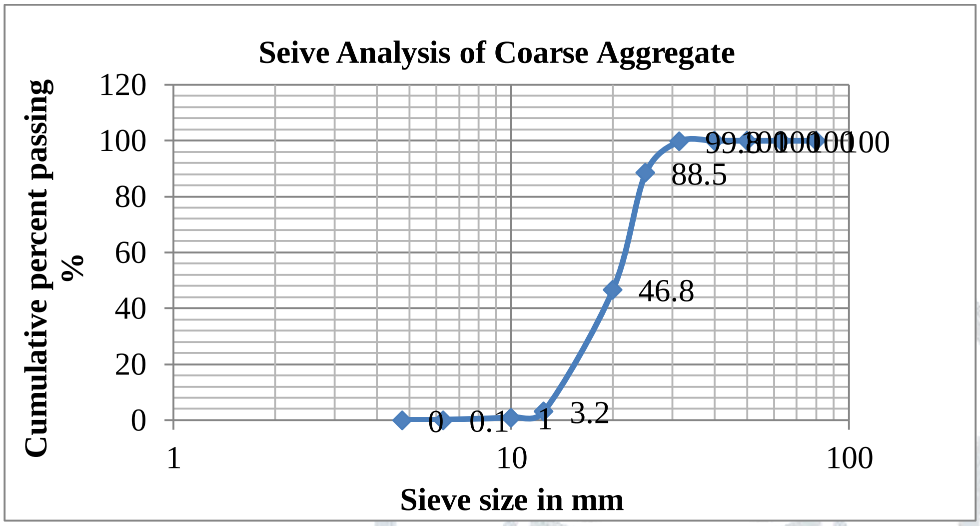

Figure: 2 Sieve Analysis of Coarse Aggregate

Specific gravity of Coarse Aggregate:

The specific gravity for coarse aggregate is determined as shown in Table-6

Table: 6 Specific Gravity of Coarse Aggregate

SPECIFIC GRAVITY OF COARSE AGGREGATE (CA)			
S.No	**Sample Description**		
1	Weight of Dry and Empty pycnometer	W_1 = 602	Gm
2	weight of pycnometer + Sand	W_2 =1102	Gm
3	weight of pycnometer + Sand + Water	W_3 =1813	Gm
4	weight of pycnometer + water	W_4 =1500	Gm
5	weight of Oven dry Aggregate Sample	W_5 = 500	Gm

$$\text{Specific Gravity of Coarse Aggregate} = \frac{W_5}{((W_2 - W_1) \quad (W_3 - W_4))}$$

$$\text{Specific Gravity of Coarse Aggregate} = \frac{500}{((1102 - 596) \quad (1813 - 1500))}$$

The specific gravity of coarse mixture is a 2.70

The physical properties of coarse mixture area unit shown in Table-7

Table: 7 Physical Properties of Coarse aggregate

S.No	Property	Results
1	Maximum nominal size	20mm
2	Bulk density (kg/m^3)	1800
3	Specific gravity	2.75

4.2.3 Water

Water used for mix and natural action is pure domestic water, orthodox to IS: 3025 – 1964 half twenty two, half twenty three and IS: 456 – 2000.

4.2.4 Super Plasticizers

Fosroc Aura combine four hundred was used for M40 and M50 Grade of concrete. The properties of super plasticizer is shown in Table- 8

Table: 8 Properties of Fosroc Aura mix 400 Super Plasticizer

Properties	
Appearance	Light yellow coloured liquid
P_H	About 6.0
Volumetric mass @ 20°C	1.09 kg/ litre
Chloride content	Nil
Alkali content	Typically less than 1.5 g Na_2o equivalent liter of admixture

4.2.5 Silica Fume

The oxide fume was utilized in these experiments conforms to ASTM C 1240 and IS 15388:2003. The oxide fume is extraordinarily fine particle that exists in white color powder kind. Oxide fume has been procured from Astrra chemicals Ltd-Chennai. The physical and chemical properties of oxide fume is shown in Table-9

Table: 9 Physical and Chemical Properties of silica fume

PHYSICAL PROPERTIES	**RESULTS**
Physical state	Micronized Powder
Odour	Odourless
Appearance	White Colour Powder
Colour	White
Pack density	0.76 gm/cc
P_H of 5% solution	6.90
Specific Gravity	2.63
Moisture	0.058%
Oil absorption	55 ml / 100 gms
CHEMICAL PROPERTIES	**RESULTS**
Silica (SIO_2)	99.886%
Alumina (Al_2O_3)	0.043%
Ferric Oxide (Fe_2O_3)	0.040%
Titanium Oxide (TiO_2)	0.001%
Calcium Oxide (CaO)	0.001%
Magnesium Oxide (MgO)	Absent
Potassium Oxide (K_2O)	0.001%
Sodium Oxide (Na_2O)	0.003%
Loss on Ignition	0.015%

HEAVY METALS:	
Lead (Pb)	Absent
Arsenic (As)	Absent

4.2.6 Nano silica

In this experimental study mixture nano oxide of **CemSyn®-XFX** is employed, it's a series of oxide based mostly binders /fillers obtained from Bee-chem.: Chemicals Ltd., Kanpur. The properties of nano silica are shown in Table-10

Table: 10 Properties of Colloidal Nano silica

State	Dispersed in water
Active nano particle Content (%w/w)	40.00-41.50
P_H (at 20° C temperature)	9.0-10.0
Specific gravity	1.30-1.32
Particle size	5-40 nm

4.3 MIX DESIGN OF CONCRETE

Mix style may be outlined because the method of choosing appropriate ingredients of concrete like cement, aggregates, water and determinative their relative proportions with the thing of manufacturing concrete of needed minimum strength, workability and sturdiness as economically as attainable. The combine proportions of M40 and M50 grades concrete area unit carried out exploitation IS: 10262-2009. Elaborated combine style for M40 and M50 grade concrete area unit explained in Annexure-A.

4.4 TEST PROGRAMME

In this gift investigation it is aimed to study the strength characteristics of concrete such as compressive strength, split durability and flexural strengths of M40 and M50 grade concretes, by modifying standard concrete with totally different percentages of oxide fume (0%, 5%, 7.5%, 100 percent & 15%) and nano oxide (1%, 1.5%, 2%, & 2.5) by partial replacement of cement by weight. Various mix proportions of M40 and M50 grade concretes with nano silica, small oxide, combinations of nano silica and micro silica are shown Table-11(a) and Table-11 (b) for M40 and M50 grade concretes.

Table-11 (a) Mix Proportions for M40 Grade Concrete

Table-11 (b) Mix Proportions for M40 Grade Concrete

Mixture	SF in %	Nano Silica in %	Cement content in kg/m^3	water content in kg/m^3	FA in kg/m^3	CA in kg/m^3	SF in kg/m^3	NS in kg/m^3	Super plasticizer
Plain	0	0	403.00	145.08	659.96	1242.80	0	0	0.5
SF-5	5	0	382.85	145.08	659.96	1242.80	20.15	0	0.6
SF-7.5	7.5	0	372.77	145.08	659.96	1242.80	30.22	0	0.7
SF -10	10	0	362.70	145.08	659.96	1242.80	40.30	0	0.85
SF - 15	15	0	342.55	145.08	659.96	1242.80	60.45	0	0.90
NS - 1	0	1	392.92	139.03	659.96	1242.80	0	10.07	0.70
NS - 1.5	0	1.5	387.88	136.012	659.96	1242.80	0	15.11	0.75
NS - 2	0	2	382.85	132.99	659.96	1242.80	0	20.15	0.85
NS - 2.5	0	2.5	377.81	129.96	659.96	1242.80	0	25.18	1

Mixture	SF in %	Nano Silica in %	Cement content in kg/m³	water content in kg/m³	FA in kg/m³	CA in kg/m³	SF in kg/m³	NS in kg/m³	Super plasticizer
Plain	0	0	439.64	145.08	682.67	1252.04	0	0	0.5
SF-5	5	0	417.65	145.08	682.67	1252.04	21.98	0	0.7
SF-7.5	7.5	0	384.68	145.08	682.67	1252.04	32.97	0	0.8
SF -10	10	0	373.69	145.08	682.67	1252.04	43.96	0	0.9
SF - 15	15	0	307.74	145.08	682.67	1252.04	65.94	0	0.92
NS - 1	0	1	435.24	138.48	682.67	1252.04	0	10.99	0.75
NS - 1.5	0	1.5	433.04	135.18	682.67	1252.04	0	16.48	0.8
NS - 2	0	2	430.84	131.89	682.67	1252.04	0	21.98	0.85
NS - 2.5	0	2.5	428.64	128.59	682.67	1252.04	0	27.47	1.1

4.5 MIXING, CASTING AND CURING

The proportions of designed mixes for M40 (1:1.694:3.107) and M50 (1:1.501:2.827) grades alongside water cement quantitative relation zero.33 and 0.36 was utilized in the current study.

The different share replacement of cement with NS and SF for the each M40 and M50 grades concrete is shown in Table- 12

Table: 12 percentage replacement of cement by using NS & SF

S.NO	Percentage of Nano Silica (N.S)	Percentage of Silica Fume (S.F)
1	1	0
2	1.5	0
3	2	0
4	2.5	0
5	0	5
6	0	7.5
7	0	10
8	0	15

To proceed with the experimental programme, ab initio specimens of ordinary cubes (150mmx150mmx150mm), cylinders (150mm diameters and 300mm length) and beams of (100mmx100mmx500mm), were taken and these specimens were clean while not mud particles and were brushed with oil on all the inner faces to facilitate simple removal of specimens for demoulding.

The mixing of concrete is crucial for the assembly of uniform concrete. The blending ought to be confirm that the concrete becomes consistent, uniform and consistency.

Mixing of concrete is completed in line with IS: 516-1959. For every combine three cubes, three beams and three cylinders were forged. All the specimens were unbroken on the surface and therefore the freshly mixed concrete was poured in to the moulds in 3 layers every layer being compacted completely with a tamping rod to avoid voids. Finally all the specimens were vibrated on the moving table. The specimens are lined with bagging luggage to keep up close wetness content. When twenty four hours the specimens were demoulded and were unbroken immersed in an exceedingly clean cistern for set. When twenty eight days of set the specimens were tested for compressive strength, flexural strength and split durability.

4.6TESTING OF CONCRETE

4.6.1 Tests on Fresh concrete

4.6.2 Tests on Hardened concrete

Testing of concrete plays a crucial role in dominant and conformist the standard of cement concrete works. Regular testing of raw materials of contemporary concrete and hardened concrete are plays a crucial half to manage the standard of the concrete that helps to attain higher performance of concrete with relevance each strength and sturdiness. The most purpose of testing hardened concrete is to substantiate that the concrete attains target mean strength.

4.6.1 Tests on Fresh concrete

Fresh concrete or plastic concrete may be a freshly mixed concrete which may be moulded into any form. Strength of concrete primarily depends upon the strength of cement past.

The following take a look at is conducted to see the standard of concrete

4.6.1.1 Compaction factor test:

Compaction issue take a look at is adopted to work out the workability of concrete. The workability is that the property of the concrete that determines the quantity of labor needed to provide full compaction. To seek out the workability of freshly ready concrete, the take a look at is distributed as per specifications of IS: 1199-1959. It provides a concept of the capability of being worked, i.e., plan to manage the number of water in cement concrete combine to urge uniform strength. The test distributed for all the mixes by using compaction factor apparatus as show within the Figure-3.

Figure: 3 Compaction Factor Test

It was observed that increasing of silica fume and nano silica in the concrete shows the decreasing order of workability. The results of compaction factor for different mixes are shown in Table-13.

Table: 13 Compaction Factor Values for Different Mixes

S.No	% Addition of silica fume to concrete	% Addition of nano silica to concrete	Compaction Factor Value	
			M 40	M 50
1	0%	0%	0.96	0.94
2	5%	0	0.94	0.92
3	7.5%	0	0.902	0.895
4	10%	0	0.88	0.87
5	15%	0	0.86	0.86
6	0	1%	0.94	0.95
7	0	1.5%	0.91	0.89
8	0	2%	0.88	0.87
9	0	2.5%	0.86	0.84
10	7.5%	2%	0.85	0.82

4.6.2 TESTS ON HARDENED CONCRETE:

Introduction:

Compressive strength of hardened concrete is that the most vital parameter and representative of just about overall quality of concrete. It chiefly depends on the water/cement quantitative relation of the combination, set and age when it's forged. Compressive strength of concrete is set by testing the cylinder and cube specimens of concrete employing a compression testing machine at numerous ages such as: three days, 7 days, 14 days, and 28 days respectively.

4.6.2.1Compressive Strength of Concrete:

The test is distributed to seek out the compressive strength of concrete for both M40 and M50 grade in an exceedingly Compressive Testing Machine (CTM) 2000 KN capacity as per IS: 516 1959. The arrangement for compression take a look at is shown in Figure-4.

∴ Compressive strength $= \frac{P}{A}$, in N/mm2

Where,

P = most applied load in KN

A = space of Specimen over that load applied.

Sample calculation of compressive strength of concrete is as shown in Table-14

Table: 14 Calculation of cube compressive strength of plain mixture of M35 grade concrete

Compressive Strength of Concrete			
S.No	**Load in KN**	**Strength in N/mm^2**	**Average Strength in N/mm^2**
1	1045	46.44	**49.56**
2	1100	48.88	
3	1200	53.33	

4.6.2.2 Split Tensile Strength of Concrete

The durability is one in all the fundamental and necessary properties of the concrete. The concrete isn't usually expected to resist the direct tension attributable to its durability and brittle nature. However, the determination of durability of concrete is critical to work out the load at that the concrete member might crack. The cracking may be a type of tension failure. The arrangement of the split tensile strength is shown in Figure-5.

Figure: 5 Split Tensile Strength Test

The magnitude of this tensile stress σsp (acting in an exceedingly direction perpendicular to the road of applied loading) is given by the formula (IS: 516-1970):

$$\sigma_{sp} = \frac{2P}{\pi dl} = 0.637\frac{P}{dl}$$

Where P is the applied load; d and l are the diameter and the length of specimen, respectively.

Sample calculation of Split durability of concrete is as shown in Table-15

Table: 15 Calculation of Split Tensile strength of plain mix of M40 grade

Split Tensile Strength of Concrete			
S.No	**Load in KN**	**Strength in N/mm^2**	**Average Strength in N/mm^2**
1	225	3.18	**3.26**
2	226	3.19	
3	241	3.41	

4.6.2.3 Flexural Strength of Concrete

Flexural strength is one live of the durability of concrete. it's a live of Associate in Nursing unreinforced concrete beam or block to resist failure in bending. The flexural strength of concrete is completed within the universal testing machine (UTM). The arrangement for flexural strength take a look at is shown in Figure-6.

Figure: 6 Flexural Strength Test

Flexural strength of concrete

$$f_b = \frac{PL}{bd^2} \text{ when } a \geq \frac{40}{3} \text{cm}$$

When 'a' is larger than 20.0cm for 15.0cm specimen or larger than 13.3 cm for a 10.0cm specimen, or

$$f_b = \frac{3Pa}{bd^2} \text{ when } \frac{40}{3} \geq a \geq 11\text{cm}$$

When 'a' is a smaller amount than 20.0 cm however larger than 17.0 cm for 15.0 specimen, or but 13.3 cm however larger than 11.0 cm for a 10.0 cm specimen wherever

b = measured breadth in cm of the specimen.

d = measured depth in cm of the specimen at the purpose of the failure,

l = length of the span on that the specimen was supported, and

p = most load in weight unit applied to the specimen.

Sample calculation of flexural strength of concrete is as shown in Table-16

Table: 16 Calculation of Flexural strength of plain mix of M40 grade concrete

Flexural Strength of Concrete				
S.No	**Load in kgf**	**Value of 'a' in cm**	**Strength in N/mm^2**	**Average Strength in N/mm^2**
1	2000	12.5	3.76	**3.8**
2	1960	13	3.82	
3	2000	12.8	3.84	

The compressive strength, split durability and flexural strength results of all mixes are shown in Table-17, Table-18 and Table-19.

CHAPTER –V

5. RESULTS AND DISCUSSION

5.1 Compressive strength:

The compressive strength of M40 and M50 grade concrete, SF concrete and NS concrete at the age of 28 days is conferred in Table-17.

Supported the experimental results, it absolutely was obtained that there's a significance improvement within the strength of concrete thanks to its high pozzolanic nature of oxide fume and nano oxide and their filling ability.

Compressive strength of 2 mixes M40 and M50 at 28 days age, with replacement of SF was exaggerated bit by bit up to AN optimum replacement level of 7.5% and so remittent. The most twenty eight days cube strength of M40 grade with 7.5% of oxide fume was 61.24 N/mm2 and of M50 grade with 7.5% SF was 69.09 N/mm2.

Compressive strength of M40 and M50 at twenty eight days age with replacement of NS was exaggerated bit by bit up to an optimum replacement level of twenty-two and so remittent. The most twenty eight days cube compressive strength of M40 grade with two NS was 59.61 N/mm2 and of M50 grade with two NS was 69.72 N/mm2.

The compressive strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 23.56% improvement and of M50 grade with 7.5% replacement shows 22.53% improvement over plain mixes of M40 and M50 grades concrete. The compressive strength of M40 grade concrete with partial replacement of cement by two NS shows twenty.278% improvement and of M50 grade with two replacement shows twenty two.23% improvement compare to plain mixes of M40 and M50 grades concrete. the share variation of compressive strength for M40 and M50 grade concrete area unit shown in Table-17

Compressive strength of M40 & M50 grades were additionally studied with the mix of SF at seven.5% and NS at two which ends in an exceedingly marginal improvement in strengths over individual optimum replacement levels of SF (7.5%) and NS (2%).Figure-7, Figure-8 and Figure-9 shows the variation of compressive strength of M40 & M50 grade with and while not SF and NS replacements.

Table No: 17 Compressive Strength of Concrete at 28 days.

S.No	% Silica Fume	% Nano Silica	Compressive Strength of Concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	49.56	0	57.03	0
2	5%	0	57.18	15.38	61.00	6.94
3	7.5%	0	61.24	23.56	69.89	22.53
4	10%	0	48.74	-1.65	44.58	-21.84
5	15%	0	46.22	-6.73	42.07	-26.23
6	0	1%	54.11	9.18	62.26	9.16
7	0	1.5%	55.25	11.48	65.79	15.34
8	0	2%	59.61	20.27	69.72	22.23
9	0	2.5%	47	-5.16	51.41	-9.85
10	7.5	2%	62.35	25.80	71.5	25.35

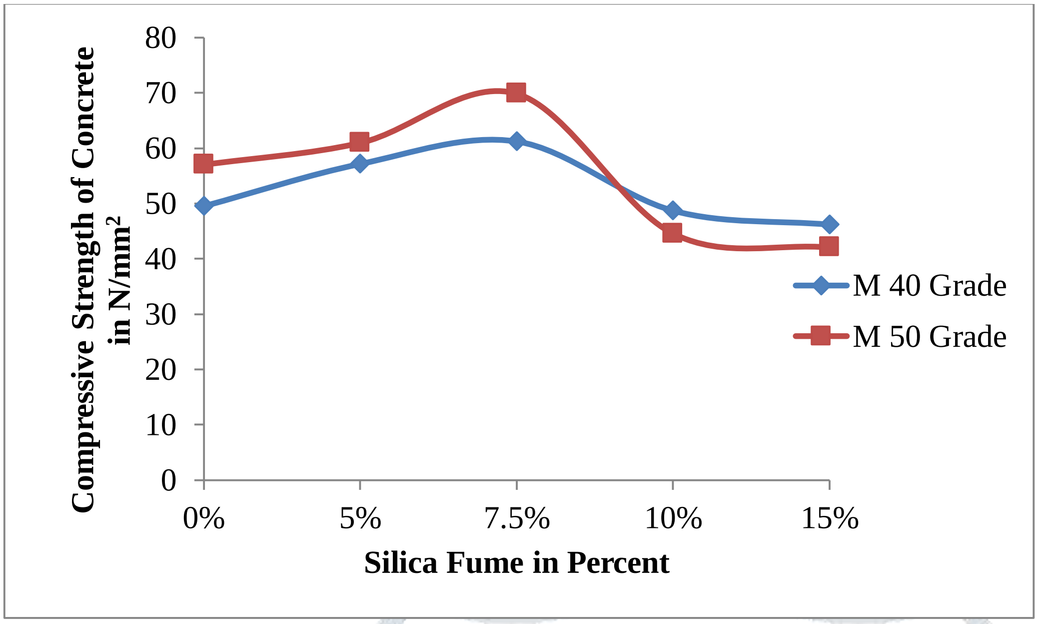

Figure: 7 Variation of compressive strength of Silica Fume concrete at 28 days

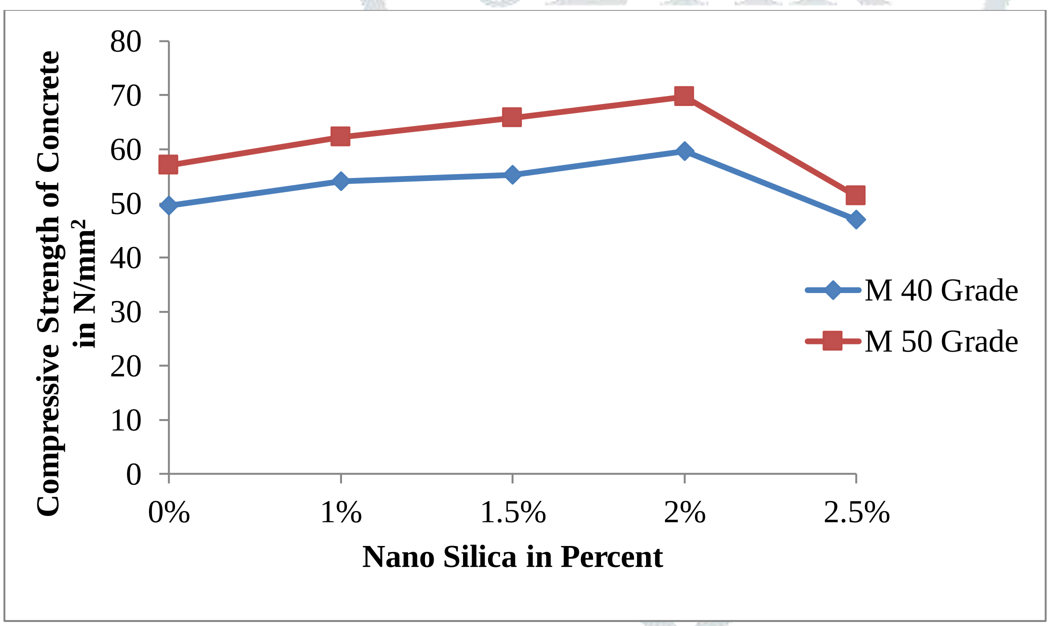

Figure: 8 Variation of compressive strength of Nano Silica concrete at 28 days

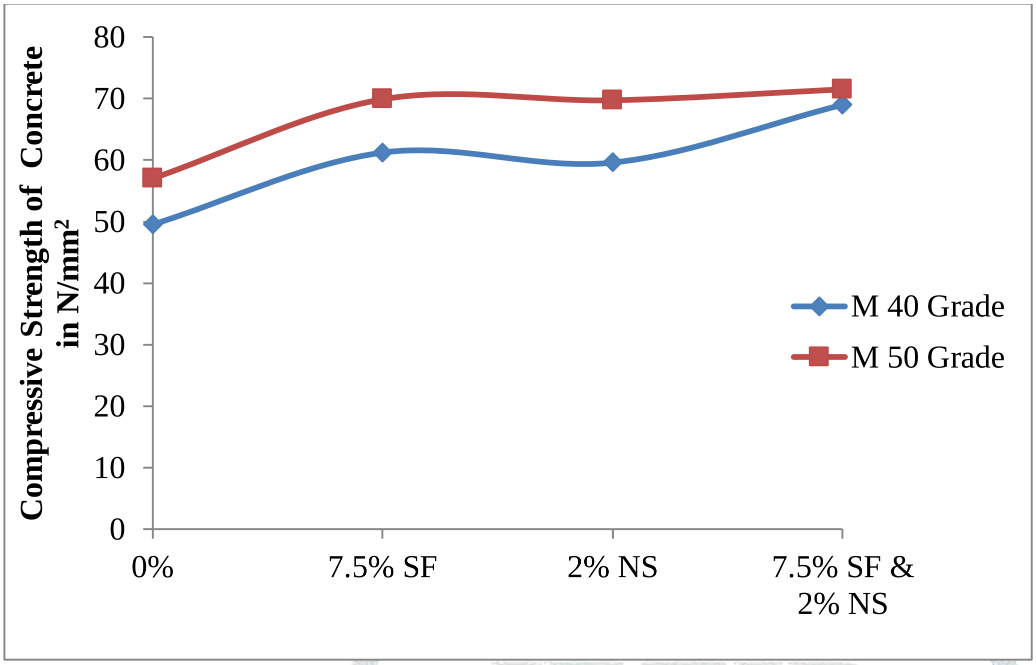

Figure: 9 Variation of compressive strength of both Silica Fume and Nano Silica concrete at 28 days

5.2 Split Tensile Strength:

Split tensile strength of two mixes M40 and M50 at 28 days age, with replacement of SF was increased gradually up to an optimum replacement level of 7.5% and then decreased. The maximum 28 days split tensile strength of M40 grade with 7.5% of silica fume was 3.96 N/mm^2 and of M50 grade with 7.5% SF was 4.12 N/mm^2.

Split tensile strength of M40 and M50 at 28 days age with replacement of NS was increased gradually up to an optimum replacement level of 2% and then decreased. The maximum 28 days Split tensile strength of M40 grade with 2% NS was 4 N/mm^2 and of M50 grade with 2% NS was 4.32 N/mm^2.

The Split tensile strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 21.47% improvement and of M50 grade with 7.5% replacement shows 17.61% improvement over plain mixes of M40 and M50 grades concrete. The Split tensile strength of M40 grade concrete with partial replacement of cement by 2% NS shows 22.70% improvement and of M50 grade with 2% replacement shows 23.32% improvement compare to plain mixes of M40 and M50 grades concrete. The percentage variation of split tensile strengths for M40 and M50 grade concrete are shown in Table-18

Split tensile strength of M40 & M50 grades were also studied with the combination of SF at 7.5% and NS at 2% which results in a marginal improvement in strengths over respective optimal replacement levels of SF (7.5%) and NS (2%). Figure-10, Figure-11 &Figure- 12 shows the variation of split tensile strength of M40 & M50 grade with SF and NS replacement.

Table No: 18 Split Tensile Strength of Concrete at 28 days

SNO	% Silica Fume	% Nano Silica	Split Tensile Strength of concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	3.26	0	3.50	0
2	5%	0	3.84	17.79	4	14.18
3	7.5%	0	3.96	21.47	4.12	17.61
4	10%	0	3.01	-7.66	3.21	-8.36
5	15%	0	3.27	0.30	3.38	-3.51
6	0	1%	3.74	14.96	3.98	13.64
7	0	1.5%	3.81	17.14	4	14.18
8	0	2%	4	22.70	4.32	23.32
9	0	2.5%	3.25	-0.21	3.68	5.05
10	7.5	2%	4.1	25.76	4.38	25.03

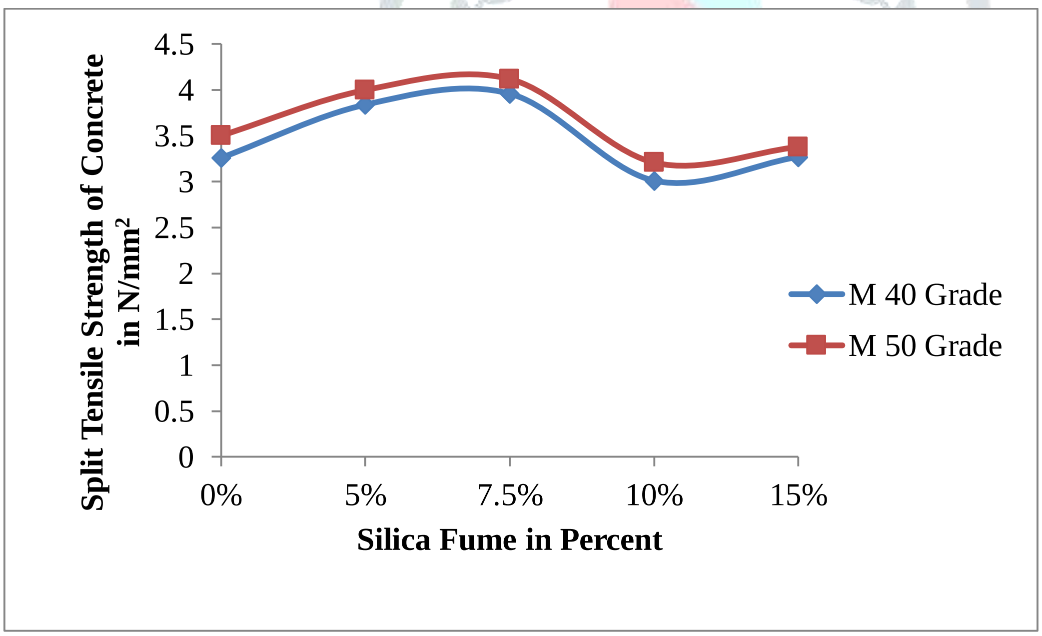

Figure: 10 Variation of Split Tensile Strength of Silica Fume concrete at 28 days

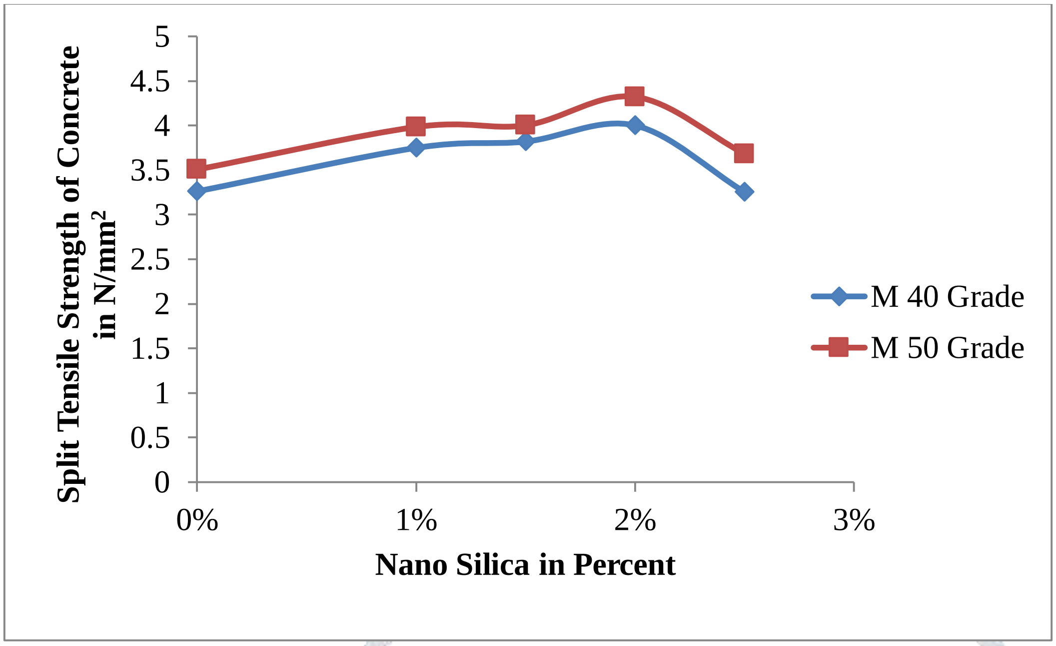

Figure: 11 Variation of Split Tensile strength of Nano Silica concrete at 28 days

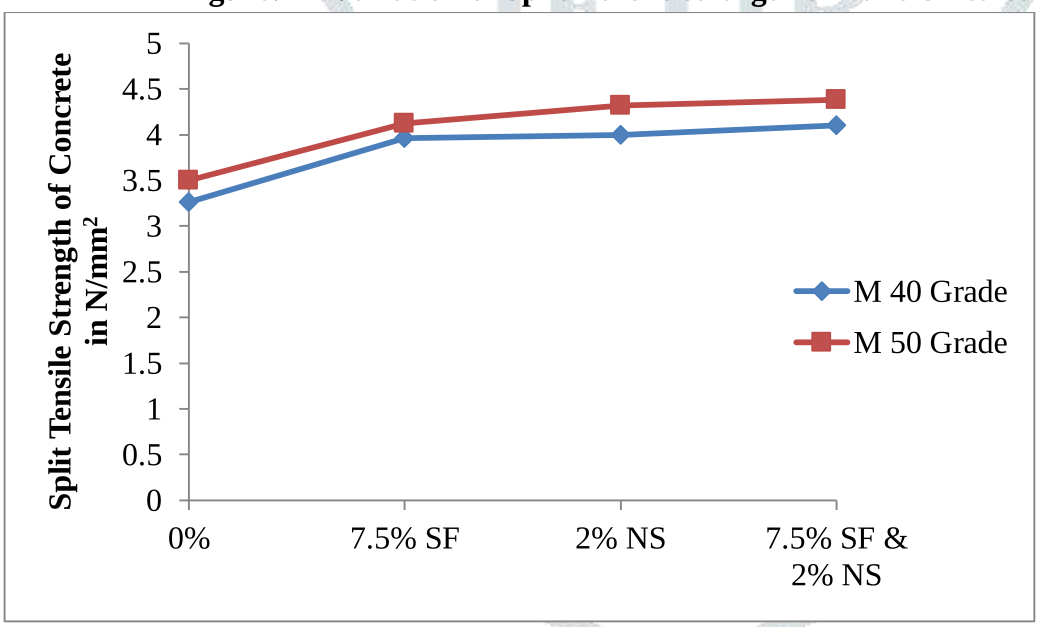

Figure: 12 Variation of Split Tensile Strength of both Silica Fume and Nano Silica concrete at 28 days

5.3 Flexural Strength:

The flexural strength of M40 and M50 grade concrete, SF concrete and NS concrete at the age of 28 days is presented in Table-19

Flexural strength of two mixes M40 and M50 at 28 days age, with replacement of SF was increased gradually up to an optimum replacement level of 7.5% and then decreased. The maximum 28 days flexural strength of M40 grade with 7.5% of silica fume was 4.160 N/mm^2 and of M50 grade with 7.5% SF was 4.560 N/mm^2.

Flexural strength of M40 and M50 at 28 days age with replacement of NS was increased gradually up to an optimum replacement level of 2% and then decreased. The maximum 28 days flexural strength of M40 grade with 2% NS was 4.45 N/mm^2 and of M50 grade with 2% NS was 4.71 N/mm^2.

The Flexural strength of M40 grade concrete with partial replacement of cement by 7.5% SF shows 9.18% improvement and of M50 grade with 7.5% replacement shows 9.35% improvement over plain mixes of M40 and M50 grades concrete. The Flexural strength of M40 grade concrete with partial replacement of cement by 2% NS shows 16.80% improvement and of M50 grade with 2% replacement shows 12.94% improvement compare to plain mixes of M40 and M50 grades concrete. The percentage variation of flexural strengths for M40 and M50 grade concrete results are shown in Table-19

Flexural strength of M40 & M50 grades were also studied with the combination of SF at 7.5% and NS at 2% which results in a marginal improvement in strengths over respective optimal replacement levels of SF (7.5%) and NS (2%). Figure-13, Figure-14 &Figure- 15 shows the variation of Flexural strength of M40 & M50 grade with and without SF and NS replacement.

Table No: 19 Flexural strength of concrete at 28 days

SNO	% Silica Fume	% Nano Silica	Flexural Strength of concrete in N/mm^2			
			M_{40} Grade	% increase or decreased	M_{50} Grade	% increase or decreased
1	0%	0	3.81	0	4.17	0
2	5%	0	4	4.98	4.28	2.63
3	7.5%	0	4.16	9.18	4.56	9.352
4	10%	0	3.76	-1.31	3.98	-4.43
5	15%	0	3.96	3.93	4.05	-2.80
6	0	1%	4	4.98	4.25	1.918
7	0	1.5%	4.2	10.23	4.59	10.07
8	0	2%	4.45	16.80	4.71	12.94
9	0	2.5%	3.8	-0.26	4	-4.07
10	7.5	2%	4.53	18.89	4.84	16.06

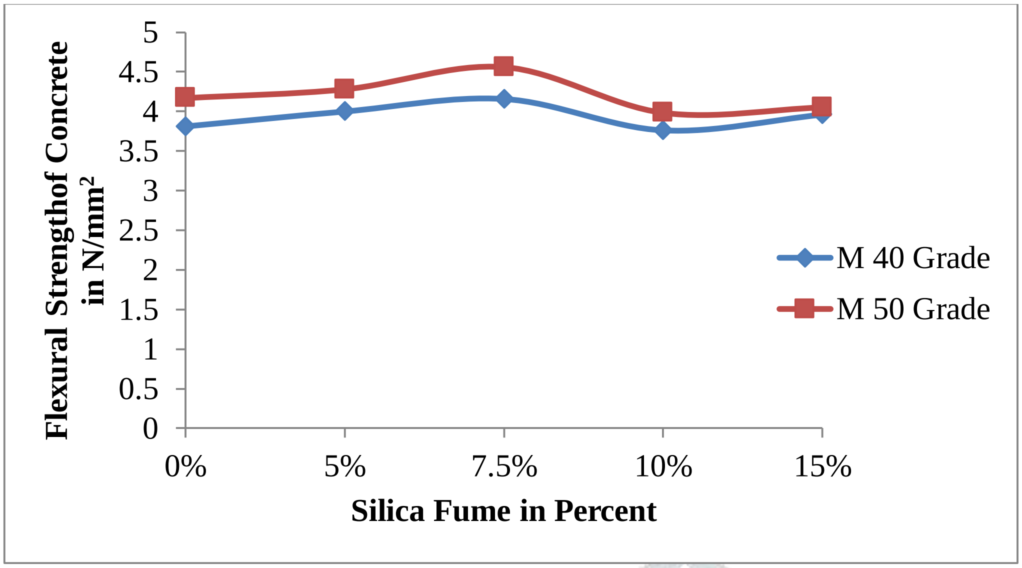

Figure: 13 Variation of Flexural strength of Silica Fume concrete at 28 days

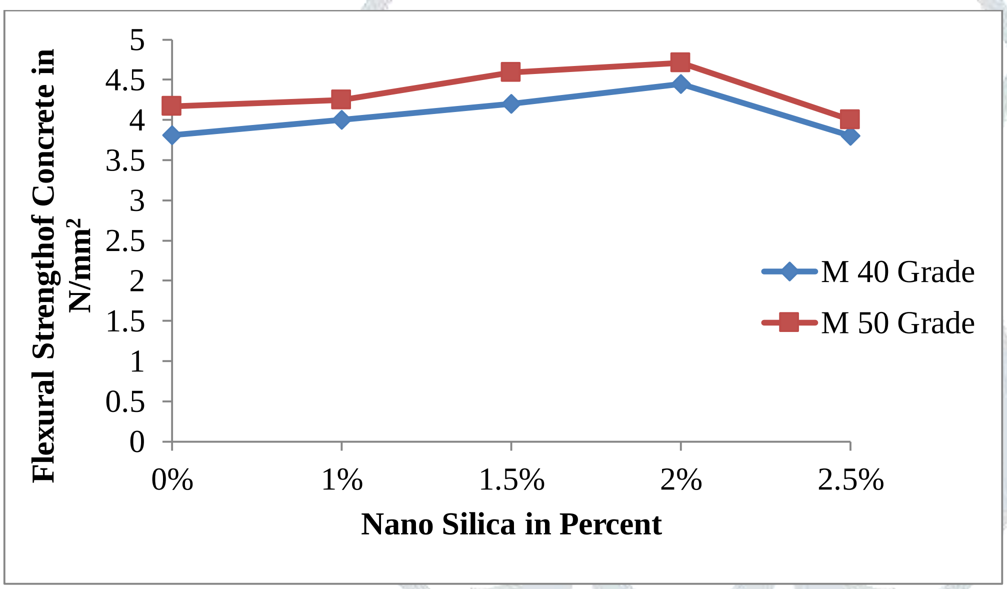

Figure: 14 Variation of Flexural strength of Nano Silica concrete at 28 days

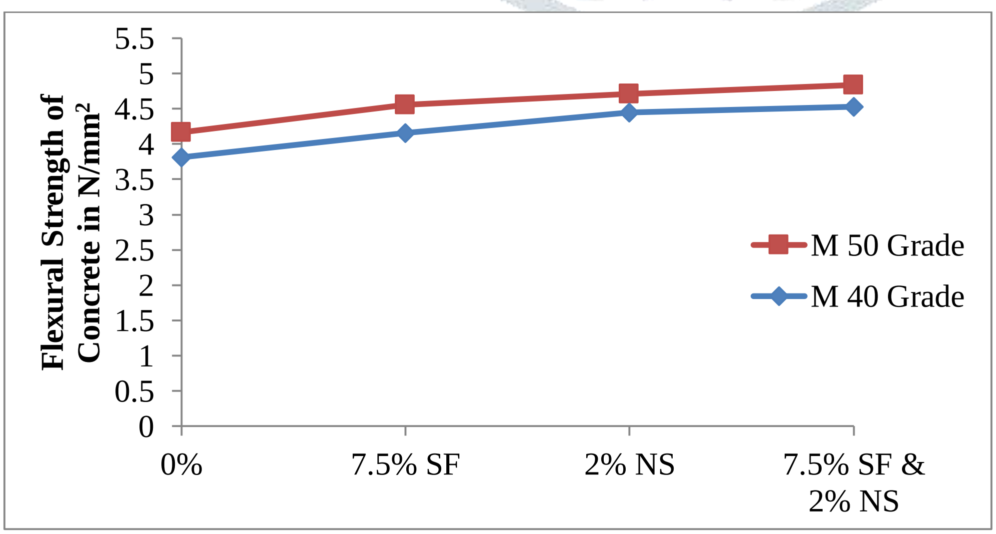

Figure: 15 Variation of Flexural strength of both Silica Fume and Nano Silica concrete at 28 day.

CHAPTER –VI

6.1 CONCLUSIONS

Based on experimental results the following conlusions are drawn

1. Compressive strength, split tensile strength and flexural strength of both mixes M40 and M50 grades were increased gradually up to replacement level 7.5% SF and up to replacement level 2% NS and then decreased.
2. The workability of both M40 and M50 grade concretes were decreased with increase in replacement of SF and NS in concrete.
3. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 7.5% SF for M40 grade concrete is 23.56%, 21.47% and 9.18% over conventional mix of M40 grades.
4. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 2% NS for M40 grade concrete is 20.27%, 22.70% and 16.80% over conventional mix of M40 grades.
5. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 7.5% SF for M50 grade concrete is 22.53%, 17.61% and 9.35% over conventional mix of M50 grades.
6. Maximum compressive strength, split tensile strength and flexural strength with replacement of cement by 2% NS for M50 grade concrete is 22.23%, 22.32% and 12.94% over conventional mix of M50 grades.
7. The percentage increase in compressive strength of concrete with combination of SF at 7.5% and NS at 2% is 25.80% for M40 grade and 25.35% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.
8. The percentage increase in split tensile strength of concrete with combination of SF at 7.5% and NS at 2% is 25.76% for M40 grade and 25.03% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.
9. The percentage increase in flexural strength of concrete with combination of SF at 7.5% and NS at 2% is 18.89% for M40 grade 16.06% for M50 grade concrete more when compared to normal concrete of M40 and M50 grades respectively.

6.2 RECOMMENDATIONS FOR FEATURE WORK

1. Further studies can be carried out with the high grade concretes.
2. In this present study colloidal nano silica was used, the further study can be carried out by using nano silica powder.

3. Further studies can be carried out with suitable combinations of different nano materials like nano metakolin, nano iron, and nano titanium and carbon nano tubes.

CHAPTER-VII

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19. IS: 4031-1988(Part-5)	Determination of Initial and Final Setting Times.
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ANNEXURE-A

MIX DESIGN FOR M40 GRADE

1. STIPULATIONS FOR PROPORTIONING:

Grade designation	= 40Mpa
Type of cement	= OPC (Ultra Tech Cement53Grade)
Maximum size of aggregate	= 20 mm
Minimum cement content	= 320 kg
Maximum water cement ratio	= 0.35
Workability	= 50 mm slump
Exposure condition	= severe
Degree of supervision	= Good
Type of aggregate	= Crushed
Maximum cement content	= 450 kg
Chemical Admixture Type	= Aura Mix SP-400 (Super plasticizer)

2. TEST DATA FOR MATERIALS:

Cement used	=OPC (Ultra Tech Cement 53Grade)
Specific gravity of cement	= 3.11
Specific gravity of coarse aggregate	= 2.67

Specific gravity of fine aggregate = 2.68

Fine aggregate conforming to grade zone II of table-4 of IS- 383

3. TARGET MEAN STRENGTH FOR MIX PROPORTIONING:

F^1_{ck} = f_{ck}+ 1.65 x s (∴ s = 5.0)

= 40 + 1.65 x 5.0

f_{ck} = 48.25 N/mm^2

Where F^1_{ck} = Target average compressive strength at 28 days,

f_{ck} = Characteristic compressive strength at 28 days,

s = Standard deviation

SELECTION OF WATER CEMENT RATIO:

From table-5 of IS-456, maximum water cement ratio = 0.45

Based on experience, adopted water cement ratio is = 0.36

4. SELECTION OF WATER CONTENT:

From Table-2 of IS: 10262-2009 maximum water content for 20mm

Aggregate [for 25-50mm slump range] = 186 liter

From table 2, Maximum water content = 186 liter (for 25 To 50 mm slump range)

As Super Plasticizer is used, the water content can be reduced up to 20 percent and above. Based on trials with super plasticizer water content reduction of 22 percentages has been achieved. Hence, the arrived water content = 186 x 0.78

5. CALCULATION OF CEMENT CONTENT:

Water cement ratio = 0.36

Cement content = 186 x 0.78

= 145.08

= 145.08÷0.36

= 403 kg/m^3

From table-5 of IS-456, Maximum cement content

For sever exposure condition = 450 kg/m^3

403 kg/m^3< 450 kg/m^3 hence ok

6. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE:

From table 3 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone II) for water cement ratio of 0.50 = 0.62.

In the present case water cement ratio is 0.36. Therefore, volume of coarse aggregate is increased to decrease the fine aggregate content. As the water cement ratio is lower by 0.10, the proportion of volume of coarse aggregate increased by 0.03 (at the rate of -/+ 0.01 for every $\pm$ 0.05 change in water cement ratio). Therefore corrected proportion of volume of coarse aggregate for the water cement ratio of 0.36 = 0.648

Volume of coarse aggregate = 0.648

Volume of fine aggregate = 0.352

7. MIX CALCULATIONS:

The mix calculations per unit volume of concrete shall be follows

a) Volume of concrete = 1 m^3

b) Volume of cement

$$= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$$

$$= (403 \div 3.11) \times \frac{1}{1000}$$

$$= 0.1296 \ m^3$$

c) Volume of water

$$= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$$

$$= \frac{145.08}{1} \times \frac{1}{1000}$$

$$= 0.14508 \ m^3$$

d) Volume of Chemical Admixture @ 0.5% by mass of Cementitious Materials

$$= \frac{\text{Mass of chemical admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1000}$$

$$= \frac{2.0151}{1.2} \times \frac{1}{1000}$$

$$= 0.00167917 \ m^3$$

e) Volume of coarse aggregate = [a-(b + c +d)]

= 1-(0.1296 +0.14508 + 0.00167917)

= 0.724 m^3

f) Mass of coarse aggregate = e x volume of coarse Aggregate x Specific Gravity of Coarse Aggregate x 1000

= 0.724 x 0.648 x 2.67 x1000

= 1252.04 kg/m^3

g) Mass of fine aggregate = e x volume of coarse aggregate x Specific Gravity of fine aggregate x 1000

= 0.724 x0.352 x2.68 x1000

= 682.67 kg/m^3

8. MIX PROPORTIONS:

Cement = 403 kg/m^3

Water = 145.08 kg/m^3

Fine aggregate = 682.67 kg/m^3

Coarse aggregate = 1252.04 kg/m^3

$\frac{\text{Water}}{\text{Cement}}$ Ratio = 0.36

Cement	Water	Fine aggregate	Coarse aggregate
403	145.08	682.67	1252.04
1	0.36	1.69	3.10

MIX DESIGN FOR M50 GRADE

1. STIPULATIONS FOR PROPORTIONING:

Grade designation = 50Mpa

Type of cement = OPC (Ultra Tech Cement53Grade)

Maximum size of aggregate = 20 mm

Minimum cement content = 320 kg

Maximum water cement ratio = 0.35

Workability = 50 mm slump

Exposure condition = severe

Degree of supervision = Good

Type of aggregate = Crushed

Maximum cement content = 450 kg

Chemical Admixture Type = Aura Mix SP-400 (Super Plasticizer)

2. TEST DATA FOR MATERIALS:

Cement used = OPC (Ultra Tech Cement 53Grade)

Specific gravity of cement = 3.11

Specific gravity of coarse aggregate = 2.67

Specific gravity of fine aggregate = 2.68

Fine aggregate conforming to grade zone II of table-4 of IS- 383

3. TARGET MEAN STRENGTH FOR MIX PROPORTIONING:

$F^{1}_{ck} = f_{ck} + 1.65 \times s$ (∴ s = 5.0)

$= 50 + 1.65 \times 5.0$

$= 58.25\ N/mm^2$

Where F^{1}_{ck} = Target average compressive strength at 28 days,

f_{ck} = Characteristic compressive strength at 28 days,

s = Standard deviation

SELECTION OF WATER CEMENT RATIO:

From table-5 of IS-456, maximum water cement ratio = 0.40

Based on experience, adopted water cement ratio is = 0.33

4. SELECTION OF WATER CONTENT:

From Table-2 of IS: 10262-2009 the maximum water content for 20mm Aggregate [for 25-50mm slump range] = 186 liter

From table 2, Maximum water content = 186 liter (for 25 to 50 mm slump range)

As Super Plasticizer is used, the water content can be reduced up 20 percent and above. Based on trials with super plasticizer water content reduction of 22 percentages has been achieved. Hence, the arrived water content = 186 x 0.78

5. CALCULATION OF CEMENT CONTENT:

Water cement ratio = 0.33

Cement content = 186 x 0.78

= 145.08

= 145.08÷0.33

= 439.64 kg/m^3

From table-5 of IS-456, Maximum cement content for sever exposure condition 450 kg/m^3

439.64 kg/m^3 < 450 kg/m^3 hence ok

6. PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE:

From table 3 volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (zone II) for water cement ratio of 0.50 = 0.62.

In the present case water cement ratio is 0.35. Therefore, volume of coarse aggregate is increased to decrease the fine aggregate content. As the water cement ratio is lower by 0.10, the proportion of volume of coarse aggregate increased by 0.03 (at the rate of -/+ 0.01 for every $\pm$ 0.05 change in water cement ratio). Therefore corrected proportion of volume of coarse aggregate for the water cement ratio of 0.33 = 0.654

Volume of coarse aggregate = 0.654

Volume of fine aggregate = 0.346

7. MIX CALCULATIONS:

The mix calculations per unit volume of concrete shall be follows

a) Volume of concrete = 1 m^3

b) Volume of cement $= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

$= (439.64 \div 3.11) \times \frac{1}{1000}$

$= 0.1414\ m^3$

c) Volume of water $= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1000}$

$= \frac{145.08}{1} \times \frac{1}{1000}$

$= 0.14508\ m^3$

d) Volume of Chemical Admixture

@ 0.7% by mass of Cementitious

Materials $= \frac{\text{Mass of chemical admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1000}$

$= \frac{2.198}{1.2} \times \frac{1}{1000}$

= 0.00183182

e) Volume of coarse aggregate = [a-(b + c +d)]

= 1-(0.1414 +0.14508 + 0.00183182)

= 0.712 m^3

f) Mass of coarse aggregate = e x volume of coarse Aggregate x Specific Gravity of Coarse Aggregate x 1000

= 0.712 x 0.654 x 2.67 x1000

= 1242.80 kg/m^3

g) Mass of fine aggregate = e x volume of coarse aggregate x Specific Gravity of Fine Aggregate x 1000

= 0.712 x0.346 x2.68 x1000

= 659.96 kg/m^3

8. MIX PROPORTIONS:

Cement = 439.64 kg/m^3

Water = 145.08 kg/m^3

Fine aggregate = 659.96 kg/m^3

Coarse aggregate = 1242.80 kg/m^3

$\frac{\text{Water}}{\text{Cement}}$ Ratio = 0.33

Cement	**Water**	**Fine aggregate**	**Coarse aggregate**
439.64	145.08	659.96	1242.80
1	0.33	1.50	2.82