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PERFORMANCE OF NANO SILICA AND RICE HUSK ASH IN CONCRETE

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CHAPTER - 1 INTRODUCTION

GENERAL

Concrete is a man-made material produced by the proper mixing of cement, coarse aggregate, fine aggregate plus an adequate and controlled amount of water. It is the most consumed worldwide material after water due to its extensive usage in most structural applications. The rapid growth of construction and buildings in developing countries in addition to vast formation of waste byproducts playing a high role to concrete makers in creating sustainable products . Therefore, utilization of mineral or artificial waste materials in concrete can give an efficient solution to disposal difficulty,sustainable development and moderating the cost of concrete structures.

Experience has revealed that by controlling some factors of the fresh concrete, such as the amount of cement, the water/cement ratios, dosage of admixtures in particular limits the long-term properties of the cement based concrete can be improved. On the other hand, concrete mix design involves complex issues, and the accurate ways of performing its design can be achieved with expert information and experience.

It is worth mentioning that the permeability of cement based concrete plays an important role in the performance and service life of concrete constructions. A highly permeable concrete helps to place excessive water inside it. Concrete resembles a “hardsponge” that absorbs liquids like water and other aggressive substances. The strength of concrete is reduced by the influence of such substances. Therefore it is essential to produce concrete with maximum impermeability to damaging liquids.

Despite of the three basic ingredients which are cement, aggregates and water in conventional concrete, active mineral additives like fly ash (FA), blast furnace slag (BFS), rice husk ash (RHA) and Nano silica (NS) particles have been incorporated to make high-strength and durable (low permeable) concrete In addition, maintaining a low water to binder ratio with adequate workability makes the design process more complicated

Nano technology has gained increasing scientific interest due to the new potentials of using Nano scale particles. The Nano size particles show unique physical and chemical properties as a result of their fine size. Pozzolanic reaction is proportional to the amount of surface for reaction and owing to the high specific surface of Nano sio2 particles, they possess high pozzolanic activity. Filling the voids of CSH gel structure and generating homogeneous distribution of the hydrated products beside reduction the quantity of big and porous portlandite macro crystals are mainly responsible for Mechanical strength improvement caused by Nano sio2 .It has been found that when the small particles of Nano sio2 uniformly disperse in the paste due to their high activity generate a large number of the nucleation sites for the precipitation of the hydrated products accelerating cement hydration.

As more than 650 million tons of rice paddy has been produced in 2008 all around the globe. As one fifth of paddy is husk, total production of rice husk is 200million tones Because Rice Husk ash in its raw form has a limited application, in the majority of rice producing countries (mostly under developed countries) much of the husk produced from the processing of rice is burnt or dumped as a waste which creates a serious environmental problem. One main use of RHA has been identified as a pozzolanic in the cement industry. It has been demonstrated that Rice Husk Ash (RHA) can be added to concrete mixtures to substitute the more expensive Portland cement to lower the construction cost.

Silica permits the reduction of about 4kg of cement. It can improve the microstructure and reduce the water permeability of hardened concrete .Nano silica application reduces the calcium leaching rate of cement pastes and therefore increases their durability. NS addition increases density, reduces porosity, and improves the bond between cement matrix and aggregates.

ADVANTAGES OF INTEGRATING NANOSILICA WITH RHA

- It can enhance the long term and short term strength of high volume and high strength concrete. Nano silica can potentially improve the negative influences caused by the Rice husk ash on the early strength of mortar.
- By combining two components with different particles, size distribution can increase the packing density.
- Nano silica can increase the pozzolanic activity of other pozzolans which have low initial activity. It reduces the porosity of cement matrix which plays a vital role in mechanical strength.
- This study intends to tentatively research the impact of Nano Silica and Rice husk ash on workability, mechanical properties (Compressive Strength and tensile strength) on Concrete.

SCOPE OF THE PRESENT STUDY

- Nano silica and Rice Husk Ash is a material which is added in the conventionalconcrete specimens. In this research work NS & RHA behavior were evaluated.
- Evaluating the tensile strength, load carrying capacity, ductility and resistanceto cracking, etc using Nano silica and Rice Husk Ash.
- Evaluating the NS & RHA with different percentages (0%, 5%, 10%, 15% and20%) of replacements with

cement in M20 grade of Concrete.

OBJECTIVES

- To Arrive The Optimum Mix Design With Effective Materials Usage.
- Investigate The Mechanical Properties And The Damage Of Structures UnderVarious Test Methods.
- Parametric Studies To Arrive At An Effective Mix By ExperimentalInvestigations
- Preparation of Guidelines \ Codal Provisions for Nano-silica And Rice HuskAsh.

CHAPTER – 2 REVIEW OF LITERATURE

RICE HUSK ASH

Akeke et al (2012), investigated the effects of introducing rice husk ash as a partial replacement of OPC on the structural properties of concrete. They found compressive strength ranging from 33-38.4N/mm² at replacement percentages of 10-25% of a mix of1:1.5:3.According to them, there is no substantial increase is tensile strength due to the addition of RHA while there is a marginal improvement in flexural with 10 to 25% RHA replacement levels. They concluded that RHA is good for structural concrete at 10% replacement level.

Ganesan, Rajagopal and Thangavel have found that the addiction of RHA in mortars can improve its compressive strength ,with optimum replacement levels less than 20% by weight of cement.

Muthadhi et al (2013) Prepared four concrete mixtures to identify the effect of RHA (added as partial replacement of ordinary Portland cement from 10% to 30%) on performance characteristics of concrete .They found that, the durability of RHA Concrete was on the higher side for all doses ,compared with nominal mixtures. Therefore, by considering the maximum strength, cost effectiveness and performance characteristics, 20% replacement of cement by RHA addition was concluded as optimum dosage in concrete making.

Nair et.al (2013) concluded that incorporation of RHA in concrete results in improved compressive strength and flexural strength was also reported. RHA-High StrengthConcrete showed a reduction in density compared with conventional concrete.

Rajput et al (2013) Studied strength characteristics of cement mortar in which RHA was used as partial replacement (5% to 30% by weight of cement) of ordinary Portland cement (OPC).From the test results author have concluded that, if approximately 10% of cement is replaced by RHA ,There is not any significant depreciation in the compressive strength at 28 days and thus the RHA, There is not significant depreciationin the compressive strength at 28 days and thus the RHA can be partial replacement of cement in the regions where the material is locally available.

Saraswathy v and song carried out the split tensile strength as per ASTM C496-90 using cylindrical specimens of 150mm diameter & 300 mm height the strength was found to gradually increasing with the amount of RHA, from 5% to 15% of substitutionwas 20-25% the strength reduced to 4.60 N/mm² & 4.5 N/mm² respectively still higher than the control mix values. The strength suffered a huge reduction at 30% substitution where it is reached to 3.67N/mm².

Siddique et al studied on the properties of RHA concrete containing bacteria (Bacillus aerius strain AKKR5) When Compared to the control concrete, Increased at 10% RHA concrete Increased by 8,7%, 10%& 13.4% at7,28,56 days. The concrete containing RHA & bacterial cells had a compressive strength of 10.2%, 11.8% and 14.7% higher than the control concrete this increase in strength can be due to the formation of calcite within the cement sand pore structure.

NANO SILICA

Alireza Naji Givi et.al (2012) studied the effect of Nanosio2 particles on water absorption of RHA blended concrete .It is concluded that cement could be replaced up to 20% by RHA in presence of Nanosio² particle up to 2% which improves physical and mechanical properties of concrete.

Bastami et al Performed a series of tests to examine the resistance to elevated temperatures of high strength concrete ,modified with NS. the mass loss residual compression strength, residual tensile strength of the samples were measured at elevated temperature of 400˚C,600˚C&800˚C at the speed of 20˚C/min Significant improvement of residual compression & tensile strength concrete is modified with NS compared with the control high strength concrete while decreases mass losses of the samples were found with presence of NS particles.

Parkasan et.al measured split tensile strength of high strength concrete made up of NS with 1% and 2% replacement levels their investigation revealed that tensile strength could improve up to 17%& 24% in comparison to the control mixture by addition 1% and 2% NS respectively they also observed they attributed this matter to poorly dispersed NS through the concrete matrix and also to a act of Ca(OH)2Production at longer ages for further reaction with unreacted Nano silica Particles.

The experiment results of **Supit and Shaikh** show that the water absorption rate of the control concrete at curing periods of 28 days and 90 days can be decreased by the addition of Sio2 Nano particles.

Tao Ji (2005) experimentally studied the effect of NanoSio² on the water permeability and microstructure of concrete. The findings show that incorporation of NanoSio² can improve the resistance to water of concrete and the microstructure becomes more uniform and compact compared to normal concrete.

HYDRATION REACTION

Nazari and Riahi investigated the effect of 0-5% N S replacement on the compressive strength of high strength compacting concrete with w/b ratio of 0.4 Their Investigation revealed that an addition of NS up to 4% led to the increase in replacement level led to the reduction. However, it should be mentioned that 5% replacement of NS Increased the compressive strength by more than 0%,1%,2%,and 3% replacement. They considered by two reasons for the reduction of compressive strength with 5% replacement. First, as the NS crosses its beneficial therefore, there is not enough lime toreact with and the produce C-S-H get during hydration. Thereby excessive NS was replaced with cementitious materials while it cannot make a contribution to the enhancement of compressive strength second a high amount of NS cannot be well dispersed through the mixture due to agglomeration & as a result cannot provide the best results.

CHAPTER – 3 EXPERIMENTAL ANALYSIS

GENERAL

The Experimental analysis is carried out to investigate the Workability, Compressive strength, split tensile strength, Flexural strength (strength tests) with addition of different percentages of Nano Silica and Rice husk ash as partial replacement of cementin the concrete.

MATERIALS USED

The properties of material used for making concrete mix are determined in the laboratory as per relevant code of practice. Different materials used in present study were cement, coarse aggregates, fine aggregates, Nano silica and Rice husk ash. Description of various materials which were used in this study are given below:

NANO SILICA (NS):

Lowered levels of environmental contamination Nano silica is typically a high effective pozzolanic material. It normally consists of very fine vitreous particles approximately 1000 times smaller than the average cement particles.

It has proven to be an excellent admixture for cement to improve strength and durability and decrease permeability. Nano silica reduces the setting time and increases the strength (compressive and tensile strength) of resulting cement in relation with other silica components that were tested Nano silica obtained by direct synthesis of silica sol or crystallization of Nano sized crystals of quartz.

Fig.3.1.1 Nano silica powder

Table 3.1.1: Physical properties of Nano silica

Description	**Values**
Particle size (nm)	15-20
Surface area (m2/g)	640
Bulk density (g/cm3)	0.08-0.10
Molecule	sio2
molecular weight	60.08
porosity(ml/g)	0.6
Morphology	porous and nearly spherical

Table 3.1.2: Chemical Composition of Nano silica

Chemical composition	**Contents%**
Silicon dioxide (SiO2)	94.3
Aluminum oxide(Al2O3)	0.06
Ferric oxide (Fe2O3)	0.46
Calcium oxide (Cao)	0.51
Titania	2.31
Loss of Ignition	2.25

RICE HUSK ASH

Rice husk ash is the solid residue after burning rice husks, an agricultural waste widely produced all over the world. Rice husk ash can be burnt into ash that fulfills the physical characteristics and chemical composition of mineral admixtures. Pozzolanic activity of rice husk ash (RHA) depends on (i) silica content (ii) silica crystallization phase and (iii) size and surface area of ash particles. In addition ash must contain only asmall amount of carbon. The optimized RHA, by controlled burn and grinding has been used as a pozzolanic material in cement and concrete. Using it provides several advantages, such as Improved strength and durability properties, and environmentally benefits related to the disposal of waste materials and to reduce CO_2 emissions. RHA produced after burning of Rice husks has high reactivity and pozzolanic properties. Chemical compositions of RHA are affected due to the burning process and temperature. Silica content in the ash increases with the higher the burning temperature.

Fig 3.1.2 Rice Husk AshTable 3.1.3: Chemical Composition of Rice Husk Ash

Chemical properties	**Value (%)**
Silicon dioxide (Sio2)	88.32
Aluminum oxide (Al2O3)	0.46
Ferric oxide (Fe2O3)	0.67
Calcium oxide (Cao)	0.51
Magnesium oxide (MgO)	0.44
Sodium Oxide (Na2O3)	0.12
Potassium Oxide (K2O)	2.91

CEMENT

Although all materials that go into concrete mix are essential, cement is very often the most important because it is usually the delicate link in the chain. The function of cement is first of all to bind the sand and stone together and second to fill up the voids in between sand and stone particles to form a compact mass. It constitutes only about 20 percent of the volume of concrete mix; it is the active portion of the binding medium and is the only scientifically controlled ingredient of concrete. Any variation in its quantity affects the compressive strength of the concrete mix. Portland cement referred to as (Ordinary Portland Cement) is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 grade, 43 grade, 53 grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipment, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantages for making stronger concrete. Although they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they offer many hidden benefits. Oneof the most important benefits is the faster rate of development of strength. .In this work Ordinary Portland Cement (OPC) of 53 grade is used in which the composition and properties is in compliance with the Indian Standard Organization.

Fig 3.1.3 Ordinary Portland Cement

FINE AGGREGATE

The Aggregates which pass through 4 .75mm IS sieve and retain on 75micron IS sieve are known as fine aggregate.

The fine aggregate may be of following type

i. Natural sand i.e. fine aggregate resulting from natural disintegration ofrocks.
ii.Crushed stone sand i.e., the fine aggregate produced by crushing hard stone.
iii. Crushed gravel sand i.e. the fine aggregate produced by crushing natural gravel.

According to size, the fine aggregate may be described as coarse, medium and dine sands. Depending upon the particle size distribution IS: 383-1970 has divided the fine aggregate into four grading zones (Grade I to IV). The grading zones become progressively finer from grading zone I to grading IV. The properties of fine aggregates such as specific gravity and fineness modulus were determined and are given in the chapter IV. Locally available natural sand was used in the present study.

Fig 3.1.2 Fine aggregate

COARSE AGGREGATE

The Aggregates which pass through 75mm IS sieve and retain on 4.75mm IS sieve are known as coarse aggregate.

Coarse aggregates may be of following types:-

i. Crushed graves or stone obtained by crushing of gravel or hard stone.
ii.Uncrushed gravel or stone resulting from the natural disintegration of rocks.
iii. Partially crushed gravel or stone obtained as product of blending of above 2 types.

The normal maximum size is gradually 10-20 mm; however particle sizes up to 40 mm or more have been used in Self Compacting Concrete. Gap graded aggregates are frequently better than those continuously graded, which might expensive grader internal friction and give reduced flow. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because of lower internal friction. 20 mm and 10 mm coarse aggregates in this proportion of 50:50 were used in this study. The properties such as specific gravity and fineness modulus of coarse aggregates were determined and are given in chapter IV.

Fig 3.1.4 Coarse Aggregate

WATER

Water plays an important role in concrete mix that it starts the reaction between cementpozzolans and the aggregates. It helps the hydration of the mix. As per IS 3025 water isto be used for mixing and should be free from impurities. Portable water is generallyconsidered satisfactory. In the present investigation water available within the campus is used for both mixing and curing purposes.

CASTING AND CURING OF TEST SPECIMENS

In this study, the specimens of standard cube (150mmx150mmx150mm) 3nos, standard prisms (100mmx100mmx500mm) 3nos and standard cylinders (150mm diax300mm height) 3nos were caste per day, Totally 135 specimens were casted.

Fig 3.2.1 Concrete specimens of standard prisms, cylinders and cubes.

BATCHING

Batching is a process of weighing the ingredients of concrete required for mixing. Generally, while designing the mix proportions of various ingredients of concrete are determined for one cumec of concrete. In the process of batching, initially we find the volume of concrete to be prepared for casting of cubes based on the volume of cubes obtained for a certain number of cubes. For this volume of concrete, weights of cement,coarse aggregate and fine aggregate are calculated. Based on the water-cement ratio, the quantity of water required for mix is also estimated. Weights of admixtures, if any are found by percentage of weight of cement.

MIXING

Measured quantities of coarse aggregate, fine aggregates were spread out over an impervious concrete floor. The dry Ordinary Portland cement was spread out on the aggregate and mixed thoroughly in dry state turning the mixture over and over until uniformity of color was achieved. Nano silica and Rice husk ash in required quantity is added to the mix. Water was measured exactly by weight and it was thoroughly mixed to obtain homogeneous concretes. The time of mixing shall be in 10-15 minutes.

Fig 3.2.2 Mixing of concrete

PLACING AND COMPACTING

The cubical moulds, prisms and cylinder moulds are cleaned, and are all cared to avoid any irregular dimension. The joints between the sections of the mould were coated withmould oil and a similar coating of oil was applied between the contact surfaces of the bottom of the moulds and the base plate in order to ensure that no water escapes during the filling. The interior surfaces of the assembled moulds were thinly coated with mould oil to prevent adhesion of concrete and for easy removal of moulds after casting.The mix was placed in 3 layers; each layer was compacted using vibrator to obtain the dense concrete.

Fig 3.2.3 Placing and Compacting of Concrete in the Moulds

CURING

The test specimens cubes, prisms, and cylinders were stored in place, free from vibration, in moist air at 90% relative humidity and at a temperature of 27±2ºC for 24±1/2 hour from the time of addition of water to the dry ingredients. After 24 hours the specimens were demoulded and immediately immersed in a clean, fresh water tank for a period of 28 days.

TESTS OF WORKABILITY

SLUMP CONE TEST

Slump cone test is a very important test for determination of workability of concrete. The slump cone is placed on a water tight leveled platform and fresh concrete is placed in four equal layers. Each is tamped with twenty five strokes of the rounded end of the tamping rod of steel of other suitable material after completely filling the cone should be lifted vertically. Lacking the support, concrete subsides (slumps). The difference between the height of the mould and that of the highest point of the specimen should bemeasured in millimeters and recorded as slump. Concrete subsides evenly and is calleda true slump. The shear slump is measured as a difference in height between the height of the mould and the average value of subsidence. If the sample shows shear slump, theslump should be measured and shows the characteristic of segregation. This also indicates poor grading of aggregate. If the mix gives shear slump, the grading of aggregate shall be checked, and corrected to satisfy the code requirements. The collapseindicates a leaner mix. The slump is usually 25 to 75 mm for low workability, 75 to 100mm for medium workability and 100 to 150 mm for high workability. This test was carried out in a mix case i.e., M20 before casting the specimens.

COMPACTION FACTOR TEST

This is the more precise and sensitive than slump cone test and test is used to determinethe workability of lower water ratio with concrete from the same specimen in layers, each layer being rammed or preferably vibrated so as to obtain full compaction. The mass of concrete in the cylinder should be measured more accurately. Normally used when concrete is to be compacted by vibration; such concrete may constantly fail to slump. The test should be made for concrete maximum size of aggregate not exceeding 40 mm. The test was conducted as per IS 1199:1959, using the standard compaction factor testing machine expressed in terms of internal required for compaction of concrete the specimen concrete is gently placed in the upper hopper and leveled. The trap door is then opened and concrete is allowed to fail in the lower hopper. Sticked concrete in the upper hopper at sides is gently pushed into the lower one. The trap door of the lower hopper is opened so that the concrete falls in the cylinder. The excess of concrete remaining above the cylinder should be cutoff and removed. The mass of concrete in the cylinder should be measured to the nearest 10 gm. This is known as the mass of partially compacted concrete. The cylinder should be refilled and it is also called as fully compacted concrete.

TESTS FOR HARDENED CONCRETE SPECIMENS

After the specimen cured for the required period were taken out from the water tankand prepared for testing on a universal testing machine to find the Mechanical properties such as compressive strength on cubes, flexural strength on prisms, split tensile strength on cylinders.

TESTING PROCEDURE FOR COMPRESSIVE STRENGTH

The specimens were tested in accordance with IS 516:1969 the testing was done on a universal compression testing machine of 2000kN velocity. The machine has the facility to control the rate of loading with a control valve. The machine has been calibrated to the required standards. The plates are cleaned and oil level is checked and kept ready in all respects for testing. After the required period of curing, the cube specimens are removed from the curing tank and cleaned to wipe off the surface water. It is placed on the machine such that the load is applied centrally the smooth surfaces ofthe specimen are placed as the bearing surfaces. The top plate is brought in contact withthe specimen by rotating the handle. The oil pressure valve is closed and the machine isswitched ON. A uniform rate of loading 140kg/sq.cm/min is maintained. The maximum load at failure at which the specimen breaks and the average value is taken as the mean strength. The compressive strength is taken as the load applied on the specimen divided by the area of the load bearing surface of the specimen (P/A).

Fig 3.4.1compressive strength test

TESTING PROCEDURE FOR FLEXURAL STRENGTH

Flexural strength is expressed in terms of modulus of rupture, which is the maximum stress at the extreme fibers in bending. It is calculated by a flexure formula. After removal of the beam specimen from the curing tank, they are tested on the load frameof 20kN capacity in accordance with IS 9399:1679. The load frame is provided withtwo rollers at a distance of 400mm apart at the base. The load is applied through two similar rollers mounted at the third point of the supporting span spaced 133mm apart and centrally with the respect to the base rollers. The axis of the specimen is carefully aligned with the axis of the loading frame. The load is applied gradually without shock increasing continuously such that the extreme fiber stresses increase at a rate of 7kg/ sq.cm/min. i.e., application to load it at the rate of 4000N/min. The load is divided equally between the two roller points and it increases until the specimen fails. The load is measured by a load gauge (proven ring) mounted on top of the loading rollers the modulus of rupture is calculated for the maximum load taken by the member.

The modulus of rupture is $fb = pl/bd^2$ for $a > 133mm$

$Fb = 3pa/bd^2$ for $133mm > a > 100mm$

Where,

p = maximum load applied to the specimen in kg.

l = length of the span on which the specimen is supported in cm. b = measured width of the specimen in cm

a = the distance between the line of facture and the nearer support,measured on the centerline of the tension side of the specimen in cm.

d= measured depth of the specimen in cm.

Fig 3.4.2 flexural strength test

TESTING PROCEDURE FOR SPLITTING TENSILE STRENGTH

The specimens were tested in accordance with IS 5816:1999. Specimens when receiveddry shall be kept in water for 24 hrs before they are taken for testing. Unless other conditions are required for specific laboratory investigation specimens shall be tested immediately on removal from the water whilst they are still wet. Surface water and grit shall be wiped off the specimens and any projecting fins removed from the surfaces which are to be in contact with the packing strips. The load shall be applied without shock and increased continuously at a nominal rate within the range 1.2N/(mm²/min) to2.4N/(mm²/min). Maintain the rate, once adjusted, until failure. On manually controlledmachines as failure is approached the loading rate will decrease at this stage the controls shall be operated to maintain as far as possible the specified loading rate. The maximum load applied shall then be recorded. The appearance of concrete and any unusual features in the type of failure shall also be noted. The rate of increase of load may be calculated from the formula: (1.2 to 2.4) x π/2 x I x d N/min. In this test, a 150mm diameter by 300mm height cylinder is subjected to compression loads along

two axial lines which are diametrically opposite. The load is applied continuously at a constant rate until the specimen fails the compressive stress procedure of transverse tensile stress, which is uniform along the vertical diameter. The splitting tensile strength is computed by the formula.

$$ft = \frac{2p}{\mu l d}$$

Where

p = maximum load applied to the specimen in N.l = length of the specimen in mm,

d = diameter of the specimen in mm.

Fig 3.4.3 split tensile strength test

CHAPTER-4 RESULTS AND DISCUSSION

GENERAL

Series of tests were carried out on the materials and the concrete specimens to obtain the physical properties of materials and Strength of concrete for different Nano silica and Rice husk ash percentage. This chapter discusses the results that were obtained from the testing. The results such as specific gravity, fineness modulus, water absorption, workability, Compressive strength test, Splitting tensile test, Flexural strength test.

TEST RESULTS OF PHYSICAL PROPERTIES OF MATERIALS

In this study, the following tests were conducted to note the physical properties of the materials i.e., specific gravity of cement and aggregates, fineness modulus of aggregates, initial and final setting time of cement, water absorption of aggregates as per the Indian standards.

CEMENT

The test results of the physical properties of cement are given in the table 4.1.1. Table 4.1.1: Physical properties

of cement

S.no	Property of cement	Relevant code	Test result
1	Specific gravity	Specific gravity bottle (IS: 2720-part III)	3.08
2	Fineness	Sieve test on sieve no. 9 (IS: 4031-part I)	1.0%
3	Normal consistency	Vicat apparatus(IS:4031-part IV)	34%
4	Initial setting time	Vicat apparatus (IS:4031-part IV)	45 minutes
5	Final setting time	Vicat apparatus (IS:4031-part IV)	600 minutes

Fig 4.1.1 Normal Consistency Test By Fig 4.1.2 Fineness test of cementVicat Apparatus

FINE AGGREGATE

The test results of the physical properties of fine aggregate are given in the table 4.1.2Table 4.1.2: Physical properties of fine aggregate

S.no	Property of fine aggregate	Relevant code	Test result
1	Specific gravity	IS 2386-PART 3	2.61
2	Fineness modulus	IS 2386-PART 3	3.17
3	sieve analysis	IS 2386-PART 3	confirming to zone II

Table 4.1.3 Sieve analysis test of fine aggregate

Sieve size (mm/µ)	Wt. retained (gm)	%Weight.Retained	Cumulative % Wt. retained	100-cumulative % Wt. retained
4.75mm	16.5	3.3	3.3	96.7
2.36mm	28.5	5.7	9	91
1.18mm	69	13.8	22.8	77.2
600 µ	151	30.2	53	47
300 µ	212	42.4	95.4	4.6
150 µ	20	4	99.4	0.6
90 µ	1.5	0.3	99.7	0.3
PAN	1	0.2	99.9	0.1

COARSE AGGREGATE

The test results of the physical properties of coarse aggregate are given in the table4.1.4Table 4.1.4: Physical properties of Coarse Aggregate

S.no	**Property of coarse aggregate tested**	**Relevant code**	**Test result**
1	specific gravity	IS 2386-PART 3	2.41
2	fineness modulus	IS 2386-PART 3	7.40
3	water absorption	IS 2386-PART 3	0.83

Table 4.1.5 Sieve Analysis of Coarse Aggregate

Sieve size (mm/µ)	Wt. retained(gm)	%Wt. retained	cumulative % Wt. retained	100-cumulative % Wt. retained
80mm	0	0	0	100
40mm	1050	21	21	79
20mm	1355	27	48	55
10mm	1155	23	71	28
4.75mm	1440	28	100	0
PAN	0	0	100	0
Fineness modulus = 7.40				

TEST RESULTS OF WORKABILITY

The workability of the fresh concrete of M20 grade with the different proportions of nano silica and rice husk ash (0%,5%,10%,15% &20%) is determined by carrying out slump cone test and compaction factor test. The tests are conducted as per IS 1199- 1959. The test results of workability are given in the table 4.2.1 and table 4.2.2.

SLUMP CONE TEST

The Test results are presented in table 4.2.1and figures 4.2.1 in this chapter. M20 grade of concrete was casted with different proportions of Nano silica and rice husk ash (0%,5%,10%,15% &20%) and the test results were compared with conventional concrete. From the results, it was observed that, the slump value for M20 Standard grade of concrete were 78 to 57 mm.

Due to the higher rate of water absorption of Nano silica & RHA the workability was getting lower with higher percentage of Nano silica & RHA. Use code (IS: 7320- 1974).

Table 4.2.1: Test results of slump cone test

S.NO	% OF NANO SILICA AND RHAIN CONCRETE	SLUMP VALUE (mm)
1	0%	78
2	5% NS & 5% RHA	71
3	10% NS & 10% RHA	65
4	15% NS & 15% RHA	62
5	20% NS & 20% RHA	57

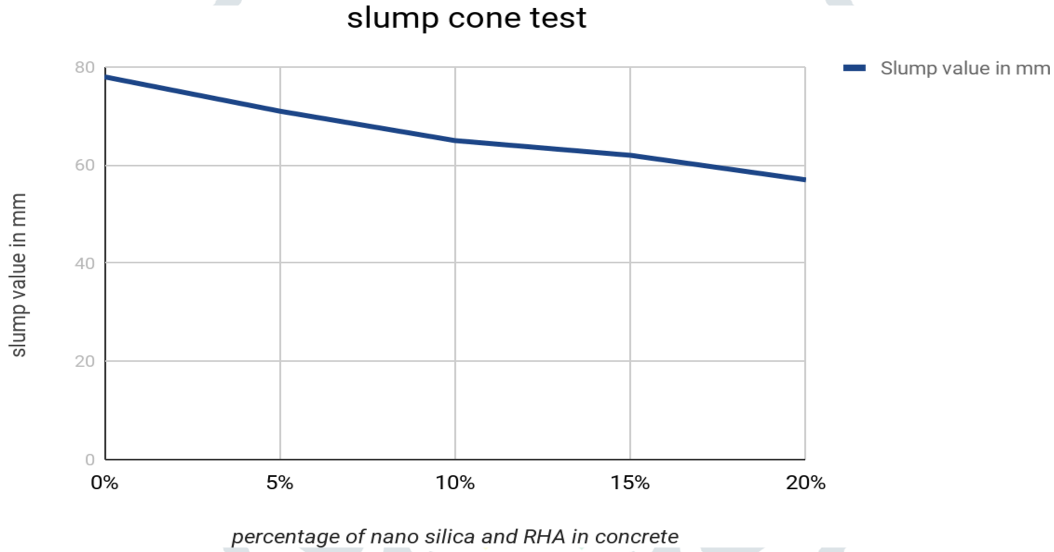

Fig 4.2.1 Comparison of test results of slump cone test of conventional concrete withdifferent proportions of Nano silica and RHA in concrete

COMPACTION FACTOR TEST

The Test results are presented in table 4.2.2 and figure 4.2.2 in this chapter. M20 grade of concrete was casted with different proportions of Nano silica and rice husk ash (0%,5%,10%,15% &20%) and the test results were compared with conventional concrete. From the results, it was observed that, the compaction factor for M20 Standard grade of concrete were 0.90 to 0.827. Due to the higher rate of water absorption of Nano silica & RHA the workability was getting lower with higher percentage of Nano silica & RHA. Use code (IS: 1199- 1959).

Table 4.2.2: Test results of compaction factor test

S.NO	% of Nano Silica and RHA	compaction factor
1	0%	0.90
2	5% NS & 5%RHA	0.883
3	10% NS & 10% RHA	0.859
4	15% NS &15% RHA	0.85
5	20% NS & 20% RHA	0.827

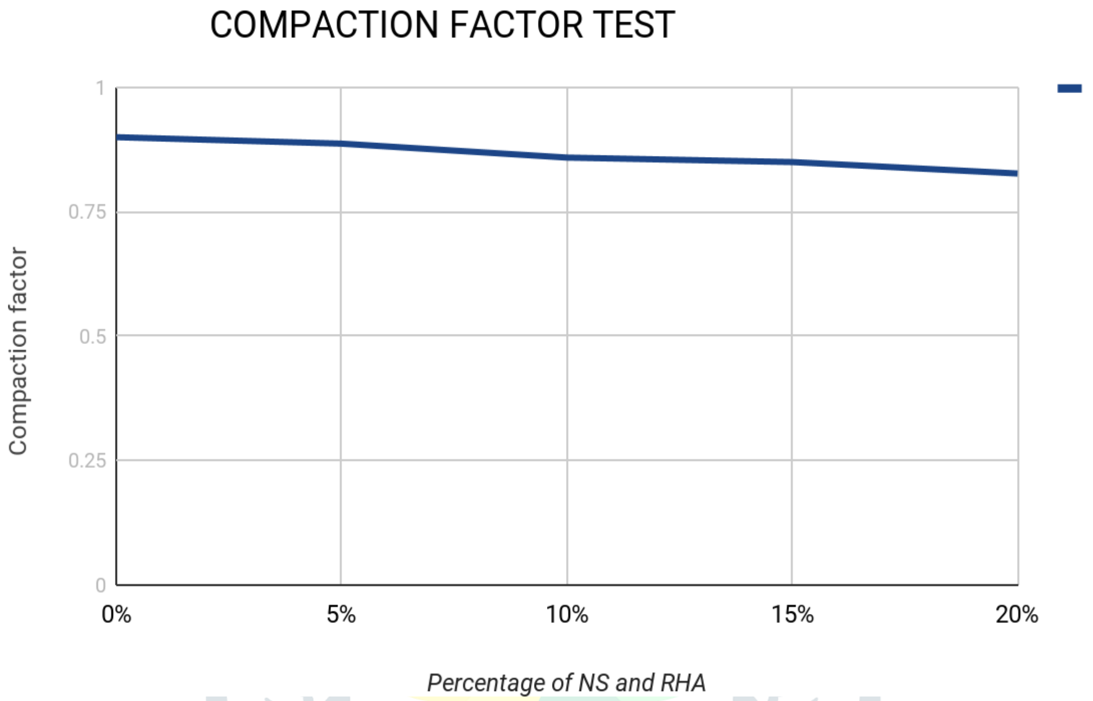

Fig 4.2.2 Comparison of test results of compaction factor test of conventional concrete with different proportions of Nano silica and RHA in concrete

MECHANICAL PROPERTIES

The following tests were conducted on the hardened concrete specimens to note the mechanical properties of the concrete.

COMPRESSIVE STRENGTH

Compressive strength of the concrete is the key property of concrete. Compressive strength of concrete is taken as a basis for evaluating various other properties of the concrete. Thus, cube compressive Strength of concrete mixes was determined at 7 days,14 days & 28 days age is carried out to verify target strength. Average results of compressive strength test for different proportions of concrete i.e. for varying addition of Nano silica and RHA have been obtained and tabulated in table 4.3.1 the graphical representation also presented in figure 4.3.1.

The average values of Compressive Strength for 0%,5%, 10%, 15% & 20% of Nano silica and rice husk ash for M20 grade of concrete 24.47N/(mm2), 27.3N/(mm2), 31.28N/(mm2), 30.71N/(mm2), 26.1N/(mm2), respectively.

The concrete compressive strength was found to increase with the increase of Nano silica and RHA up to 10% due to the rapid consumption of calcium hydroxide which was formed during the hydration process. The reduced strength by further addition of Nano silica and RHA may be due to the fact that the quantity of Nano silica and RHA present in the mix is higher than the amount required to combine with the liberated limeduring the process of hydration.

Table 4.3.1 Compressive Strength of Concrete at 7 Days, 14 days, 28 Days.

S.NO	Percentage of Nano silica and RHA in concrete	Compressive strength @ 7days in N/mm2	Compressive strength @ 14 days in N/mm2	Compressive strength @28 daysin N/mm2
1	0%	17.822	20.748	24.47
2	5% NS&5%RHA	18.354	23.14	27.3
3	10% NS & 10%RHA	19.94	26.25	31.28
4	15% NS &15%RHA	19.152	25.536	30.71
5	20% NS & 20%RHA	18.62	22.89	26.1

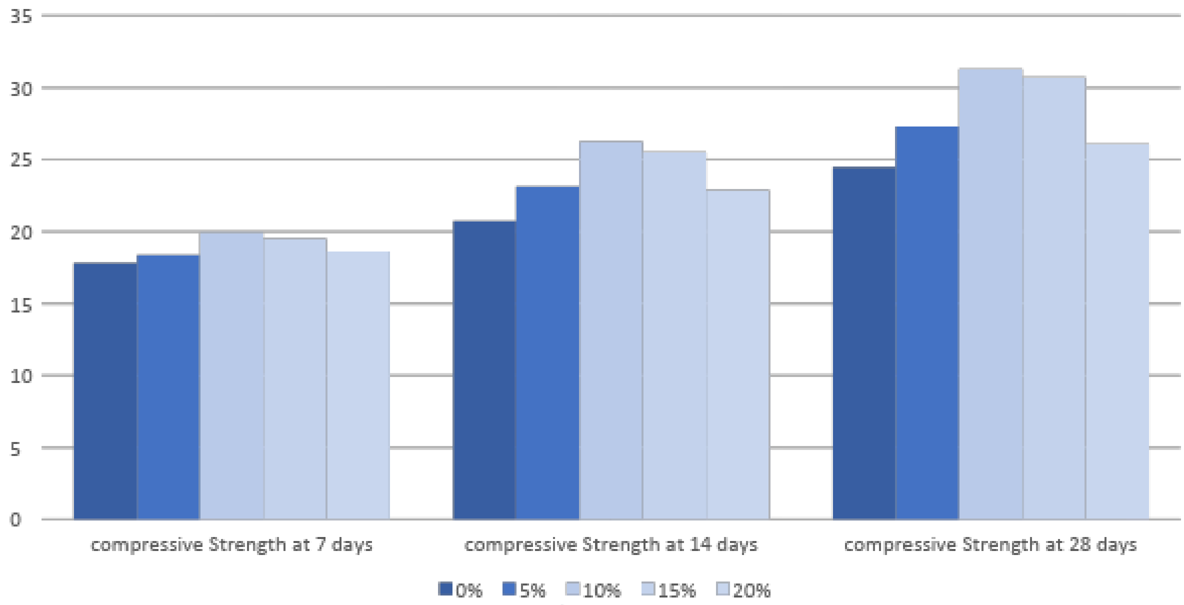

Fig 4.3.1 Comparison of test results of compressive strength of conventional concretewith different proportions of Nano silica and RHA in concrete

The addition of Nano silica and RHA increases the compressive strength for 28 days upto 10% and decreases at further increase in addition of nano silica and RHA for the M20 grade concrete.

FLEXURAL STRENGTH

The flexural strength of specimens is a measure of its ability to resist bending. Flexural strength can be expressed in terms of "modulus of rupture". The flexural test indicates an increasing trend of flexural strength when the percentage of Nano silica was increased. Table4.3.2shows the flexural strength recorded during the test, the graphical representation also presented in figure 4.3.2.

Flexural strength for 0%, 5%, 10%, 15% and 20% Nano silica and RHA of M20 gradeconcrete specimens are 3.71 N/(mm2), 3.91N/(mm2), 42 N/(mm2), 4.15N/(mm2),3.83N/(mm2) respectively.

The concrete strength was found to increase with the increase of Nano silica and RHA up to 10% due to the rapid consumption of calcium hydroxide which was formed during the hydration process. The reduced strength by further adding of Nano silica & RHA may be due to the fact that the quantity of Nano silica present in the mix is higherthan the amount required combined with the liberated lime during the process of hydration.

Table 4.3.2 flexural Strength of Concrete at 7 Days, 14 days, 28 Days.

S.NO	Percentage of Nano silica and RHA in concrete	flexural strength@ 7days in N/mm2	flexural strength @ 14 days in N/mm2	flexural strength @28 days in N/mm2
1	0%	3.16	3.412	3.71
2	5% NS&5%RH	3.21	3.60	3.91
3	10% NS & 10% RHA	3.34	3.842	4.2
4	15% NS &15%RHA	3.28	3.789	4.15
5	20% NS & 20% RHA	3.23	3.58	3.83

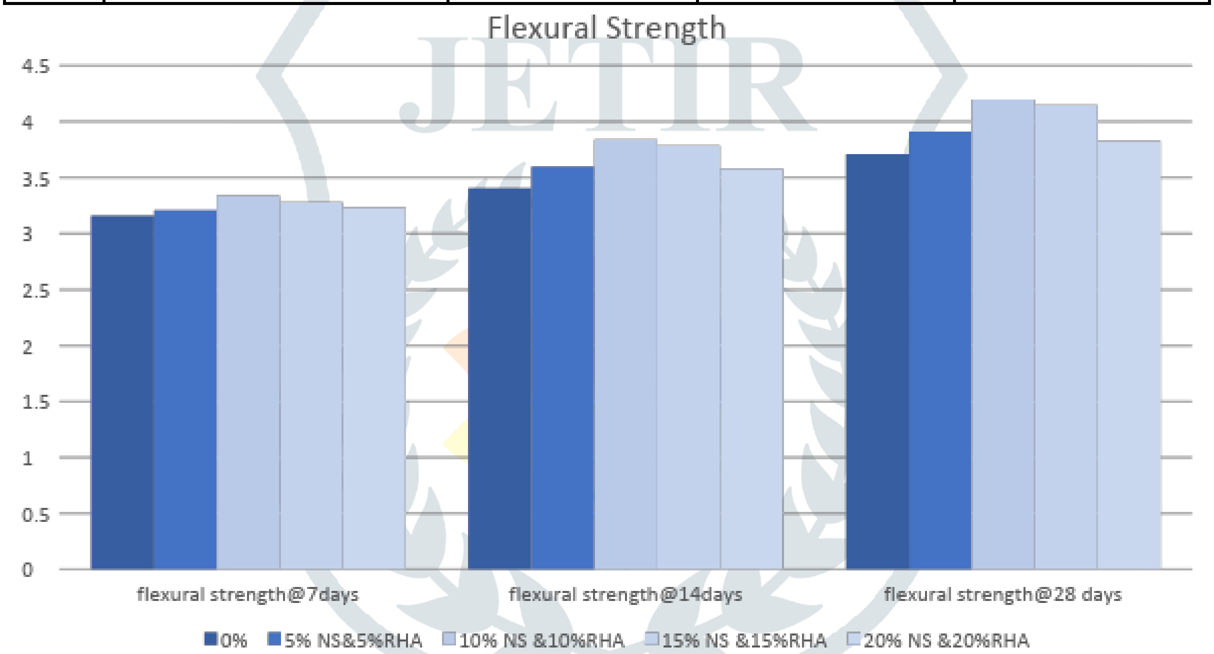

Fig 4.3.2 Comparison of test results of flexural strength of conventional concrete withdifferent proportions of Nano silica and RHA in concrete

The addition of Nano silica and RHA increases the Flexural strength for 28 days up to10% and decreases for further increase in addition of NS and RHA for the M20 gradeof concrete.

SPLITTING TENSILE STRENGTH

The splitting tensile test indicates an increasing trend of tensile strength when the percentage of Nano silica and RHA was increased. Table 4.3.3 shows the splitting tensile test values recorded during the test. From the graph 4.3.3 can be inferred that thetensile strength is gradually increasing for the concrete specimens. With addition of 0%, 5%, 10% , 15% ,20% of Nano silica and RHA.

Splitting tensile strength for 0%, 5%, 10%, 15%, and 20% Nano silica & RHA for M20grade concrete specimens are2.56N/(mm2), 2.73 N/(mm2), 3.28 N/(mm2), 3.07N/(mm2), 2.6 N/(mm2) respectively.

The concrete strength was found to increase with the increase of Nano silica & RHA upto 10% due to the rapid consumption of calcium hydroxide which was formed during the hydration process. The reduced strength by further adding of Nano silica & RHA may be due to the fact that the quantity of Nano silica & RHA present in the mix is higher than the amount required to combine with the liberated lime during the process of hydration.

Table 4.3.3 split tensile Strength of Concrete at 7 Days, 14 days, 28 Days.

S.NO	Percentage of Nanosilica and RHA in concrete	splitting tensile strength @ 7daysin N/mm2	splitting tensile strength @ 14 days in N/mm2	splitting tensile strength @28 days in N/mm2
1	0%	1.98	2.32	2.562
2	5% NS&5%RH	2.16	2.502	2.73
3	10% NS & 10% RHA	2.7	2.96	3.28
4	15% NS &15%RHA	2.34	2.71	3.07
5	20% NS & 20% RHA	2.03	2.35	2.66

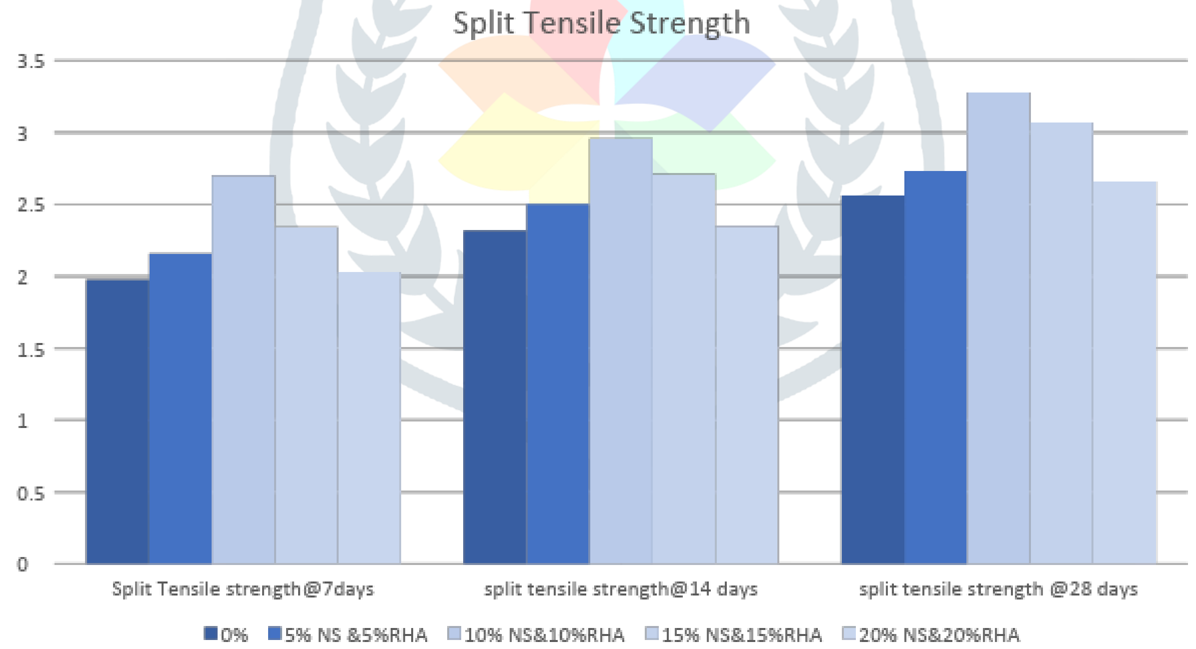

Fig 4.3.3 Comparison of test results of split tensile strength of conventional concretewith different proportions of Nano silica and RHA in concrete

The addition of Nano silica & RHA increases the Split Tensile strength for 28 days upto 10% and decreases by further increase in addition of NS & RHA for the M20 grade.

Fig 4.3.4 fractured concrete specimens

CHAPTER – 5 CONCLUSION

- The addition of Nano silica and Rice husk ash has affected the workability aspects of concrete. It can be concluded the workability decreased with the increase in percentage of Nano silica & RHA.
- The addition of Nano silica & RHA increases the compressive strength for 28 days upto 10% and decreases for further increase in the addition of Nano silica and RHA for the M20 grade of Concrete.
- The addition of Nano silica & RHA increases the flexural strength for 28 days upto 10% and decreases for further increase in the addition of Nano silica and RHA for the M20 grade of Concrete.
- The addition of Nano silica & RHA increases the splitting tensile strength for 28 days upto 10% and decreases for further increase in the addition of Nano silica and RHA for the M20 grade of Concrete.
- The waste or by-product can be utilised for the construction, which increases the performance and strength of concrete.

SCOPE FOR THE FUTURE STUDY

This present study can be extended for future as follows,

- Performance can be further improved by varying the silica content inRHA.
- Performance can be further improved by varying the different types of RHA heating temperature.
- By changing the concrete type like HPC.

APPENDIX 1

MIX DESIGN FOR M20 GRADE CONCRETE

Design Stipulations:

Grade of concrete (designation)= M20Type of cement = OPC 53 grade

Minimum nominal size of aggregate= 20 mm

Workability= 75 – 100 mm (slump)Exposure condition= mild

Method of concrete placing = normalDegree of supervision = good Specific gravity of cement = 3.10

Specific gravity of coarse aggregate= 2.70 Specific gravity of fine aggregate = 2.56Sieve analysis= zone 2 (IS 383 – 1970)

Design:

Step 1: Target mean strength

f_{ck} = f_{ck} + 1.65s

= 20 + 1.65 x 4

f_{ck} = 26.6 N/mm^2

From Table 1 of IS 10262 - 2009Standard deviation, s = 4

Step 2: Selection of water cement ratio

From Table 5 of IS 456 – 2000

For M20 concrete, maximum w/c ratio = 0.5

Based on experience adopt water cement ratio = 0.5

Step 3: Selection of water content

From Table 2, of IS 10262 – 2009

Maximum water content for 20 mm aggregate = 186 kg / m^3 (for 25 to 50 mm slump)

Increase 3% of water content for every 25 mm slump range.

To attain max of 100mm slump range = 6% increase in water contentEstimated water content for 100mm slump = 186 + (6/100) (186)

= 197.16 kg / m

Step 4: Calculation of cement content

Water cement ratio Cement content

From Table 5, of IS 456 – 2000

= 0.5

= 197.16 / 0.5

= 394.32 Kg / m^3

Minimum Cement Content for 'mild' exposure condition = 300 kg / m^3 above calculate cement content value is > 300 kg / m^3

Hence ok

Step 5: Volume of coarse aggregate & fine aggregate content

From table 3 of IS 10262 – 2009, Volume of coarse aggregate corresponding to20 mm size aggregate and fine aggregate (Zone II).

For w/c ratio of 0.5 the volume of coarse aggregate per unit volume of total aggregate is 0.48. Therefore, in the present case w/c ratio is 0.5, the corrected proportion of volume of coarse aggregate is 0.47(w/c adjustment). As the water cement ratio is increased by 0.05, the proportion of volume of coarse aggregate is decreased by 0.01(at the rate of -/+ 0.01 for every ± 0.05 change inwater cement ratio).

Volume of fine aggregate content = 1 – 0.62 = 0.38.

Step 6: Mix calculations

Mix calculations percent volume of concrete shall as follows,

Volume of concrete= 1m^3

Volume of Cement = $\frac{mass\ of\ cement}{sp.gravity\ of\ cement} x \frac{1}{1000}$

(for w/c ratio 0.5) = $\frac{394.32 \, x \, 1}{3.10 \, x \, 100}$ = 0.127 m^3

Volume of water = $\frac{mass\ of\ water}{sp.gravity\ of\ water} x \frac{1}{1000}$

$= \frac{197.16 \times 1}{1 \times 1000} = 0.197m^3$

Volume of all in aggregate = (a – (b + c))

= 1 – (0.127 + 0.197)

= 0.676 m^3

Mass of coarse aggregate = (d x volume of coarse aggregate x sp.gravity ofcoarse aggregate x 1000)

= 0.676 x 0.62 x 2.7 x 1000 = 1159.61 kg

Mass of fine aggregate = (d x volume of fine aggregate x sp.gravity of fine aggregate x 1000)

= 0.676 x 0.38x 2.56x 1000 = 669.527 kg

Water Cement Ratio (kg/m³)	**Cement (kg/m³)**	**fine Aggregate (kg/m³)**	**coarse Aggregate (kg/m³)**
186	394.32	669.527	1159.61
0.5	**1**	**1.698**	**2.940**

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