CHAPTER 1
INTRODUCTION

1.1 General Remarks

In the present situation, concrete is one of the most widely used construction material in the world. The most common form of concrete is Ordinary Portland Cement (OPC) concrete, which consists with coarse aggregate, fine aggregate, cement and water. In most of the countries, different cementitious materials such as Fly-Ash, Ground Granulated Blast Furnance Slag (GGBS), Silica Fume and Rice Husk Ash (RHA) are used to achieve high performance, good quality and low cost concrete mixture. The use of mineral admixture in combination with chemical admixture has allowed the concrete technologists to tailor the concrete with many specific requirements. Amongst the mineral admixture, Silica fume, , proved to be most useful, because of its finely divided state and very high percentage of amorphous silica if not essential for the development of very high strength concrete and concrete of very high durability. In spite of its numerous advantages silica fume suffers from one major disadvantages that it is very costly. In this work an attempt has made to find a rice husk ash (RHA) as a suitable alternate of silica fume.

The world at the end of the 20th century that has just been left behind was very different to the world that its people inherited at the beginning of that century. The latter half of the last century saw unprecedented technological changes and innovations in science and engineering in the field of communications, medicine, transportation and information technology, and in the wide range use of materials. The construction industry has been no exception to these changes when one looks at the exciting achievements in the design and construction of buildings, bridges, offshore structures, dams, and monuments, such as the Channel Tunnel and the Millennium Wheel. There is no doubt that these dramatic changes to the scientific, engineering and industrial face of the world have brought about great social benefits in terms of wealth, good living and leisure, at least to those living in the industrialized nations of the world. But this process of the evolution of the industrial and information technology era has also, however, been followed, particularly during the last four to five decades, by unprecedented social changes, unpredictable upheavals in world economy, uncompromising social attitudes, and unacceptable pollution and damage to our natural environment. In global terms, the social and societal transformations that have occurred can be categorized in terms of technological revolutions, population growth, worldwide urbanization, and uncontrolled pollution and creation of waste. But perhaps overriding all these factors is ***globalization*** - not merely in terms of economics, technologies and human and community lives - but also with respect to climatic changes and weather conditions of the world.

1.2 Objective of the Project

To study the relative strength development at different ages of Rice husk ash Concrete
with Control concrete of the same grade.

1.3 Scope of study

The Experimental investigation is planned as under :

1) To obtain mix proportions of control concrete by IS method.
2) To conduct compression test on RHA and control concretes on standard IS specimen size 150 x 150 x 150 mm.

1.4 Role of Cement Industry in Global Warming

Ordinary Portland cement (OPC) consists of 95-98% clinker and 2-5% gypsum. The clinker is produced from crushing limestone together with other minerals and then heating them at high temperatures (900-1,450°C). During grinding, the gypsum is added to the clinker as it is ground to a small particle size (typically 10-15 microns). The clinker is the most energy and emissions intensive aspect of cement production, thus it is known as “the clinker factor”; for example, OPC has a clinker factor of 0.95. The global warming potential (GWP) of the cement is reduced by reducing the clinker factor – this is achieved in blended cements by inter-grinding pozzolans or slags with the clinker during finishing. Blended cements are far more popular in Europe, than in North America, the U.K. and most of Asia.

On average about 0.9 tonnes of CO_2 are emitted for every tonne of clinker produced. Energy use is currently responsible for 0.3 to 0.4 tonnes of this CO2; these emissions should be reduced. The 0.53 tonnes of CO_2 emitted per tonne of clinker cannot be reduced. These are known as “process emissions”, this is the CO_2 released from the calcination of limestone. When it is heated, it breaks down into quick lime and CO2 (CaCO3CaO+CO_2). According to an independent evaluation of the industry in 2006, in the last 25 years, there have been 30% reductions in CO_2 emissions, by some companies. These are attributed mainly to the adoption of more fuel-efficient kiln processes. The most potential for further improvement is in the increased utilization of renewable alternative fuels and the production of blended cements with mineral additions substituting clinker.

1.5 Concrete and the environment

Concrete as a construction material is still rightly perceived and identified as the provider of a nation's infrastructure and indirectly, to its economic progress and stability, and indeed, to the quality of life. It is so easily and readily prepared and fabricated into all sorts of conceivable shapes and structural systems in the realms of infrastructure, habitation, transportation, work and play. Its great simplicity lies in that its constituents are most readily available anywhere in the world; the great beauty of concrete, and probably the major cause of its poor performance, on the other hand, is the fact that both the choice of the constituents, and the proportioning of its constituents are entirely in the hands of the engineer and the technologist. The most outstanding quality of the material is its inherent alkalinity, providing a passivating mechanism and a safe, non-corroding environment for the steel reinforcement embedded in it. Long experience and a good understanding of its material properties have confirmed this view, and shown us that concrete can be a reliable and durable construction material when it is built in sheltered conditions, or not exposed to aggressive environments or agents. Indeed, there is considerable evidence that even when exposed to moderately aggressive environments, concrete can be designed to give long trouble-free service life provided care and control are exercised at every stage of its production and fabrication, and this is followed by well-planned inspection and maintenance schemes.

1.6 Environmental impacts

Engineers cannot afford to ignore the impact of construction technology on our surroundings - and this applies to our environment at a regional, national and global scale. The construction industry has a direct and visible influence on world resources, energy consumption, and on carbon dioxide emissions. Compared to metals, glass and polymers, concrete has an excellent ecological profile. For a given engineering property such as strength, elastic modulus or durability, concrete production consumes least amount of materials and energy, produces the least amount of harmful byproducts, and causes the least damage to the environment. In spite of this, we have to accept that Portland cement is both resource and energy - intensive. Every tonne of cement requires about 1.5 tonnes of raw material, and about 4000 to 7500 MJ of energy for production.

The cost of energy to produce a tonne of cement is estimated to account for 40 - 45% of the total plant production cost. Much more importantly, every tonne of cement releases 1.0 to 1.2 tonnes of CO_2 into the environment by the time the material is put in place. In the world we live in, the use of resources and energy, and the degree of atmospheric pollution that it inflicts are most important.

It is now well-established that the incorporation of industrial byproducts such as PFA, slag and Rice Husk Ash in concrete can significantly enhance its basic properties in both the fresh and hardened states. Apart from enhancing the rheological properties and controlling bleeding of fresh concrete, these materials greatly improve the durability of concrete through control of high thermal gradients, pore refinement, depletion of cement alkalis, resistance to chloride and sulphate penetration and continued microstructural development through long-term hydration and pozzolanic reactions.

1.7 Areas of Use of Rice Husk Ash

Pozzolans improve strength because they are smaller than the cement particles, and can pack in between the cement particles and provide a finer pore structure. RHA is an active pozzolan. RHA has two roles in concrete manufacture, as a substitute for Portland cement, reducing the cost of concrete in the production of low cost building blocks, and as an admixture in the production of high strength concrete.

There are two areas for which RHA is used, in the manufacture of low cost building blocks and in the production of high strength cement concrete.

a) Low cost building blocks
b) Enhanced properties of RHA cement concrete

a) Low cost building blocks :

Ordinary Portland cement (OPC) is expensive and unaffordable to a large portion of the world's population. Since OPC is typically the most expensive constituent of concrete, the replacement of a proportion of it with RHA offers improved concrete affordability, particularly for low-cost housing in developing countries. The potential for good but inexpensive housing in developing countries is especially great. Studies have been carried out all over the world, such as in Guyana, Kenya and Indonesia on the use of low cost building blocks. Portland cement is not affordable in Kenya and a study showed that replacing 50% of Portland cement with RHA was effective, and the resultant concrete cost 25% less. Using a concrete mix containing 10% cement, 50% aggregate and 40% RHA plus water, an Indonesian company reported that it produced test blocks with an average compressive strength of 12N/mm2. This compares to normal concrete blocks, without RHA, which have an average compressive strength of 4.5 to 7N/mm2 or high strength concrete blocks which have a compressive strength of 10N/mm2. Higher strength concrete with RHA allows lighter weight products to be produced, such as hollow blocks with enhanced thermal insulation properties, which provide lighter walls for steel framed buildings. It also leads to reduced quantities of cement and aggregate.

b) Enhanced properties of RHA cement :

Portland cement reduces lime on hydration. Adding a pozzolan, such as RHA, this combines with lime in the presence of water, results in a stable and more amorphous hydrate (calcium silicate) hydration is stronger, less permeable and more resistant to chemical attack. RHA concrete is useful in a wide variety of environmental circumstances such as reactive aggregate, high sulphate soils, freeze-thaw conditions, and exposure to salt water, de-icing chemicals, and acids are deleterious to concrete. Laboratory research and field experience has shown that careful use of pozzolans is useful in countering all of these problems. The pozzolan is not just a "filler”, but a strength and performance enhancing additive. Pulverized fly ash and ground granulated blast furnace slag are the most common pozzolan materials for concrete. Many studies have been carried out to determine the efficacy of RHA as a pozzolan. They have concentrated on the quantity of ash in the mix and the improved characteristics resulting from its use.

1.8 Other uses*:*

There are other uses for RHA which are still in the research stages:

- in the manufacture of roof tiles,
- as a free running agent for fire extinguishing powder,
- abrasive filler for tooth paste,

- a component of fire proof material and insulation,
- extender filler for paint,

1.9 LITERATURE REVIEW

Ravande Kishore, V.Bhikshma and P.Jeevana Prakash (2011) [1]:

M40 and M50 grade mixes were investigated. The Strength effects an High-Strength Concrete with replacement up to 15% Rice Husk Ash of both the grade were compared with that of the high-strength concrete without Rice Husk Ash. [1]

Qijun Yu, K. Sawayama, S.Sugita, M.Shoya, Y. Isojima (1999) [2] :

One of the main reasons for the improvement of concrete properties due to addition of RHA attributes to the formation of more C-S-H gel and less portlandite in concrete due to the reaction occurring between RHA and Ca^{2+}, OH^{-} ions, or $Ca(OH)_2$ in hydrating cement.

M.U Dabai, C.Muhammad, B.U. Bagudo and A. Musa (2009) [3] :

Insulating blocks have been made with cement and rice husk ash motar. Six mortar cube with cement replaced by rice husk ash (RHA) at (0,10,20,30,40 and 50%) were tested against compressive strength after the curing age of 3, 7, 14 and 28 days. Rice husk ash which contains higher amount of silica fume, is important as a cement substitute.

R. N. Krishna (2012) [4]:

M 30 and M 35 grades of concrete with Ordinary Portland Cement (OPC) and Rice Husk Ash Cement (replacing OPC 30% by weight) have been used. The use of durability enhancing mineral admixture is a key to long service life of structure. Therefore RHA can be used as an effective and green supplementary cementing material. RHA can be used for a wide variety of applications starting from a simple water proof coating to an admixture for cement to resist a wide variety of chemicals including mild acids like lactic acid(milk) alkalies, etc. in bathroom floors, swimming pools, Industrial factory floorings, foundation concreting when concrete is exposed to both chlorides and sulphate attack and as an effective repair mortar to resist chlorides.

R. B.Y. B. Uduweriya, C. Subash1, M. M. A. Sulfy and Sudhira De Silva(2010) [5]:

Rice husk ash (RHA) can be used as a highly reactive pozzolanic material to improve the microstructure of the interfacial transition zone (ITZ) between the cement paste and the aggregate in high-performance concrete. The reaction of the rice husk ash with the cement is dependent on several factors. Burning duration, burning temperature and the particle size of the ashes are the most significant. The optimum temperatures are around 600^0C for 2-3 hrs burning and 400^0C for 4 hrs burning. There is an optimum temperature for each burning time and burning at higher temperatures beyond a certain limit does not necessarily help to produce quality ash.

Muhammad Shoaib Ismail and A. M. Waliuddin (1996) [6]:

The effect of rice husk ash (RHA) passing through 75μm to 45μm sieves as a l0-30% replacement of cement on the strength of high strength concrete (HSC) was studied. Compressive and split tensile strengths of the test specimens were determined. Cube strength over 70 MPa was obtained without any replacement of cement by RHA. Test results indicated that strength of HSC decreased when cement was partially replaced by RHA for maintaining same level of workability. The rate of hydration in concrete made with part replacement of cement by RHA is slow as compared to concrete with OPC.

Alireza Naji Givi, Suraya Abdul Rashid, Farah Nora A. Aziz, Mohamad Amran Mohd Salleh (2010) [7]:

Rice husk ash used as pozzolanic material in mortar and concrete, and has demonstrated the influence in improving the mechanical and durability properties of mortar and concrete. It is prooved that the long term deterioration of concrete and corrosion of reinforcing steel commonly occurs by entrancing the chloride ions into body of concrete structures. It is also well known that the rate of chloride ion diffusion into concrete is related to the permeability and pore size distribution. Concretes made with blended cements generally have lower permeability and more discontinuous pore structure than plain Portland cement concrete. Therefore, the diffusivity of chloride ions in blended cement concretes tends to be low. RHA blended concrete can decrease the temperature effect that occurs during the cement hydration. RHA blended concrete can improve the workability of concrete compared to OPC.

Strength development of concrete with rice-husk ash [8]:

Study on the development of compressive strength up to 91 days of concrete with rice-husk ash, in which RHA produced by controlled incineration. Two different replacement percentages of cement by RHA, 10% and 20%, and three different water/cementicious material ratio (0.50,0.40and 0.32) were used. The results were compared with concrete without RHA, with splitting tensile strength and air permibility. It is concluded that RHA provides a positive effect on the compressive strength at early ages.

Study on the Properties of Concrete with Partial Replacement of Ordinary Portland Cement by Rice Husk Ash [9]:

The main aim of this work is to determine the optimum percentage (0, 5, 10, 15 & 20%) of RHA as a partial replacement of cement for M30 and M60 grade of concrete and also to study the effect of super plasticizer on mechanical properties. A significant improvement in compressive strength of the concrete with rice husk ash content of 10% for different grades namely M30 and M60 and at different ages i.e. 7 days and 28 days.

CHAPTER 2

THEORITICAL CONSIDERATION

2.1 General

Rice husks are produced during the de husking of paddy rice. 1000 Kg of paddy rice can produce about 200 kg of husk, which on combination produces about 40 kg of ash. Rice husk constitute about 1/5th of the 300 million metric tons of rice produced annually in the world. The yearly production of approximately 500 million tones of rice husk as a waste product from milling. Rice husk is also not used for feeding animals since it is less nutrition properties and its irregular abrasive surface is not naturally degraded and can cause serious accumulation problems. Controlled burning of rice husk between 500 & 600^{o} C for short duration of about 2 Hrs yield ash with low un-burnt carbon and anamorphous silica. When rice husk burnt in an uncontrolled manner, the ash, which is essentially silica, is converted to crystalline forms and is less reactive. Both the crystalline and amorphous rice husk ash is used to manufacture a lime-rice husk ash mix or a Portland rice husk ash cement or the rice husk ash can be used as a Portland cement replacement in concrete.

Rice husk ash, like pulverised fuel ash or fly ash, is an artificial pozzolan. In finely divided form and in the presence of moisture, it chemically reacts with calcium hydroxide $Ca(OH)_2$ at ordinary temperature to form compounds possessing cementitious properties. The reactivity of RHA depends on various factors including the burning process, fineness and carbon content.

The hydration process of RHA cement has a great effect on the resistance of RHA concrete to acid attack. In simple terms, RHA reacts with $Ca(OH)_2$, which is a by-product of OPC on hydration, to from calcium silicate hydrate (C- S- H). This reduction in the amount of free lime in concrete leads to a great increases in resistance to attack by acid solution.

2.2 Advantages of using Rice Husk Ash in Concrete

The use of RHA in concrete has been associated with the following essential assets:

- Reduced permeability

- Increases resistance to chemically attack
- Increased durability
- Reduce shrinkage due to particle packing, making concrete highly packed
- Enchanced workability of concrete
- Reduce heat gain through the walls of buildings

2.3 Effect of carbon in RHA

Carbon in RHA is the reason for the blackish colour the ash exhibits. Removed the carbon from the black ash by further burning at the same temperature as before for one hour. The existence of carbon in RHA is not beneficial and it is possible to remove it by the reburning process. The carbon content in RHA exceeding 10% reduces the overall activity of the ash. However, Mehta and Pitt (1976) stated that the presence of some well dispersed carbon atom in silica is believed useful in stabilising the disordered structure of silica in a manner analogous to the stabilisation of martensitic structure in the physical metallurgy of iron and steel.

2.4 Chemical Analysis of Rice Husk Ash used in Experimental Study

Chemical Composition tests were carried out with the help of ACI Cement Testing Lab at Ropar. The chemical composition of a RHA sample used in experimental investigation is below:

Parameters	Values
Silicon Dioxide (SiO_2)	85.07%
Aluminium Oxide (Al_2O_3)	2.17%
Ferric Oxide (Fe_2O_3)	1.23%
Calcium Oxide (CaO)	3.46%
Magnesium Oxide (MgO)	0.41%
Sulphur trioxide (SO_3)	0.28%
Carbon (C)	5.10%
Loss Of Ignition	4.50%

2.5 Acid Attack

In the hydration of ordinary Portland Cement, calcium silicate hydrates. $3CaO.2SiO_2 . 3H_2O$, or in short (C-S-H) are formed liberting $Ca(OH)_2$. The latter reacts with the reactive silica in the RHA to form further C-S-H. The chemical reactions may be represented by the following equations:

$$2(3CaO.SiO_2) + 6H_2O \rightarrow 3CaO.2SiO_2.3H_2O + 3Ca(OH)_2$$

$$2(2CaO.SiO_2) + 4H_2O \rightarrow 3CaO.2SiO_2.3H_2O + Ca(OH)_2$$

$$3Ca(OH)_2 + 2SiO_2 \rightarrow 3CaO.2SiO_2.3H_2O$$

With regard to the durability of cement paste to acidic attack, it may be noted that OPC contains 60-65% CaO and upon hydration , a considerable portion of lime is released as free $Ca(OH)_2$, which is primarily responsible for the poor performance of OPC concrete in acidic environments. RHA cements, on the other hand, may contain as low as 20% Cao. Further upon hydration of the RHA cement, RHA reacts with the released $Ca(OH)_2$ to form more products of C-S-H. Therefore RHA cement paste is more resistant to acid attacks. Its resistance to acid attack makes it useful as a material of construction for applications in some chemical environment.

2.6 Super Plasticizer (*GLENIUM SKY 777*)

Glenium SKY is an innovative superplasticizer based on second-generation polycarboxylate ether (PCE) polymers. It is derived directly from the Total Performance Control concept and is specially engineered to provide high water reduction and slump retention for ready-mix concrete simultaneously. As compared with other PCE superplasticizers, it is possible to obtain a high-quality concrete mix with accelerated strength development and extended workability without delayed setting characteristics. ***Nanotechnology*** Nanotechnology is a science dealing with the interaction of extremely small objects measured in nanometres. A nanometre (nm) is millionth of a millimetre – the dimension of molecules and polymeric chains. This technology has made enormous strides in the last decade on the predictability of both structure and properties. Today, each individual atom or molecule can be manipulated in order to design functionality into materials at the nanoscale.

In-house expertise in nanotechnology allows BASF Construction Chemicals to control the chemical and physical behaviour of polymers and their interactions with cement by augmenting chain length, side chain length and density, and electrical charges as well as free functional groups. For the first time, nanotechnology allows local requirements and conditions to be met in way.

Mechanism of action

The dispersion effect of superplasticizers is based on the adsorption of molecules on cement particles, imparting a negative charge that causes electrostatic repulsion and steric hindrance between them and, therefore, dispersion. The hydration, and particularly the ettringite formation, work against the superplasticizer. Already adsorbed molecules are covered by the ettringite lawn, thus are ineffective. The particular configuration of the Glenium SKY molecules allows its delayed adsorption onto the cement particles and disperses them efficiently over a long period of time. The molecular structure is essential for the early development of strength. With superplasticizers based on conventional polycarboxylate ether, the molecules cover the entire surface of the cement grain and build a barrier against contact with water. Therefore, the hydration process takes place slowly. The Glenium SKY molecules on the other hand leave sufficient room on the cement surface to allow a rapid hydration reaction, resulting in high early strength development.

CHAPTER 3

EXPERIMENTAL STUDY

3.1 Portland Cement

Ordinary Portland cement (OPC) of 53 grade obtained from single source is to be used in this investigation. Test were conducted on its sample and their results are given in Table 3.1

Table 3.1: Test results of cement sample

Property	Results	Limiting Value Conforming to IS: 12265 - 1987
Specific Gravity	3.15	
Normanl Consistency	29%	
Setting Time Initial Setting Time Final Setting Time	 72 mins. 266 mins.	 not less than 30 minutes not more than 600 minutes
Fineness of Modulus (by 90 micron sieve)	5% retained	not more than 10% retained

3.2 Fine Aggregates

Natural, washed sand with maximum aggregate size passing from 4.75mm sieve was used for all mixes. The sand was already washed by the supplier to eliminate all organic matters as well as salt. Table 3.3 gives the ranges for different grading Zone of sand and Table 3.4 gives the range of coarse aggregate as per IS Code 383:1963. coarse sand - II belongs to Zone I shown in Table 3.5 and typical grading curve shown in graph 3.1. The coarse sand - I belong to Zone II shown in Table 3.6 and typical grading curve is shown in graph 3.2.

Water absorption and Specific Gravity tests for the two fine aggregate were conducted as per IS 383 : 1963 and their test results are shown in Table 3.2

Table 3.2: Specific gravity and Water absorption test results of Coarse Sand

Particulars	Coarse Sand - I	Coarse Sand - II
Specific Gravity	2.44	2.77
Water Absorption	0.54%	1.0%
Zone	II	I

According to the percentage of sand or aggregate passing through IS : 600 micron sieve, the sand is divided in to four zones. The particles of an aggregate of uniform size when compacted contains a huge amount of voids and thus makes the mix unstable. Admixture of aggregates having aggregates of various grades are preferred over single grade aggregates.

Table 3.3: Ranges for different grading Zone of sand as per IS Code 383:1963

Grading Limit For Fine Aggregate				
IS Sieve	Zone 1	Zone II	Zone III	Zone IV
10 mm	100	100	100	100
4.75 mm	90 - 100	90 - 100	90 - 100	95 - 100
2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
1.18 mm	30 - 70	55 - 90	75 - 100	90 - 100
600 µm	15 - 34	35 - 59	60 - 79	80 - 100
300 µm	5 - 20	8 - 30	12 - 40	15 - 50
150 µm	0 - 10	0 - 10	0 - 10	0 - 5

Table 3.4: Grading limits for coarse aggregate as per IS Code 383:1963

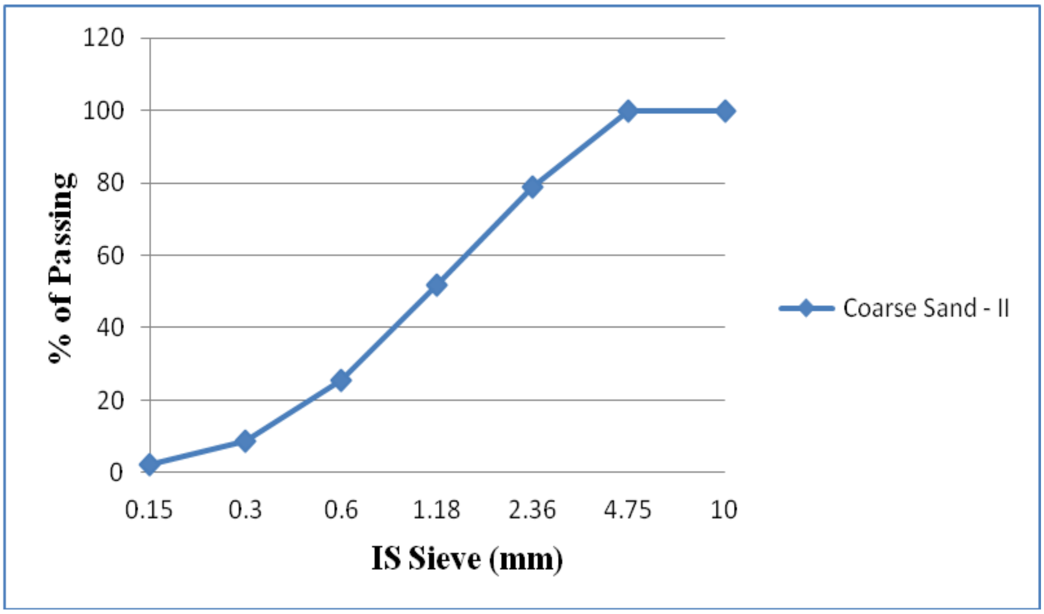
Grading Limit For Coarse Aggregate										
Percentage Passing for Single Sized Aggregate of Nominal Size (by weight)							Percentage Passing for Graded Aggregate of Nominal Size (by weight)			
IS Sieve	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
80 mm	100						100			
63 mm	85 - 100	100								
40 mm	0 - 30	85 - 100	100				95 - 100	100		
20 mm	0 - 5	0 - 25	85 - 100	100			30 - 70	95 - 100	100	100
16 mm				85 - 100	100				90 - 100	
12.5 mm					85 - 100	100				90 - 100
10 mm		0 - 5	0 - 20	0 - 30	0 - 45	85 - 100	10 - 35	25 - 55	30 - 70	40 - 85
4.75 mm			0 - 5	0 - 5	0 - 10	0 - 20	0 - 5	0 - 10	0 - 10	0 - 10
2.36 mm						0 - 5				

Table 3.5: Fineness modulus of coarse Sand - II

IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
4.75 mm	20.3	2.03	0	100
2.36 mm	189.4	18.94	20.97	79.03
1.18 mm	271.8	27.18	48.15	51.85
600 µm	265.3	26.53	74.68	25.32
300 µm	168	16.8	91.48	8.52
150 µm	64.7	6.47	97.95	2.05

Fineness modulus	3.33

Table 3.5 shows that the % passing of corse sand – II relate to the Zone I as per IS Code 383:1963. Graph 3.1 shows the % of passing of coarse aggregate against the IS sieves



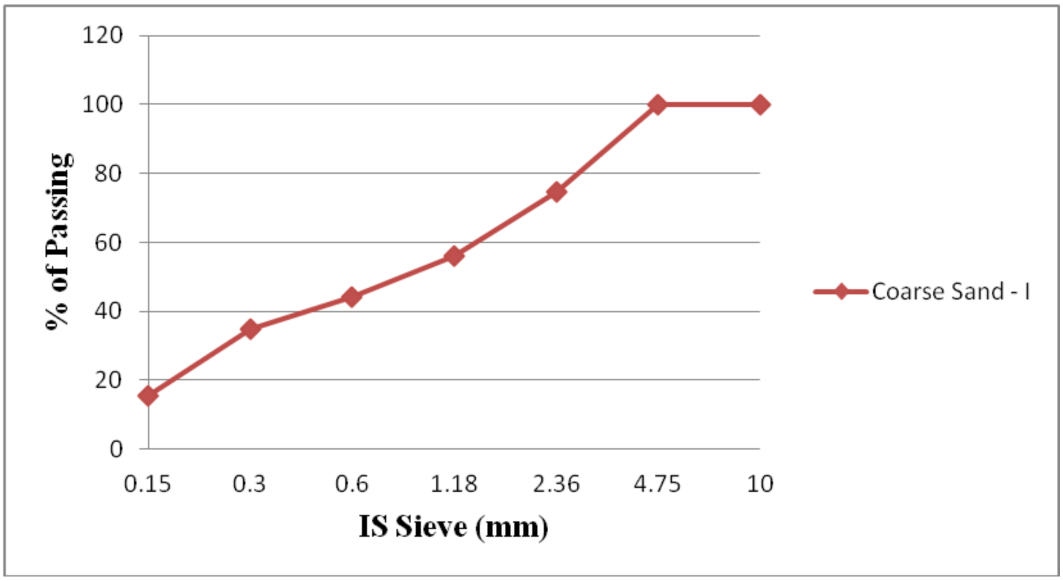
Graph 3.1: Fineness modulus of Coarse Sand - II

Table 3.6: Fineness modulus of Coarse Sand - I

IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
4.75 mm	13.3	1.33	0	100
2.36 mm	240.3	24.03	25.36	74.64
1.18 mm	184.3	18.43	43.79	56.21
600 µm	118.9	11.89	55.68	44.32
300 µm	93.7	9.37	65.05	34.95
150 µm	195.8	19.58	84.63	15.37

Fineness modulus	2.75

Table 3.6 shows that the % passing of Corse sand - I relate to the Zone II and graph 3.2 shows the % of passing of coarse aggregate against the IS sieves



Graph 3.2: Fineness modulus of Coarse Sand - I

3.3 Coarse Aggregates

Crushed blast with size of 10, 20mm were used in this study. Water Absorption, Specific Gravity and fineness modulus test were conducted for both Aggregate and their respective fineness modulus graph plotted obtain % of passing against IS Sieve. Water absorption and Specific Gravity tests for the two coarse aggregate were conducted as per IS 383 : 1963 and their test results are shown in Table 3.7. Coarse Aggregate – I grading 20 mm as shown in Table 3.8 and typical grading curve graph 3.3. Coarse Aggregate - I grading 10 mm as shown in Table 3.9 and typical grading curve graph 3.4. Coarse Aggregate – II 20 mm grading shown in Table 3.10 and typical grading curve is shown in graph 3.5. Coarse Aggregate – II 10 mm grading shown in Table 3.11 and typical grading curve is shown in graph 3.6.

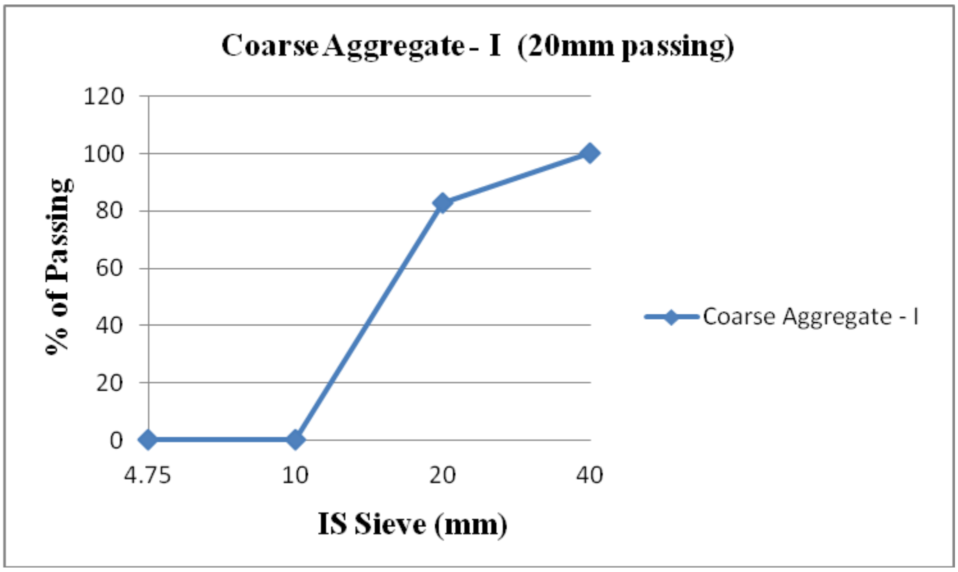
Table 3.7: Water absorption and Specific gravity test results of Coarse Sand

Description	Coarse Aggregate - I		Coarse Aggregate - II	
	20mm	10 mm	20 mm	10 mm
Water Absoprtion	0.05%	0.16%	0.58%	0.88%
Specific Gravity	2.74	2.73	2.94	2.81

Table 3.8: Coarse Aggregate – I

Coarse Aggregate – I (20mm passing)				
IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
40 mm	0	0	0	100
20 mm	172.1	17.14	17.142	82.858
10 mm	831.8	82.85	99.991	0.009
4.75 mm	0	0.00	99.991	0.009

Fineness modulus 2.17

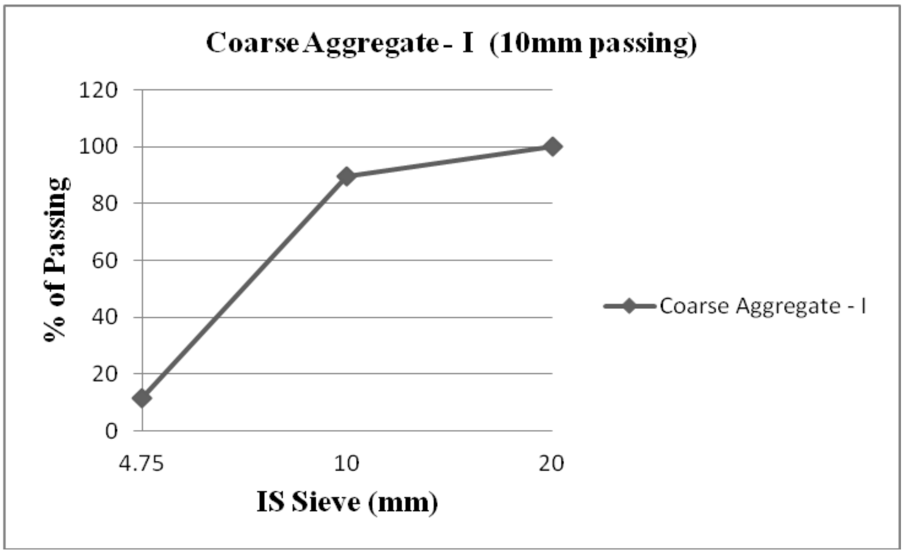


Graph 3.3: Fineness modulus of coarse aggregate – I (20 mm passing)

Table 3.9: Coarse Aggregate - I

Coarse Aggregate - I (10mm passing)				
IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
20 mm	0	0	0	100
10 mm	104.4	10.44	10.44	89.56
4.75 mm	780.5	78.05	88.49	11.51

Fineness modulus 0.99

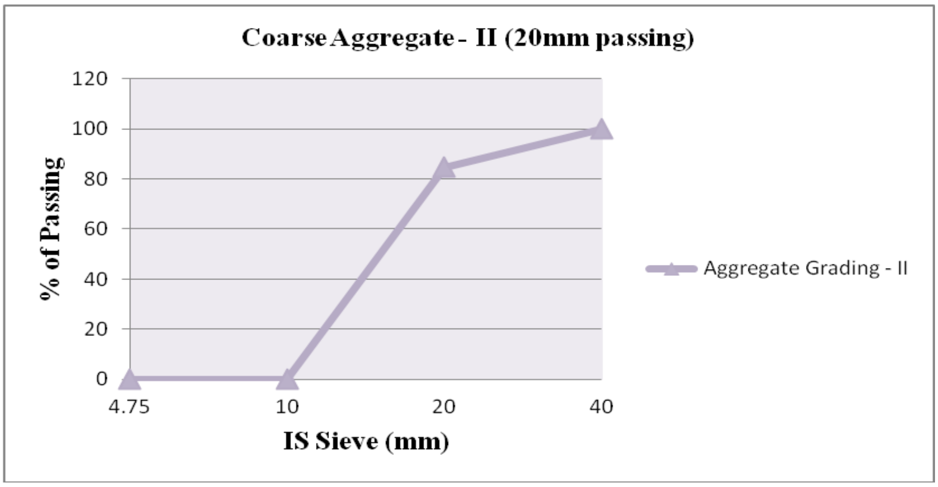


Graph 3.4: Fineness modulus of coarse aggregate – I (10mm passing)

Table 3.10: Coarse Aggregate – II

Coarse Aggregate – II (20 mm passing)				
IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
40 mm	0	0	0	100
20 mm	154	15.40	15.4	84.6
10 mm	846	84.60	100	0
4.75 mm	0	0.00	100	0

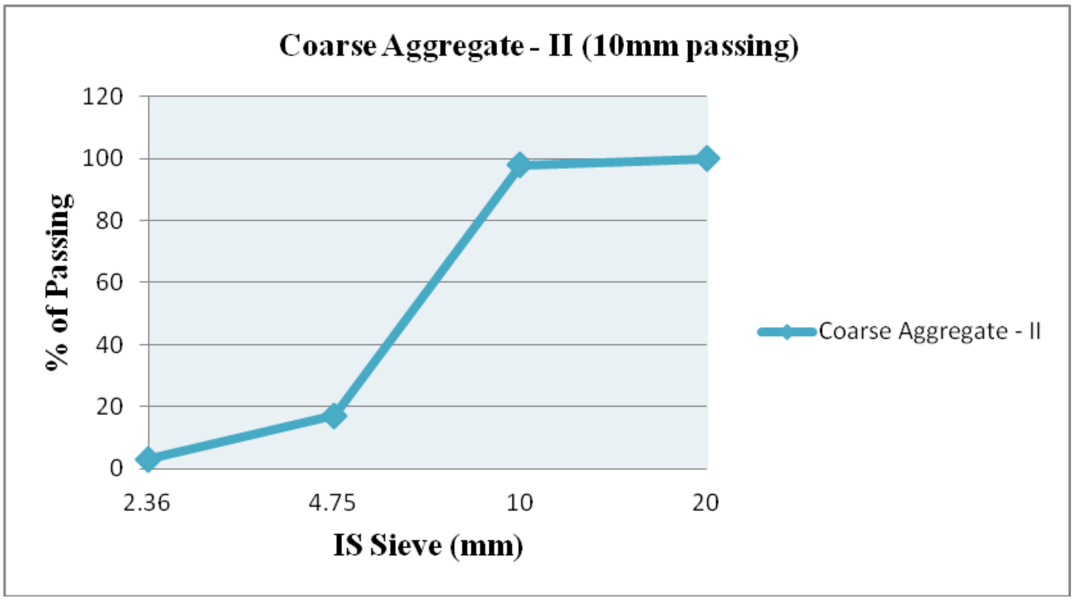
Fineness modulus 2.15



Graph 3.5: Fineness modulus of coarse aggregate – II (20mm passing)

Table 3.11: Coarse Aggregate – II

Coarse Aggregate – II (10mm passing)				
IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
20 mm	0	0	0	100
10 mm	81.2	8.12	8.12	97.88
4.75 mm	806.6	80.66	88.78	17.22
2.36 mm	81.3	8.13	96.91	3.09
		Fineness modulus	0.75	



Graph 3.6: Fineness modulus of coarse aggregate – II (10mm passing)

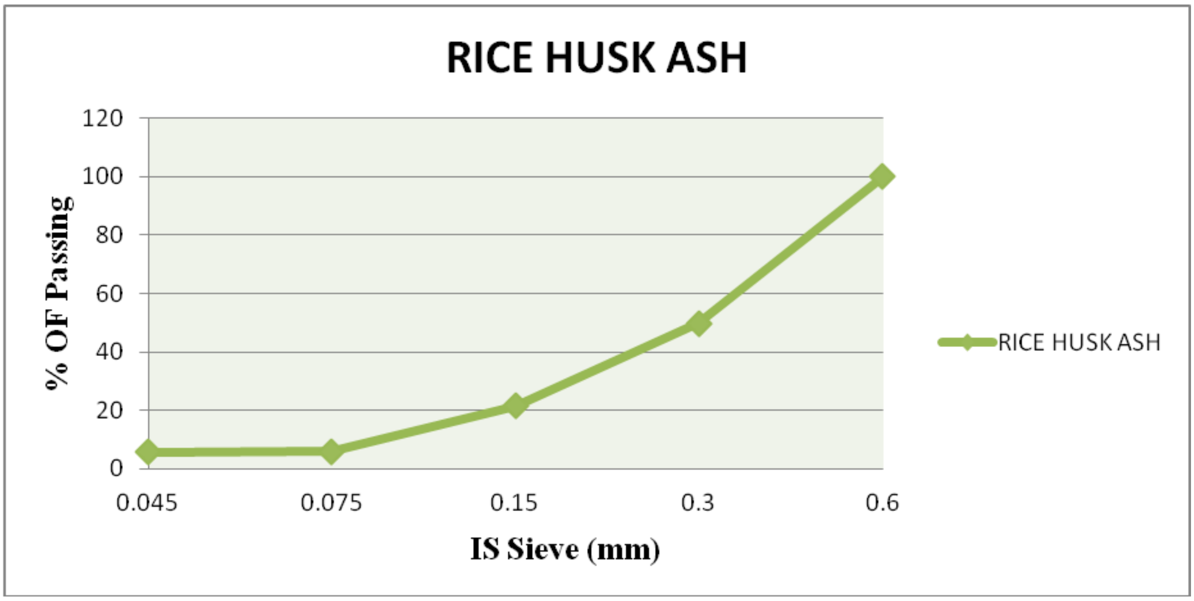
3.4 Rice Husk Ash

Fineness modulus of rice husk ash (RHA) as shown in Table 3.12 and the fineness modulus curve is also plotted as shown in graph 3.7

Table 3.12: Rice Husk Ash Fineness modulus

IS Sieve	Wt. Retained	% of weight Retained	Cumulative % of weight Retained	% passing
600 µm	16.8	5.6	0	100
300 µm	134.1	44.7	50.3	49.7
150 µm	84.6	28.2	78.5	21.5
75 µm	46.5	15.5	94	6
45 µm	0.7	0.24	94.24	5.76

Fineness modulus 3.17



Graph 3.7: Fineness modulus of RHA

The graph shown the particle size distribution of RHA. The graph obtain the value of % of passing against IS Sieve.

CHAPTER 4

DESIGN AIDS

In first part of the work, a total of three cubes (150mm x 150mm x 150mm) were cast for each of the four different mixes using OPC 53 grade and with coarse sand - I and coarse aggregate - I. Cubes were tested in compression at 7 days. The proportioning of the aggregate in the first part of the work was done by trial and error. In the second part of the work final mix design ratio was decided using ACI method 12 cubes were cast for each of the five mixes using OPC 53 grade with coarse sand - II and coarse aggregate - II. The replacement of OPC by RHA was 20%, 25%, 30%, 35% by weight. A vibrating table was used for compaction so that adequate compaction is achieved.

4.1 Mix proportion of the 4 trial mixes

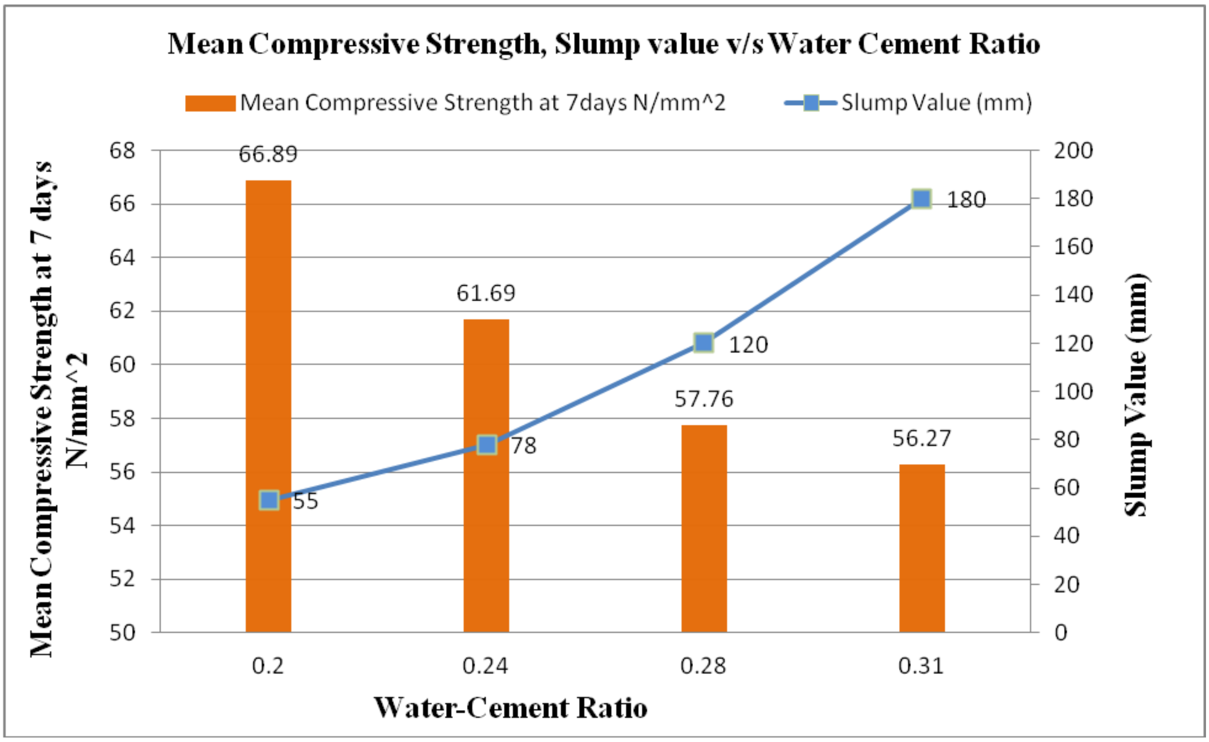
IS method of mix designing using IS:10262:2009 (concrete mix proportioning – guidelines) Mix proportion of four trial mixes as shown in Table 4.1 and their mean compressive strength of 3 cubes of each trial is shown in Table 4.2 and Graph 4.1 shows the relationship between the compressive strength, slump value against the water-cement ratio.

Table 4.1: Mix proportion of trial mixes

Mix	**Cement kg/m^3**	**C A 20 mm kg/m^3**	**C A 10 mm kg/m^3**	**Fine Agg kg/m^3**	**Chemical Admixture kg/m^3**	**Water kg/m^3**	**w/c ratio**
Trail - 1	445.58	581.56	579.44	713.25	4.46	143.20	0.31
Trail - 2	450	660.45	658.04	595.23	5.63	130.60	0.28
Trial - 3	450	684.98	682.48	595.46	5.63	112.65	0.24
Trial - 4	450	708.95	706.37	594.19	6.75	94.69	0.2

Table 4.2: Mean strength of trial mixes at 7 days N/mm^2

Trial Mix	Mean Strength at 7 days N/mm^2	Slump Value (mm)	w/c ratio
Mix - 1	55.51	180	0.31
Mix - 2	57.5	120	0.28
Mix - 3	61.06	78	0.24
Mix - 4	66.46	55	0.2



Graph 4.1: Relationship between the Compressive strength , Slump value V/S Water-Cement ratio

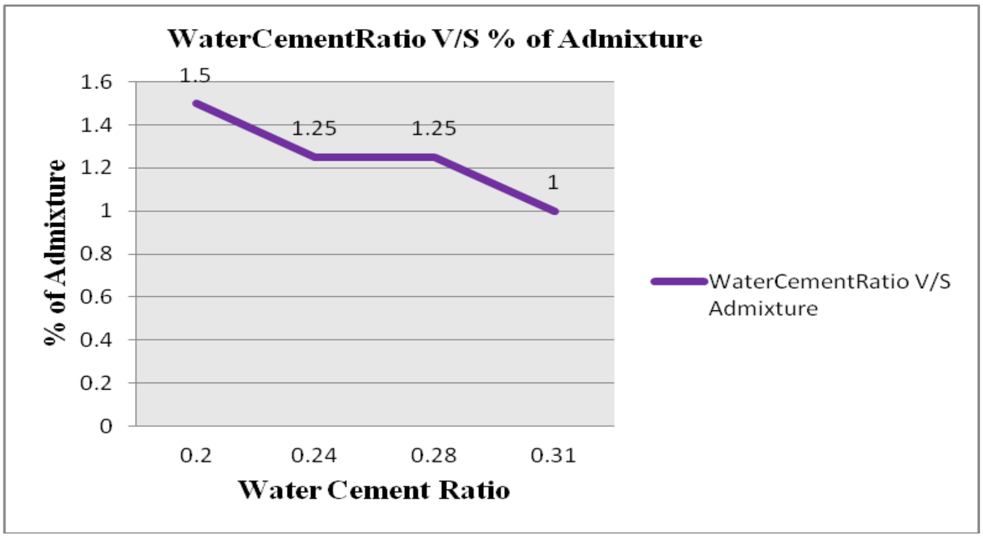
The figure 4.1 shows that the increase in water-cement ratio decrease in mean compressive strength and the slupm value also increases with increses in water-cement ratio. From this graph we can prove that the relationship between the mean compressive strength and the water-cement ratio is inversly proportional. And the relationship between the water-cement ratio and the slump value is linearly proportional.

4.1.1 Water Cement Ratio V/S Admixture

The water-cement ratio v/s admixture graph shows the water-cement ratio decreases as % of admixture increases shown in Table 4.3 and the respective graph 4.2 is shown.

Table 4.3: Requirement of water-cement ratio v/s % of admixture

Water Cement Ratio	% of Admixture
0.2	1.5
0.24	1.25
0.28	1.25
0.31	1



Graph 4.2: Relationship between the Water-Cement ratio v/s % of Admixture

Figure 4.2 shows that the amount of water-cement ratio decreases as a percentage of admixture increases. But minimum amount of water should be added as per IS 10262 : 2009 to obtain a extended workability without delayed setting characteristics.

4.2 Trial Mixes with Rice Husk Ash (RHA)

12 cubes were cast for each of the five mixes in OPC 53 grade with coarse sand - II and coarse aggregate - II. The replacement of OPC by RHA was 0%, 20%, 25%, 30%, 35% by weight. A vibrating table is used so that adequate compaction is achieved. The standard cubes were cast 150 x 150 x 150 mm and the moulds were removed after 24 Hrs and placed in the curing tank until the testing dates. The compressive strength was the key mechanical property evaluated for hardened concrete. The compression strength of various amount of replacements of cement viz., 20%, 25%, 30%, 35% with rice husk ash were compared with that of concrete without rice husk ash. The compressive strength at 7, 28, 56, 90 days, have been obtained. Table 4.4 show the mix proportion of 5 trial mixes The rice husk used in this project was obtained from the rice mill that used rice husk as a fuel to generate electricity for the mill only. The burning temperature of rice husk is around 400^0 C for 3 to 4 hrs. The average particle size of rice husk ash obtained from fineness modulus is 150 μm. The average particle size of rice husk ash is large because of this it consume more that the design mix water requirement. Table 4.5 shows the percentage (%) of of water added in RHA trials during casting. Table 4.6 show the mean compressive strength of 3 cubes of each trial at 7, 28, 56, 90 days and their respective slump value.

4.2.1 Mix proportion of the RHA trial mixes

The results of the four different replacement percentage of RHA in concrete (20%, 25%, 30%, 35%) were compared with the concrete that does not contain RHA. All the samples were tested for compressive strength. Table 4.4 show the mix proportion of five trials .

Table 4.4: Mix proportion of RHA trial mixes

Mix	**Cementitious Kg/m^3**		**C A 20 mm Kg/m^3**	**C A 10 mm Kg/m^3**	**F A Kg/m^3**	**Chemical Admixture Kg/m^3**	**Water Kg/m^3**	**w/c ratio**
	Cement	**RHA**						
OPC	613.6	0	778.2	48.6	965	12.3	135	0.22

Mix	**Cementitious Kg/m^3**		**C A 20 mm Kg/m^3**	**C A 10 mm Kg/m^3**	**F A Kg/m^3**	**Chemical Admixture Kg/m^3**	**Water Kg/m^3**	**w/c ratio**
	Cement	**RHA**						
RHA 20%	490.88	122.72	778.2	48.6	1004.4	12.3	135	0.22
RHA 25%	460.2	153.4	778.2	48.6	993.9	12.3	135	0.22
RHA 30%	429.52	184.08	778.2	48.6	983.5	12.3	135	0.22
RHA 35%	398.84	214.76	778.2	48.6	973.1	12.3	135	0.22

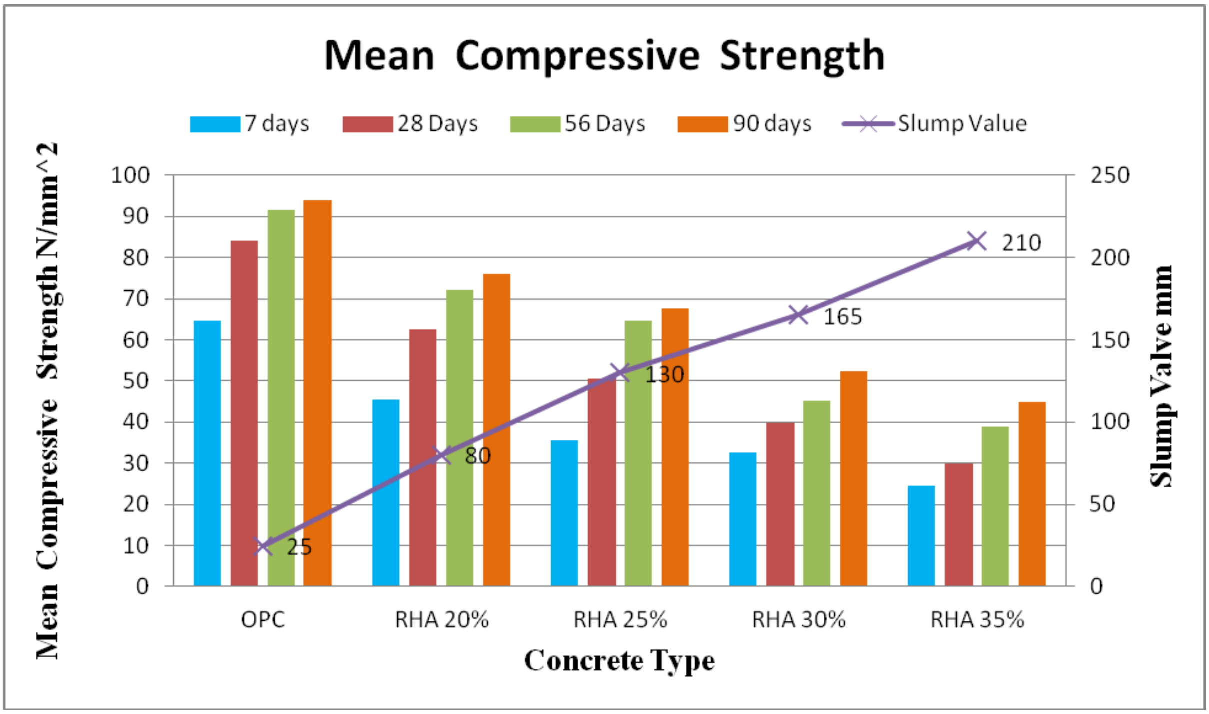
Table 4.5: Percentage (%) of water increases

	Designed Water Quantity for per m^3	Actual Water Required for per m^3	% of Water Increases
	Litre	Litre	kg
Trial - 1	135	135	0
Trail - 2	135	176.932	0.31
Trail - 3	135	219.26	0.624
Trail - 4	135	261.588	0.937
Trial - 5	135	303.916	1.251

The designed water content for RHA mix was not sufficient to make a finished mix. Increase in the percentage of RHA increases the consumption of water, therefore results in decrease of compressive strength. Table 4.6 shows the % of water increases during trial mixes and Table 4.5 shows the amount of water added during casting.

Table 4.7: Mean compressive strength

Trial Mix	Mean Compressive Strength N/mm^2				Slump Value (mm)
	7 Days	28 Days	56 Days	90 Days	
OPC	64.7	84.2	91.6	94.07	25
RHA 20%	45.6	62.6	72.1	74.8	80
RHA 25%	35.6	50.5	64.7	67.5	130
RHA 30%	32.6	39.7	45.2	50.5	165
RHA 35%	24.5	29.7	38.9	44.8	210



Graph 4.3: Relationship between Mean compressive strength, slump value v/s % of RHA

From the Graph 4.3 it is clearly shown that as the percentage of rice husk ash increases the compressive strength decreases and the slump value increases. As % of RHA increases simultaneously the demand of water increases. The main reason for decreasing the strength is adding extra water during casting which is necessary to produce a finished mix, therefore the slump value also increases. A significant improvement on the compressive strength was achieved at 20% RHA replacement at 56 days. A further addition of RHA from 25% to 35% causes major reduction in compressive strength as compared to mix containing only OPC.

CHAPTER 5

CONCLUSION

5.1 Conclusion

Based on the study carried out on the strength behaviour of Rice Husk Ash, the following conclusions are drawn:

1) When more then 20% cement is replaced by rice husk ash (RHA) the amount of water increases dramatically 0.31%, 0.624%, 0.937%, 1.251% for 20%, 25%, 30%, 35% respectively. The higher replacement level, especially beyond 20% led to reduction in compressive strength. The use of RHA as a partial replacement of cement revealed the different behaviour of compressive strength development. The compressive strength of High Strength Concrete was obtained by using 20% RHA. But on this results, it is clear that RHA can be used to produce High Strength Concrete for a replacement less than 25%.

2) By using this rice husk ash in concrete as replacement the emission of green house gases can be decreased to a greater extent. As a result there is greater possibility to gain more number of carbon credits.
3) The use of RHA should be encourage in construction industry.

5.2 Future Scope

- ❖ For use of Rice husk ash concrete as a structural material, it is necessary to investigate the behaviour of reinforced Rice husk ash concrete under flexure, shear, torsion and compression.
- ❖ Other levels of replacement with combination of Rice husk ash and Silica Fume can be researched for High Performance Concrete.
- ❖ Some tests relating to durability aspects such as water permeability, resistance to penetration of chloride ions, corrosion of steel reinforcement, resistance to sulphate attack durability in marine environment etc. with Rice husk ash and Silica fume need investigation.

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