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Experimental Investigation On Fly Ash Based High Performance Concrete With Rise Husk Ash And Polypropelene Fiber

A PROJECT REPORT

submitted by

ASWATHY M A

Reg No: IGW23CESC03

to

The APJ Abdul Kalam Technological University

in partial fulfilment of the requirements for the award of the Degree

of

MASTER OF TECHNOLOGY

In

STRUCTURAL ENGINEERING AND CONSTRUCTION MANAGEMENT

(CIVIL ENGINEERING)

DEPARTMENT OF CIVIL ENGINEERING

INDIRA GANDHI INSTITUTE OF ENGINEERING &

TECHNOLOGY, KOTHAMANGALAM

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DECLARATION

I undersigned hereby declare that the project report “Experimental investigation on fly ash based high performance concrete with rise husk ash and polypropylene fiber”, submitted for partial fulfilment of the requirements for the award degree of Master of Technology of the APJ Abdul Kalam Technological University, Kerala is a Bonafide work done by me under supervision of Asst Prof. Geethika G Pillai. This submission represents my ideas in my own words and where ideas or words of others have been included, I have adequately and accurately cited and referenced the original sources. I also declare that I have adhered to ethics of academic honesty and integrity and have not misrepresented or fabricated any data or idea or fact or source in my submission. I understand that any violation of the above will be a cause for disciplinary action by the institute and/or the University and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been obtained. This report has not been previously formed the basis for the award of any degree, diploma or similar title of any other University.

Place: Nellikuzhi

ASWATHY M A

Date: 17/4/2026

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DEPARTMENT OF CIVIL ENGINEERING

INDIRA GANDHI INSTITUTE OF ENGINEERING AND TECHNOLOGY, KOTHAMANGALAM

CERTIFICATE

This is to certify that the report entitled, **"EXPERIMENTAL INVESTIGATION ON FLY ASH BASED HIGH PERFORMANCE CONCRETE WITH RISE HUSK ASH AND POLYPROPELENE FIBER"** submitted by ASWATHY MA(IGW23CESC03) to the APJ Abdul Kalam Technological University in partial fulfilment of the requirements for the award of the Degree of Master of Technology in Structural Engineering and Construction Management (Civil Engineering) is a bonafide record of the project work carried out by her under my guidance and supervision. This report in any form has not been submitted to any other University or Institute for any purpose.

GEETHIKA G PILLAI

Internal Supervisor

External Supervisor

ALEENA RAHMAN

PG Coordinator

GEETHIKA G PILLAI

Head of the Department

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

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ABSTRACT

The focus on High Performance Concrete (HPC) has immensely increased due to utilization of large quantity of concrete, thereby leading to the development of infrastructure, buildings, industrial structures, hydraulic structures, bridges and highways etc. A concrete mixture which has high strength, high workability, high density, low permeability and high durability is generally said to be High Performance Concrete. HPC is produced by careful selection and proportioning of its constituents namely cement, fine aggregate, coarse aggregate, supplementary materials such as fly ash, silica fume, slag, fibers, chemical and mineral admixtures. This study focus on the potential use of the Rice Husk Ash (RHA) as a supplementary cementitious material and Polypropylene (PP) fibers as performance enhancers in Fly Ash based High Performance Concrete. Fly ash added at 20% and replacement of cement by RHA is done at 5 %, 10%, 15% and 20%. PP Fiber is to be added at 0.25, 0.5% and 0.75 % with optimum percentage of RHA. This study investigates the effect of RHA and PP Fiber in Fly ash based M65 grade HPC by finding out the Compressive strength and durability.

Keywords: High Performance Concrete, Fly Ash, Rice Husk Ash, Polypropylene Fiber, Compressive strength, Durability.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

CHAPTER 1

INTRODUCTION

1.1 GENERAL

Concrete is the most used construction material in India, with an annual consumption exceeding 100 million cubic meters. Recent earthquakes worldwide have highlighted the importance of designing structures with high ductility. The strength and ductility of structures mainly depend on proper reinforcement detailing in beam-column joints. During seismic excitations, the beam- column joint area is subjected to high horizontal and vertical forces whose magnitudes are much higher than those within the adjacent beams and columns. Ordinary Portland Cement (OPC) concrete, designed on the basis of compressive strength, is found to be deficient in aggressive environments, time of construction, energy absorption capacity, and repair and retrofitting jobs. It also loses its tensile resistance after the formation of multiple cracks. Therefore, there is a need to design High Performance Concrete (HPC), which is far superior to conventional concrete, as the ingredients of HPC contribute most efficiently to the various requirements.

The term "High Performance" implies an optimized combination of structural properties, such as strength, toughness, energy absorption capacity, stiffness, durability, multiple cracking and corrosion resistance, considering the final cost of the material and, above all, of the produced manufactured. HPC concretes are usually designed using materials other than cement alone to achieve these requirements, such as Fly Ash (from the coal burning process), Ground Blast Furnace Slag, or Silica fume. Different amounts of these materials are combined with Portland cement in varying percentages depending on the specific HPC requirements.

Although there are many definitions for HPC, the most widely accepted one is given by the American Concrete Institute, which states that "High Performance Concrete is concrete that meets special performance and uniformity requirements that cannot always be achieved routinely by using only conventional materials and normal mixing, placing and curing practices." A unique definition of HPC cannot be given without determining the performance requirements of the intended use of the concrete.

The requirements may involve enhancing characteristics such as placement and compaction without segregation, long-term mechanical properties, and early age strength or service life in

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severe environments. Concretes possessing many of these characteristics often achieve High Strength. To achieve higher strength, the water-cement ratio must be as low as possible, but lowering the water content will result in less workable concrete. Thus, more compaction is required while placing this type of concrete to avoid segregation and honeycombs. Superplasticizers can also be used to increase workability for the desired water content or decrease the water content for the desired workability. Mineral admixtures like fly ash and silica fume are also used in high-performance concrete to increase compressive strength. Materials like silica fume, being a very fine powder of size in microns with cementitious properties, bind well with cement to produce a stiff mix with high strengths of the order of 80MPa or more.

1.2 AIM

To experimentally investigate the properties and durability characteristics of Fly Ash based High Performance Concrete using Rice Husk Ash and Polypropylene Fiber.

1.3 OBJECTIVES

The objectives of the present study are given below:

- To establish the M65 grade Fly Ash (20%) based High Performance Concrete.
- To determine the optimum percentage of Rice Husk Ash (5%,10%, 15% and 20%) as replacement of cement in M65 grade Fly ash based HPC.
- To estimate the optimum percentage of Polypropylene Fiber (0.25%, 0.5% and 0.75%) in M65 grade Fly ash based HPC with optimum % of RHA.
- To analyze the flexural behavior and durability characteristics of Fly Ash based HPC with optimum % RHA and PP Fibers.

1.4 SCOPE OF THE PROJECT

- Effective utilization of industrial byproducts such as RHA in concrete, leading to sustainability.
- HPC improves productivity at the job site by delivering prefabricated assemblies such as walls, beams, floor slabs and columns.
- The goal is to develop concrete mixtures with good compressive and flexural strength and durability.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

1.5 SCOPE OF THE STUDY

- The study is limited to M65 grade Fly Ash (20%) based on HPC only.
- There is no detailed study about the fresh properties of concrete.
- The study is limited to Hardened properties and durability characteristics of HPC.
- Durability study is limited to water permeability tests and Rapid chloride penetration test.

1.6 METHODOLOGY

The methodology adopted for the project is as follows:

1. Selection of Topic: The topic for the project was selected.
2. Literature review: The research problem was identified and the information required for the progress of work was collected through the literature survey.
3. Material Collection: The materials cement, Fly ash, coarse aggregate, fine aggregate, RHA, PP Fibers and super plasticizers were collected.
4. Material Testing: The materials were tested to determine their properties required for designing the mix.
5. Mix design: The mix design of M65 grade Fly Ash (20%) based HPC
6. Casting of specimen: Casting of specimen with RHA (5%, 10%, 15% and 20%) by weight of cement and PP Fiber (0.25%, 0.5%, 0.75%) with optimum % of RHA
7. Testing samples: Mechanical properties (compressive strength, split tensile strength, Flexural strength) and durability
8. Discussion and conclusion: The analysis of results will be discussed and concluded.

International Journal of Engineering Research & Technology (IJERT)
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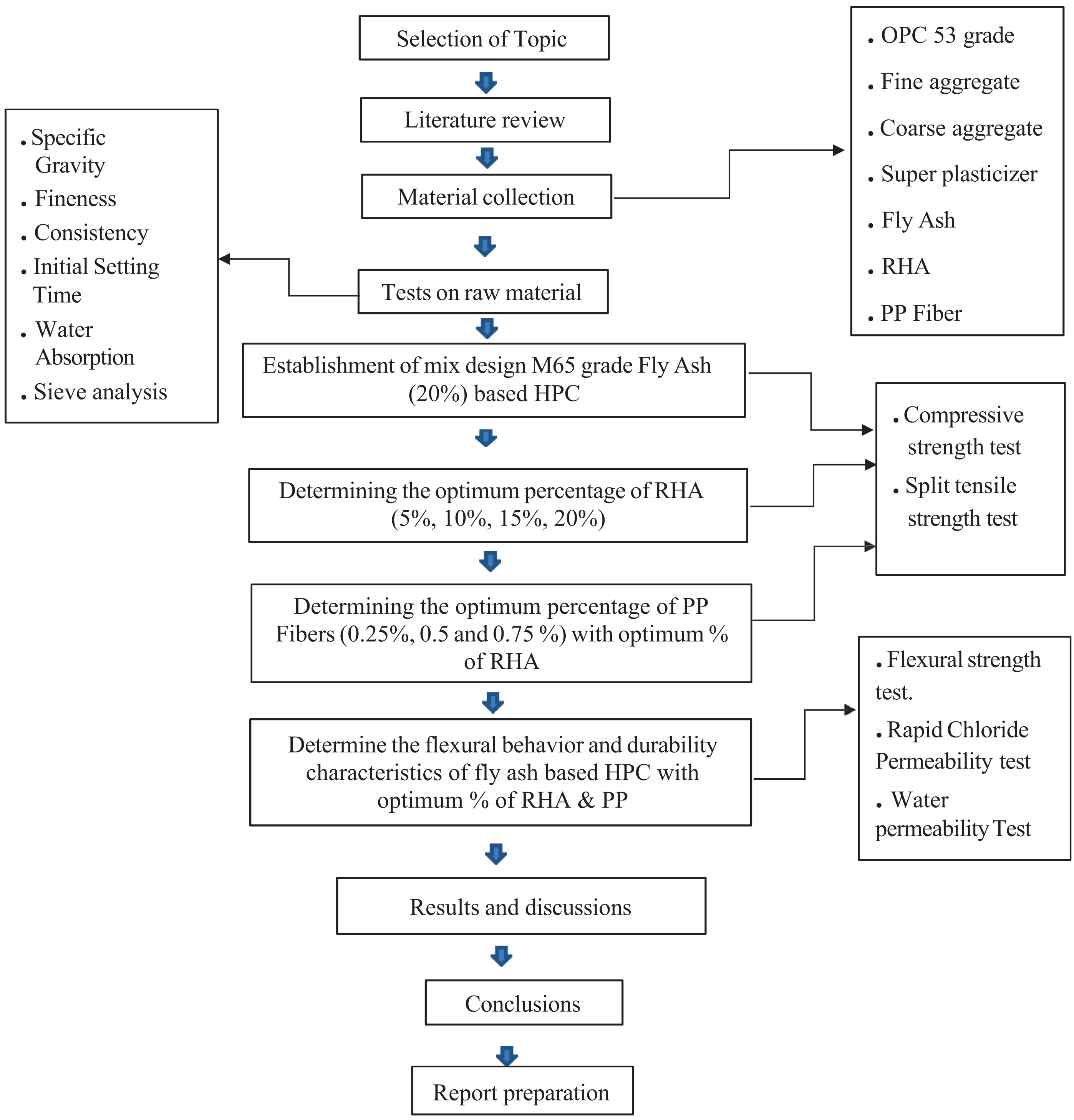

Fig. 1.1 Flowchart of Methodology

International Journal of Engineering Research & Technology (IJERT)
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Vol. 15 Issue 05 , May - 2026

1.7 ORGANAIZATION OF THE PROJECT

Chapter 1	Introduction	Briefly describes the general background, aim, objective, scope and methodology.
Chapter 2	Literature survey	Describes the critical review on literature study.
Chapter 3	Experimental study	Includes description about materials, material testing, mix design, casting of specimens, testing of specimens etc.
Chapter 4	Result and discussion	Results obtained were analyzed and compared.
Chapter 5	Conclusion and future scope	The results were evaluated and describe future scope.

1.8 SUMMARY OF THE CHAPTER

This chapter includes an introduction of Fly ash based M65 grade High performance concrete and possibilities of incorporation of RHA and PP Fiber, scope of the project, scope of the study, objectives and methodology of the project. The objectives of this project were set by considering the scope of the study and literature studies conducted. The methodology describes the way through which the objectives are achieved.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

CHAPTER 2

LITERATURE REVIEW

2.1 GENERAL

This chapter includes the literature review carried out to understand the concept behind thetopic and to plan experimental works for research.

2.2 HIGH STRENGTH CONCRETE

Ahamed T W et.al, (2024) studied that growing interest in using recycled aggregate which is locally available from the devastating buildings damaged by the war in Iraq's Mosul City (2017) as a replacement with coarse natural aggregate in concrete. In this study, the coarse Normal Aggregate (NA) in high strength concrete (HSC) mixes containing silica fume was replaced by 0%, 50% and 100% of coarse Recycled Aggregate (RA) with the addition of different proportions of polypropylene fiber (PP) of 0%, 0.15%, 0.3%, 0.45%, 0.6%, 0.75% and 0.9%. An experimental program was performed to scout their effects on concrete mechanical properties. The results showed that the addition of PP fiber intensifies the mechanical properties of the RA concrete up to 0.6%, where the increases in compressive strength of the 0%, 50% and 100% RA were 20.8%, 15.2%, and 11.6% respectively.

Chao-Lung Hwang et.al, (2024), studied about the properties of high strength polypropylene (PP) fiber reinforced concretes with 0, 0.5, 1 and 1.5% fiber content, and 0.2 water-binder ratio. The results show that the addition of PP fiber to high strength concretes will reduce by 3 to 5% compressive strength as well as decreasing by 5% of the dynamic modulus of elasticity. The flexural strength of PP fiber reinforced concrete at7 days was decreasing 10% as compared with the specimen without addition PP fiber. At 28 days, the addition of PP fiber tends to improve the toughness index and the impact loading as well.

Guruvu S K et.al, (2026), carried out a study about the problems due to pushing up the cost of construction materials. Fly-ash has already been used as partial substitution for ordinary Portland cement. But one of the agro-based wastes is rice-husk. Some progress has been made to convert this rice husk to ash; rice-husk ash contains 85-95% silica when open burnt and ground to a fineness of 16000Sq-cm/gm. Some investigations were reported on using rice-husk ash concretes and were shown to be good when comparable with concrete with no replacements. The present study was carried out on the development of high strength concrete (HSC) using rice husk ash and Ground

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Granulated Blast Furnace Slag (GGBS) which was procured. The cement has been replaced by rice husk ash, GGBS accordingly in the range of 0%, 5%, 10%, 15%, 20%, 25% & 30% by weight of cement for mix respectively. Concrete specimens were prepared, tested and compared in terms of compressive strengths with Conventional concrete. These tests were carried out to evaluate the compressive strength properties for the test results of 28, 56, 90 days.

Hariharan A.R et.al, (2025), evaluated the strength of high-strength concrete in which fly ash and silica fume partially replaced cement. In this study, Class C fly ash was used at various weight fractions of 40%, 30% and 50% of the cement weight and silica fume was used at 6% and 10% of the cement weight. The concrete mix ratio was a constant water-to-binder ratio of 0.4, with superplasticizer added based on the required workability level. Total binder content was 450 kg/m3. Concrete samples were cured with normal wet curing at normal ambient temperature. Compressive strength was measured at various ages up to 90 days. Results show that concrete produced at these levels generally exhibits superior freshness and hardening properties, as the combination is somewhat synergistic. Addition of silica fume shows early strength-increasing properties and addition of fly ash shows long-term strength. The Portland cement-fly ash-silica fume ternary system has been found to increase the compressive strength of concrete at all ages compared to concrete made solely from fly ash and silica fumes.

2.3 HIGH PERFORMANCE CONCRETE

Bharatkumar B.H et.al, (2020), studied that the High-Performance Concrete (HPC) which meets special performance and uniformity requirements that cannot always be achieved by conventional materials, normal mixing, placing and curing practices. Special performance requirements using conventional materials can be achieved only by adopting low w/c, which necessitates use of high cement content. But judicious choice of chemical and mineral admixtures can reduce the cement content, and this results in economic HPC. However, the effect of a mineral admixture on the strength of concrete varies significantly with its properties and replacement levels. Mix proportioning methods of normal concrete cannot adequately account for the large variations in the properties of ingredients. This paper presents a modified mix design procedure, which utilizes optimum water content and the efficiency factor of mineral admixture. Results of experimental investigations on mixes using the modified mix design are presented.

J.J. Chena et.al, (2024), studied the packing model of concrete materials, addition of fly ash microspheres (FAM) to fill the voids between cement grains, followed by addition of condensed

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

silica fumes (CSF) to further fill the voids between FAM would reduce the water content to achieve the desired flowability. This could allow the adoption of lower water/cementitious materials (W/CM) ratio to produce High-Performance Concrete (HPC). This study aimed to evaluate the effects of FAM and CSF on the packing density of cementitious materials and the flowability and strength of cement paste.

The results showed that the addition of FAM and CSF can significantly increase the packing density, thereby enhancing flowability and strength performance concurrently.

Jaeyoung Lee et.al, (2023), investigated and done research to clarify the reasons for explosive spalling of high strength concrete exposed to high heat flux during fire. The effect of moisture content and non-uniform heating was examined by ISO 834 standard fire tests. The specimens were small columns-shaped specimens (100x100x400 mm) made of 100MPa compressive strength concrete. Two types of concrete mix design were applied. One is, with fibre reinforcement at 1.5 kg/M3 and the other is without fibre reinforcement. The moisture content was adjusted by the curing conditions either in water or in air. Resultant moisture content was 2.7-4.2% by weight for specimens cured in air, 4.1-5.0% by weight for specimens cured in water. The conditioned specimens were heated either partially (by two surfaces) or entirely (by four surfaces). The degree of spalling, shape of failure surfaces and fragments were analyzed. Experimental results showed that severe spalling took place in the specimens without fiber, especially in case of partial heating. In case of fiber reinforced specimens, spalling was limited only to a small portion of surfaces. By the analysis of volume and weight loss, the effects of partial / total heating and moisture content were examined. The effect of partial heating dominates the overall tendency, while the effect of moisture content is important in the range of moisture content over 4% by weight. The result implies that the effect of thermal stress is dominant rather than the pore pressure created by the evaporation of moisture.

M.K. Haridharan et.al, (2021), studied about the role of cementitious materials in growth and development of infrastructure and as a substitute material which will lead us towards a green and sustainable solution. The research aims at identifying the characteristics of High-Performance Concrete (HPC) by partially replacing silica fume (10%) and fly ash (20%) with concrete. In this analysis, compressive strength of concrete values for distinct trial blend ratios was determined on the 7th, 14th and 28th day. Based on this compressive strength of the trial mixes the proportions of the material are resolved. Using this outcome, samples are cast with a steady water-to-cement proportion (w / c = 0.28), retained for curing. The study's primary goal was to examine and identify the optimum dosage of superplasticizer, substitute cement with different ratios of silica fume and

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

fly ash and evaluate the mechanical characteristics like compressive and split tensile strength of HPC with Silica Fume and Fly ash with an addition of natural fiber (jute) and later study later on study the durability properties like sportively, acid attack, etc. The following result confirmed that concrete also works better in mechanical and durability characteristics with jute at 1 percent than any other concrete.

G.S. Ryu et.al, (2025), studied about the role of micro silica in hydration of UHPC. The behavior of two different types of micro silica in UHPC was investigated about their filler effect and pozzolanic reaction by using analytical techniques. The micro silica with high pozzolanic activity led to the higher level of Al- substitution for Si in C-S-H and the denser structure, thus increasing compressive strength. In the UHPC showing high filler effect, additional hydration of C3S and C2S occurred at later ages, increasing the fraction in C-S-H and decreasing the porosity in the pore diameter region below 10 nm. Consequently, a significant increase in the compressive strength of this UHPC was achieved.

Le Tenga et.al, (2020), investigated the Ultra-high-performance concrete (UHPC) which is attracting increasing interest worldwide due to its superior mechanical properties and durability. Securing proper rheological properties can affect fiber dispersion and alignment with marked effect on UHPC performance. Tailoring the rheological properties of UHPC to secure enhanced performance is not widely considered in the mixture design stage. In this paper, an overview of the rheological properties of UHPC, applicable flow models, measurement techniques and errors associated with the interpretation of rheological measurements are discussed. The effect of various constituent materials on rheological properties of UHPC is presented. This includes cementitious materials, sand, chemical admixtures, fibers, nanomaterials, and internal curing agents. Most importantly, the paper discusses the rheological properties requirements of UHPC and strategies to control rheology of UHPC targeted for different applications, such as repair and rehabilitation, bridge deck panel connections, construction of structural and architectural elements, and digital fabrication.

Peng Liu et.al, (2022), prepared the ultra-high-performance concrete (UHPC) by using the limestone coarse aggregate and ordinary Portland cement. The effects of sand ratio, water to cement ratio (W/C), cementitious materials, type and content of fiber, dosage of water reducer and defoamer on the mechanical and rheological properties of the UHPC were investigated. The correlations among influence factors and performances of UHPC were discussed. Moreover, the internal relationship between loading rate and elasticity modulus of UHPC was also studied. The results indicate that the compressive strength of UHPC first increases and then decreases with the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

increase of sand ratio, and a maximum compressive strength of UHPC was found at the sand ratio of 41%. The water reduced content of fresh UHPC firstly decreases and then increases with the increase of sand ratio. The compressive strength of UHPC firstly increases and then decreases with the increase of W/C, which also increases with the increase of cementitious materials. The elasticity modulus of UHPC decreases with increase of sand ratio and cementitious materials content, and the compressive strength and elasticity modulus of UHPC cured for 28 d increase with the increase of deformer dosage.

2.4 HIGH PERFORMANCE CONCRETE WITH RICE HUSK ASH

Aleksandrova O et.al, (2025), studied the mathematical modeling dependence of the compressive strength of high-performance concrete (HPC) at the ages of 3, 7 and 28 days on the amount of rice husk ash (RHA) and fly ash (FA), which are added to the concrete mixtures by using the Central composite rotatable design. The result of this study provides the second-order regression equation of objective function, the images of the surface expression and the corresponding contours of the objective function of the regression equation, as the optimal points of HPC compressive strength. These objective functions, which are the compressive strength values of HPC at the ages of 3, 7 and 28 days, depend on two input variables as: x1 (amount of RHA) and x2 (amount of FA).

RA.B. Deepa et.al, (2023), Studied the effect of rice husk ash in gaining strength properties. The influence of 15% rice husk ash on strength properties has been compared with normal M30 concrete. The water cement ratio has been kept constant as 0.45. Strength tests like compressive strength, split tensile strength, flexure strength has been carried out at 28 days for normal concrete and 15% rice husk ash replaced concrete mix. For practical application of rice husk ash, reinforced beams were cast with normal concrete and rice husk ash. Both the beams were checked for load deflection. From strength tests, rice husk ash mix gave good compressive strength, split tensile strength and flexure strength values. Test on reinforced beam indicated that rice husk ash beam gave higher ultimate load value compared to normal M30 concrete beam.

Kavita S.K et.al, (2023), conducted detailed study the effect of partial replacement of cement by Fly Ash and Rice Husk Ash in combine proportion started from 30% FA and 0% RHA. The replacement of cement with the gradual increase of RHA by 2.5% and simultaneously gradual decrease of FA by 2.5%. Last proportion was taken 15%FA and 15% RHA. The tests on hardened concrete were destructive in nature which includes compressive test on cube for size (150 x 150 x 150 mm) at 7,14,28,56 and 90 days of curing as per IS: 516 1959, Flexural strength on beam (150 x

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

150 x700 mm) at 28 days of curing as per IS: 516 1959 and split tensile strength on cylinder (150 mm ø x 300mm) at 28 days of curing as per IS: 5816 1999. The work presented in this paper reports the effects on the behavior of concrete produced from cement with combination of FA and RHA at different proportions on the mechanical properties of concrete such as compressive strength, flexural strength, and split tensile strength. Investigation reported that compressive strength increases by 30.15% compared with targeted strength and reduces by 8.73% compared with control concrete at 28 days, flexural strength increases by 4.57% compared with control concrete at 28 days, split tensile strength decreases by 9.58% compared with control concrete at 28 days, were obtained at combination of 22.5% FA and 7.5% RHA. Partial replacement of FA and RHA reduces the environmental effects, produces economical and eco-friendly concrete.

2.5 HIGH PERFORMANCE CONCRETE WITH POLYPROPELENE FIBERS

Bentegri et.al, (2020), studied about the influence of polypropylene fibers (PPF) on concrete performance in terms of mechanical properties, shrinkage and fire resistance. However, in regards to fresh state properties, the workability is negatively affected by fibers inclusion. Therefore, several studies have been done to evaluate the workability loss of fiber-reinforced concrete (FRC), but there has been little research about the rheological and tribological properties such as the plastic viscosity and the viscous constant. In this context, the present study aims to evaluate the effect of PPF inclusion on both rheological and tribological properties of ordinary concrete through two phases (without and with incorporation of superplasticizer), using fibrillated twist and wave fibers shapes at different dosages (0.12, 0.24, 0.36%) and with various lengths (19, 30 and 54 mm). The obtained results of the first part showed that the plastic viscosity of FRC without superplasticizer is not affected by fibers length while it augments with increasing PPF percentage. Regarding the tribological behavior, segregation phenomenon was observed for mixtures with high fiber dosage (0.24 and 0.36%) during the test. In the second part, the use of superplasticizer has improved the concrete workability in addition to the rheological and tribological behaviors.

Behfarnia K et.al, (2024), studied the application of high-performance polypropylene fibers (HPP fibers) in concrete lining of water tunnels. A comparison between the behavior of steel fiber reinforced concrete and HPP fiber reinforced concrete with ordinary concrete is drawn. Advantages and shortcomings of HPP fibers used for concrete lining of water tunnels are also presented. The results obtained showed that the HPP fibers were not effective in compressive strength when compared to steel fibers, but the effects of HPP fibers on tensile strength, flexural strength, toughness

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

and energy absorption of concrete was significant. Based on the results, the effects of HPP fibers on concrete characteristics such as the flexural toughness, concrete permeability and resistance to chloride penetration were higher than those of steel fibers. The results also showed that with application of HPP fibers, durability and serviceability of the concrete linings can be improved. The compressive strength results showed that HPP fibers had no significant effects on compressive strength as by adding 0.8% volume fibers to the concrete mix, 3.3% increase in compressive strength was observed. Application of 0.8% steel fibers and HPP fibers increased the splitting tensile strength of concrete specimens by 10%.

Julia Blazy et.al, (2020), investigated fiber reinforced concrete is a cementitious material with a dispersed reinforcement in a form of fibers. Polypropylene fibers can be divided into microfibers and microfibers depending on their length and the function that they perform in the concrete. An overview of selected polypropylene fibers available on the market was presented. Moreover, the influence of polypropylene fibers on physical and mechanical properties of concrete such as workability; elasticity modulus; compressive, flexural, and tensile strength; toughness; impact, spalling, freeze-thaw, abrasion resistance; water absorption; porosity; permeability; durability, and eco-friendly and economic properties were discussed. Additionally, certain restrictions while designing fiber reinforced concrete mixture were mentioned. The article proved that public spaces are a promising field of polypropylene fiber reinforced concrete application. Since they are subjected to unfavorable environmental conditions, impact damages, surface abrasion, and vandalism, the use of concrete with enhanced propertied will be undeniably beneficial. The main role that polypropylene fibers play in the structure of concrete is the reduction of plastic shrinkage cracks.

Momin A.A et.al, (2025), carried out study about the Mix proportioning of HPC. The process involved the determination of correct combination of its ingredients such that the resulting mix yields desired characteristics at its lowest possible cost. The proportioning of HPC requires a special method of mix design as compared to NSC because of its lower water-binder ratio and use of different chemical admixtures and supplementary cementitious materials that would change the properties of concrete in both fresh and hardened state. Chemical admixture must produce HPC to achieve the desired strength. The effect of admixture on the type of cement should be verified using trail mixes, as HPC uses both chemical and mineral admixtures (SCM). For strength greater than 70 MPa, silica fume must produce HPC. BIS method of mix design is applicable for a maximum compressive strength of 40Mpa hence it cannot be applied directly for HPC.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

2.6 CRITICAL REVIEW

The inclusion of supplementary cementitious materials such as Fly ash, RHA, and PP Fiber as substitutes for cement has been observed to enhance strength and durability properties. By using fly ash to fill gaps between cement grains and improving the packing density of cementitious materials, the flowability and strength of cement paste can be increased [17]. Due to the lower water-binder ratio and the incorporation of supplementary cementitious materials, the mixing process for HPC must be carried out using a unique method to ensure that the concrete properties are modified in both the fresh and hardened states. [19]. Strength properties of M30 concrete with and without 15% rice husk ash were compared by conducting compressive strength, split tensile strength, and flexural strength tests at 28 days. The water-cement ratio was maintained at a constant value of 0.45 for both normal concrete and the concrete mix with 15% rice husk ash replacement. [9]. The rheological and tribological properties of polypropylene fiber reinforced concrete were evaluated by incorporating a 30% cement replacement of a combination of Rice Husk Ash and Fly Ash. [4]. The replacement of cement with a combination of Fly Ash (FA) and Rice Husk Ash (RHA) started with a mix containing 30% FA and 0% RHA in concrete. The proportion of RHA was then gradually increased by 2.5% while simultaneously reducing the proportion of FA by 2.5%. [20].

While several studies have investigated the use of Rice Husk Ash (RHA) and various types of fibers in concrete, there is a lack of literature on the application of RHA and PP Fiber in High Performance concrete. This study aims to address the gaps by investigating the strength and durability properties of HPC with RHA and PP Fiber.

2.7 SUMMARY OF CHAPTER

This chapter includes the review on various research in the field of HPC, RHA and PP Fiber. The critical review of the reviewed papers was also included. In critical review gaps were identified and study is proposed based on the same.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

CHAPTER 3

EXPERIMENTAL STUDY

3.1 GENERAL

This chapter presents the description of materials used in the study, preliminary investigations conducted on material properties, the mixed design of concrete mixes and description of tests conducted on concrete at fresh and hardened state.

3.2 MATERIALS

The materials used in the experimental work are cement (OPC), fine aggregate, coarse aggregate, water, fly ash and super plasticizer.

3.2.1 Cement

In the present experimental work, OPC 53 grade was used. Ordinary Portland Cement (OPC) is the most widely and commonly used cement in the world. It is manufactured by mixing limestone and other raw materials which consist of argillaceous, calcareous and gypsum. This cement is available in three grades namely OPC 33, OPC 43 and OPC 53. These grades imply the maximum strength of the cement after 28 days. Specific gravity, initial setting time, fineness and standard consistency of cement were tested.

Fig.3.1 Cement
(Source: by author)

3.2.2 Fine Aggregate

Fine aggregates generally consist of natural sand (river, floodplain, or marine) or crushed stone. In which M sand or manufactured sand has higher fineness modules Index compared to the

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

natural river sand, which gives good workability for concrete. M sand is free from silt and clay particles which offer better abrasion resistance, higher unit weight and lower permeability. M sand was used as the fine aggregate in the present study. M sand used was conforming to Zone II of IS 2386:1963

Fig.3.2 Fine aggregate
(Source: by author)

3.2.3 Coarse aggregate

Coarse aggregates are irregular in shape, broken stones, crushed stone or naturally occurring round gravels that are commonly considered as inert fillers. It reduces volume changes resulting from settling and hardening processes. The various properties of coarse aggregates include shape and texture, size gradation, moisture content, specific gravity, reactivity, soundness and bulk density. Coarse aggregates can be 60 to 80% of the volume and 70 to 85% of the weight of concrete. So, their properties are crucial to the properties of concrete.

Fig.3.3 Coarse aggregate
(Source: author)

3.2.4 Water

Water fit for drinking is generally used for making concrete. It should be free from acids, oils,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

alkalis and vegetables or other impurities. Soft water also produces weak concrete. Water is

The key ingredient, which when mixed with cement, forms a paste that binds the aggregate together. For the proper hydration reaction of concrete good quality of water is essential.

3.2.5 Superplasticizer

Superplasticizers are a type of water reducers; however, the difference between superplasticizers and water reducers is that superplasticizer will significantly reduce the water required for concrete mixing. Mechanism of superplasticizer is through giving the cement particles highly negative charge so that they repel each other due to the same electrostatic charge. By deflocculating the cement particles, more water is provided for concrete mixing. Asian Paints SmartCare Maximoplast PC300 are used.

Fig.3.4 Superplasticizer
(Source: by author)

3.2.6 Fly Ash

Fly ash is a heterogeneous by-product material produced in the combustion process of coal used in power stations. It is a fine grey colored powder having spherical glass particles that rise with the flue gases. As fly ash contains pozzolanic materials components which reach with lime to form cementitious materials

Fig.3.5 Fly Ash
(Source: by author)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

3.2.7 Rice Husk Ash

Rice husks are the hard protective coverings of rice grains which are separated from the grains during milling process. Rice husk is an abundantly available waste material in all rice producing countries, and it contains about 30%–50% of organic carbon. During a typical milling process, the husks are removed from the raw grain to reveal whole brown rice which upon further milling to remove the bran layer will yield white rice.

Fig.3.6 Rice Husk Ash
(Source: by author)

3.2.8 Polypropylene Fibers

Polypropylene fiber (PPF) is a kind of linear polymer synthetic fiber obtained from propylene polymerization. Polypropylene fibers have certain features that make them an ideal complement to achieve specific advantages when used for building works, more specifically, when added to concrete. They mainly comprise continuous or discontinuous polypropylene fibers arranged within a plastic matrix.

Fig.3.7 PP Fibers
(Source: by author)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

3.3 TESTING OF MATERIALS

To examine the basic properties of the materials chosen the following tests were carried out.

3.3.1 Tests on cement

Cement is the most important ingredient in concrete. Therefore, quality of cement should be checked before using it. Various tests on cement are performed to evaluate the specific gravity, standard consistency and initial setting time.

(i) Specific gravity of cement

The specific gravity is the ratio between the weight of a given volume of material and weight of an equal volume of water. The dry Le Chatelier Flask was cleaned and filled with keroseneup to the mark. 60g of cement was taken. The initial reading of flask (V_1) was noted. Add 60gof cement into the flask with care. Care should be taken so that cement falls properly intothe flask. Shake the flask with stopper so that no cement is stick to walls of flask. The cement was allowed to settle. The final reading of flask (V_2) was noted. Fig. 3.8 shows the Le Chatlierflask.

Fig.3.8 Le Chatelier Flask

(Source: by author)

Volume of cement particles = V_2 -V_1

Weight of kerosene = (V_2- V_1) x Specific gravity of kerosene

$$\text{Specific gravity of cement} = \frac{Weight\ of\ cement}{Weight\ of\ kerosene}$$

The laboratory test was conducted, and results are shown in

annexure A1

(ii) Standard consistency

About 300 g of cement was weighed accurately and placed in an enamel trough. To start with,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

added about 25% of clean water and mixed it thoroughly with cement. Care should be taken that the time of gauging is not less than 3 minutes and not more than 5 minutes. The gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould. The Vicat's mould was filled with this paste. Make the surface of the cement paste in level with the top of the mould with a trowel. The mould was placed under the rod bearing the plunger. The indicator was adjusted to show 0-0 reading when it touched the surface of the test block. The plunger was released quickly, allowing it to sink in to the plate.

Fig. 3.9 Vicat apparatus
(Source: by author)

$$\text{Standard Consistency} = \frac{Weight\ of\ water\ added}{Weight\ of\ cemet} * 100$$

The laboratory test was conducted, and results are shown in annexure A1

(iii) Initial setting time

About 300 grams of cement was weighed. A neat cement paste was prepared by adding 0.85 times the percentage of water required for standard consistency. The stopwatch was started at the instant when water was added to the cement. The Vicat's mould was filled with the cement34 paste prepared. Gauging time should not be less than 3 minutes and more than 5 minutes. Filled the mould completely and smoothened the surface of paste making it level with the top of the mould to give a test block. The test block was placed confined in the mould under the load bearing medium. Lowered the needle gently till it encountered the surface of test block and was quickly released, allowing it to penetrate the test block and noted penetration after every two minutes. This procedure was repeated until the needle failed to pierce the blockfor about 5mm, measured from the bottom of the mould. The stopwatch was stopped and the initial setting time was noted.

The laboratory test was conducted, and the results are shown in annexure

(iv) Fineness of cement

Weigh approximately 100g of cement to the nearest 0.01g and place it on standard 90-micronsieve. Agitate the sieve by swirling, planetary and linear movements, until no finer material passes through it. Weigh the residue and express its mass as a percentage, of the quantity firstplaced on the sieve to the nearest 0.1 percent. Repeat the whole procedure for two more such samples. According to IS specification, the fineness of cement should be less than 10 %.

$$\text{Fineness} = \frac{(W2)}{(W1)} \times 100\%$$

W1= weight of sample

W2= weight of residue

The laboratory test was conducted, and results are shown in annexure A1

3.3.2 Tests on fine aggregate

Fine aggregates are very important component of concrete, so its quality really matters. Various tests such as specific gravity and sieve analysis are performed on fine aggregates to check its quality. Specific gravity test of aggregates is done to measure the strength of the aggregates.

(i) Specific gravity of fine aggregate

The pycnometer was cleaned, dried and weighed accurately with its cap screwed on (W1). About 300g to 500g of oven dry sample in the pycnometer was taken and weighed again (W2).Distilled 35 water was added in the pycnometer and stirred using glass rod to remove the entrapped air. Filled the pycnometer with distilled water up to the hole in the conical cap and weighed it (W3). The pycnometer was emptied and cleaned. Filled the pycnometer with distilled water up to the hole in the conical cap and weighed it (W4).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Fig. 3.10 Pycnometer
(Source: by author)

$$\text{Specific gravity} = \frac{(W2-W1)}{(W2-W1)-(W3-W4)}$$

The laboratory test was conducted and results are shown in annexure A2

(ii) Sieve analysis of fine aggregate

About 2 kg of fine aggregate was taken in IS sieve size of 4.75mm, 2.36mm, 1.18mm, 600µ, 300µ, 150µ were arranged in the decreasing order of size and put the fine aggregate taken. Sieved the aggregates and the amount which is passing through greater size was taken and retained on the next. A graph of percentage finer versus sieve size was plotted with the values obtained from the tests.

The laboratory test was conducted, and results are shown in annexure A2

3.3.3 Tests on coarse aggregate

Coarse aggregates are very important components of concrete, so their quality really matters. Various tests such as specific gravity, sieve analysis are performed on coarse aggregates to check its quality. Specific gravity test of aggregates is done to measure the strength of the aggregates.

(i) Specific gravity of coarse aggregate

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

About 2 Kg of thoroughly washed coarse aggregate was placed in the wire basket and immersed it in distilled water. The weight of the saturated aggregate suspended in water with the basket was weighed and noted as (W1). Removed the basket and aggregate from the water and allowed it to drain. Immerse the basket in water and the empty weight (W2) was taken. The weight of surface dried aggregate (W3) was noted. Oven dried the aggregates for a temperature of 110°C for 24 hours. The weight of oven dried aggregate (W4) was noted. The test results are given in annexure A3.

Fig. 3.11 wire basket
(Source: by author)

(ii) Sieve analysis of coarse aggregate

About 2 kg of Coarse aggregate was taken in IS sieve size of 20mm, 16mm, 12.5mm, 10mm, 4.75mm, 2.36 mm and 1.18mm. The sieves were arranged in the decreasing order of size and put the coarse aggregate taken. Sieved the aggregates and the amount which is passing throughgreater size was taken and retained on the next. The sieve analysis test results are given in annexure A3.

Fig. 3.12 Sieve
(Source: by author)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

3.4 MIX DESIGN

Control Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade high performance concrete with trial mix was found.

1. Stipulations for proportioning

Grade designation : M65
Type of cement : OPC 53 grade confirming to IS 269
Silica fume : Confirming to IS 269
Maximum nominal size of aggregate : 12 mm
Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)
Workability : 200 mm slump
Method of concrete placing : Pumping
Degree of supervision : Good
Type of aggregate : Crushed angular aggregate
Maximum cement (OPC) content : 450 kg/m^3
Chemical admixture type : Superplasticizer (PCE)

2. Test data for materials

Cement used : OPC 53 grade confirming to IS 269
Specific gravity of cement : 3.12
Specific gravity of
a) Coarse aggregate (at SSD condition) : 2.74
b) Fine aggregate (at SSDA condition): 2.69
c) Fly Ash : 2.2
d) Rice Husk Ash : 2.15
Chemical admixture : 1.09
Water absorption
a) Coarse aggregate : 0.2
b) Fine aggregate : 2.2
Moisture content NIL (Dry aggregates)
Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. Target strength for mix proportioning

f'ck = fck + 1.65 x S

Where,

f'ck = Target strength

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. Approximate air content

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. Selection of water-cement ratio

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining target strength.

0.28 < 0.45, Hence OK.

6. Selection of water content

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. Calculation of cement content

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Cement content = 535-107 = 428

No revised w/c ratio, so it fixes into 0.28

Check min. & max. OPC cement content, 320<428<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

8. Proportion of volume of course and fine aggregate content

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. Mix calculations

a) Total Volume	= 1 m^3
b) Volume of entrapped air	= 0.008 m^3
c) Volume of cement	= Mass of cement/Sp. Gravity x1000
	= 428/(3.12x1000) = 0.137 m^3
d) Volume of water	= 150 kg = 0.150 m^3
e) Volume of Flyash	= 107/(2.2x1000) = 0.0486 m^3
f) Volume of chemical admixture	= (535 x 0.8%)/(1.09x1000) = 0.00025
g) Vol. of aggregates	= (a-b)–(c+d+e+f)
	=(1-0.008) -(0.137+0.150+0.0486+0.004)= 0.6524
h) Volume of coarse aggregate	= 0.6524 m3 x 0.564 = 0.368 m^3
i) Weight of coarse aggregate	=Vol.of coarse aggr. X sp. gra. x 1000
	= 0.368x2.74x1000= 1008 kg/ m^3
k) Volume of fine aggregate	= Total vol. – Coarse aggregate vol.
	= 0.6524 – 0.368 = 0.2844
l) Weight of fine aggregate	= 0.2844 x 2.69 x1000 = 765 kg/ m^3

10. Mix proportions for trial

Cement	= 428 kg/m^3
Fly ash	= 107 kg/m^3
Water	= 150 kg/m^3
Fine Aggregate	= 765 kg/m^3
Coarse Aggregate	= 1008 kg/m^3
Chemical Admixture	= 4.28 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Note:

• Admixture dosage should be confirmed as following the in-situ trials.

• Moisture correction and absorption to be considered. All mix designed in SSD condition as per IS 10262-2019.

• All mix design trials should be done and evaluated before the application.

• Moisture correction and water absorption of the aggregate should be considered.

Table 3.1 Mix proportion of control mix

Mix ID	Cement kg/m³	Fly ash kg/m³	Fine aggregate kg/m³	Coarse aggregate kg/m³	Water kg/cm³	Superplasticizer kg/m³
CM	428	107	765	1008	150	4.28

Table 3.2 Mix Designation

Mix ID	DESIGNATION
HPC FA 20	Control mix of HPC with 20 % Fly ash
HPC RHA 5	HPC containing 5% Rice husk ash
HPC RHA 10	HPC containing 10% Rice husk ash
HPC RHA 15	HPC containing 15% Rice husk ash
HPC RHA 20	HPC containing 20% Rice husk ash
HPC RHA 10 PP 0.25	HPC containing 10% Rice husk ash and 0.25% PP Fibers
HPC RHA 10 PP 0.5	HPC containing 10% Rice husk ash and 0.5% PP Fibers
HPC RHA 10 PP 0.75	HPC containing 10% Rice husk ash and 0.75% PP Fibers

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

3.5 TESTS ON HIGH PERFORMANCE CONCRETE

The mechanical properties of HPC were evaluated by conducting compressive strength test, Flexural strength test, Split tensile strength test and durability tests such as Rapid chloride penetration test and water permeability test.

3.5.1 Mechanical tests of High-Performance Concrete

(i) Compressive Strength

The compressive strength of concrete was assessed by crushing to the destruction of the test cubes by means of compression testing machine according to IS 516:1959. Cubes of 150 mm size were used for the testing. Load at the failure divided by area of specimen gives the compressive strength of concrete. Fig 3.14 shows the compressive strength testing of the specimen

Fig 3.13 Compressive strength testing of specimen

(Source: by author)

(ii) Flexural Strength

The flexural test was carried out in accordance with IS 516:1959 (Reaffirmed 2013) on concrete beams 500 mm long and 100 x 100 mm in cross section. Fig 3.16 shows the flexural strength testing of the specimen. The test was conducted on Universal Testing Machine (UTM) with two-point loading setup. The load increased continuously without shock until the specimen failed and the maximum load was recorded as P. The flexural strength is given by

Flexural strength = Pl/bd^2

Where l = length of specimen

b = width of specimen

d = depth of specimen

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Fig 3.14 Flexural strength testing of specimen
(Source: by author)

(iii) Split Tensile Strength

Split tensile strength test on concrete cylinder is a method to determine the split tensile strength of pervious concrete. The split tensile test was carried out as per IS 5816-1999 (Reaffirmed 2008) by placing the cylindrical specimen horizontally between the loading surfaces of compression testing machine and then load was applied until the failure of the cylinder along the vertical diameter. Cylindrical specimens of diameter 150 mm and height 300 mm were used for this test. Fig 3.17 shows the split tensile strength testing of the specimen.

Fig. 3.15 Split tensile strength testing of specimen

(Source: by author)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

The split tensile strength was calculated by Tensile strength = $2P/\pi DL$

Where, P = applied load

D = diameter of the cylinder

L= length of the cylinder

3.5.2 Durability tests of Fly ash based High Performance Concrete

i) Rapid Chloride Penetration Test

This test determines the electrical conductance of the different grades of concrete mixes and indicates its resistance to the penetration of chloride ions. Standardized testing procedures are in AASHTO T 277 or ASTM C 1202.

The concrete specimen having dia 100mm and thickness of 50mm is cast and saturated. The concrete sample is placed in between the two reservoirs (known as a single cell) having NaCl solution in one reservoir and NaOH solution in the other.

Fig. 3.16 Rapid Chloride Penetration Testing of specimen

(Source: by author)

These reservoirs are connected to DC supply and the voltage of 60V is applied to the concrete specimen at both ends for 6 hours. Now, the current passing through the concrete at different time intervals is measured. It is determined by an LCD that is connected to the cell.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Table 3.3 Chloride ion penetrability based on charge passed

Charge Passed (coulombs)	Chloride Ion Penetrability
>4000	High
2000-4000	Moderate
1000-2000	Low
100-1000	Very low
<100	Negligible

(Source: ASTM C-1202-22, Table 1)

ii) Water Permeability Test

The DIN 1048-5 Water Permeability Test, also known as the German standard water penetration test of concrete cube, is used to determine the permeability of concrete to water. To conduct the test, concrete cubes of 150mm x 150mm x 150mm dimension are cast from a fresh concrete mix and cured for 28 days. After the curing period, excess water is removed from the surface of the cubes, and they are placed on a metal plate. Water is then applied at a water pressure of 0.5N/mm2 acting normal lo the mould-filling direction, for a period of three days. This pressure shall be kept constant throughout the test. If water penetrates through to the underside of the specimen, after the pressure has been released, the specimen shall be removed and split down the centre with the face which was exposed to water facing down.

When the split faces show signs of drying (after about 5 to 10 minutes), the maximum depth of penetration in the direction of cube thickness shall be measured in mm and the extent of water permeation established. Table 3.7 shows the classification of concrete based on depth of penetration according to DIN-1048 part 5.

Table 3.4 Classification of concrete based on water penetration

Depth of Penetration in mm	Classification of Concrete
0	Impermeable Concrete
0-25	Low Permeable Concrete
25-50	Moderately Permeable Concrete
>50	Highly Permeable Concrete

(Source: DIN-1048 part 5)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

3.6 SUMMARY OF THE CHAPTER

This chapter includes the description of materials used in the study, the preliminary investigations conducted on the material properties, the mix design of High Performance Concrete as per IS 10262:2019 and the tests conducted for the HPC at hardened state.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

CHAPTER 4

RESULTS AND DISCUSSION

4.1 GENERAL

Preliminary examination of materials is done to determine the various properties of materials used in the High-Performance Concrete. This was followed by the testing of concrete specimens of M65 grade HPC. The compressive strength test, flexural strength test, split tensile test and durability test were conducted on hardened concrete.

4.2 MATERIAL SPECIFICATIONS

Properties of cement, fine aggregate, coarse aggregate, RHA, PP Fiber and super plasticizers

4.2.1 Cement

Fineness, Specific gravity, standard consistency, Initial setting time of OPC Cement are tested and the results are tabulated.

Table 4.1 Properties of cement

Sl. No.	Property	Result	Allowable limit
1.	Fineness	295 m^2/kg	Min. 225 m^2/kg
2.	Specific gravity	3.12	3.1-3.16
3.	Standard Consistency	24	25-35%
4.	Initial setting time	100	Not less than 30 minutes

4.2.2 Fly Ash & Rice Husk Ash

Specific gravity of Fly ash and Rice husk ash are tested and the results are tabulated:

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Table 4.2 Properties of Fly Ash and RHA

Sl. No.	Property	Result	Allowable limit
1	Specific gravity of Fly Ash	2.2	Not specified
2	Specific gravity of RHA	2.25	Not specified

4.2.3 Fine aggregate

Specific gravity and water absorption of Fine aggregate are tested and the results are tabulated.

Table 4.3 Properties of fine aggregate

Sl. No.	Property	Result	Allowable limit
1	Specific gravity	2.69	2.1-3.2
2	Water absorption	3.1 %	Max 5%

4.2.4 Coarse aggregate

Specific gravity and water absorption of coarse aggregate are tested and the results are tabulated.

Table 4.4 Properties of Coarse aggregate

Sl. No.	Property	Result	Allowable limit
1	Specific gravity	2.74	2.6-2.8
2	Water absorption	0.2%	0.1-2%

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

4.2.5 Super plasticizers

Aspect, Specific gravity and pH of Super plasticizers are shown in Table 4.5

Table 4.5 Properties of super plasticizers

Property	Value
Aspect	Reddish brown liquid
Specific gravity	1.09
pH	> 6

4.3 TEST RESULTS

4.3.1 Compressive Strength Test

The compressive strength of concrete was assessed by crushing the cubes by means of compression testing machine according to IS 516: 1959 (Reaffirmed 2004). Cubes of 150 X 150 X 150 mm sizes are used for testing. Table 4.6 shows the results obtained from the test which shows the compressive strength for M65 grade HPC in 7days.

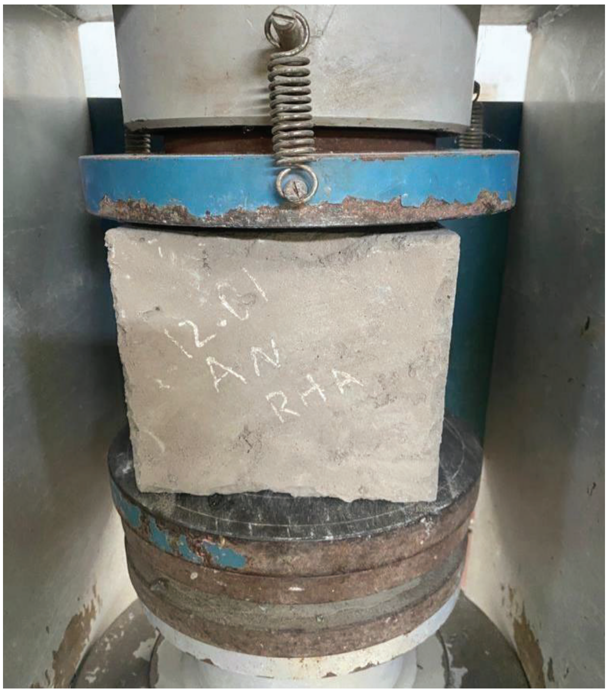

Figure 4.1 Compressive strength test
(Source: by author)

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Table 4.6 Compressive strength of Fly Ash based HPC

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC FA 20	59.58	59.58	67.2	66.82
2	HPC FA 20	61.84		66.71	
3	HPC FA 20	57.33		66.82	

Table 4.7 Compressive strength of Fly Ash based HPC- with varying % of RHA

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 5	53.15	53.46	64.97	64.66
2	HPC RHA 5	53.55		64.66	
3	HPC RHA 5	53.68		64.35	
4	HPC RHA 10	60.53	60.75	66.57	67
5	HPC RHA 10	60.88		66.93	
6	HPC RHA 10	60.84		67.73	
7	HPC RHA 15	57.28	56.98	63.33	63.15
8	HPC RHA 15	56.8		62.97	
9	HPC RHA 15	56.88		63.15	
10	HPC RHA 20	53.95	53.9	59.2	59
11	HPC RHA 20	54.44		58.6	
12	HPC RHA 20	53.6		58.9	

From the results, we can understand that the compressive strength of concrete increases with the addition of RHA. 10% RHA replacement with cement shows the maximum compressive strength. Beyond 10% replacement compressive strength decreases. The presence of a good amount of calcium and silica in RHA increases the rate of hydration process and improves the pozzolanic reaction and formation of C-S-H gel.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

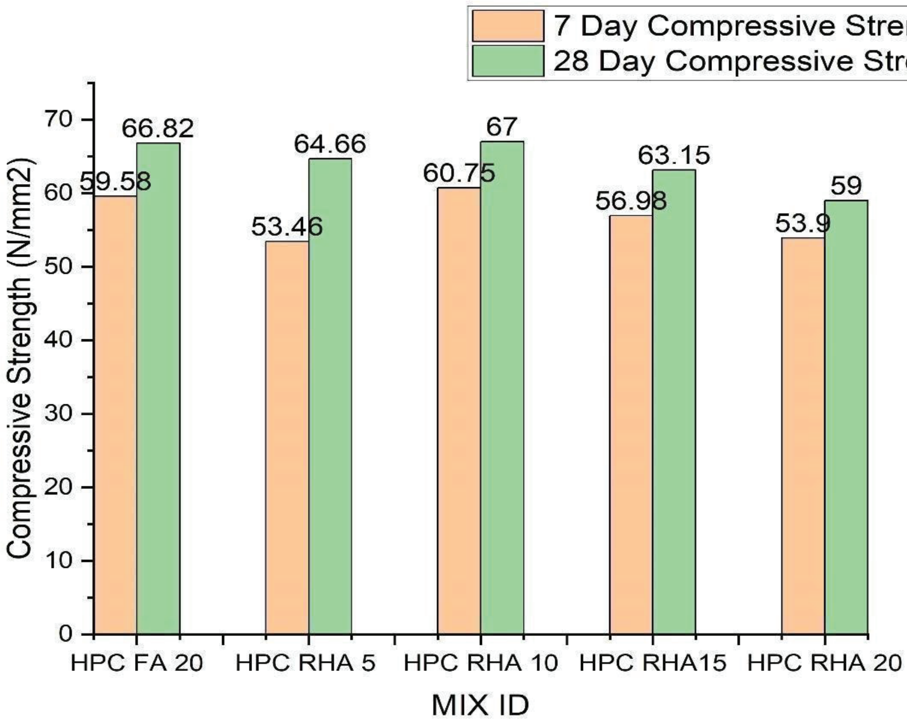

Fig 4.2 Variation in Compressive strength for various % of RHA

From the results, we can understand that the compressive strength of concrete increases with the addition of RHA. 10% RHA as replacement with cement shows the maximum compressive strength.

Table 4.8 Compressive strength of Fly Ash based HPC- with Optimum % of RHA (10%) and varying % of PP Fiber

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 10 PP 0.25	61.5	61	66.9	67.5
2	HPC RHA10 PP 0.25	60.5		67.9	
3	HPC RHA 10 PP 0.25	61		67.8	
4	HPC RHA 10 PP 0.5	62.7	62.4	69.6	69.5
5	HPC RHA 10 PP 0.5	62.1		68.9	
6	HPC RHA 10 PP 0.5	62.4		69.9	
7	HPC RHA 10 PP 0.75	62.4	61.9	66.6	67.4
8	HPC RHA 10 PP 0.75	61.8		68	
9	HPC RHA 10 PP 0.75	61.6		67.8	

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

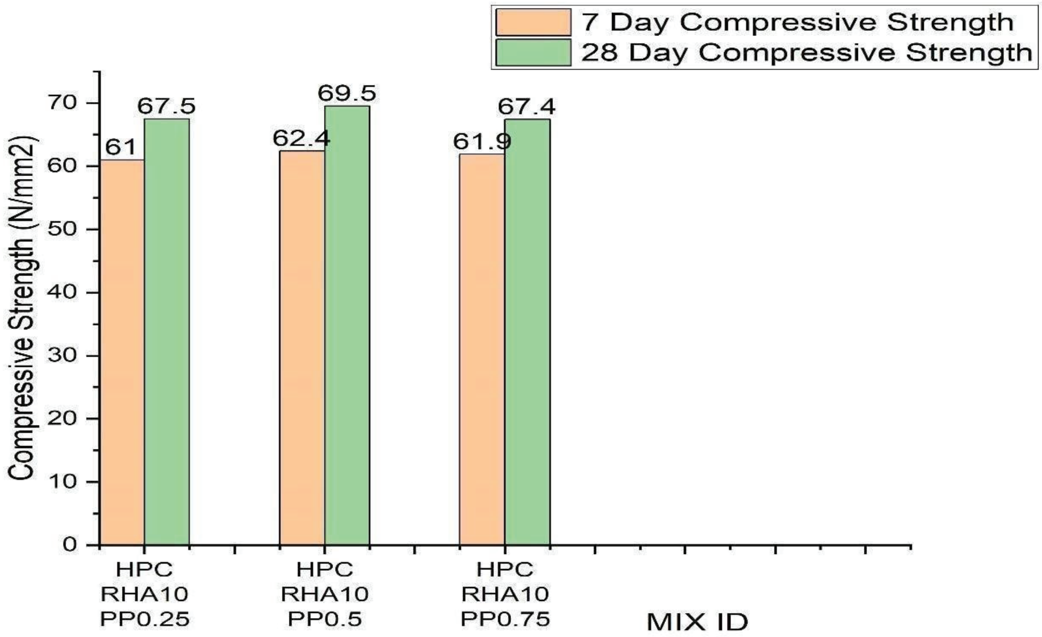

Fig 4.3 Variation in Compressive strength for 10% of RHA & various % of PP fiber

4.3.2 Split Tensile Strength

The tensile strength of concrete is one of the basic and important properties. Splitting tensile strength test on the concrete cylinder is a method to determine the tensile strength of concrete as per IS 5816: 1999 (Reaffirmed 2004). The concrete is very weak under tensile force, due to its brittle nature and is not expected to resist the direct tension. The concrete develops cracks when subjected to tensile forces. Thus, it is necessary to determine the tensile strength of concrete to determine the load at which the concrete members may crack. Tensile strength is an important property of concrete because concrete structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself.

Fig 4.4 Split tensile strength test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Table 4.9 Split tensile strength of Fly ash based HPC

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC FA 20	4.11	4.11	7.03	7.02
2	HPC FA 20	4.09		7	
3	HPC FA 20	4.13		7.05	

(Source: by author)

Table 4.10 Split tensile strength of Fly ash based HPC- with Optimum % of RHA (10%)

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 10	4.9	4.6	7.1	7.4
2	HPC RHA 10	4.6		7.7	
3	HPC RHA 10	4.3		7.4	

(Source: by author)

Table 4.11 Split tensile strength of Fly ash based HPC- with Optimum % of RHA (10%) and Optimum % of PP Fiber (0.5%)

SI No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 10 PP 0.5	5.5	5.2	9.2	9.2
2	HPC RHA 10 PP 0.5	5.2		9.1	
3	HPC RHA 10 PP 0.5	4.9		9.3	

(Source: by author)

4.3.3 Flexural Strength

The flexural strength of HPC was found using universal testing machine after 28 days of curing. Flexural strength test was conducted based on IS 516 1959 (Reaffirmed 2004).

Fig 4.5 Flexural strength test

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Table 4.12 Flexural strength of Fly ash based HPC

Sl No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC FA 20	6.4	6.6	8.8	9.2
2	HPC FA 20	6.8		9.6	
3	HPC FA 20	6.6		9.2	

(Source: by author)

Table 4.13 Flexural strength of Fly ash based HPC-with Optimum % of RHA (10%)

Sl No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 10	7.6	7.3	10.6	10.8
2	HPC RHA 10	7.1		10.7	
3	HPC RHA 10	7.2		11.1	

(Source: by author)

Table 4.14 Flexural strength of Fly ash based HPC-with Optimum % of RHA (10%) & Optimum % of PP Fiber (0.5%)

Sl No	Mix ID	Compressive strength (N/mm²)			
		7 Day	Mean 7 Day	28 Day	Mean 28 Day
1	HPC RHA 10 PP 0.5	7.8	7.8	11.3	11.4
2	HPC RHA 10 PP 0.5	7.9		11.7	
3	HPC RHA 10 PP 0.5	7.9		11.4	

(Source: by author)

4.3.4 Durability

(i) Rapid Chloride Penetration Test Value

This test determines the electrical conductance of the different grades of concrete mixes and indicates its resistance to the penetration of chloride ions. Standardized testing procedure is ASTM C 1202. RCPT monitors the amount of electrical current passed via concrete specimens for a specified time. The movement of ions in a porous medium under a concentration gradient is called diffusion. It is

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

often necessary to ascertain the impermeability of concrete to chloride ions as a quality control measure and assessment of improvements in properties of new concrete.

The concrete specimen having dia 100mm and thickness of 50mm is cast and saturated. The test was conducted after 28 days of curing.

Table 4.15 RCPT value of HPC RHA 10 PP 0.5

Mix ID	Date of Casting	Period of Test	Total Charge Passed
HPC RHA 10 PP 0.5	17-03-2023	21-03-2023	1290

(Source: by author)

The values indicated that casted concrete have low permeability as per ASTM C 1202. The above table shows that optimum fiber dosage will provide good durability standard in 28 days. This is due to replacement of cement by 10% RHA and 0.5% PP Fibers. Both materials have highly secondary reaction within concrete that makes concrete impermeable.

(ii) Water Permeability Test Value

The test was conducted as per DIN EN 12390-8:2017. The water penetration test was carried out successfully in concrete specimens, and the results were found to be reliable and accurate. The test helped to determine the ability of the concrete to resist water penetration, which is an essential factor in ensuring the durability of concrete structures. The depth of water penetration was measured and recorded for each specimen, and the results obtained provided valuable insights into the performance of the concrete mixtures. The data obtained from the test showed that similar degrees of water penetration depth. Table 4.16 shows the water penetration depth.

Table 4.16 Water permeability value of HPC RHA 10 PP 0.5

Mix ID	Date of Casting	Depth of Water Penetration in mm	Classification of Concrete
HPC RHA 10 PP 0.5	17-03-2023	9	Low Permeable Concrete
HPC RHA 10 PP 0.5	17-03-2023	7	
HPC RHA 10 PP 0.5	17-03-2023	8	

(Source: by author)

The results of the water penetration test indicate that the inclusion of RHA and PP Fibers in the concrete mix resulted in a significant reduction in the water penetration depth. This suggests that the addition of that material improved the durability of the concrete by reducing its permeability. This

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

improvement in durability may be attributed to the pozzolanic action of supplementary cementitious material, which helps to refine the pores in the concrete, thereby reducing the number of voids and increasing its density.

Both the tests were carried out at the external laboratory- Bureau veritas.

4.4 SUMMARY OF CHAPTER

The chapter includes the results for various tests conducted on the materials, hardened properties and durability of concrete. All the tests showed that the values of all physical properties of materials used for investigation are conforming to relevant codes of practice. Compressive strength, flexibility, split tensile and durability rests are satisfying.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

CHAPTER 5

CONCLUSIONS

Based on experimental investigation the performance of RHA and PP Fiber are evaluated in Fly ash based HPC. Cement content has been replaced by Fly Ash at the ratio of 20 %. This improved the hardened properties of concrete. It was observed that all the materials satisfy the required properties as specified in the IS codes. Mix design was carried out with the help of guidelines given in IS 10262:2019. Based on the results of presented work, the following main concluding remarks are made:

- The replacement of cement by RHA enhanced the strength properties of concrete. 10%replacement of cement with RHA shows the maximum compressive strength value of 67 N/mm² in 28th day. There is an increase of 12.5 % in strength by the addition of RHA
- The maximum value of Split tensile strength with optimum % of RHA (10%) obtained as 7.4 N/mm² in 28th day. Beyond that the strength gets reduced. There is an increase of 5.5 % in strength by the addition of RHA.
- The maximum value of Flexural strength with optimum % of RHA (10%) obtained as 10.8 N/mm² in 28th day. Beyond that the strength gets reduced. There is an increase in 17.4 % in strength by the addition of RHA.
- The replacement of cement by RHA and PP Fiber enhanced the strength properties of concrete. 10%replacement of cement with RHA and 0.5 % replacement with PP Fiber shows the maximum compressive strength value of 69.5 N/mm² in 28th day. There is an increase of 16.5 % in strength from Fly ash-based concrete and 3.7% increase in strength from RHA (10%) concrete.
- The maximum value of Split tensile strength with optimum % of RHA (10%) and optimum percentage of PP Fiber (0.5 %) obtained as 9.2 N/mm² in 28th day. There is an increase of 24.3 % in strength when considering the concrete with RHA (10%) alone.
- The maximum value of Flexural strength with optimum % of RHA (10%) and optimum percentage of PP Fiber (0.5 %) obtained as 10.8 N/mm² in 28th day. Beyond that the strength get reduced. There is an increase of 5.5 % in strength with RHA (10%) alone.
- The durability tests such as RCPT and Water Permeability test were performed in the selected optimum percentage of fiber mix HPC RHA 10 PP 0.5.
- The result of RCPT was 1290 Coulombs, which indicates that the cast concrete has good durability performance. The result was in the range of very low permeability (<1500 Coulombs) on 28th day.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

- The water permeability result is in the range of low permeable concrete, the evaluated reading was 8 mm, which will give better durability standards as per MORTH specification (< 25mm).

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

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International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

APPENDIX – A

TEST RESULTS OF MATERIALS

A1 CEMENT

(i) Specific gravity of cement

Weight of cement used = 60 g

Initial reading of flask, V1 = 0.8

Final reading of flask, V2 = 25.1 ml

Volume of cement particle = V2 - V1 =25.1 – 0.8 = 24.3 ml

Weight of kerosene = (V2 –V1) x specific weight of kerosene

= 24.3 x 0.79 = 19.19g

Specific gravity of cement = Weight of cement/Weight of kerosene

= 60/19.19 = 3.12

(ii) Standard consistency

Table A.1 Standard consistency of Cement

Weight of cement used		300 g	
Sl. No	Amount of water added(g)	Percentage by dry weight of cement (%)	Penetration (mm)
1	72	24	5

Percentage of water required for preparing a cement paste of Standard consistency = (w/c) x100

= (72/300) x100 = 24%

(iii) Fineness of cement

Value referred to as cement manufacturing test certificate. It has been done by Blaines air permeability method.

A-2 FINE AGGREGATE

(i) Specific gravity

Weight of pycnometer (W1) =640 g

Weight of pycnometer + sand (W2) = 1140.5 g

Weight of pycnometer + sand +water (W3) = 1849g

Weight of pycnometer +water (W4) = 1538 g

Specific gravity = $(W2-W1)/((W2-W1)-(W3-W4))$ = 2.69

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

(ii) Water absorption of fine aggregate

Weight of surface dried sand (W1) = 500gm

Weight of oven dried sand (W2) =485gm

Water absorption= ((W1-W2)/W2) X100 =3.1%

(iii) Sieve analysis of fine aggregate

Table A.2 Sieve analysis of fine aggregate

Sieve size (mm)	Weight retained(g)	Cumulative Weight(g)	Cumulative percentage retained	Percentage of weight passed
4.75 mm	43	43	4.3	95.7
2.36 mm	110	153	15.3	84.7
1.18 mm	197	350	35	65
600 mic	186	536	53.6	46.4
300 mic	246	782	78.2	21.8
150 mic	175	957	95.7	4.3
Pan	43	1000	100	0

Fineness Modulus = (Sum of cumulative % weight retained)/100 = 2.18

According to IS 383-1970, it confirms to zone II

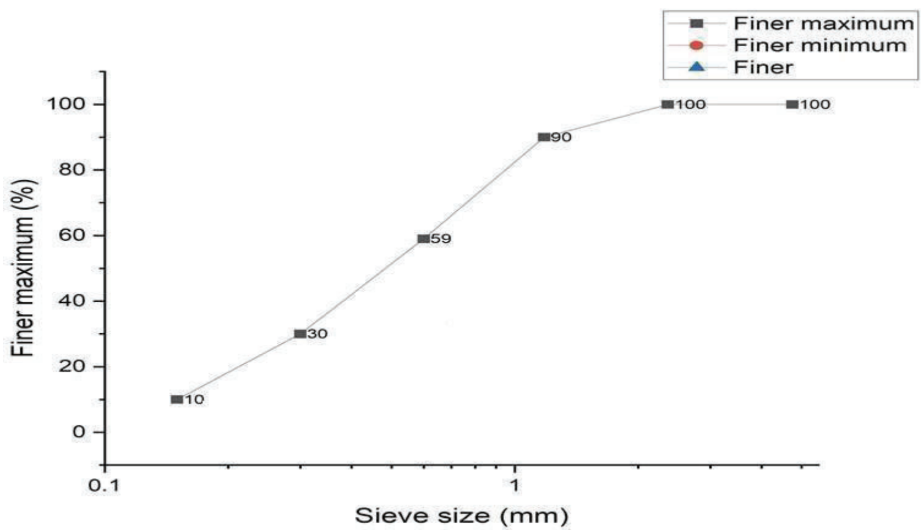

Fig A1. Fineness Modulas

A-3 COARSE AGGREGATE

(i) Specific gravity

Weight of saturated aggregate and basket in water, W1 = 1.963kg

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Weight of basket in water, W2 = 0.710kg

Weight of saturated surface dry aggregate in air, W3 = 1.993kg

Specific gravity = $W3/((W3)-(W1-W2))$ = 2.74

Water absorption of coarse aggregate

Weight of surface dried sand (W3) = 1.99kg

Weight of oven dried sand (W4) = 1.988kg

Water absorption= ((W3-W4)/W4) X100 =0.2%

(ii) Sieve analysis of coarse aggregate

Table A.3 sieve analysis of coarse aggregate

Sieve size (mm)	Weight Retained (g)	Cumulative Weight (g)	Cumulative percentage retained	Percentage of weight passed
20	0	0	0	100
12.5	390	390	13	87
10	1765	2155	71.83	28.16
6.3	800	2955	98.5	1.5
4.75	20	2975	99.16	0.83
pan	25	3000	100	0

GRADATION CURVE OF COARSE AGGREGATE

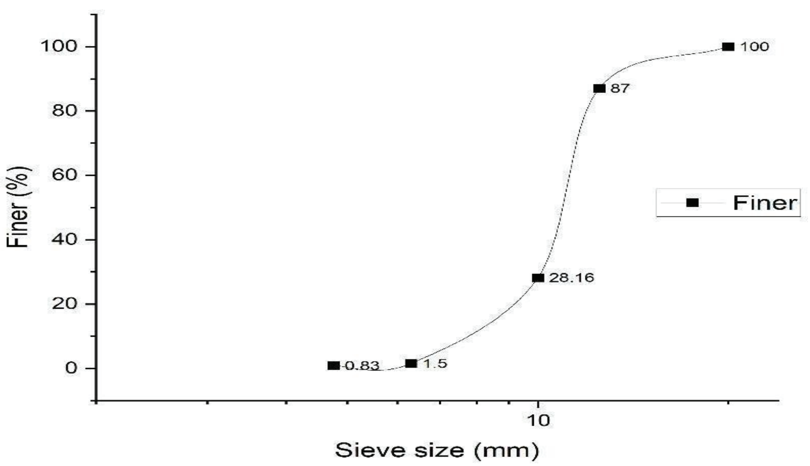

Fig A.2 Gradation Curve for Coarse Aggregate

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN

Control Mix- Fly Ash based M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

c) Fly Ash : 2.2

d) Rice Husk Ash : 2.15

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

$f'ck = fck + 1.65 \times S$

Where,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Cement content = 535-107 = 428

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<428<450 kg/m^3

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume = 1 m^3

b) Volume of entrapped air = 0.008 m^3

c) Volume of cement = Mass of cement/Sp. Gravity x1000

= 428/(3.12x1000) = 0.137 m^3

d) Volume of water = 150 kg = 0.150 m^3

e) Volume of Flyash = 107/(2.2x1000) = 0.0486 m^3

f) Volume of chemical admixture = (535 x 0.8%)/(1.09x1000) = 0.00025

g) Vol. of aggregates = (a-b)–(c+d+e+f)

= (1-0.008) - (0.137 +0.150 +0.0486+0.004) = 0.6524

h) Volume of coarse aggregate = 0.6524 m3 x 0.564 = 0.368 m^3

i) Weight of coarse aggregate =Vol.of coarse aggr. X sp. gra. x 1000

= 0.368x2.74x1000= 1008 kg/ m^3

k) Volume of fine aggregate = Total vol. – Coarse aggregate vol.

= 0.6524 – 0.368 = 0.2844

l) Weight of fine aggregate = 0.2844 x 2.69 x1000 = 765 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement = 428 kg/m^3

Fly ash = 107 kg/m^3

Water = 150 kg/m^3

Fine Aggregate = 765 kg/m^3

Coarse Aggregate = 1008 kg/m^3

Chemical Admixture = 4.28 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-5 % RICE HUSK ASK

Control Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation	: M65
Type of cement	: OPC 53 grade confirming to IS 269
Silica fume	: Confirming to IS 269
Maximum nominal size of aggregate	: 12 mm
Exposure conditions as per Table 3 and Table S of IS 456	: Severe (for reinforced concrete)
Workability	: 200 mm slump
Method of a concrete placing	: Pumping
Degree of supervision	: Good
Type of aggregate	: Crushed angular aggregate
Maximum cement (OPC) content	: 450 kg/m^3
Chemical admixture type	: Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used	: OPC 53 grade confirming to IS 269
Specific gravity of cement	: 3.12
Specific gravity of	
a) Coarse aggregate (at SSD condition)	: 2.74
b) Fine aggregate (at SSDA condition)	: 2.69
Fly Ash	: 2.2
Rice Husk Ash	: 2.89
Chemical admixture	: 1.09
Water absorption	
a) Coarse aggregate	: 0.2
b) Fine aggregate	: 2.2
Moisture content	NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

$f'ck = fck + 1.65 \times S$

Where,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

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Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

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From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

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Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

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Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 5% by weight of Cementitious material = 535 x 0.05 = 26.75 = 27 kg/m^3

Cement content = 535-107-27 = 401

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<401<450 kg/m^3

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume = 1 m^3

b) Volume of entrapped air = 0.008 m^3

c) Volume of cement = Mass of cement/Sp. Gravity x1000

= 401/(3.12x1000) = 0.129 m^3

d) Volume of water = 150 kg = 0.150 m^3

e) Volume of Flyash = 107/(2.2x1000) = 0.0486 m^3

d) Volume of Rice Husk Ash = Mass of cement/Sp. Gravity x1000

= 27/(2.15x1000) = 0.0125 m^3

f) Volume of chemical admixture = (535 x 0.8%)/(1.09x1000) = 0.004

g) Vol. of aggregates = (a-b)–(c+d+e+f)

=(1-0.008) - (0.129 +0.150 +0.0486+0.0125+0.004) = 0.648

h) Volume of coarse aggregate = 0.648 m3 x 0.564 = 0.365 m^3

i) Weight of coarse aggregate =Vol.of coarse aggr. X sp. gra. x 1000

= 0.365x2.74x1000= 1001 kg/ m^3

k) Volume of fine aggregate = Total vol. – Coarse aggregate vol.

= 0.648 – 0.365 = 0.283

l) Weight of fine aggregate = 0.281 x 2.69 x1000 = 761 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement = 401 kg/m^3

Fly ash = 107 kg/m^3

Rice husk ash = 27 kg/m^3

Water = 150 kg/m^3

Fine Aggregate = 761 kg/m^3

Coarse Aggregate = 1001 kg/m^3

Chemical Admixture = 4.28 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-10 % RICE HUSK ASK

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

Fly Ash : 2.2

Rice Husk Ash : 2.89

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

$f'ck = fck + 1.65 \times S$

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Where,

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 10% by weight of Cementitious material = 535 x 0.1 = 53.5 = 54 kg/m^3

Cement content = 535-107-54 = 374

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<374<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume = 1 m^3

b) Volume of entrapped air = 0.008 m^3

c) Volume of cement = Mass of cement/Sp. Gravity x1000

= 374/(3.12x1000) = 0.12 m^3

d) Volume of water = 150 kg = 0.150 m^3

e) Volume of Flyash = 107/(2.2x1000) = 0.0486 m^3

d) Volume of Rice Husk Ash = Mass of cement/Sp. Gravity x1000

= 54/(2.15x1000) = 0.025 m^3

f) Volume of chemical admixture = (535 x 0.8%)/(1.09x1000) = 0.004

g) Vol. of aggregates = (a-b)–(c+d+e+f)

=(1-0.008)-(0.12 +0.150 +0.0486+0.025+0.004) = 0.6444

h) Volume of coarse aggregate = 0.6444 m3 x 0.564 = 0.363 m^3

i) Weight of coarse aggregate =Vol.of coarse aggr. X sp. gra. x 1000

= 0.363x2.74x1000= 996 kg/ m^3

k) Volume of fine aggregate = Total vol. – Coarse aggregate vol.

= 0.6444 – 0.363 = 0.2814

l) Weight of fine aggregate = 0.2814 x 2.69 x1000 = 757 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement = 374 kg/m^3

Fly ash = 107 kg/m^3

Rice husk ash = 54 kg/m^3

Water = 150 kg/m^3

Fine Aggregate = 757 kg/m^3

Coarse Aggregate = 996 kg/m^3

Chemical Admixture = 4.28 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-15 % RICE HUSK ASK

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

Fly Ash : 2.2

Rice Husk Ash : 2.89

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = fck + 1.65 x S

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Where,

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 15% by weight of Cementitious material = 535 x 0.15 = 80.25 = 80 kg/m^3

Cement content = 535-107-80 = 348

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<348<450 kg/m

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume	= 1 m^3
b) Volume of entrapped air	= 0.008 m^3
c) Volume of cement	= Mass of cement/Sp. Gravity x1000
	= 374/(3.12x1000) = 0.12 m^3
d) Volume of water	= 150 kg = 0.150 m^3
e) Volume of Flyash	= 107/(2.2x1000) = 0.0486 m^3
d) Volume of Rice Husk Ash	= Mass of cement/Sp. Gravity x1000
	= 80/(2.15x1000) = 0.037 m^3
f) Volume of chemical admixture	= (535 x 0.8%)/(1.09x1000) = 0.004
g) Vol. of aggregates	= (a-b)–(c+d+e+f)
	=(1-0.008)-(0.12 +0.150 +0.0486+0.037+0.004) = 0.6324
h) Volume of coarse aggregate	= 0.6324 m3 x 0.564 = 0.356 m^3
i) Weight of coarse aggregate	=Vol.of coarse aggr. X sp. gra. x 1000
	= 0.356x2.74x1000= 975.44 kg/ m^3
k) Volume of fine aggregate	= Total vol. – Coarse aggregate vol.
	= 0.6324 – 0.356 = 0.2764
l) Weight of fine aggregate	= 0.2764 x 2.69 x1000 = 743.51 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement	= 348 kg/m^3
Fly ash	= 107 kg/m^3
Rice husk ash	= 80 kg/m^3
Water	= 150 kg/m^3
Fine Aggregate	= 761 kg/m^3
Coarse Aggregate	= 1004 kg/m^3
Chemical Admixture	= 5.35 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-20 % RICE HUSK ASK

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

Fly Ash : 2.2

Rice Husk Ash : 2.89

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = fck + 1.65 x S

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Where,

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Cement content = 535-107- 107= 321

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<321<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume = 1 m^3

b) Volume of entrapped air = 0.008 m^3

c) Volume of cement = Mass of cement/Sp. Gravity x1000

= 374/(3.12x1000) = 0.12 m^3

d) Volume of water = 150 kg = 0.150 m^3

e) Volume of Flyash = 107/(2.2x1000) = 0.0486 m^3

d) Volume of Rice Husk Ash = Mass of cement/Sp. Gravity x1000

= 80/(2.15x1000) = 0.037 m^3

f) Volume of chemical admixture = (535 x 0.8%)/(1.09x1000) = 0.004

g) Vol. of aggregates = (a-b)–(c+d+e+f)

=(1-0.008)-(0.12 +0.150 +0.0486+0.037+0.004) = 0.6324

h) Volume of coarse aggregate = 0.6324 m3 x 0.564 = 0.356 m^3

i) Weight of coarse aggregate =Vol.of coarse aggr. X sp. gra. x 1000

= 0.356x2.74x1000= 975.44 kg/ m^3

k) Volume of fine aggregate = Total vol. – Coarse aggregate vol.

= 0.6324 – 0.356 = 0.2764

l) Weight of fine aggregate = 0.2764 x 2.69 x1000 = 743.51 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement = 321 kg/m^3

Fly ash = 107 kg/m^3

Rice husk ash = 107 kg/m^3

Water = 150 kg/m^3

Fine Aggregate = 761 kg/m^3

Coarse Aggregate = 1003 kg/m^3

Chemical Admixture = 5.35 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-10 % RHA AND 0.25 % PP FIBER

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

Fly Ash : 2.2

Rice Husk Ash : 2.89

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

$f'ck = fck + 1.65 \times S$

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Where,

f'ck	=	Target strength
fck	=	Characteristic compressive strength
S	=	Standard Deviation
F'ck	=	65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 10% by weight of Cementitious material = 535 x 0.1 = 53.5 = 54 kg/m^3

Cement content = 535-107-54 = 374

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<374<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume	= 1 m^3
b) Volume of entrapped air	= 0.008 m^3
c) Volume of cement	= Mass of cement/Sp. Gravity x1000
	= 374/(3.12x1000) = 0.12 m^3
d) Volume of water	= 150 kg = 0.150 m^3
e) Volume of Flyash	= 107/(2.2x1000) = 0.0486 m^3
d) Volume of Rice Husk Ash	= Mass of cement/Sp. Gravity x1000
	= 54/(2.15x1000) = 0.025 m^3
f) Volume of chemical admixture	= (535 x 0.8%)/(1.09x1000) = 0.004
g) Vol. of aggregates	= (a-b)–(c+d+e+f)
	=(1-0.008)-(0.12 +0.150 +0.0486+0.025+0.004) = 0.6444
h) Volume of coarse aggregate	= 0.6444 m3 x 0.564 = 0.363 m^3
i) Weight of coarse aggregate	=Vol.of coarse aggr. X sp. gra. x 1000
	= 0.363x2.74x1000= 996 kg/ m^3
k) Volume of fine aggregate	= Total vol. – Coarse aggregate vol.
	= 0.6444 – 0.363 = 0.2814
l) Weight of fine aggregate	= 0.2814 x 2.69 x1000 = 757 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement	= 374 kg/m^3
Fly ash	= 107 kg/m^3
Rice husk ash	= 54 kg/m^3
PP Fiber	= 1.35 kg/m^3
Water	= 150 kg/m^3
Fine Aggregate	= 757 kg/m^3
Coarse Aggregate	=996 kg/m^3
Chemical Admixture	= 4.28 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

MIX DESIGN-10 % RHA AND 0.5 % PP FIBER

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation	: M65
Type of cement	: OPC 53 grade confirming to IS 269
Silica fume	: Confirming to IS 269
Maximum nominal size of aggregate	: 12 mm
Exposure conditions as per Table 3 and Table S of IS 456	: Severe (for reinforced concrete)
Workability	: 200 mm slump
Method of a concrete placing	: Pumping
Degree of supervision	: Good
Type of aggregate	: Crushed angular aggregate
Maximum cement (OPC) content	: 450 kg/m^3
Chemical admixture type	: Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used	: OPC 53 grade confirming to IS 269
Specific gravity of cement	: 3.12
Specific gravity of	
a) Coarse aggregate (at SSD condition)	: 2.74
b) Fine aggregate (at SSDA condition)	: 2.69
Fly Ash	: 2.2
Rice Husk Ash	: 2.89
Chemical admixture	: 1.09
Water absorption	
a) Coarse aggregate	: 0.2
b) Fine aggregate	: 2.2
Moisture content	NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

f’ck = fck + 1.65 x S

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

Where,

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = 65+1.65x6 = 74.9 N/mm^2

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 10% by weight of Cementitious material = 535 x 0.1 = 53.5 = 54 kg/m^3

Cement content = 535-107-54 = 374

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<374<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 05 , May - 2026

8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume	= 1 m^3
b) Volume of entrapped air	= 0.008 m^3
c) Volume of cement	= Mass of cement/Sp. Gravity x1000
	= 374/(3.12x1000) = 0.12 m^3
d) Volume of water	= 150 kg = 0.150 m^3
e) Volume of Flyash	= 107/(2.2x1000) = 0.0486 m^3
d) Volume of Rice Husk Ash	= Mass of cement/Sp. Gravity x1000
	= 54/(2.15x1000) = 0.025 m^3
f) Volume of chemical admixture	= (535 x 0.8%)/(1.09x1000) = 0.004
g) Vol. of aggregates	= (a-b)–(c+d+e+f)
	=(1-0.008)-(0.12 +0.150 +0.0486+0.025+0.004) = 0.6444
h) Volume of coarse aggregate	= 0.6444 m3 x 0.564 = 0.363 m^3
	=Vol.of coarse aggr. X sp. gra. x 1000
	= 0.363x2.74x1000= 996 kg/ m^3
k) Volume of fine aggregate	= Total vol. – Coarse aggregate vol.
	= 0.6444 – 0.363 = 0.2814
l) Weight of fine aggregate	= 0.2814 x 2.69 x1000 = 757 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement	= 374 kg/m^3
Fly ash	= 107 kg/m^3
Rice husk ash	= 54 kg/m^3
PP Fiber	= 2.7 kg/m^3
Water	= 150 kg/m^3
Fine Aggregate	= 757 kg/m^3
Coarse Aggregate	=996 kg/m^3
Chemical Admixture	= 4.28 kg/m^3

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MIX DESIGN-10 % RHA AND 0.75 % PP FIBER

Mix- M65 Grade Concrete

Mix design was done as per IS 10262: 2019. Mix design of M65 grade High Performance Concrete with trial mix was found.

1. STIPULATIONS FOR PROPORTIONING

Grade designation : M65

Type of cement : OPC 53 grade confirming to IS 269

Silica fume : Confirming to IS 269

Maximum nominal size of aggregate : 12 mm

Exposure conditions as per Table 3 and Table S of IS 456 : Severe (for reinforced concrete)

Workability : 200 mm slump

Method of a concrete placing : Pumping

Degree of supervision : Good

Type of aggregate : Crushed angular aggregate

Maximum cement (OPC) content : 450 kg/m^3

Chemical admixture type : Superplasticizer (PCE)

2. TEST DATA FOR MATERIALS

Cement used : OPC 53 grade confirming to IS 269

Specific gravity of cement : 3.12

Specific gravity of

a) Coarse aggregate (at SSD condition) : 2.74

b) Fine aggregate (at SSDA condition) : 2.69

Fly Ash : 2.2

Rice Husk Ash : 2.89

Chemical admixture : 1.09

Water absorption

a) Coarse aggregate : 0.2

b) Fine aggregate : 2.2

Moisture content NIL (Dry aggregates)

Sieve analysis of fine aggregate confirming to grading Zone 2 of table 9 of IS 383

3. TARGET STRENGTH FOR MIX PROPORTIONING

f'ck = fck + 1.65 x S

International Journal of Engineering Research & Technology (IJERT)
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Vol. 15 Issue 05 , May - 2026

Where,

f'ck = Target strength

fck = Characteristic compressive strength

S = Standard Deviation

F'ck = $65+1.65x6 = 74.9\ N/mm^2$

4. APPROXIMATE AIR CONTENT

Approximate air content for 12.5 mm aggregate from Table 6, IS 10262 (higher strength concrete) is 0.8%

5. SELECTION OF WATER-CEMENT RATIO

From Table 8, the maximum water cement ratio required for the strength of 74.9 N/mm^2 is 0.28 for 12.5 mm aggregate.

Considering the w/c ratio is 0.28 for attaining the target strength.

0.28 < 0.45, Hence OK.

6. SELECTION OF WATER CONTENT

From Table 7, Water content for 12.5 mm aggregate = 195 kg/m^3 (for 50 mm slump)

Estimated Water Content = 195 + (18/100) x 195 = 230.1 kg/m^3

Adding superplasticizers to reduce the water content by 35 percent

Hence, the reduced water content = 230.1 x 0.65 = 149.56 = 150 kg/m^3

7. CALCULATION OF CEMENT CONTENT

Water Cement ratio = 0.28

Water Content = 150 kg/m^3

Cement Content = 150/0.28 = 535 kg/m^3

It is proposed to add 20% of fly ash by weight of cementitious material.

Total Cementitious content = 535 kg/m^3

Fly ash, 20% by weight of Cementitious material = 535 x 0.20 = 107 = 107 kg/m^3

Rice Husk ash, 10% by weight of Cementitious material = 535 x 0.1 = 53.5 = 54 kg/m^3

Cement content = 535-107-54 = 374

No revised w/c ratio, so it fix into 0.28

Check min. & max. OPC cement content, 320<374<450 kg/m^3

International Journal of Engineering Research & Technology (IJERT)
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8. PROPORTION OF VOLUME OF COARSE AND FINE AGGREGATE CONTENT

From Table 10,

Volume of coarse aggregate corresponding to 12.5 mm size aggregate and fine aggregate grading zone 2 = 0.56 per unit volume of total aggregate. This is valid for water-cementitious material ratio at 0.3. As water cementitious material ratio is actually 0.28, the ratio is taken as 0.564.

Volume of fine aggregate content = 1-0.564 = 0.436 per unit volume of total aggregate.

9. MIX CALCULATIONS

a) Total Volume = 1 m^3

b) Volume of entrapped air = 0.008 m^3

c) Volume of cement = Mass of cement/Sp. Gravity x1000

= 374/(3.12x1000) = 0.12 m^3

d) Volume of water = 150 kg = 0.150 m^3

e) Volume of Flyash = 107/(2.2x1000) = 0.0486 m^3

d) Volume of Rice Husk Ash = Mass of cement/Sp. Gravity x1000

= 54/(2.15x1000) = 0.025 m^3

f) Volume of chemical admixture = (535 x 0.8%)/(1.09x1000) = 0.004

g) Vol. of aggregates = (a-b)–(c+d+e+f)

=(1-0.008)-(0.12 +0.150 +0.0486+0.025+0.004) = 0.6444

h) Volume of coarse aggregate = 0.6444 m3 x 0.564 = 0.363 m^3

i) Weight of coarse aggregate =Vol.of coarse aggr. X sp. gra. x 1000

= 0.363x2.74x1000= 996 kg/ m^3

k) Volume of fine aggregate = Total vol. – Coarse aggregate vol.

= 0.6444 – 0.363 = 0.2814

l) Weight of fine aggregate = 0.2814 x 2.69 x1000 = 757 kg/ m^3

10. MIX PROPORTIONS FOR TRIAL

Cement = 374 kg/m^3

Fly ash = 107 kg/m^3

Rice husk ash = 54 kg/m^3

PP Fiber = 4.05 kg/m^3

Water = 150 kg/m^3

Fine Aggregate = 757 kg/m^3

Coarse Aggregate = 996 kg/m^3

Chemical Admixture = 4.28 kg/m^3