TO STUDY THE LIGHTWEIGHT CONCRETE BY USING SILICA FUME, FLY ASH, BRICK BALLAST AND ALUMINIUM POWDER

A Dissertation Report

Submitted in the Partial fulfilment of the Requirement for Award of the Degree

of

MASTER OF TECHNOLOGY

In

STRUCTURAL ENGINEERING

By

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CERTIFICATE

This is to certify that **Mr. Taba Peter** has completed M.Tech dissertation tiltled **"To Study the Lightweight Concrete by using silica fume, fly ash, Brick ballast and aluminium powder"** under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the dissertation has ever been submitted for any other degree or diploma.

This dissertation is fit for the submission and the partial fulfilment of the condtions for the award of M.Tech Structural Civil Engineer.

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DECLARATION

I hereby declare that the dissertation entitled, "**To Study the Lightweight Concrete by using silica fume, fly ash, Brick ballast and aluminium powder",** submitted for the M.Tech degree is entirely my original work and all ideas and references have been duly acknowledge. It does not contain any work for the award of any other degree or diploma.

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ABSTRACT

Lighter concrete than conventional which is formed by increase the volume with mixing an expanding agent such as aluminium powder, and adding admixtures such as fly ash & silica fume to minimize the quantity of cement.

The materials used are cement, sand, coarse aggregate, brick ballast of 20mm size is used as lightweight aggregate, silica fume, fly ash, & aluminium powder.

The materials used to develop lightweight concrete are cement, fine aggregates, coarse aggregates, brick ballast as light weight aggregate, silica fume & fly ash as admixtures and aluminium powder as air entraining agent. Brick ballast is low specific gravity and porous material that can absorb water in high percentage. So, brick ballast used as light weight aggregate that replaced the natural aggregate. The adding of aluminium powder as air entraining agent which react with cement and slurry mix makes the cellular structure and fill with the hydrogen agent which increases the volume of concrete with low density. The admixtures silica fume and fly ash improves the various concrete properties.

The compressive strength and flexural strength of the lightweight concrete are relatively equal to the normal or conventional concrete.

The main advantages are that there can be a reduction of dead load in some extent can build faster building rates in construction and minimize in handling and haulage costs. It can be considered as a versatile and important material in construction in modern days. The applications such as multi-storey frames and floors, prestressed and bridges, partition walls, roof of building and all types of elements. The major properties of the lightweight concrete are compressive strength, its water absorption, density of supplementary materials and using of the water-cement ratio to produce adequate cohesions between water and cement. It can maintain the large voids and cement films. Use of too much water can causes cement to run-off from aggregates to form film layer, subsequently it will weaken the strength.

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CHAPTER 1
INTRODUCTION

1.1 General

The predetermined proportions mixing of cement, sand, coarse aggregates and water by artificially hardening is concrete. When all these materials are mixed to form a mass that can be poured to desired mould or forms which naturally takes place by the reaction of cement and water and other ingredients in the mixture to form hardened concrete. By replacing or adding with the suitable materials or admixtures with the cement, aggregates and water can control and improve the quality and other related properties of the concrete. The properties of concrete depend on the material that is adding in mixtures. Likewise the Lightweight concrete (LWC) is itself means “light in weight” which are generally less in dead weight and is typically 20% to 40% lighter than the normal weight concrete. Lightweight concrete is defined as a concrete type which involves an expanding agent that can increases the volume of mixture while lessened the dead weight and lighter than conventional concrete.

The different materials used for the lightweight concrete can be depending on the region or location and available resources in its vicinity. The most important materials to develop lightweight concrete are lightweight coarse aggregate, air entraining agent and admixtures. The materials that can be used are cement, calcium oxide, silica fume, fly ash, alumina, iron oxide, crinkle aggregate, fine aggregate, water, plasticizer, magnesia, foam agent, air entraining agent, expanded clayey etc. Design flexibility and substantial cost saving can offers by making Lightweight concrete. It can provides less dead load, better fire resist, improve seismic structural response, less reinforcing steel and can cast thinner section.

The materials which have been used for the lightweight concrete are cement, fine aggregates, coarse aggregates, brick ballast as light weight aggregate, silica fume & fly ash as admixtures and aluminium powder as air entraining agent. Brick ballast is low specific gravity and porous material that can absorb water in high percentage. So, brick ballast used as light weight aggregate that replaced the natural aggregate. The adding of aluminium powder as air entraining agent which react with cement and slurry mix makes the cellular structure and fill with the hydrogen agent which increases the volume of concrete with low density. The admixtures silica fume and fly ash improves the various concrete properties.

1.2 Need of study

The mixtures of cement, sand, coarse aggregates and water are conventional practice concrete work. As in this technologies world the work focuses to reuse waste material, develop sustainable materials which can minimize the work process and get maximum output in the field work. Till date no efforts have been study lightweight concrete by using brick ballast as lightweight aggregate, silica fume & fly ash as admixtures with aluminium powder as air entraining agent. The need of study on this project are how the brick ballast, admixtures i.e. silica fume and fly ash both improve the concrete properties along with air entraining agent i.e. aluminium powder.

1.3 Objective of the study

Concrete which has a high compressive strength, with age it hardens increases and the process of hardening goes on for a long time after the concrete has attained it's enough strength. Usually concrete form by mixing cement, water, fine and coarse aggregates and sometimes is made by adding admixtures in their proper proportion. Because of more demand of RCC structure the rates of building materials are also increased. To optimize the rate one can use the waste product in valuable products. By adding silica fume and fly ash can reduces cement usage and improve the concrete properties. The main objectives are:

- To reduce the dead loads of the concrete.
- To compare the weight of the lightweight concrete and conventional concrete.
- To study the properties like compressive strength, tensile strength, ease of placing & handling and economy.
- To use the waste material like broken or wasted brick at construction site.
- To spread more awareness about the use of lightweight concrete.

CHAPTER 2
LITERATURE REVIEWS

2.1 General

Lightweight concrete itself says “concrete which is light in weight or density” or low in density which reduces the dead weight of the concrete. It can be develop by the using of porous aggregate with less specific gravity which is called lightweight aggregates. These aggregates can be natural like pumice stone, expanded clay and volcanic rock and artificial products like Lytag, rubber tyre. It can also be made by using air entraining agent, foaming agents. They reviewed the soundness, earthquake resistant, lifespan, insulation properties, workability, modulus of elasticity, water absorption capacity, coating, materials saving. The following are the literature reviews on the structural and different properties of lightweight concrete and aggregate. These are:

1. Kennnet, S. Hermon,(2005) United States, *Engineering properties of structural Lightweight concrete*, PE, Carolina Stalite Company, USA.

The paper was discussed the physical characteristics of expanded slate rotary kiln lightweight aggregates for the producing high strength of lightweight concrete. The properties like splitting tensile strength, compressive strength and other properties are significantly affect the concrete properties. The production of concrete, transportation, placing and pumping is also affected. By the using of silica fume, lightweight aggregates and natural aggregate with cement the compressive strength is getting 47 MPa to 80 Mpa in 30 to 50 day and splitting tensile of 3.5-4.5 Mpa in 35 days. By the use of lightweight aggregate the dead load and concrete densities get reduce and properties like fire resistance, ease of placing, handling and transportation are increased. The compressive strength of 82.75 Mpa are achieved in average of 28 days by using the cement, type I, Fly Ash, class F, normal aggregates keeping water cement ratio of 0.32. It can be utilized in office buildings and residential in order to achieve long clear span.

2. By Kevin Jerome Simons,(2010) “*Affordable lightweight high performance concrete (ALWHPC) expanding the envelope of concrete mix design*”, University of Nebraskaa, Omahae.

It stated that

- The structural lightweight concrete has a several valuable characteristics as excellent thawing and freezing, internal curing, reduced deal load and durability.
- The differences in weight can be achieved with the use of lightweight aggregate, usually expanded shale, clay, or slate, silica fume and fly ash.

The researches explored the uses of lightweight aggregate, fine and coarse aggregates, with different local fly ash and Portland cement and admixtures and develop a lightweight high performance and design of concrete mix.

The several factors for the particular strengths, performance and long-term of the concrete mixtures are depending on:

- Cement quality
- Water-Cement ratio
- Quality and strength of aggregates
- Adhesion between aggregates and cement paste
- Ingredients adequate mixing
- Compaction and proper finishing of the fresh concrete

Lightweight concrete is a viable and economical solution for building roof, floor and slabs and reduce traditionally dead load of a structure and subsequently reduce the size and configuration of structural elements.

3. Dhawal Desai,(2011), " *Development of Lightweight concrete"*, IIT Bombay, India.

It discussed with the development of lightweight concrete by pumice stone (lightweight aggregate) and water floating type using aluminum powder as air entraining agent. The water-cement ratio for the lightweight aggregate i.e. pumice stone relates to the surface smoothness and control the concrete expansion.

The composition of cement, sand, high water-cement ratio and aluminium powder are formed aerated concrete which does not contain coarse aggregate and is much lighter concrete and can also float on the water. They found within 5 minutes it can expanded up to 30% which consists of many pores. It can be used in place of conventional bricks which are good insulator of sound and heat and where structure does not bear much load. The general properties reviewed:

i. The compressive strength varied between 2.00 to 7.00 N/mm^2.
ii. It is good sound proof and can be suitable for parting walls.
iii. Products are light in weight and ease to handling and placing.
iv. It can be easily drilled, shaped and sawed.

4. Mohd. Shazlii, Kamsiiah, Manafe,(2007) , "*Study of Lightweight concrete Behavior"*, Saudi Arabia.

It defined the lightweight concrete as concrete which increases the mixtures volume with improve in qualities and reduced the dead load by using expanding agent and generally lighter than conventional concrete. The aerated lightweight concrete performance was reviewed as 3.45 MPa of compressive strength are results at 28 days. It varied the percentage of foam agent, foam, cement/sand ratio, as a result higher percentage of foam voids are increased throughout the mould. The density of 2041 kg/m^3, 1820 kg/m^3, 1811 kg/m^3, and 1472 kg/m^3 are getting at 25%, 50%, 75% and 100% respectively.

For the industrial system of building, light weight concrete has the desirable strength and alternative construction material. The low density mixtures have low aerated strength lightweight concrete which results in the increase of empty or voids in the sample due to foam which lead to decrease the compressive strength. The lightweight concrete made from foamed are not good for the use of non-loading bearing wall because the required compressive strength is 27% less than recommended.

5. Heinry G Russel,(2009), *"Lighteight Concrete-Material properties for structural design"*, Inc. Glenview, IL.

This paper describes a compilation and process of research related to lightweight concrete and its properties which include modulus of elasticity, creep, modulus of rupture, shrinkage, flexural and axial force design. The density of lightweight concrete is very less than that of normal concrete. It defined the various material properties of lightweight concrete and it was found that the all these properties are relevantly matched with normal weight concrete.

6. Ben C Gerwicck, Dal, E Barner, Hajian shah,(2008), *"Application of High-performance Lightweight concrete in a floating barge gate",* Oakland, California, USA.

The paper contains the use of barge gate have improved different important properties of concrete with good workability, high strength, increase durability and low permeability which give serviceability to structures. The project used high strength porous shale as lightweight coarse aggregate, lightweight sand, fly ash, Basf MB90 as air-entraining agent. It used DCIS as corrosion inhibitor which enhanced chloride tolerance for reinforcement of steel the durability of concrete. A low water-cement of 0.39 was critical factor of lightweight concrete for more durability of concrete.

The use of highly porous light-weight aggregates substantially reduced the dead load while enhances the other properties of concrete. The significant contribution is that a low water-cement ratio decreases the pores present in hardened cement state.

2.2 Summary of Reviews

Generally the lightweight concrete is lighter than the conventional concrete, these are produced by the lightweight aggregate, expanding agent, foaming agent, organic and inorganic natural aggregate. The main advantages of lightweight concrete are:

i. Reducing the dead load of concrete with improving other concrete properties while increasing the volume of concrete mixtures.
ii. The overall construction cost is reduced by size reduction of structural elements, reducing the volume of concrete and required less steel reinforcing.
iii. The lightweight aggregate provides porosity which lead to a source of water for internal curing and continued increases the strength of concrete.
iv. It has been used for structural elements as piers, slab, beams, bridge deck, partition wall element etc,.

Adding of admixtures such as corrosion inhibitor, plasticizer, micro silica, fly ash, magnesia, air entraining agents etc improved the quality of concrete properties.

2.3 Scope of the Study

Many researchers have been done on the lightweight concrete in different corner of the countries. The reviewed paper described about application of Lightweight concrete and properties of materials. Lightweight concrete offers design flexibility and substantial costs saving. The scopes of study are:

- Less in dead load.
- 20% to 40% lighter than the conventional concrete.
- Good fire resistance.
- Good compressive strength.
- Reasonable flexural strength.
- Good quality of concrete mix.
- Ease of placing for handling and placing.

3.1 Research Methodology

3.1.1 General

An academic activity which comprises defining and redefining problems, formulating hypothesis or suggested solutions, collecting, organizing and evaluating data, making deduction and conclusions, testing the hypothesis conclusion whether they are giving relevant result or correct output is called research methodology.

3.1.2 Research process

The study which gives the necessary training in arranging and gathering materials for the field work and also training in techniques for the collection of data appropriate to problem is said to be research methodology. The following are the methodologies which have been worked:

i. Data Collection: The collection of necessary information and data collection related to the Lightweight concrete. Collected important journal and thesis paper which have been done before.

ii. Abstraction of data: Abstracting and journals indexing of the data collected and bibliographies of the some paper have been discussed in the literature reviews.

iii. Selection of Materials: The Structural lightweight concrete are mostly using the mixtures of cement, lightweight aggregates, natural aggregates, air entraining agents, and admixtures. The following are material selected for the project execution:

   a. Cement
   b. Natural Aggregates
   c. Brick ballast
   d. Silica fume
   e. Fly ash
   f. Aluminium powder

iv. Mix Proportioning Design: The proportioning of concrete is the process of selection of relative proportions of cement. Sand, coarse aggregate and water to obtain a desired concrete quality. The mix proportioning conforming as per “Recommended guidelines for concrete mix design” IS:10262-1982.

v. Study the Physical and Chemical properties of Materials: Collect the important physical and chemical properties of the cement, fine aggregates, coarse aggregates, brick ballast, silica fumes, Fly Ash and aluminium powder which will be discuss in next section.

vi. Work Execution: The experimental study comparing the result of Normal concrete with the concrete inclusive with the Lightweight materials to obtain the optimum strength for uses as structural concrete. The following experimental methods is use to find the related properties:

a. Tests on Materials or Aggregate:
   i. Specific gravity and Water Absorption
   ii. Sieve analysis

b. Tests on cement:
   i. Compressive strength of cement
   ii. Initial and final setting time of cement

c. Tests on concrete
   i. Workability test (compacting factor test)
   ii. Compressive strength of concrete by cube and cylinder.
   iii. Flexure strength test

vii. Result analysis: Based on the experimental execution the collected data are analysed as per mix design.

viii. Report Preparation: It is writing of report which includes introduction, summary of findings, main text or report, conclusion, appendices.

3.1.3 Proposed work Plan with Timelines

This project is composed of jobs, activities and different tasks which are related to one another in some manner and all are need to be completed in assigned time to complete the project.

The statuses of the proposed work are given below:

Table 1: Work Plan

S No	Proposed Work	Expected Plan	Remarks
1	Problem Finding	Feb 2014	Completed
2	Literature review on problem	March 2014	Completed
3	Problem Defining	April 2014	Completed

4	Scope and Objective of Work	April 2014	Completed
5	Methodology	May 2014	Completed
6	Testing of Material	August 2014	Completed
7	Design mix of concrete	September 2014	Completed
8	Design of Cube	October 2014	Completed
9	Concreting Process	January 2015	Completed
10	Testing of Fresh and Hardened concrete	January 2015	Completed
11	Casting of cube	January 2015	Completed
12	Curing	Jan- Feb 2015	Completed
13	Properties Testing	February-April 2015	Completed
14	Calculation of result	Feb – April 2015	Completed
15	Analysis of result data	Feb -April 2015	Completed
16	Conclusion of experimental work	April 2015	Completed
17	Thesis Preparing	March-May 2015	Completed

3.2 Equipments and Apparatus

The construction projects are generally complex work in nature, it can be easily done on scientific and proper use of equipments and apparatus. The equipments which are used for performing the experimental works are shovels, trowels, platform weighing machine, hand scoop, tamping rod, bolt and nuts, wrenches, brush and tin, measuring tape etc.

3.3 Experimental Setups

The necessary information of the concrete, aggregates and other materials can be discharge efficiently designed, collected and presented by the experiments. The following are the setup for necessary information:

1. Cube: (150mmx150mmx150mm) & standard size of 10x10x50cm of mould.

The mould which allowed casting concrete mixtures for various sample and is made from cast iron.

2. Cylinder (150 mm Diameter and 300 mm height):

As we know that the concrete is compression member, so the compressive strength of the concrete is the major parameter. Higher durability of the concrete depends on the compressive strength. 150 mm cubes are generally used for testing the compressive strength at 28 days, etc. 150mm diameter and 300 mm high of cylinder are also used for the compressive strength test.

3. Beam size or 150x150x700 mm :

To maintaining the continuity of concrete structure and corrosion of reinforcement the flexure strength of concrete is conducted. The standard beam mould of 15cmX 15cmX70cm is used for the aggregate size upto 30 mm. The machine which are use to determine flexure strength of concrete is Universal Testing Machine (UTM) which are capable of applying load of 4 kN/min for 150 mm specimen and 1.8 kN/min for 100 mm specimen.

4. Compacting factor apparatus: (as per IS : 1199) :

This apparatus is use to determine the slump value and workability of concrete mixtures. Workability is the amount of work necessary to achieve full compaction of concrete. Compacting factor test works on a principle of determining the degree of compaction achieved by a standard amount of work by allowing the concrete to fall through a standard height.

5. 1000 KN compression testing machine:

As concrete is primarily strong in compression and in actual construction, the concrete is used in compression. This apparatus is use to test for compressive strength of the concrete, which is very important in quality control of concrete. The cube mould of 15 cm size is to be used as per IS: 516 for testing at 7 days, 28 days etc.

Figure 1: 1000 KN Compressive Testing Machine

6. Sieves Analysis:

Sieves type- square hole perforated plate, 30cm diameter (80mm, 63mm, 40mm, 20mm, 16mm, 12.5mm and 10mm). This analysis enables us to determine the proportion of different sizes of particles. It results are given in terms of percentage of total aggregate passing through each size of sieve. The effort is made to get the good concrete and combined grading of fine and coarse aggregate.

Before we do any design, one required to find all the related properties of the materials. This experimental work will deal mainly the testing of various ingredients and concrete as per specifications of BIS, the testing like aggregates, cement, admixtures and concrete. The test will strictly follow the general guidelines of the BIS codes.

3.4 Materials

The engineering structures are mainly comprised of materials which are called as engineering materials or construction materials. The service conditions of structures dependent on a wide range of materials and various properties of materials such as strength, appearance, permeability, water resistance, temperature resistance, physical and chemical properties are to be properly studied before the final selection of material for particular use. To improve the quality aspect and quantity of a building structure, a particular and suitable material is to be select as per the required properties.

3.4.1 Properties of Material

Before using any building materials the engineers are required to know the particular properties of material to be used. The general properties such as bulk density, porosity, water absorption, strength, chemical resistance, weathering resistance, durability etc, are needed to study.

In this section the different chemical and physical properties of cement, aggregates, fly ash, and silica fume and aluminium powder will be discussed.

3.4.2 Cement

Cement is by far the most important constituent of concrete, in that it forms the binding medium for the discrete ingredients. Cement is adhesive and cohesive materials which are capable of bonding together particles of solid matter into a compact durable mass. Their constituent are calcareous cements containing compounds of lime as their chief constituent, its primary function is to bind the fine (sand) and coarse (grits) aggregate particles together. The most of the cement are Ordinary Portland Cement (OPC).The Ordinary Portland Cement has been classified as 33 Grade (IS269:1989), 43 Grade (IS8112:1989), and 53 Grade (IS12669-1987). The 43-Grade cements are mostly available in the market. The UltraTech Cement of 43 grade OPC are taken for the cast of cubes sample. The important physical properties of 43 grade Ordinary Portland Cement (UltraTech Cement) as per IS: 8112-1989 is given below:

Table 2: Physical Properties of Cement

S No.	Physical Characteristics	43 Grade Ordinary Portland Cement- Specification as per IS 8112-1989	Experimental Value
1	Fineness (Blaine's air permeability methods (IS 4031(part 2)-1988))	Not less than 225 m^2/kg	315 m^2/kg
2	Initial Setting time (Vicat apparatus method)	Not less than 30 minutes	142 minutes
3	Final setting time (Vicat Apparatus method)	Not more than 600 minutes	493 minutes
4	Compressive Strength 72±1 hours 168±2 hours	 Not less than 23 MPa Not less than 33 MPa	 37 MPa 56 MPa
5	Specific gravity	3.15	3.15
6	Bulk Density	-	1440 m^3

3.4.3 Aggregates:

It is a general term applied to those chemically inactive or inert materials which are mostly used natural occurring aggregates such as crushed rocks, gravel and sand, when bonded together by cement form concrete. Aggregate contributes about 75% of the bulk of concrete. The property of concrete depends of the shape, size, presence of impurities, crushing strength and grading of the aggregate. It is divided into

i. Fine aggregates:

The aggregates which are less than 4.75mm are known as fine aggregates. Natural sands are generally used as fine aggregates. Sands may be obtained from river, lake, sea-shore and pits. The specific gravity of sand is 2.65 and bulk density of fine sand is 1.44 kg/litre. The river sand is used as fine aggregates.

ii. Coarse aggregates (10mm-20mm):

The materials which are retained on 4.75mm sieve are termed as coarse aggregate for concrete. Coarse grained rocks make harsh concrete and need high proportion of sand and water cement ratio to get reasonable degree of workability. The size may vary from 10mm or more. The specific gravity of stone is 2.66 and bulk density is 1.60 kg/litre.

Table 3: Sieve Analysis 10 mm Aggregate sized

IS Sieve (mm)	Retained Weight (kg)	Cumulative Retained weight (kg)	Cumulative Retained (%)	Cumulative Passing %
20	0	0	0	100
10	0.745	0.745	14.9	85.1
4.75	3.947	4.69	93.85	6.15
2.36	0.150	4.84	96.85	3.15
1.18	0.157	4.99	100	0
			Sum=305.6	

Fineness Modulus = sum/100 = 3.056

Table 4: Sieve Analysis: 20mm aggregate sized

IS Sieve (mm)	Retained Weight (kg)	Cumulative Retained weight (kg)	Cumulative Retained (%)	Cumulative Passing %
20	0	0	0	100
10	0.402	0.402	8.05	91.95
4.75	4.310	4.712	94.25	5.75
2.36	0.263	4.975	99.5	0.5
1.18	0.025	5.000	100	0
			Sum=301.8	

Fineness Modulus = Sum/100 = 3.018

Table 5: Sieve Analysis of Fine aggregate

IS Sieve (mm)	Retained Weight (kg)	Cumulative Retained weight (kg)	Cumulative Retained (%)	Cumulative Passing %
10	0.033	0.033	6.6	93.4
4.75	0.083	0.116	23.3	76.8
2.36	0.131	0.247	49.4	50.6
1.18	0.104	0.351	70.2	29.8
600 micron	0.041	0.392	78.4	21.6
300 micron	0.073	0.465	91	7
pan	0.035	0.500	100	0
			Sum = 420.08	

Fineness Modulus = Sum/100 = 4.208

Table 6: Bulk Density of 20 mm sized aggregate (Brick ballast)

Description (kg)	Trail 1	Trail 2	Trail 3	Average
Empty weight of container	6.75	6.75	6.75	6.75
Total weight of NCA-Loose density	14.40	14.29	14.45	14.39
Total weight of NCA-Compacted density	16.46	16.51	16.48	16.48

Loose Density $=\frac{Average\ value\ of\ Loose\ Density}{Volume\ of\ Container}$ = 1466.84 kg/m^3

Compacted Density $=\frac{Average\ value\ of\ Compacted\ Density}{Volume\ of\ Container}$ = 1679.92 kg/m^3

Table 7: Specific gravity and Water Absorption

Sample	W_1 (kg)	W_2(kg)	W_3(kg)	W_4(kg)
1	2.002	0.637	1.910	1.995
2	2.013	0.177	1.432	1.994
3	2.007	0.108	1.382	1.991
Average	2.007	0.307	1.574	1.993

Where,

W_1 = Weight of saturated dry sample

W_1 = Weight of wire basket in water

W_1 = Weight of wire basket + sample in water

W_1 = Weight of Oven dry sample

Therefore,

Specific Gravity = $\frac{1.993}{1.993-(1.574-0.307)}$ = 2.74

Water Absorption % = $\frac{2.007-1.993}{1.993}$ x 100 =0.7%

iii. Brick ballast:

The brick is known as the oldest building material and it is extensively used as a leading construction material due to its low cost, light weight, strength, durability and easy availability but it is wasted during the construction of building. To make these wasted brick useful; one can use it as coarse aggregate by crushing it into desired size. As bricks are porous material, it has high water permeability and contains silica, alumina, magnesia and lime, organic matter and oxides of iron. The minimum compressive strength of bricks is generally 3.51 N/mm^2. So, the crushed brick ballast also has good compressive strength.

3.4.4 Admixtures:

The chemical product that is mixed to concrete mixtures in small percent by the mass of cement during mixing to achieve a special modifying with the normal concrete mixes is called admixtures. The composition of admixtures may be inorganic and organic but their chemical properties are different from mineral. It is not an essential component for the concrete but adding of adding improves the various properties of concrete. The admixtures are generally classified as water-reducing, retarding, accelerating, water-reducing and retarding, water-reducing and accelerating, superplasticizer based on their chemical composition. Fly Ash and silica fume are used as admixtures.

3.4.4.1 Fly ash:

It is also known as pulverised-fuel ash, is the ash precipitated electro-statically or mechanically from the exhaust gases of coal-fired power stations; it is the most common artificial pozzolana. The fly ash particles are spherical and have a very high fineness: the vast majority of particles have a diameter less than 1micronmeter and 100micronmeter, and the specific surface of fly ash is usually between 250 and 600 m^2/kg. Class C fly ash is high-lime ash originating from lignite coal and may have lime content as high as 24%. The typical compressive strength of Fly Ash is 7.1 MPa to 47.5 MPa in 1 to 365 days. Fly Ash is a by-product of many plants, thermal power plants which nearly produces 70% of fly ash on the burning of 40% of coal. The physical and chemical properties are given in Table 8.

3.4.4.2 Silica Fume:

It is a relatively recent arrival cementing supplementary materials. It was originally introduced as a pozzolana. It is also referred as microsilica or condensed silica fume and it is by-product of the manufacture of silicon and ferrosilicon alloys from high purity quartz and coal in submerged-arc electric furnace. Typical silica contents are as follows: silicon metal-94-98%, ferrosilicon-90%. The specific gravity of silica fume is generally 2.20, but it is slightly higher when the silica content is lower. The diameter of particle size of silica fume is mostly ranging between 0.03 and 0.3 micrometer. It has a very low bulk density: 200 to 300 kg/m^3. Silica fume is available in the densified form of micro-pellets with bulk density of 500 to 700 kg/m^3. The general physical properties of concrete when silica fume is added are:

i. Permeability is reduced.
ii. The heat of hydration is decreased or retarded.

iii. More resistance to erosion due to water action and reduced thawing and freezing action.

iv. Resistance to sulphate.

v. Increase the strength of concrete.

Adding of silica increase water demand as the heat of hydration are low and imparts cracking, if water-cement ratio is not well maintained. The chemical properties are given in Table 9.

Table 8: Physical and Chemical Properties of Fly Ash

Chemical and Physical properties in Mass percentage (%)	**Mass Percentage (%)**
Specific gravity	2.61
Specific surface area (sq.cm/g)	8400
Silica	45.00-60.00
Aluminium	20.00 – 36.0
Manganese	0.11 -0.31
Iron	3.05 – 4.00
Sulphur	0.11-0.55
Potassium	0.50-1.50
Calcium	4.50 – 10.50
Sodium	0.25 – 0.90

Table 9: Physical and chemical properties

Properties (Mass Percentage %)	**Mass Percentage (%)**
Specific gravity	2.21
Specific surface area(sq.cm/g)	210000
Silica	90.00
Iron oxide	0.50
Aluminium oxide	1.50
Calcium oxide	2.20
Manganese	1.50
Sulphur	0.60
Potassium	0.7

3.4.5 Air-Entraining Agent

The mineral agents which are mixes with concrete mixtures, the agent react with calcium hydroxide present in cement and produce hydrogen gas. This gas when present in mix gives cellular structure and escape on hardened state which form air voids in concrete. Therefore make concrete lighter than normal concrete. Aluminium powder is used as the air-entraining agent because it produces hydrogen gas in the form of bubbles when mixed with lime slurry and increases the volume of the concrete. This hydrogen gas popping out during mixture and escape after setting. It is added during the last stage of mixing.

3.4.6 Water

It acts as lubricant for the coarse and fine aggregates and acts chemically with the cement to form the binding paste for the aggregates and reinforcement. Water is also used for curing the concrete after it has been cast into the forms. Water used for both mixing and curing should be free from injurious amount of deleterious materials. Generally portable water is considered satisfactory for mixing and curing of concrete.

3.5 Concrete Mix Design

The proportioning of concrete is the process of selection of relative proportions of cement, sand, coarse aggregate and water to obtain a desired concrete quality. The mix proportioning conforming as per “Recommended guidelines for concrete mix design” IS:10262-1982. The proportioning of cement, sand, coarse aggregate, fine aggregate and water generally should have enough workability, maximum density and can be easily placed in the formwork.

3.5.1 Target Strength

For high strength concrete, proportioning of concrete mix are generally 1:1:2 and 1:1.2:2.4 and for the nominal proportioning of concrete mix and grading of concrete conforming “Plain and Reinforced Concrete-Code for practice” IS 456:2000. So for heavily loaded RCC M25 grade are selected with proportions of 1:1:2.

As per IS 10262:2009, the target strength for mix proportioning are

$$f'_{ck} = f_{ck} + 1.65\, s$$

Where, f'_{ck} is target mean compressive strength at 28 days in N/mm^2

f_{ck} is characteristic compressive strength at 28 days in N/mm^2

S is standard deviation in N/mm^2 (for value refer IS 10262 : 2009)

The target Strength for grade M25,

$f_{ck} = 25\ N/mm^2$

$S = 4.0\ N/mm^2$ (from IS 10262 : 2009)

Therefore, target mean compressive strength,

$f_{ck} = 25 + 1.65 \times 4.0 = 31.6\ N/mm^2$ at 28 days.

3.5.2 Water-Cement Ratio

The ease of handling, transportation, and placing between the formwork with minimum homogeneity loss is called workability. To maintain workability, water-cement ratio play vital role for setting and hardening of concrete. For the enough degree of workability the quantity of water used should be minimum or in general water-cement ratio is inversely proportional to the strength of concrete. So, w/c ratio should be carefully decided.

3.5.3 Mix Design

For required workability and mean strength, the mixes are designed for M25 grade with 1:1:2 mix proportioning. To attain the required strength, the proportioning of cement, fine aggregates, coarse aggregates and water have following specification.

i. Grade of Concrete is M25
ii. Type of Cement is 43 Grade OPC (Ultratech Cement).
iii. Maximum nominal size of aggregates is 20 mm.
iv. Maximum water-cement ratio is 0.50.
v. Mix proportion for nominal mix is 1: 1: 2.

3.5.4 Working Module

The different mix proportioning of silica fume, fly ash, brick ballast and aluminium powder in the mix design. These are as follows:

i. Normal concrete mix: The conventional mix concrete of cement, sand, coarse aggregate and water in the proportion of 1 : 1 : 2 for M25.
ii. Silica fume: It is replacing 0%, 5% and 10% of cement.
iii. Fly ash: It’s also replace 0%, 5% and 10% of cement.

iv. Brick Ballast : As it is porous material, thus used as lightweight aggregate with 50% replacing the natural aggregates.

v. Aluminium Powder: As it is air-entraining agent, to expand to volume of concrete mix thus it is adding 0%, 3% and 5 % of cement.

3.5.4.1 For Cube: 150x150x150mm

The mould which allowed casting concrete mixtures of various sample and made from cast iron. It is used for the test of compressive strength of concrete.

Table 10: Admixture proportioning

Admixture Mix percentage		
Replacing of Cement by SF & Fly Ash (%)	**5%**	**10%**
Silica Fume	0.0905	0.181
Fly Ash	0.0905	0.181
Adding Aluminium Powder to cement (%)	**3%**	**5%**
	0.1086	0.181

Table 11: Mix Design for Cube

Design Mix			
Materials	**Mix 1**	**Mix 2**	**Mix 3**
Adding(each SF & Fly Ash)	**0%**	**5%**	**10%**
Cement (kg)	1.81	1.629	1.448
Fine aggregate(kg)	1.81	1.81	1.81
Coarse Aggregate (kg)	3.62	1.81	1.81
Brick Ballast(20mm, kg)	0	1.81	1.81
Silica fume(Kg)	0	0.0905	0.181
Fly Ash(Kg)	0	0.0905	0.181
Aluminium Powder(kg)	0	0.1086	0.181
w/c ratio	0.45	0.45	0.45
Water content (kg)	0.8145	0.73305	0.6516

3.5.4.2 Beam size or 100x100x700 mm

To maintaining the continuity of concrete structure and corrosion of reinforcement the flexure strength of concrete is conducted. The standard beam mould of 15cmX 15cmX70cm is used for the aggregate size upto 30 mm. The machine which are use to determine flexure strength of concrete is Universal Testing Machine (UTM) which are capable of applying load of 4 kN/min for 150 mm specimen and 1.8 kN/min for 100 mm specimen.

Table 12: Mix Design for Beam mould

Materials	Mix 1	Mix 2	Mix 3
Adding (each SF & Fly ash)	**0%**	**5%**	**10%**
Cement (kg)	2.68	2.412	2.144
Fine aggregate(kg)	2.68	2.68	2.68
Coarse Aggregate (kg)	5.36	2.68	2.68
Brick Ballast(20mm,kg)	0	2.68	2.68
Silica fume(Kg)	0	0.134	0.268
Fly Ash(Kg)	0	0.134	0.268
Aluminium Powder(kg)	0	0.0804	0.134
w/c ratio	0.45	0.45	0.45
Water content (kg)	1.206	1.0854	0.9648

Table 13: Admixture Proportion for beam mould

Replacing of Cement (%)	5%	10%
Silica Fume	0.134	0.268
Fly Ash	0.134	0.268
Adding Aluminium powder to cement(%)	**3%**	**5%**
	0.0804	0.134

3.5.4.3 For Cylinder of 150 mm diameter and 300 mm height

As we know that the concrete is compression member, so the compressive strength of the concrete is the major parameter. Higher durability of the concrete depends on the compressive strength. 150 mm cubes are generally used for testing the compressive strength at 28 days, etc. 150mm diameter and 300 mm high of cylinder are also used for the compressive strength test. The mix design of cylinder is prepared as per volume of the cylinder.

Table 14: Mix design for Cylinder mould

Materials	Mix 1	Mix 2	Mix 3
Adding (each SF & Fly ash)	**0%**	**5%**	**10%**
Cement (kg)	2.84	2.556	2.272
Fine aggregate(kg)	2.84	2.84	2.84
Coarse Aggregate (kg)	5.68	2.84	2.84
Brick Ballast(20mm, kg)	0	2.84	2.84
Silica fume(Kg)	0	0.142	0.284
Fly Ash(Kg)	0	0.142	0.284
Aluminium Powder(kg)	0	0.0852	0.142

w/c ratio	0.45	0.45	0.45
Water content (kg)	1.278	1.1502	1.0224

Table 15: Admixture proportion for cylinder mould

Replacing of Cement (%)	**5%**	**10%**
Silica Fume	0.142	0.284
Fly Ash	0.142	0.284
Adding Aluminium powder to cement(%)	**3%**	**5%**
	0.0852	0.142

CHAPTER 4
RESULT AND DISCUSSION

4.1 Introduction

After the full literature reviews, the one can get good quality and affordable structural concrete which are light in weight and called Lightweight concrete by adding admixtures such as silica fume and Fly Ash. In general, proper proportioning mixing of cement, sand, silica fume, aggregates and Fly ash can produce high compressive strength to the concrete. It will reduce the dead load of the structural element; increase the fire resistance and durability, and economically as compared to conventional concrete. The appropriate aggregates, proportioning, mixing, their batching, transportation and placing make the quality of concrete durable. It is found that the water-cement ratio plays very important factors in the concrete mix, strength, setting time and workability of the concrete. Less the water/cement ratio more the workable and faster initial setting. Generally the 0.45 to 0.5 Water-cement ratios are used.

4.2 Laboratory Investigation

The various casting, curing and testing procedure which has been taken for the project are discussed below. In this section, the experimental data are analyzed as per design mix concrete, representing various data in graphical.

4.2.1 Casting of Mould

For controlling the quality of concrete work, proper methods of casting should be adopted as it is depend on the fresh concrete mix properties. The cube, cylinder and beam moulds are taken for the sample casting. The total number of mould casted is 27, and 9 samples mould for cube, cylinder, and beam respectively. Following are the details:

Table 16: Number of Samples

Mould	Number of sample for Testing target days		
	7 Days	**14 days**	**28 days**
Cube (150x150x150mm)	3	3	3
Cylinder (150mm dia, 300mm Height)	3	3	3
Beam (700x100x100mm)	3	3	3

The concrete sample casting is one the important factors which depends upon the mix proportioning, quality of aggregates, batching proportioning, mixing, placing and transportation. The casting samples during the execution of work are depicted as follows:

Figure 2: Mould and Material preparation

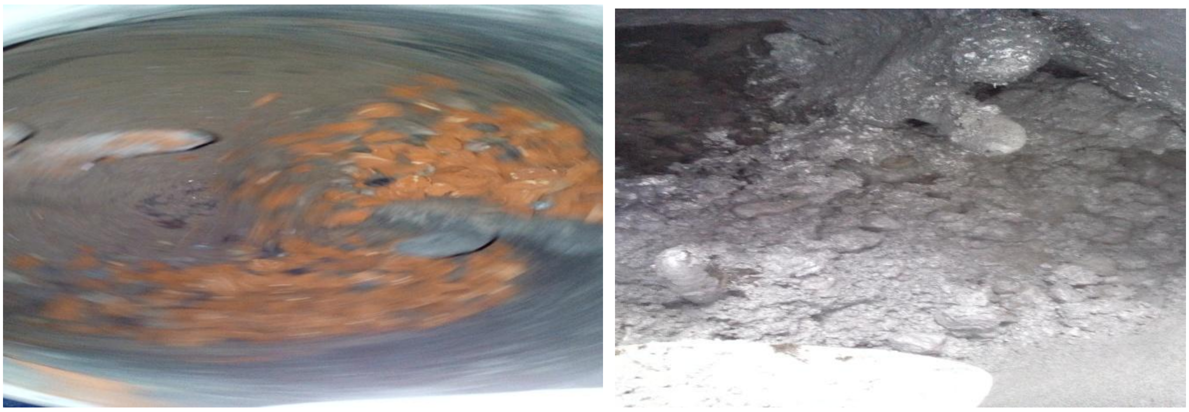

Figure 3: Batch Mixing

Figure 4: Sample Casting

All the moulds shall be stripping without vibration and shock to avoid the damage of concrete sample. Before remove the mould, bolts and nuts shall be removed by carefully. After removed the mould the samples are kept in the curing tank for gain the desired strength in respective days.

Figure 5: Demoulding

4.2.2 Testing of Specimens

For greater achieving of efficiency of the used material, sample testing is very important to determine the compressive strength, flexural strength and durability of samples. The test methods conforming IS : 516 – 1959 for strength of concrete. The test is conducted under compression testing machine (CTM).

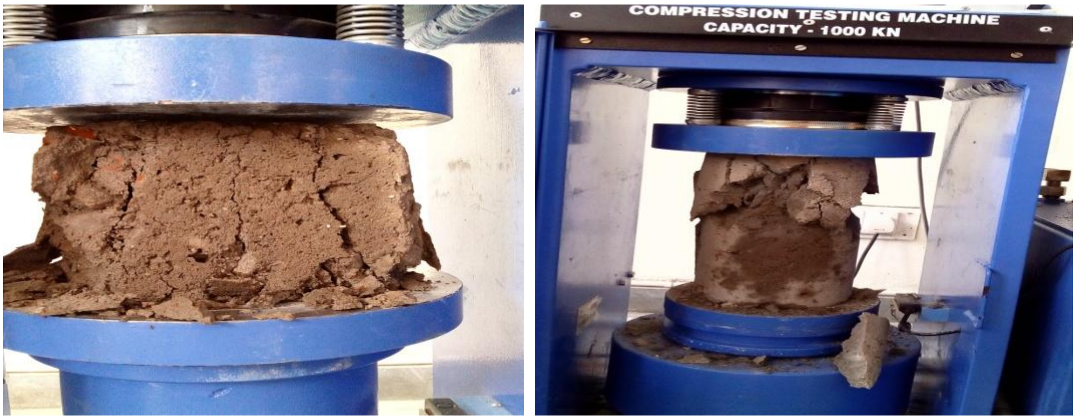

Figure 6: Cube and Cylinder testing

As concrete is primarily strong in compression and in actual construction, the concrete is used in compression. This apparatus is use to test for compressive strength of the concrete, which is very important in quality control of concrete. The cube mould of 15 cm size is to be used as per IS: 516 for testing at 7 days, 28 days etc.

Figure 7: Beam sample Testing

4.3 Result Analysis

4.3.1 Adding of Aluminium Powder: During the mixing of aluminium powder at the final stage of mixtures, the mixtures produces heat which consequences that the chemical reactions are taking place in mix batches. When mixtures are poured into the mould, the hissing sound was produced and foul smell was also produced which shows the presence of gas in the mixture. After a few minutes of the pouring of mixtures into the mould, the mixtures slurry was raised from top of mould which confirmed that increased in the volume of concrete mix.

Figure 8: Raised mixtures

Table 17: Percentage of Volume Increased

Mould	Dimension (cm)				Dimension Increased in sample (cm)				Increased (%)
	Length	Breadth/ Dia	Depth	Volume (cm^3)	Length	Breadth /Dia	Depth	Volume (cm^3)	
Cube	15	15	15	3375	15	15	16.1	3622.5	7.33
Cylinder		15	30	5298.75		15	32	5652	6.67
Beam	50	10	10	5000	50	10	11.3	5650	13

From the above table, it is noted that the volume increased between 7% to 15% normal volume of mould, which witness the forming of lightweight concrete.

4.3.2 Adding of Silica fume and fly ash

Silica fume and Fly ash minimize the amount of cement which will be economical but the excess use of these admixtures can lead to reduced the desired target like compressive strength, durability, fire resistance and even can failure in the element of structure. These admixtures will enhance the concrete properties if we use proper proportioning. This proportioning will be performing as per the mix design that made.

Replacing cement by 5% and 10% of silica fume results the increase in compressive strength, reduces permeability, good workability, less bleeding and segregation. 5% and 10% of silica gave good results overall as compared to the normal or conventional practices. It is found that the 10% of silica fume adding to cement result relatively improved the properties of concrete such as compressive strength, permeability and workability.

Also 5% and 10% of fly ash results that the longer strength gaining, lower shrinkage, good finishing surface, enhances the initial setting time of concrete. It is found that 10% fly ash replacing cement has decreases the initial setting time as more content of fly ash increases the setting time of concrete.

As silica fume and fly ash are adding 5% and 10% of cement weight respectively, the total admixtures adding for Mix 2 is 10% and Mix 3 is 20% of cement weight respectively. So, the Mix 2 results in low initial setting time, fast gaining of compressive strength, more permeability and good workability as compared to Mix 3, because the percentage of admixtures adding to the cement is more and both silica fume and fly ash are accelerating admixtures.

4.3.3 Adding of Brick Ballast:

As brick is the universal building material, which is cheaper than other material, less lifting material, ease of placing handling and transportation. The brick is porous material which has a bulk density of 16 to 18 kN/m^3 generally and has a compressive strength of 3.50 kN/m^2 and crushing strength of 7 N/mm^2 to 14 N/mm^2.

In the project, the wasted brick at construction sites are broken into a 10mm to 20mm of size. This is uses as lightweight aggregates by replacing 50% of natural coarse aggregate. As brick ballast is light in weight, it decreased the weight of concrete mix. Since, it is porous material the water absorption are more and results more demand in water content in the mix, but presence of aluminium powder nullify the water demand in the mixtures.

4.3.4 Compressive Strength

Concrete is primarily strong in compression. The Compression Testing Machine is use to test for compressive strength of the concrete, which is very important in quality control of concrete. The cube mould of 15 cm and cylinder of 150mm diameter and 300 mm height is used for the testing of hardened specimens conforming as per IS: 516 f at 7 days, 14days and 28 days. The following shows the experimental results of compressive strength for conventional concrete and lightweight concrete.

The value of experimental work is as follows:

Table 18: Compressive Strength Vs Days

Days	Compressive Strength (N/mm^2)		
	Mix 1	Mix 2(5%)	Mix 4(10%)
7	3	3.2	4.7
14	13.7	9.3	11.8
28	25	17.1	17.6

Table 19: Compressive Strength against Admixture adding (%)

Aluminium Powder (%)	Silica fume (%)	Fly Ash (%)	Normal Mix	Mix 2	Mix 3
0	0	0	3	0	0
3	5	5	13.7	10.5	11.8
5	10	10	25	21.3	23.73

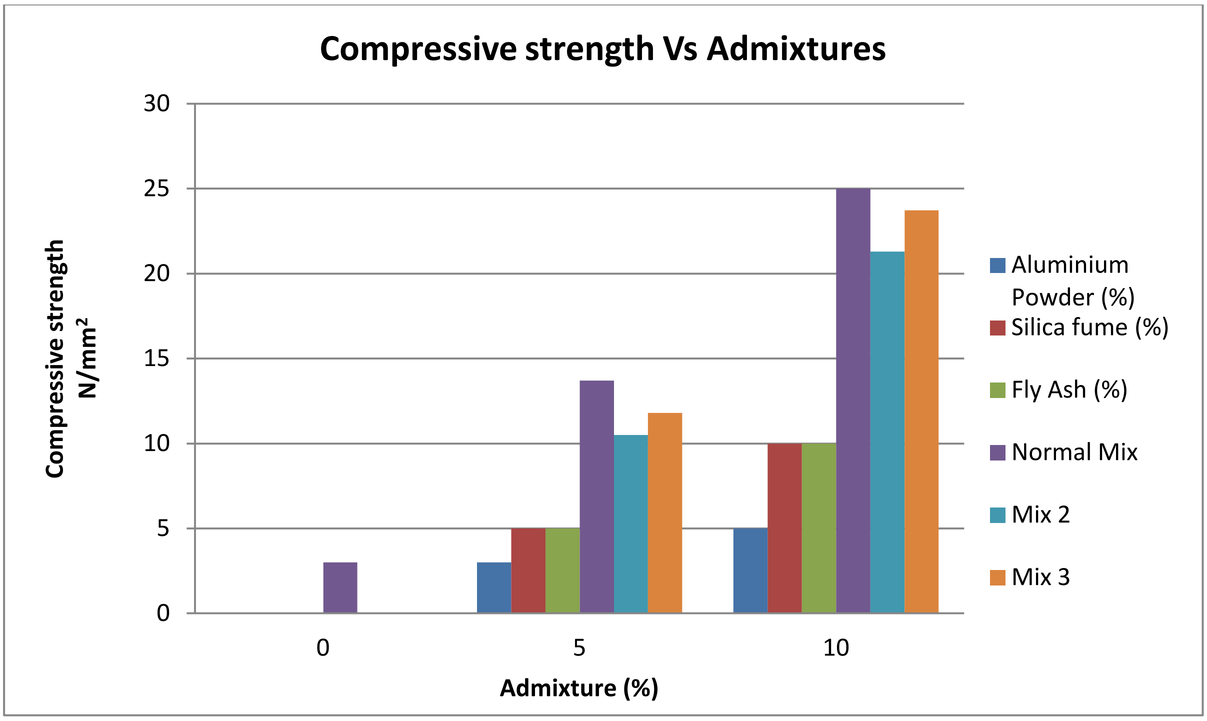

Figure 9: Compressive Strength Vs Admixtures(%)

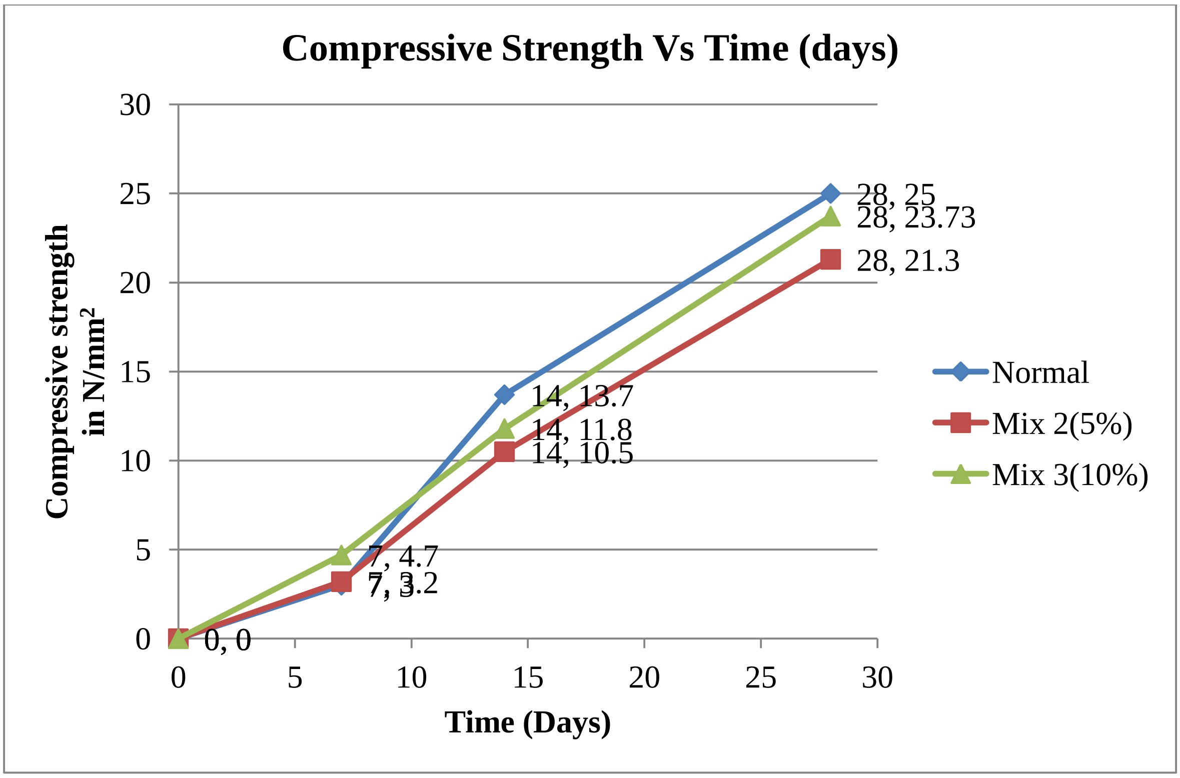

Figure 10: Compressive Strength Vs Age

4.3.5 Flexural Strength

The beam size of 500mmx100mmx100mm is used to determine the flexural strength of concrete. The testing of concrete conforming IS: 516, for the method of testing procedure. The various results as per test specimens are as follows:

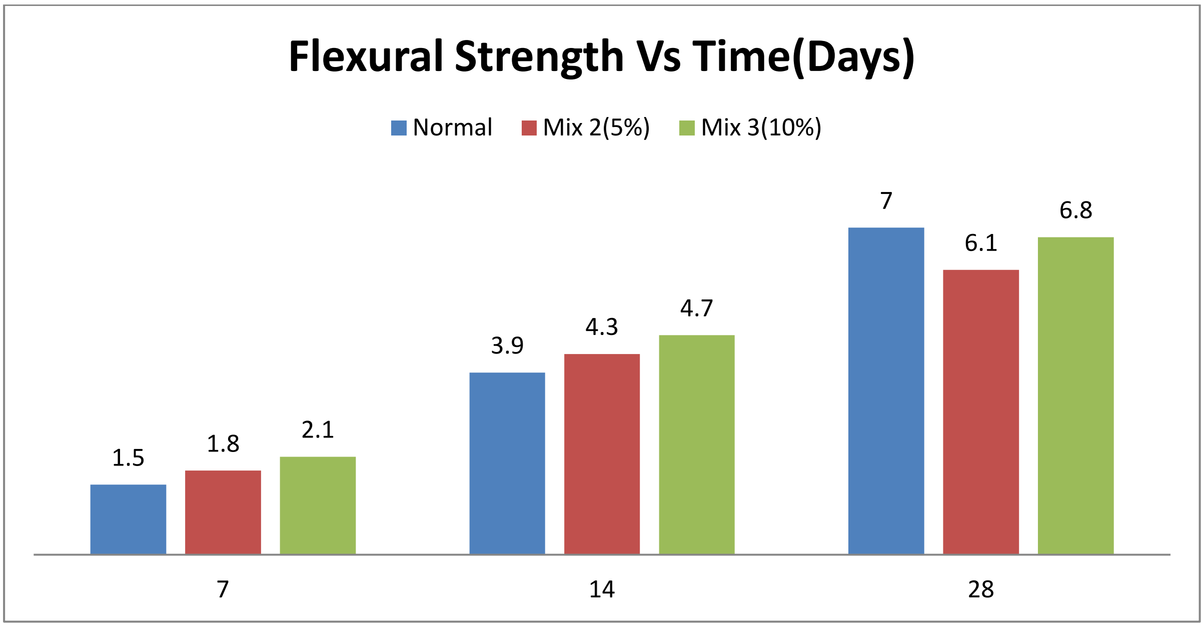

Figure 11: Flexural strength Vs Age

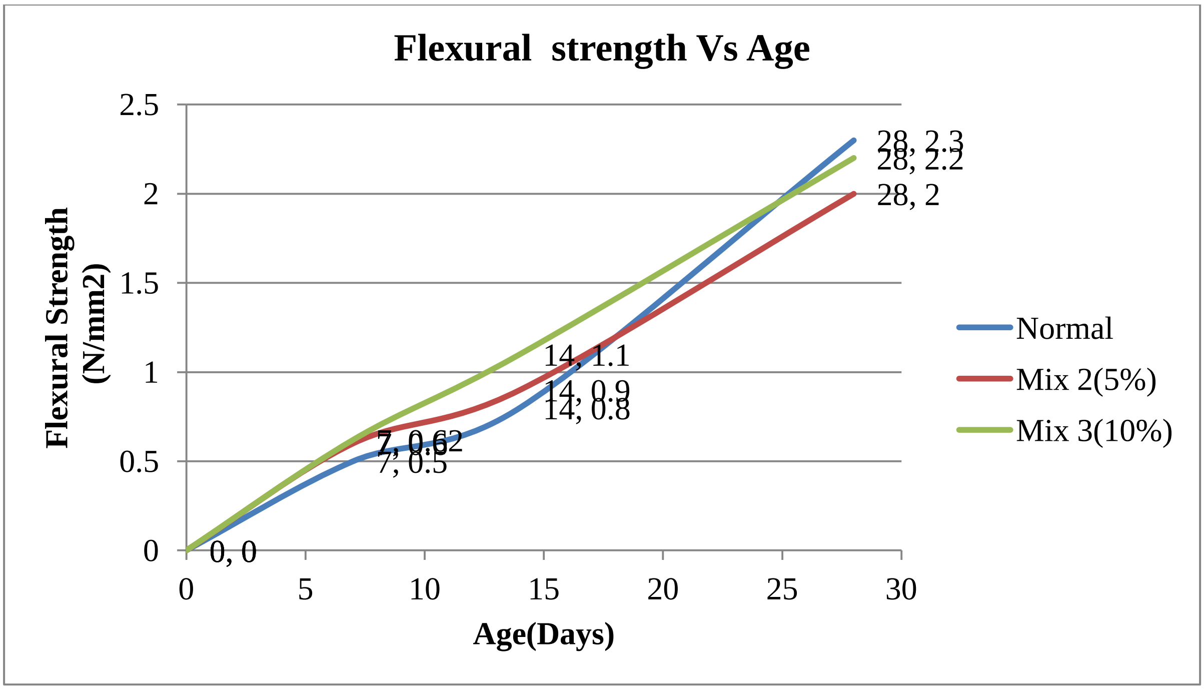

Figure 12: Flexural strength

Table 20: Flexural Strength

		Flexural Strength (N/mm^2)	
Days	Normal (Mix 1)	Mix 2	Mix 3
7	1.5	1.8	2.1
14	3.9	4.3	4.7
28	7	6.1	6.8

4.3.6 Percentage of weight Reduction

The main important factors which define Lightweight concrete is its dead weight or self weight. The volume of concrete increases due to presence of aluminium powder, which reduced the self-weight of concrete and relatively the use of brick ballast as lightweight aggregate has massive impact on the self-weight of concrete.

Figure 13: Self-Weight of Normal Concrete (Cylinder & Beam)

Figure 14: Self-weight of normal cube

Figure 15: Self-weight of Lightweight concrete

Figure 16: Self-weight of LW beam

The 3% and 5% of aluminium powder are added to mix 2 and mix 3 respectively. It is found that 30.9%, 33.92% and 39.79% reduction of self-weight of lightweight concrete as compared to normal or conventional concrete mix.

Table 21: Weight Reduction

Mould	**Weight (kg)**		**Reduced Weight (%)**	
For Cube				
Mix 1	Mix 2(3%)	Mix 3(5%)	Mix 2	Mix 3
7.7	5.5	4.9	28.57	36.36
8.7	6.15	5.1	29.31	41.38
8.9	5.8	5.2	34.83	41.57
		Average Reduction	30.90	39.77
For Cylinder				
12.7	8.02	7.3	36.85	42.52
13.1	9.47	7.8	27.71	40.46
12.9	8.1	7.1	37.21	44.96
		Average Reduction	33.92	42.65
For Beam				
11.59	7.85	7.1	32.27	38.74
12.5	8.93	7.3	28.56	41.60
12.3	8.79	6.9	28.54	43.90
		Average Reduction	29.79	41.41

4.4 DISCUSSION

After the analysis of result, the adding of 3% and 5% of aluminium powder to cement, aggregates massively increases the volume of concrete mix and produces gases in the mixtures which later on escaped and formation of small pores in concrete. It result in reduced the self-weight of concrete and reduced the quantity of other materials which is economic factor.

Replacing the natural aggregates by brick ballast (50%) contributes to developing of lightweight concrete. Brick ballast is a material with porous nature which absorbs water during mixing and dries after sufficient curing.

The compressive strength and flexural strength of Lightweight concrete are relatively lowered than the normal concrete or conventional concrete. It is due to the over expansion of concrete and unwell strength of brick ballast but it lowered the economic factor which are most important in construction management.

Table 22: Water Absorption for Cube specimen

S No.	**Weight of Fresh Mix Concrete (kg)**				**Dry Weight (After 28 Days) in Kg**			**Water Absorption of normal mould (%)**	
	Mix 1	**Mix 2**	**Mix 3**	**Mix 1**	**Mix 2**	**Mix 3**	**Mix 1**	**Mix 2**	**Mix 3**
1.	17.44	11.21	9.5	7.7	5.5	4.9			
2.	18.34	12.32	10.8	8.7	6.15	5.1			
3.	18.61	12.37	10.31	8.9	5.8	5.2	53.48	51.39	50.34
Average	18.13	11.97	10.20	8.43	5.82	5.07			

The absorption of water percentage is more in normal mixes or conventional concrete mix i.e Mix 1, thus it increases the dead weight of concrete. The Mix 2 and Mix 3 has contain less water thus light in weight.

CHAPTER 5
CONCLUSION AND FUTURE SCOPE

5.1 General

The main objective is to develop lightweight concrete by adding available lightweight aggregates, admixtures such as fly ash and silica fume and aluminium powder as air entraining agent. To study the compressive strength, tensile strength, creep, durability, fire resistance, ease of placing & handling and it's economical. The objective is to reduce excess material use and it would be to lighten the load on a structure, ease for placing, handling, and fast construction and to gain high compressive strength. The proper proportioning mixing of cement, sand, silica fume, aggregates and Fly ash can produce high compressive strength to the concrete. It will reduce the dead load of the structural element; increase the fire resistance and durability, and economically as compared to conventional concrete. The appropriate aggregates, proportioning, mixing, their batching, transportation and placing make the quality of concrete durable. It is found that the water-cement ratio plays very important factors in the concrete mix, strength, setting time and workability of the concrete

5.2 Conclusion

Lightweight Concrete is generally lighter than conventional concrete. It is developed by replacing natural aggregate with 50% brick ballast and adding 3% and 5% of aluminium powder to the cement. As silica fume and fly ash are adding 5% and 10% of cement weight respectively, the total admixtures adding for Mix 2 is 10% and Mix 3 is 20% of cement weight respectively. So, the Mix 2 results in low initial setting time, fast gaining of compressive strength, more permeability and good workability as compared to Mix 3, because the percentage of admixtures adding to the cement is more and both silica fume and fly ash are accelerating admixtures.

Aluminium powder added in the mixtures form gas and escape after setting which lead to the formation of empty voids filled by air thus it is good for soundness effect. It also can absorb the thermal effect. The compressive strength and flexural strength of Lightweight concrete are relatively lowered than the normal concrete or conventional concrete. It is due to the over expansion of concrete and unwell strength of brick ballast but it lowered the economic factor which are most important in construction management.

Thus the developing of lightweight concrete can lead to next generation building materials. The using of silica fume and fly ash minimize the cement requirement, it also improve the various concrete properties. The lightweight concrete has following properties:

i. 25% to 40% lighter than conventional concrete.

ii. Relatively good compressive strength as compared to conventional concrete.

iii. Using of silica fume and fly ash give better workability.

iv. Flexural strength varies between 0.5 to 3 N/mm^2.
v. Good sound resistance.
vi. Give better surface finishing.
vii. Ease of handling, placing and transportation.
viii. Less in self-weight or dead weight.

5.3 Future scope of Lightweight Concrete

The lightweight concrete can be developing by any lightweight aggregates and expanding agent which are available at vicinity of construction site. Application of lightweight concrete can be widely used as:

i. Due to less in dead weight, lightweight concrete can be used in partition walls and high rise building.
ii. It can be used on the roof or top of the building as less dead weight.
iii. It can be used where no live load are acting.
iv. It can be used as thermal and sound resistance.
v. Because of ease of placing, handling and transportation, no requirement of skilled labour which will lower the economic factors.
vi. It can be used in the place of earthquake prone area as it will reduce the dead load of structures.
vii. Lightweight concrete can be cast in bulk, which the production of samples will be more.

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