“BISMILLAHIR RAHMANIR RAHIM”

COMPARATIVE STUDY ON FLEXURAL STRENGTH OF NORMAL CONCRETE SLAB AND STEEL WIRE MESH CONCRETE SLAB

By

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A thesis submitted to the Department of Civil Engineering in partial fulfillment for the degree of Bachelor of Science in Civil Engineering

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Sonargaon University
147/I, Green Road, Dhaka-1215, Bangladesh
Section: 17B
Fall-2022

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We hereby declare that this thesis/project or any part of it has not been submitted elsewhere for the award of any degree or diploma. All information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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Dedicated
to
Our
Beloved Parents

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ABSTRACT

In this study, experimental investigations were performed on Normal Concrete and Steel wire mesh concrete to evaluate performance characteristics such as flexural Strength and load capacity. The flexural strength of concrete is one measure of the strength of unreinforced concrete. It refers to the ability of the concrete beam or slab that is being tested to resist bending. Concrete is the most widely used construction material in the modern construction practice. Due to its relatively low tensile resistance, concrete tends to experience tensile failure and cracking under external loads. To enhance the tensile performance and ductility of concrete material, possible solution including steel wire mesh reinforcement are investigated in the present study. Normal Concrete and steel wire meshes were mixing ratio 1: 1.5: 3in the concrete mixer. In this study slab specimen size was 24”x18”x5”. Experiments have been conducted using 3 slabs for normal concrete slabs and 3 slabs for Steel wire mesh concrete slabs and were tested for 7 days, 14 days and 28 days. Ordinary Portland cement (OPC) was used in our study. Results found from our test results indicate that the flexural strength of the normal concrete slab and steel wire mesh concrete slab increases with the increase of different days. Static material tests including uniaxial compression and flexural bending tests showed that the steel wire mesh addition yielded better strength. The advantages and disadvantages of using different reinforcing materials are discussed. From the results, the advantages of replacing steel wire mesh were demonstrated.

In this study, in our test we found the flexural strength of steel wire mesh concrete slab to be higher than that of normal concrete slab. So we can say that steel wire mash concrete slab is better to use than normal concrete slab as per our experiment.

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CHAPTER 1
INTRODUCTION

1.1 General

In conventional construction practice, concrete is proportioned to minimize cost while achieving adequate workability and strength.
Water, aggregate, and cement composes main composite material in concrete. By replacing the construction materials from the industrial waste materials. In the concrete mix the percentage of aggregate is 60 – 70%. When comparison is done to the conventional concrete and the concrete prepared by replacing by product shows improved workability and durability and can be used in the construction works.

Our Thesis topic is Comparative study of flexural strength of normal concrete slab and steel wire mesh concrete slab. In this experiment we have tried to compare the strength of normal concrete and steel wire mesh concrete. Here we used sylhet sand, stone chips, cement and steel wire mesh to prepare the slab. Normal Concrete and steel wire meshes were mixing ratio 1: 1.5: 3 in the concrete mixer. To enhance the tensile performance and ductility of concrete material, possible solutions including fibre reinforcement and steel wire mesh reinforcement are investigated in the present study. This experiment is based on which flexural strength works better between normal concrete and steel wire mesh concrete.

Low tensile strength and brittleness are the main reason for concrete shear damage and spallation, and efforts have been devoted to improving concrete tensile performance. In a previous experimental study, an optimal amount of high-performance fibre addition has been proven to be effective providing micro confinement and bridging effect so as to increase the concrete tensile capacity. In addition, researchers confirmed that concrete shear strength also benefits from the addition of fibre material [3].

1.2 Objectives

A study was, therefore, made in the Department of Civil Engineering,Sonargaon University, with the following objectives:

1) To observe the variation of flexural strength of normal concrete slab and steel wire mesh concrete slab.

2) To determine the relationship of load-deflection behaviour of wire meshes.

3) To find out a suitable alternative of normal concrete with enhanced strength.

1.3 Materials

This study was conducted in the Concrete and Material Testing Laboratory of Sonargaon University. The materials used and the methods followed for testing the specimens are discussed below.

1.3.1 Steel Wire mesh

The welded wire mesh is a metal wire screen that is made up of low carbon steel wire or stainless steel wire.
Steel fibre reinforcement, steel wire mesh is another option that can be used to reinforce the high strength concrete or UHPC in which less or none coarse aggregates are used. Steel wire meshes enable a wide range of structural shapes with programmable structural mechanical and physical properties. Comparing with micro steel fibers of which the mix material cost is high, steel wire mesh is a relatively cost effective solution to reinforce the high strength concrete [9].

1.3.2 Cement

Normal Portland (Type-I) cement passing ASTM 300 micron sieve was used for making cement mofiar.

1.3.3 Sand

Sylhet sand passing ASTM sieve No. 4 (4.75 mm) and having fineness modulus (F.M) of 3.98 was used throughout the study.

1.3.4 Water

Supplied tape water was mixed with cement to make mortar, and the same water was used for curing of test specimens.Water binder ratio 0.45 was considered for experimental work.

1.3.5 Tying of wire mesh

All types of meshes were cut into a rectangular cross-section of 900x300mm and the steel rods were cut into a length of 900mm. For each type of wire mesh three different series of reinforcement were applied. In first series, one layer of wire mesh was tied with skeletal steel using tying wire of 22 gauge (0,559 mm). The skeletal steels were used longitudinally at 150mm center to center. For second series, two layers of wire mesh were used and each layer was tied on both sides of the skeletal steel. in the third series, four layers of mesh were used: two layers were tied on one side and two layers on other side of the skeletal steel.

1.3.6 Mortar preparation

The proportion of cement-sand generally varies from 1 part cement with 1.5 sand. In the present study a cement-sand proportion of 1:1.5 was selected and for all mixes a water cement ratio of 0.4 was maintained. Sand was properly sieved and thoroughly dry-mixed with cement using trowel. Then the requisite amount of water was added and mixed until a uniform mix was obtained.

1.3.7 Plastering

The plastering operation was done on the floor of the concrete laboratory. The ground was cleaned and a poletheline sheet was spread over the area before the wooden frame was laid. At frrst, a thick layer (about 10mm) of mortar was laid and the wire mesh was placed over the wet mortar in such a way that the mortar encases the bottom layer of mesh in the slab having an effective cover of 5mm. Plastering was continued over the wire mesh and the surface was leveled with a wooden float maintaining the thickness of slab to 25mm all over the specimen.

1.3.8 Curing

The curing of ferrocement slabs was started 24 hours after completion of the plastering. Jute bags were used to cover the slab for curing. They were kept moist at all times for 28 days with regular application of water.

1.4 Properties of Fine and Coarse Aggregate and Steel Wire Mesh

1.4.1 Properties of Fine Aggregate

The properties of the Fine Aggregates are as follows:

- Size.
- Strength.
- Shape.
- Specific Gravity.
- Surface Texture.
- Fineness Modulus.
- Water Absorption.
- sorptivity.

1.4.2 Properties of Coarse Aggregate

The properties of the Coarse Aggregates are as follows:

- Composition.
- Size and Shape.
- Surface Texture.
- Specific Gravity.
- Bulk Density.
- Voids.
- Porosity and Absorption.
- Bulking of Sand.

1.4.3 Properties of Steel Wire Mesh

The Properties of Steel Wire Mesh are as follows:

- Corrosion Resistance. Metals like iron are not used in a pure form due to poor corrosion resistance properties.
- Temperature Tolerance.
- Easy To Manufacture.
- Aesthetic Appeal.
- Low Maintenance [5].

1.4.3.1 Corrosion Resistance

Metals like iron are not used in a pure form due to poor corrosion resistance properties. Stainless steel, on the other hand, has a very high threshold with respect to corrosion and can withstand extreme temperature fluctuations, pressure changes, variations in moisture, acidity, alkalinity and more [5].

1.4.3.2 Temperature Tolerance

This type of wire mesh also has the ability to handle extreme temperature fluctuations, and consequently pressure change. Thus, it is often used in construction to pour concrete or as a filler to hold it together. However, the wire mesh will need to be treated differently depending on its application, as regular stainless steel behaves differently in extremely low and high temperatures [5].

1.4.3.3 Easy To Manufacture

Due to high tensile strength and malleability, stainless steel wire meshes can be easily manufactured by weaving them in a loom according to the required patterns [5].

1.4.3.4 Aesthetic Appeal

Apart from being non-corrosive, the presence of chromium also adds a glossy, metallic look to the steel mesh, making it an aesthetic and functional choice for many purposes such as wall decoration and perimeter fencing [5].

1.4.3.5 Low Maintenance

Since it is highly durable and tough, this steel wire mesh can serve its purpose for a long time without the need for replacement or repair.Thus, it's quite cost-effective for companies to install them, as they require little to no maintenance. Moreover, it is also easily cleanable, making it an integral part of the medicine and foodservice industry due to its hygienic qualities [5].

1.5 Determination of Flexural Strength

1.5.1 Flexural Strength

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis.
The flexural strength is expressed as the modulus of rupture (MR) in psi (MPa). There are two standard test methods to determine the flexural strength of a concrete slab: Center point loading test (as per ASTM C 293) – In this test method, the entire load is applied at the center of the slab's length.
So to calculate the flexural strength (σ), multiply the force by the length of the sample, and then multiply this by three. Then multiply the depth of the sample by itself (i.e., square it), multiply the result by the width of the sample and then multiply this by two. Finally, divide the first result by the second.

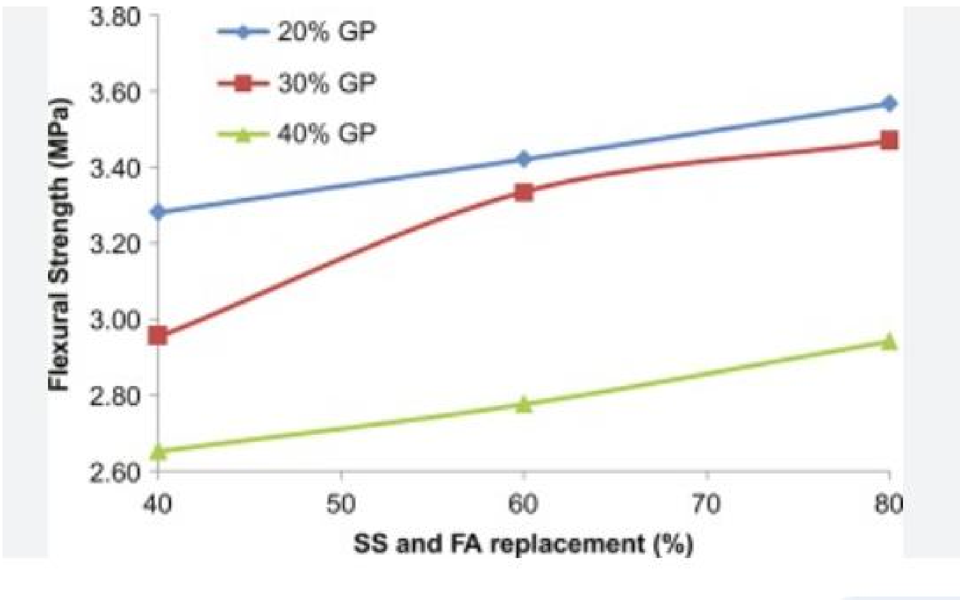

Figure 1.1 : Flexural Strength
(Collect From Wikipedia)

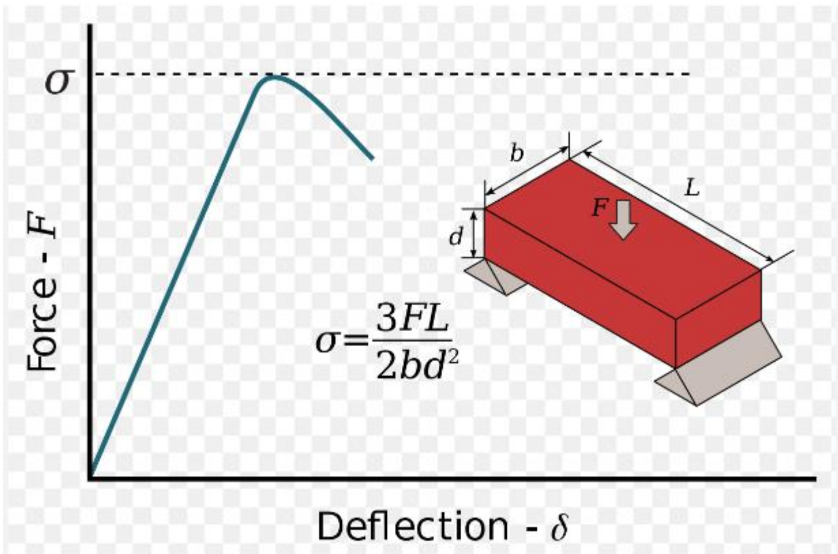

Figure 1.2 : Flexural Strength
(Collect From Wikipedia)

Note: Depiction of the flexural strength, the surface stress at failure in bending. It is equal or slightly larger than, the failure stress in tension.

1.6 Organization of the Thesis

The Thesis contains five chapters

Chapter One Introduction and Objectives. This chapter provides the background and motivations of the research. The overall objectives and expected outcomes are also described in this chapter and Outline of the Methodology and organization of the Thesis

Chapter Two Presents a review of Literature.

Chapter Three Materials and Methodology. This chapter describes the methodology adopted to carry out the research.

Chapter Four Includes results and detailed analysis.This chapter describes the results of the variation of flexural strength of normal concrete slab and steel wire mesh concrete slab.

Chapter Five includes the conclusions of the research work and recommendations. This chapter summarizes the conclusions and major contributions of this study and provides recommendations for future studies.

Figure 1.3 : Flow Chart of Comparative Study on Flexural Strength of Normal Concrete Slab and Steel Wire Mesh Concrete Slab.

CHAPTER 2
LITERATURE REVIEW
2.1 Introduction

Strength and workability are both dominating factors in the making of concrete. Strength can be increased by increasing cement content but this in fact reduces the workability. Moreover,the water content can be increased for better workability, but this affects the strength. Hence, a perfect balance is to be maintained for both strength and workability. Furthermore, besides cement and water content, some other factors contribute greatly, which will be discussed as follows.

2.2 Factor Affects The Rate of Concrete Strength
2.2.1 Quality of Raw Materials

Cement: Provided the cement conforms with the appropriate standard and it has been stored correctly (i.e. in dry conditions), it should be suitable for use in concrete.
Aggregates: Quality of aggregates, its size, shape, texture, strength etc determines the strength of concrete. The presence of salts (chlorides and sulphates), silt and clay also reduces the strength of concrete.
Water: frequently the quality of the water is covered by a clause stating “the water should be fit for drinking”. This criterion though is not absolute and reference should be made to respective codes for testing of water construction purpose [7].

2.2.2 Water Cement Ratio

The higher the water/cement ratio, the greater the initial spacing between the cement grains and the greater the volume of residual voids not filled by hydration products. There is one thing missing on the graph. For a given cement content, the workability of the concrete is reduced if the water/cement ratio is reduced. A lower water cement ratio means less water, or more cement and lower workability. However if the workability becomes too low the concrete becomes difficult to compact and the strength reduces. For a given set of materials and environment conditions, the strength at any age depends only on the water-cement ratio, providing full compaction can be achieved [7].
The relation between water cement ratio and strength of concrete is shown in the plot as shown below:

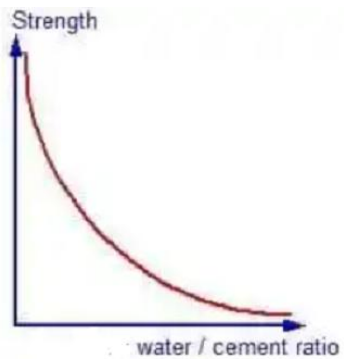

Figure 2.1 : Water Cement Ratio and Strength of Concrete.

2.2.3 Coarse / Fine Aggregate Ratio

Following points should be noted for coarse/fine aggregate ratio:

- If the proportion of fines is increased in relation to the coarse aggregate, the overall aggregate surface area will increase.
- If the surface area of the aggregate has increased, the water demand will also increase.
- Assuming the water demand has increased, the water cement ratio will increase.
- Since the water cement ratio has increased, the compressive strength will decrease.

2.2.4 Aggregate Cement Ratio

Aggregates are the main reason to impart strength to concrete, hence increasing the cement-to-aggregate ratio will result in the increase of strength. Aggregates that are better in quality tend to absorb less water and so that the amount of water can be used for hydration of cement.
Following points must be noted for aggregate cement ratio:

- If the volume remains the same and the proportion of cement in relation to that of sand is increased the surface area of the solid will increase.
- If the surface area of the solids has increased, the water demand will stay the same for the constant workability.
- Assuming an increase in cement content for no increase in water demand, the water cement ratio will decrease.
- If the water cement ratio reduces, the strength of the concrete will increase [7].

The influence of cement content on workability and strength is an important one to remember and can be summarized as follows:

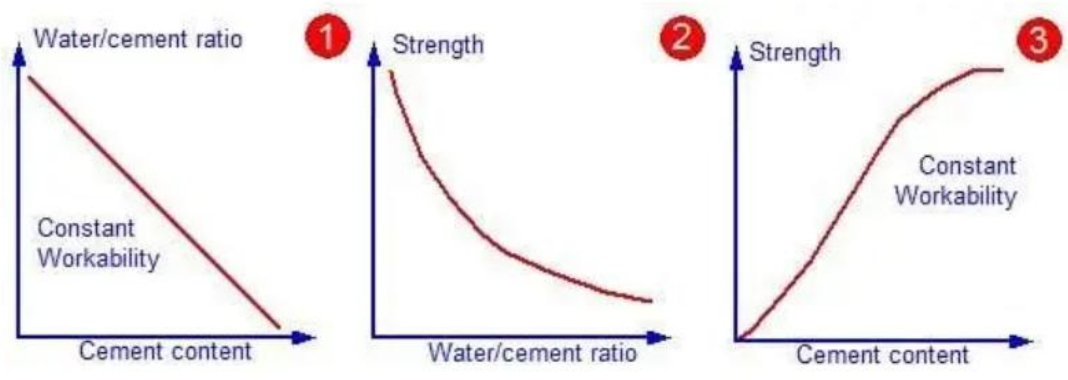

Figure 2.2 : Aggregate Cement Ratio and Strength of Concrete.

1. For a given workability an increase in the proportion of cement in a mix has little effect on the water demand and results in a reduction in the water/cement ratio.
2. The reduction in water/cement ratio leads to an increase in strength of concrete.
3. Therefore, for a given workability an increase in the cement content results in an increase in strength of concrete [7].

2.2.5 Cement Type and Quality

Cement is the primary ingredient of concrete, Increasing quantity of cement can significantly increase strength and durability of concrete. But excess amount of cement content has negative effect: increased amount of cement causes higher internal during finishing and curing, makes the mixture sticky and may load to increased risk of shrinkage and cracking problem.

Rapid hardening cement gain strength more rapidly portland cement.Again ordinary portland cement gain strength at early age whereas portland composite cement gain strength in long term.

2.2.6 Age of Concrete

The degree of hydration is synonymous with the age of concrete provided the concrete has not been allowed to dry out or the temperature is too low. In theory, provided the concrete is not allowed to dry out, then it wil always be increasing albeit at an ever reducing rate. For convenience and for most practical applications, it is generally accepted that the majority of the strength has been achieved by 28 days [7].

2.2.7 Temperature

The higher the temperature of concrete at placement the greater initial rate of strength development, but lower the long term strength. The rapid initial hydration causes non-uniform distribution of concrete gel with a poorer physical structure which produces more porous concrete. The reason is that at with high initial temperature, there is insufficient time available for the product of hydration to diffuse away from cement grain and it results in concentration of hydration products in the vicinity of hydrating cement grain. This process retards subsequent hydration.
High concrete temperatures increase the rate of hydration, thermal stresses, the tendency for drying shrinkage cracking, and permeability and decrease long-term concrete strengths and durability as a result of cracking.

2.2.8 Admixture

An admixture is defined as “a material other than water, aggregates, cementitious materials, and fiber reinforcement, used as an ingredient of a cementitious mixture to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing”.

Concrete admixtures are natural or manufactured chemicals or additives added during concrete mixing to enhance specific properties of the fresh or hardened concrete, such as workability, durability, or early and final strength.

Concrete's strength may also be affected by the addition of admixtures. Admixtures are substances other than the key ingredients or reinforcements which are added during the mixing process. Some admixtures add fluidity to concrete while requiring less water to be used. An example of an admixture which affects strength is superplasticizer. This makes concrete more workable or fluid without adding excess water. A list of some other admixtures and their functions is given below. Note that not all admixtures increase concrete strength. The selection and use of an admixture are based on the need of the concrete user.

Concrete strength enhancement can be achieved through use of superplasticizer admixtures to produce a low water/cement ratio giving high performance concrete. These admixtures promote a high slump, extremely flowable concrete that achieves high strengths while providing superior workability and pumpability.

2.3 Cement

Cement, as it is commonly known, is a mixture of compounds made by burning limestone and clay together at very high temperatures ranging from 1400 to 1600C [2].

Cement is manufactured through a closely controlled chemical combination of calcium, silicon, aluminum, iron and other ingredients. Common materials used to manufacture cement include limestone, shells, and chalk or marl combined with shale, clay, slate, blast furnace slag, silica sand, and iron ores.

Portland cement, commonly known as “cement”, is an inorganic material obtained by mixing together material such as limestone, sand, clays and iron ores; burning them at a clinkering temperature and grinding the resulting clinker. It develops strength by chemical reaction with water by formation of hydrates. Hydrate products form the binding component that binds together building blocks of concrete gravels. So cement quality largely determines the strength and durability of overall concrete itself. In such various properties of cement need to be checked while approving it for a project.

2.3.1 Chemical composition of Cement

Concrete is prepared by mixing cement, water, and aggregate together to make a workable paste. It is molded or placed as desired, consolidated, and then left to harden. Concrete does not need to dry out in order to harden as commonly thought.

The concrete (or specifically, the cement in it) needs moisture to hydrate and cure (harden). When concrete dries, it actually stops getting stronger. Concrete with too little water may be dry but is not fully reacted. The properties of such a concrete would be less than that of a wet concrete. The reaction of water with the cement in concrete is extremely important to its properties and reactions may continue for many years. This very important reaction will be discussed in detail in this section [2].

Portland cement consists of five major compounds and a few minor compounds. The composition of a typical Portland cement is listed by weight percentage in Table 1.

Cement Compound	Weight Percentage	Chemical Formula
Tri-calcium silicate	50 %	Ca_3SiO_5 or $3CaO{\cdot}SiO_2$
Di-calcium silicate	25 %	Ca_2SiO_4 or $2CaO{\cdot}SiO_2$
Tri-calcium aluminate	10 %	$Ca_3Al_2O_6$ or $3CaO{\cdot}Al_2O_3$
Tetra-calcium aluminoferrite	10 %	$Ca_4Al_2Fe_2O_{10}$ or $4CaO{\cdot}Al_2O_3{\cdot}Fe_2O_3$
Gypsum	5 %	$CaSO_4{\cdot}2H_2O$

Table 2.1: Composition of Portland cement with chemical composition and weight percent.

2.3.2 Hydration of cement

Hydration of cement is the reaction between cement particles and water, including chemical and physical processes. The properties of fresh concrete, such as setting and hardening, are the direct results of hydration. The properties of hardened concrete are also influenced by the process of hydration. Hence, to understand the properties and behavior of cement and concrete, some knowledge of the chemistry of hydration is necessary. The water causes the hardening of concrete through a process called hydration.
The Chemical reaction that takes place between cement and water is called as hydration of cement. This reaction is exothermic in nature, due to which considerable amount of heat is released during hydration of cement. This is called as 'heat of hydration'. The hydration of cement is not a sudden process. This reaction is faster in early period and continues indefinitely at a decreasing rate.

During hydration of cement, C_3S and C_2S react with water and calcium silicate hydrate (C-S-H) is formed along with calcium hydroxide $Ca(OH)_2$.

$2\ C_3S + 6H \rightarrow C_3S_2H_3 + 3\ Ca(OH)_2$
$2\ C_2S + 4H \rightarrow C_3S_2H_3 + Ca(OH)_2$

Calcium silicate hydrate is one of the most important product of hydration process and it determines the good properties of cement. It can be seen from the above reactions that C_3S produces more quantity of calcium hydroxide than C_2S.

Calcium hydroxide is not a desirable product in concrete mass as it is soluble in water and gets leached out thereby making the concrete porous, particularly in hydraulic structures, thus decreasing the durability of concrete.

Calcium hydroxide also reacts with sulphates present in water and soils to form calcium sulphate which further reacts with C_3A and causes deterioration of concrete. This process is known as Sulphate Attack. The only advantage of calcium hydroxide is that, being alkaline in nature it maintains a high pH value in concrete which resists the corrosion of reinforcement.

2.4 Water

Water is the key ingredient, which when mixed with cement, forms a paste that binds the aggregate together [2].
Water is necessary to make the mix adequately workable and it is necessary to hydrate the cement. However, water is not just a liquid used to make concrete, it is involved in the whole life of concrete. Most actions on concrete in service, other than loading, involve water, either pure of carrying salts or solids. The important influences of water, in addition to those on workability and strength, are those on: setting, hydration, bleeding, drying shrinkage, creep, ingress of salts. So the quality of water is important because impurities in it may interfere with setting of concrete, may adversely affect strength of concrete. In many specification; the quality of water is covered by a clause saying that water should be fit for drinking. But drinking water may be unsuitable if it contains high concentration of sodium or potassium. As a rule, any water with pH of 6 to 8 which does not taste saline or brackish is suitable for use. Tested water or treated water should be used as this will increase the strength of cement concrete and enhance the life of building.

2.5 Aggregate

Aggregate are inert materials which are mixed with binding material such as cement or lime for manufacturing of mortar or concrete. Aggregates are used as filler in mortar and concrete and also to reduce their cost. Granular material of mineral composition such as sand,gravel ,shale, slag or crushed stone.
Aggregate generally occupy 70% to 80% of concrete volume. So the importance of right type of quality aggregate cannot be compromised.

Aggregate was originally viewed as an man material dispersed throughout the cement paste largely for economic reasons. It is possible, however, to take an opposite view and to OPC on aggregate as a building material connected into a cohesive whole by means of the cement paste. In fact, aggregate is not truly inert and its physical, thermal and sometimes also chemical properties influence the lic-performance of concrete. Aggregate not only may limit the strength but also can affect the durability of concrete.

Natural aggregate are formed by process of weathering and abrasion. Crushed aggregate is produced by crushing quarry rock, boulders, cobbles, or large size gravel. Recycled concrete is a viable source of aggregate and has been satisfactorily used in granular sub-bases, soil-cement, and in new concrete. After harvesting, aggregate is processed: crushed, screened, and washed to obtain proper cleanliness and gradation. If necessary, a benefaction process such as jigging or heavy media separation can be used to upgrade the quality. Once processed, the aggregates are handled and stored to minimize segregation and degradation and prevent contamination.

In construction sector, aggregate is divided into two broad way.
They are -

- Fine Aggregate
- Coarse Aggregate

2.5.1 Fine Aggregate

According to ASTM Standards material passing No.4 sieve (4.75mm) are termed as fine aggregate.Fine aggregates are essentially any natural sand particles won from the land through the mining process. Fine aggregates consist of natural sand or any crushed stone particles that are ¼" or smaller. This product is often referred to as ¼" minus as it refers to the size, or grading, of this particular aggregate.
In construction line Aggregate means sand, which generally considered having a lower size limit of about 0.07mm.Fine aggregate content usually 35% to 45% by mass or volume of total aggregate. The fine aggregates serve the purpose of filling all the open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength. The fine aggregates serve the

purpose of filling all the open spaces in between the coarse particles. Thus, it reduces the porosity of the final mass and considerably increases its strength.

Figure 2.3 : Sample of Fine Aggregate

2.5.2 Coarse Aggregate

According to ASTM Standards material retained on No.4 sieve (4.75mm) are termed as coarse aggregate. But in construction work size of coarse aggregate is limited maximum to 19mm. Most commonly used coarse aggregates are crushed stone, gravel; broken pieces of burnt bricks, etc. Gravels constitute the majority of coarse aggregate used in concrete with crushed stone. The sizes of gravel affect several aspects, mainly workability and strength.

Figure 2.4 : Sample of Coarse Aggregate

2.5.3 Particle Size, Shape and Surface Texture

Aggregate particle shape and surface texture are important for proper compaction, deformation resistance and workability. However, the ideal shape for HMA, and PCC is different because aggregates serve different purposes in each material. In HMA, since aggregates are relied upon to provide stiffness and strength by interlocking with one another, cubic angular-shaped particles with a rough surface texture are best. However, in PCC, where aggregates are used as an inexpensive high-strength material to occupy volume, workability is the major issue regarding particle shape. Therefore, in PCC rounded particles are better. Relevant particle shape/texture characteristics are discussed below.

2.5.3.1 Particle Shape

Rounded particles create less particle-to-particle interlock than angular particles and thus provide better workability and easier compaction. However, in HMA less interlock is generally a disadvantage as rounded aggregate will continue to compact, shove and rut after construction. Thus angular particles are desirable for HMA (despite their poorer workability), while rounded particles are desirable for PCC because of their better workability (although particle smoothness will not appreciably affect strength).

2.5.3.2 Flat or Elongated Particles

These particles tend to impede compaction or break during compaction and thus, may decrease strength.

2.5.3.3 Smooth-Sufaced Particles

These particles have a lower surface-to-volume ratio than rough-surfaced particles and thus may be easier to coat with binder. However, in HMA asphalt tends to bond more effectively with rough-surfaced particles, and in PCC rough-surfaced particles provide more area to which the cement paste can bond. Thus, rough-surface particles are desirable for both HMA and PCC.

2.6 Moisture Content of Concrete

2.6.1 Moisture Content

Moisture content is, simply, how much water is in a product. It influences the physical properties of a substance, including weight, density, viscosity, conductivity, and others. It is generally determined by weight loss upon drying.

In fresh concrete, the volume occupied by the aggregate is the volume of the particles including all the pores. If no water movement into the aggregate is to take place, the pores must be full of water. On the other hand, any water on the surface of the aggregate will contribute to the water in the mix and will occupy a volume in excess of that of the aggregate articles. This is particularly true of fine aggregate, and the surface moisture must be allowed for in the calculation of batch quantities. Coarse aggregate rarely contains more than 1 per cent of surface moisture but fine aggregate can contain in excess of 10 per cent. The surface moisture is expressed as a percentage of the mass of the saturated and surface-dry aggregate, and is termed moisture content.

2.6.2 Concrete Floor Slab Drying Time

Assisting drying by closing in the slab to protect it from the rain and maintaining good ventilation. Fans to circulate air may be helpful but attempts to dry the concrete with heaters or dehumidifiers are generally unsuccessful. Moreover, such force-drying only affects the top few millimeters of the concrete, leading to misleadingly low moisture measurements.

As we already learn, a common drying time of a concrete slab will take several months. Under normal drying conditions, a rule of thumb allows at least one month of drying for every 1 inch of slab thickness after closing the building. For a 4-inch-thick slab, this means a minimum drying time of 4 months is necessary or maybe longer if there is:

- low air temperature
- high humidity
- poor ventilation because of airflow limitation across the slab

The construction schedule must allow for poor drying conditions. Forcing the drying time of concrete slabs using dehumidifiers or heaters is not a good choice. As it results in drying the top surface only – the moisture within the slab remains.

The number of floor-covering failures constantly growing in recent years. Mainly due to fast-track construction schedules and the reduction of more tolerant solvent-based flooring adhesives for environmental reasons [8].

2.6.3 Concrete Design can help to keep Relative Humidity

Where drying times are crucial, optimize the concrete mix design using low water-to-cement ratios with chemical admixtures providing the necessary plasticity. Furthermore, consider covering with polythene sheeting that will help to cure properly. This holds the mixing water without adding any extra moisture. You should avoid any curing compounds.

2.6.4 Moisture Migration Systems

Sometimes waiting for the slab to dry completely isn't practical because of time constraints or a damaged or absent damp-proof membrane. Surface-applied moisture mitigation systems can reduce the vapor transmission rates to acceptable levels, but you should decide to rely on such a system carefully.

Always get the flooring supplier to write a warranty covering any damage to the floor if the system fails.

The most effective mitigation systems include purpose-designed epoxy coatings, which can cope with most vapor transmission rates. Non-emulsifying acrylics are generally restricted to solving less severe moisture problems and help isolate the applied flooring material from the pH rising effects of soluble alkalis leached from the concrete. Dense copolymer-modified cementitious overlays serve a similar function.

The least costly mitigation protections are often reactive penetrants based on potassium or sodium silicates. These work by chemically reacting with the calcium hydroxide in the concrete and forming additional cementing material that reduces surface porosity.

Achieving a successful result depends on many factors, including adequate concrete penetration, which normally necessitates shot-blasting of the surface. Conversely, an over-generous application can result in an unstable surface film. Consequently, it would be best if you used them with extreme caution for this purpose [8].

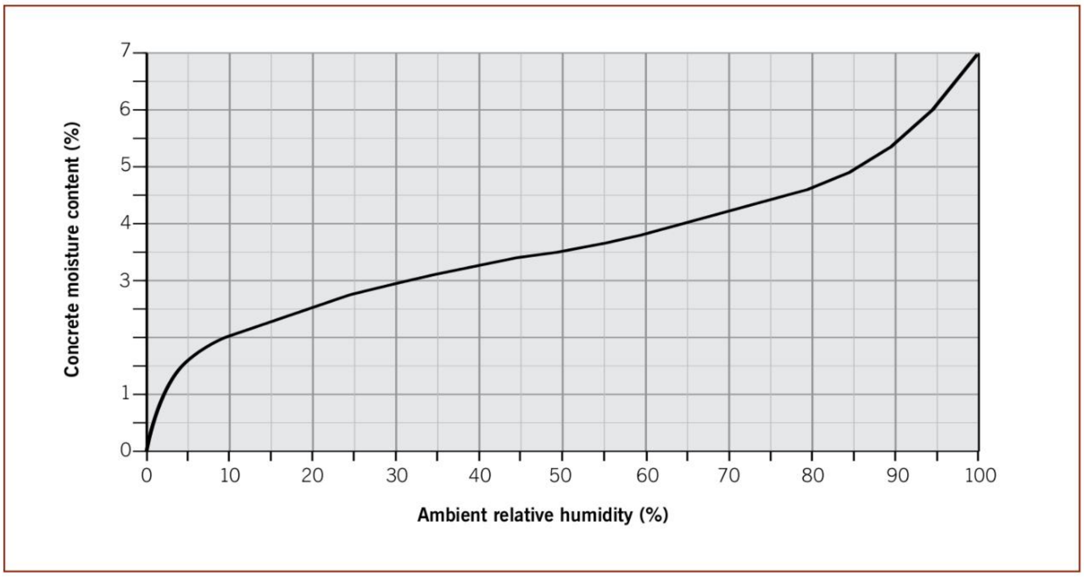

Figure 2.5 : Concrete Moisture Content.

CHAPTER 3
MATERIALS AND METHODOLOGY

3.1 General

Methodology is a very important prerequisite for a successful research work . Both quality and quantitative are the chief commitment fir better understanding of various aspects and components relating to the research studies. The experimental program of ties research work includes the followings Flexural strength test of concrete , sieve analysis, specific gravity, unit weight. To determine the material properties and to compare the load carrying capacity of slab some methods were followed which are discussed here in this chapter.

3.2 Materials

The key materials used in this work are as follows:

- Fine Aggregate (Sylhet Sand)
- Coarse Aggregate (Stone Chips)
- Binder (Cement)
- Steel Wire Mesh

3.3 Determination of Material Properties

Various properties of materials are given below.

3.3.1 Fine Aggregate

Sylhet sand is used as fine aggregate. Fine aggregates act as filler materials which provide improved volume stability. Various basic properties of fine aggregate such as specific gravity, fineness modulus (FM) and bulking are significantly correlated with compressive strength, water absorption, and sorptivity in this work.

Figure 3.1 : Sample of Fine Aggregate

3.3.2 Coarse Aggregate

Stone chips of 3/4” downgrade size were used as coarse aggregate. Specific gravity, absorption and unit weight were determined according to ASTM C127, ASTM C29 testing standards respectively.

Figure 3.2 : Sample of Coarse Aggregate

3.3.3 Binder (Cement)

A cement is a binder, a chemical substance used for construction that sets, hardens, and adheres to other materials to bind them together. When cement is mixed with water, it can bind sand and gravel into a hard, solid mass called concrete.

The most common, called Ordinary portland cement (OPC), is grey, Ordinary Portland cement (simply called ordinary cement) refers to the hydraulic binding material ground by mixing Portland cement clinker, 6% ~ 15% blended materials, and appropriate amount of gypsum.

Figure 3.3 : Cement

3.3.3.1 Ordinary Portland Cement (OPC)

This type of cement is the most commonly used in construction.OPC has higher strength rate at its early days of casting but the later gain in strength is smaller. The basic chemical components of OPC are:

- Calcium
- Silica
- Alumina
- Iron

3.4 Steel Wire Mesh

Steel wire mesh is a common method to reinforce poured concrete. The wire mesh makes a square grid pattern which is laid down before the concrete gets poured. The wire mesh is usually one layer of a two-dimensional grid that runs along the length and width of the poured concrete, but not the height.
The properties of stainless steel wire mesh, particularly its high tensile strength and durability, make it an excellent material choice for withstanding high impact and break-in attempts. Stainless steel mesh is nearly impossible to cut, gouge, or break and can even resist bullets.

The underlying idea behind this combination is to satisfy the ultimate strength limit state through the steel mesh reinforcement (main reinforcement) [4].
For steel wire mesh reinforced concrete, due to the fact that steel wire meshes are two dimensional reinforcements and provided mainly flexural resistance in the concrete mix, only flexural tests were conducted. The steel wire mesh dimension is shown in Figure 3.4. Flexural tests configuration is shown in Figure 3.7 (page 30) [1].

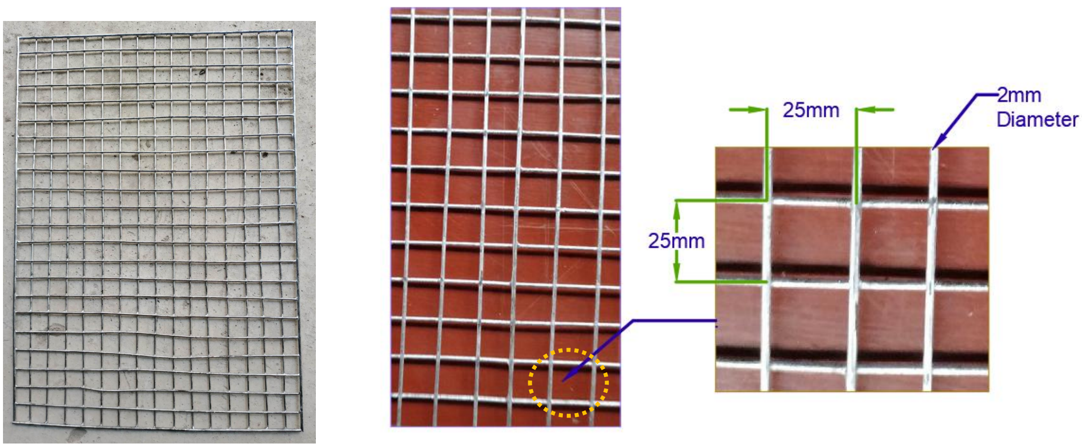

Figure 3.4 : Steel Wire Mesh Dimension

3.5 Sieve Analysis of Fine and Coarse Aggregate

The term “sieve analysis” is the sample operation of dividing a sample of aggregates into fractions each consisting of particles between specific limits. The analysis is conducted to determine the grading of material proposed for use as aggregates. The term Fineness Modulus (F.M) is a ready index of coarseness or fineness of material. It is an empirical factor obtained by adding the cumulative percentages of aggregates retained on each of the standard sieves and dividing this sum arbitrarily by 100.

No. 100, No. 50, No. 30, No. 16, No. 8, No. 4, and 3/8 in. are the ASTM standard sieves. This test method conforms to the ASTM standard requirements of specification C136.

3.5.1 Aggregate Picture

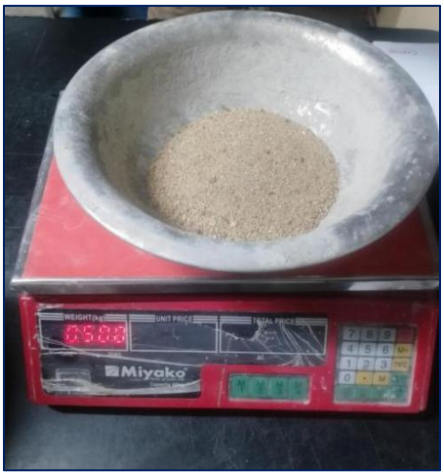

Figure 3.5 : Sieve Analysis of Fine Aggregate

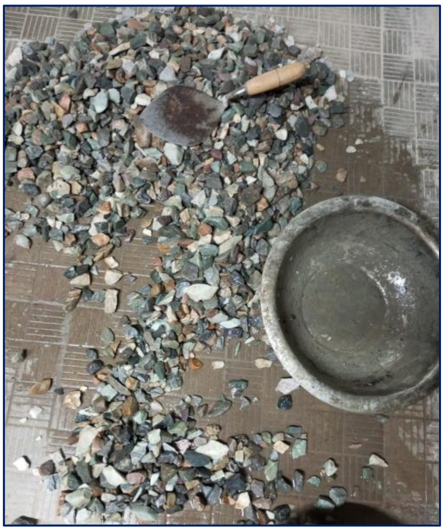

Figure 3.6 : Sieve Analysis of Coarse Aggregate

3.6 Fineness Modulus And Grading Curve

3.6.1 Fineness Modulus (FM)

It is an index which gives an idea about fineness or coarseness of aggregate.

- FM is not an indication of grading of aggregates as an infinite number of grading can have same FM.
- Mathematically, FM is
- FM For good Concrete
  FM for FA is (2.25-3.25)
  FM for CA is (5.50-7.50)
- The smaller the value of FM, the more is smaller sizes in aggregate.

3.6.2 Grading Curve

The results of a sieve analysis can be grasped much more easily if represented graphically and for this reason, grading charts are very extensively used. By using a chart, it is possible to see at a glance whether the grading of a given sample conforms to that specified, or is too coarse or too fine, or deficient in a particular size.

- Gap grading caused uneconomical mix
- Uniformly grading ….. lot of voids
- More finely grading caused …... less workability, low strength concrete
- More coarsely grading caused segregation.
- Uniformly grading caused segregation

3.7 Specific Gravity And Absorption Capacity of Fine Aggregate

Aggregates generally contain pores, both permeable and impermeable, for which specific gravity has to be carefully defined. With this specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required in calculating the compacting factor in connection with workability measurements. This test method covers the determination of bulk and apparent specific gravity, 23/23^{0}C (73.4/72.4^{0}F) and absorption capacity of fine aggregate. This is used for i) calculation of the volume occupied by the aggregate of varying mixtures on an absolute volume basis, ii) the computation of voids in aggregate and iii) the determination of moisture in aggregate.

The specific gravity of a porous solid, when the volume of the solid as used in the calculation includes both the permeable and impermeable voids. Bulk Specific Gravity (also known as Bulk Dry Specific Gravity) is the ratio of the weight in air of a unit volume of aggregate at a stated temperature to the weight in air of an equal volume of gas free distilled water at the stated temperature.

Apparent specific gravity is the ratio of the weight in air of a unit volume of the impermeable portion of aggregate (does not include the permeable pores in aggregate) to the weight in air of an equal volume of gas-free distilled water at the stated temperature.

3.7.1 Apparatus

- **Balance-** sensitive to 0.1gm or less.

- **Pycnometer-** A flask or other suitable container of 1000ml capacity. The volume of the container filled to mark shall be at least 50% greater than the space required to accommodate the sample of fine aggregate.

- **Mold-** A Metal mold in the form of a frustum of a cone with dimensions as follows:
  40 ± 3 mm inside diameter at the top
  90 ± 3 mm inside diameter at the bottom
  75 ± 3 mm in height
  0.8 mm minimum thickness of metal

- **Tamper-** A metal tamper weighing 350 ± 15gm and having a flat circular tamping face 25 ± 30 mm diameter.

3.7.2 Test of Sample

- Partially fill the Pycnometer with water. Immediately introduce into the Pycnometer 500 ± 10 ml of saturated surface dry fine aggregate prepared and fill with additional water to approximate 90% of capacity. Roll, nvert, and agitate the Pycnometer to eliminate all air bubbles. Adjust the temperature to 23 ± 1.7^{0}C (73.4 ± 3^{0}F). If necessary by immersionin circulating water bring the eater level in the Pycnometer to its calibrated capacity. Determine the total weight of the Pycnometer, specimen, and water.
- Remove the fine aggregate from the Pycnometer, dry to constant weight at a temperature of 110 ± 5^{0}C (230 ± 9^{0}F), cool in air at room temperature for 1 ± ½ hr. and weigh.

- Determine the weight of the Pycnometer filled to its calibration capacity with water at 23 ± 1.7^{0}C (73.4 ± 3^{0}F)

3.7.3 Calculation

Bulk Specific Gravity (Dry)= A/ (B+S-C)

Bulk Specific Gravity (Saturated)= S/ (B+S-C)

Apparent Specific Gravity = A/ (B+A-C)

Absorption Capacity (%) = (S-A)x100/A
Where,
A = weight of oven-dry specimen in air, gm
B = weight of Pycnometer filled with water, gm
S = weight of the saturated surface-dry specimen, gm and
C = weight of Pycnometer with specimen and water to calibration mark, gm

3.8 Specific Gravity And Absorption Capacity of Coarse Aggregate

This test method covers the determination of specific gravity and absorption of coarse aggregate. All the terminologies and their uses are same as the specific gravity and absorption of fine aggregate (see Expt-5).
This test method conforms to the ASTM standard requirements of specification C127.

3.8.1 Apparatus

- Balance- Sensitive to 0.05% of the sample weight at any point within the range used for the test, or 0.5g; whichever is greater.

- Sample container- A wire basket of 3.35mm (no. 6) or finer mesh, or a bucket of approximately equal breath and height, with a capacity of 4 to 7 liter for 37.5mm (1.5 in) nominal maximum size aggregate. The container shall be constructed so as to prevent trapping air when the container is submerged.

- Water tank- A watertight tank into which the sample container may be placed while suspended below the balance.

- Sieves – A 4.75 mm (No. 4) sieve or other sizes as needed.

3.8.2 Test of Sample

- Thoroughly mix the sample of aggregate and reduce it to the approximate quantity needed. Reject all material passing a 4.75mm (No. 4) sieve by sieving and thoroughly washing to remove dust or other coatings from the surface. If the coarse aggregate contains a substantial quantity of material finer than the
4.75mm sieve use the 2.36mm (No. 8) sieve in place of the 4.75mm sieve.

3.8.3 Calculation

Bulk Specific Gravity (Dry)= A/ (A-C)

Bulk Specific Gravity (Saturated)= B/ (B-C)

Apparent Specific Gravity = A/ (B-C)

Absorption Capacity (%) = (B-A)x100/A

Where,
A = weight of oven-dry specimen in air, gm
B = weight of Pycnometer filled with water, gm
S = weight of the saturated surface-dry specimen, gm and
C = weight of Pycnometer with specimen and water to calibration mark, gm

3.9 Unit Weight and Voids in Aggregate

This test method covers the determination of unit weight in a compacted or loose condition of fine and coarse aggregates. Unit weight values of aggregates are necessary for use in many methods of selecting proportions for concrete mixtures. They may also be used for determining mass/volume relationships for conversions and calculating the percentages of voids in aggregates. Voids inside particles, either permeable or impermeable, are not included in Voids as determined by this test method. This test method conforms to the ASTM standard requirements of specification C29.

3.9.1 Apparatus

- Balance- Accurate within 0.1% of the test load and graduated to at least 0.1 lb (0.05 kg)

- Tamping rod- A round, straight steel rod, 5/8 in. (16 mm) in diameter and approximately 24 in. (600 mm) in length, having one end rounded to a hemispherical tip.

- Measure- A cylindrical metal measure, preferably provided with handles, shall be watertight, with the top and bottom true and even, and sufficiently rigid to retain its form under rough usage. The measure shall have a height approximately equal to the diameter, but in any case the height shall not be less then 80% nor more than 150% of the diameter. The capacity of the measure shall conform to the limits in **Table-1** for the aggregate size to be tested. The thickness of metal in the measure shall conform to the limits as described in **Table-2**. The interior wall of the measure shall be smooth and continuous surface.

Nominal Maximum size of Aggregate		Capacity of Measure	
inch	mm	ft3	liter (m^3)
0.5	12.5	1/10	2.8(0.0028)
1.0	25.0	1/3	9.3 (0.0093)
1.5	37.5	½	14(0.014)
3.0	75	1	28(0.028)
4.5	112	2.5	70(0.070)
6.0	150	3.5	100(0.100)

Table 3.1: Capacity of Measures

Note: The indicated size of measure shall be used to test aggregates of a nominal maximum size equal to or smaller than those listed. The actual volume of the measure shall be at least 95% of the normal volume listed.

Capacity of Measure	Thickness of Metal (minimum)		
	Bottom remainder	Upper of wall	1.5 in. or 38 mm of wall
Less than 0.4 ft^2	0.20 in	0.10 in.	0.10 in.
0.4 ft^3 to 1.5 $ft^{3,}$ in.	0.20 in	0.20 in	0.12 in
Over 1.5 to 2.8 ft^3, in.	0.20 in.	0.25 in.	0.15 in.
Over 2.8 to 4.0 ft^3, in.	0.40 in.	0.30 in	0.20 in.
Less than 11 liter	0.50 in.	2.5 mm	2.5 mm
11 to 42 liter, in.	5.0 mm	5.0 mm	3.0 mm
Over 42 to 80 liter, in.	10.0 mm	6.4 mm	3.8 mm
Over 80 to 133 liter in.	13.0 mm	7.6 mm	5.0 mm

Table 3.2 : Requirements for Measures

Note: The added thickness in the upper portion of the wall may be obtained by placing a reinforcing bang around the top of the measure.

- Calibration Equipment- A piece of plate glass, preferably at least ¼ in. (6 mm) thick andat least 1 in. (25 mm) larger than the diameter of the measure to be calibrated. A supply of water pump or chassis grease that can be placed on the rim of the container to prevent leakage.

3.9.2 Test of Sample

The size of the sample shell be approximately 124 to 200% of the quantity required to fill the measure, and shall be handled in a manner to avoid segregation. Dry the aggregate sample to essentially constant mass, preferably in an oven at 230 ± 9^0F (110 ± 5^0C).

3.9.3 Calibration of Measure

- Fill the measure with water at room temperature and cover with a piece of plate glass in such a way as to eliminate bubbles and excess water.
- Determine the mass of the water in the measure using the balance.
- Measure the temperature of the water and determine its density from **Table-3**, interpolating if necessary.
- Calculate the volume, V, of the measure by the dividing the mass of the water required to fill the measure by its density. Alternatively, calculate the factor for the measure F (=1/V) by dividing the density of the water by the mass required to fill the measure.

Temperature		Density	
^{0}F	^{0}C	Ib/ft^3	Kg/m^3
60	15.6	62.366	999.01
65	18.3	62.366	998.54
70	21.1	62.301	997.97
(73.4)	(23.0)	(62.274)	(997.54)
75	23.9	62.261	997.32
80	26.7	62.216	996.59
85	29.4	62.166	995.85

Table 3.3 : Unit Weight of Density of Water

Measures shall be recalibrated at least once a year whenever there is reason to question the accuracy of the calibration.

3.9.4 Selection of Procedure

Three different procedures are generally followed for the determination of unit weight.
They are:

a) Shoveling procedure
b) Rodding procedure
c) Jiggling procedure

The shoveling procedure for loose unit weight shall be used only when specifically stipulated. Otherwise, the compact unit weight shall be determined by the Roding procedure for aggregates having a nominal maximum size of 1.5 in (37.5 mm) or lesser, by the jiggling procedure for aggregates having a nominal maximum size greater than 1.5 in. (37.5 mm) and not exceeding 6 in. (150 mm).

3.9.4.1 Shoveling procedure

i. Fill the measure to overflowing by means of a shovel or scoop, discharging the aggregate from a height not exceeding 2 in. (50 mm) above the top of the measure. Exercise care to prevent, as far as possible, segregation of the particle sizes of which the sample is composed of. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.
ii. Determine the mass of the measure plus its contents, and the mass of the measure alone, and record the values to the nearest 0.1 lb. (0.05kg).

3.9.4.2 Rodding procedure

i. Fill the measure one-third full and level the surface with the fingers. Rod the layer of aggregate with 25 strokes of the tamping rod evenly distributed over the surface. Fill the measure two-thirds full and again level and rod as above. Finally, fill the measure to overflowing and rod again in the manner previously mentioned. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.

ii. In Roding the first layer, do not allow the rod to strike the bottom of the measure forcibly. In roding the second and the third layers, use vigorous effort, but do not apply such a force as to cause the tamping rod to penetrate to the previous layer of aggregate.

iii. Determine the mass of the measure plus its contents, and the mass of the measure alone, and record the values to the nearest 0.1lb (0.05kg).

3.9.4.3 Jiggling Procedure

i. Fill the measure in three approximately equal layers as described previously, compacting each layer by placing the measure on a firm base such as a cement concrete floor, raising the opposite sides alternately about 2 in. (50 mm), and allowing the measure to drop in such a manner as to hit with a sharp, slapping blow. The aggregate particles, by this procedure, will arrange themselves in a densely compacted condition. Compact each layer by dropping the measure 50 times in the manner described, 25 times on each side. Level the surface of the aggregate with the fingers or a straightedge in such a way that any slight projections of the larger pieces of the coarse aggregate approximately balance the larger voids in the surface below the top of the measure.

Determine the mass of the measure plus its contents, and the mass of the measure alone, and record the values to the nearest 0.1 lb (0.05kg).

3.10 High Strength Concrete Mix Development

In the present study, concrete mixes are proportioned to achieve an optimized packing order for the granular constituents, including cement, silica flour and silica fume, sand and nano particles. The largest granular material in the UHPC mix is sand, with particle size ranging from 150 to 600 µm. Cement particles have the second largest size in the mix, with a nominal size of 15 µm, and silica flour with a nominal size of 10 µm. Silica fume is the second smallest particle within the mix, with a diameter of 0.5 µm. Nanoscale particles Nano-CaCO3 is the smallest particle with diameter 40–80 nm with a purity of 96.0%. Particle sizes of silica fume and Nano-CaCO3 are sufficient to fill the voids among the mix constituents. Hence, they increases the strength and reduces the permeability of the mix [1] .

3.11 Flexural Strength Test of Concrete

The Three-Point bending test is conducted on a loading frame to determine the flexural tensile strength on standard slab specimens of size 600x450x125mm. The specimens were cured in water for 7-days, 14-days and 28-days. The minimum reinforcement is provided for confined slab specimen tests.

The slab specimen is simply supported on two rollers of 75mm diameter. The flexural tensile strength is calculated as the ratio of the calculated bending moment and section modulus of the slab specimen and is presented in Table 4.5 (Page 47) and Table 4.6 (Page 48) Show the flexural tensile strength after deducting the flexural tensile strength (approximate) of provided reinforcement. The flexure test set-up is shown in Figure 3.8 [6].

Flexural Strength Formula:

Flexural strength is calculated using the equation: **$F = PL/(bd^2)$** Where, F= Flexural strength of concrete (in MPa). P= Failure load (in N). L= Effective span of the slab.

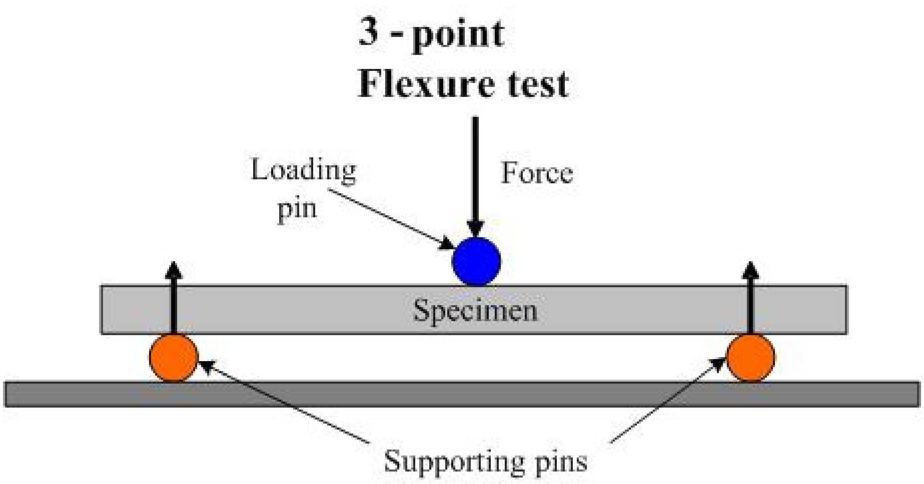

Figure 3.7 : 3-Point (Single Roller) Flexural Strength Test

3.12 Flexural Strength Test of Normal Concrete Slab

Figure 3.8 : Flexural Strength Test Set-up (Normal Concrete Slab 7 Days)

Figure 3.9 : Test Results on Normal Concrete Slab (7 Days)

Figure 3.10 : Flexural Strength Test Set-up (Normal Concrete Slab 14 Days)

Figure 3.11 : Test Results on Normal Concrete Slab (14 Days)

Figure 3.12 : Flexural Strength Test Set-up (Normal Concrete Slab 28 Days)

Figure 3.13 : Test Results on Normal Concrete Slab (28 Days)

Note : Flexural strength is measured by what is essentially a bend test. As can be noted, From the Figure 3.8 it has been found that for 7 days Flexural Test of Normal concrete slab flexural model with broke down slab mid-span. Slab of 14 days Normal Concrete reinforcement fail in the intended flexural mode. And Slab of 28 days Normal Concrete reinforcement increases flexural load.
Slab of 7 days Normal Concrete reinforcement flexural load is 28 kN (see Figure. 3.9). Comparing the results with Normal Concrete reinforcement 14 days and 28 days (See Figure 3.11 and Figure 3.13 the maximum flexural load increased from 40 kN to 60 kN From Table 4.6.

3.13 Flexural Strength Test of Steel Wire Mesh Concrete Slab

Figure 3.14 : Flexural Strength Test Set-up
(Steel Wire Mesh Concrete Slab 7 Days)

Figure 3.15 : Brnding Test Results on Steel Wire Meshes
Reinforced Concrete (7 Days)

Figure 3.16 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (7 Days)

Figure 3.17 : Flexural Strength Test Set-up (Steel Wire Mesh Concrete Slab 14 Days)

Figure 3.18 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (14 Days)

Figure 3.19 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (14 Days)

Figure 3.20 : Flexural Strength Test Set-up
(Steel Wire Mesh Concrete Slab 28 Days)

Figure 3.21 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (28 Days)

Figure 3.22 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (28 Days)

Figure 3.23 : Bending Test Results on Steel Wire Meshes Reinforced Concrete (28 Days)

Note : As can be noted, From the Figure 3.14 it has been found that for 7 days Flexural Test of slab with 2 layers steel wire mesh concrete flexural model with cracks at slab mid-span. Slab with 2 layers of 14 days steel wire mesh reinforcement did not fail in the intended flexural mode but by shearing.And Slab with 2 layers of 28 days steel wire mesh reinforcement increases flexural load and by shearing.
To improve the shear resistance of the steel wire mesh reinforced concrete, small amount of micro steel fibres were mixed into the protective layer of the slab sample. The improved design achieved the designated flexural failure as shown in Figure 3.15 and Figure 3.16, and the sample sustained much greater mid-span deflection with excellent crack control.Slab with 2 layers of 7 days steel wire mesh reinforcement flexural load is 85 kN. (see Figure3.15 and Figure 3.16). Comparing the results with 2 layer steel wire mesh reinforcement, the maximum flexural load increased from 97 kN to 110 kN From Table 4.7. and the energy absorbed during the tests increased by 204.3% [1].

3.14 Formwork

Formwork, Mold used to form concrete into structural shapes (beams, columns, slabs, shells) for building. Formwork can be of timber, steel, plastic, or fiberglass. The inside surface is coated with a bond breaker (plastic or oil) to keep the concrete from sticking to the mold. Formwork may be made of wood, metal, plastic, or composite materials: Traditional timber formwork. The formwork is built on site out of timber and plywood or moisture-resistant particleboard. It is easy to produce but time-consuming for larger structures, and the plywood facing has a relatively short lifespan.

Concrete is one of the most widely used construction materials, thanks to its exceptional properties. However, to create building elements with concrete, it must be poured into a specially designed mold. This is known as formwork or shuttering.

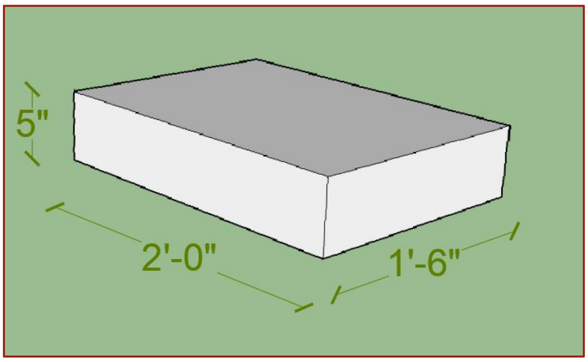

Figure 3.24 : Formwork Dimension

3.15 Prepearing Material And Mixing of Concrete

Mixing concrete is simply defined as the "complete blending of the materials which are required for the production of a homogeneous concrete" (Young, 267). This can vary from hand to machine mixing, with machine mixing being the most common.

Concrete mixing is a process of mixing the ingredient of concrete such as cement, sand, aggregate, water, and admixture together to make concrete of suitable grade. To make the different grades of concrete, the mixing of concrete materials should be done properly as per the mix design of concrete to achieve the design strength of concrete.

3.15.1 Process of Hand Mixing of Concrete

The measured quantity of sand is spread on the platform and then the cement is dropped over the sand. The sand and cement are mixed thoroughly for several times with the help of shovels in the dry state until the mixture attains an even colour throughout and is free from streaks.

3.15.2 Some Pictures of Hand Mixing of Normal Concrete

Step : 01

Step : 02

Step : 03

Step : 04

Step : 05

Step : 06

Step : 07

Step : 08

Figure 3.25 : Step by step hand mixing of Normal concrete Slab

3.15.3 Some Pictures of Steel Wire Mesh Concrete

Figure: Steel Wire Mesh

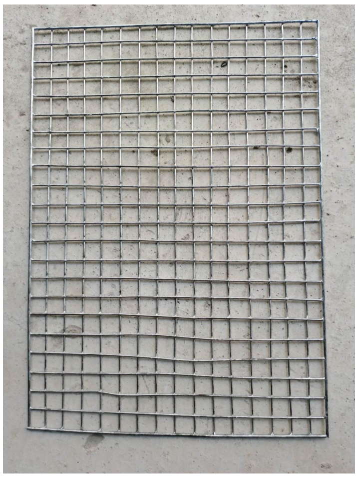

Figure: Steel Wire Mesh Jali

Figure: Stone Chips

Figure: Cement

Figure: Sylhet Sand

Figure: 1st Layer of Steel Wire Mesh Concrete Slab

Figure: 2nd Layer of Steel Wire Mesh Concrete Slab

Figure: Steel Wire Mesh Concrete Slab.

Figure 3.26 : Step by Step hand mixing of Steel Wire Mesh concrete Slab

NOTE: 2 Layer of Steel Wire Mesh Concrete Slab

1st Layer of steel wire mesh concrete slab is 1inch Concrete Mixture From the Bottom Level Then steel wire mesh jali and 3inch Concrete mixture and 2nd Layer of Steel Wire Mesh jali and 1 inch concrete mixture from the Top Level.Then Finally made a steel wire mesh concrete slab.

3.15.4 Mold preparation

Molding or moulding is the process of manufacturing by shaping liquid or pliable raw material using a rigid frame called a mold or matrix. This itself may have been made using a pattern or model of the final object.

3.15.5 Mixing Proportion of Concrete

As the study followed to keep in similarity with local practice so a commonly practiced mixing ratio of **Cement: FA: CA = 1 : 1.5 : 3** and w/c ratio of 0.45 was used.

The yield of concrete per bag means we have to find a wet volume of concrete. For M20, 1 : 1.5 : 3. In the above ratios, 1 represents cement, 1.5 represents sand, 3 represents aggregate.

3.16 Analysis of Test Results

For analysis purpose graphs has been drawn to compare strength gain at different ages of 7 days , 14 days and 28 days for 1:1.5:3 mixing percentage of Normal Concrete and Steel wire mesh Concrete.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Introduction

Flexural strength of concrete is the most important parameter of concrete.It gives an overall view of quality of concrete because it is directly related to the structure of harden cement paste. Flexural strength is measured by what is essentially a bend test. Concrete is an important, widely used material in modern-day construction.
This chapter includes the results of the tests conducted in the Laboratory for this thesis work. It sieve analysis of specific gravity and water absorption,unit weight and flexural strength all the results of slab test in the from of table,graph and bar diagram. The results are discussed in following articles.
Flexural Strength has been tasted for each mixing ratio for 7 days, 14 days and 28 days.

4.2 Sieve Analysis of Fine and Coarse Aggregate

4.2.1 Fine Aggregate (Data Sheet)

Data Sheet

Sieve Number	Sieve Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % retained	Percent finer
4	4.75	0	0	0	
8	2.36	24	4.8	4.8	
16	1.19	144	28.8	33.6	
30	0.59	164	32.8	66.4	298.4/100 =2.98
50	0.30	141	28.2	94.6	
100	0.15	22	4.4	99	
Pan		05	-	-	

Fineness Modulus = 2.98

Table 4.1 : Sieve Analysis of Fine Aggregate

4.2.2 Coarse Aggregate (Data Sheet)

Data Sheet

Sieve Number	Sieve Opening (mm)	Materials Retained (gm)	% Materials Retained	Cumulative % retained	Percent finer
$3/4$	19.05	662	66.2	66.2	
$3/8$	9.5	329	32.9	99.1	265.3/100 =2.653
4	4.75	09	0.9	100	

Fineness Modulus = 2.653

Table 4.2 : Sieve Analysis of Fine Aggregate

4.3 Unit Weight Test

Bucket Weight = 4000 gm
Temping Rod Dia = 16mm
Temping Rod Height = 240mm
Temping Rod Weight = 100gm

- **(a) Shoveling procedure**
  Bucket Weight = 4000 gm
  Bucket + Aggregate Weight = 7536 gm
  So Aggregate Weight = 7536 - 4000 = 3536 gm.
- **(b) Rodding procedure**
  Bucket Weight = 4000 gm
  Bucket + Aggregate Weight = 8295 gm
  So Aggregate Weight = 8295 - 4000 = 4295 gm.
- **(c) Jiggling/Sheking procedure**
  Bucket Weight = 4000 gm
  Bucket + Aggregate Weight = 8387 gm
  So Aggregate Weight = 8387 - 4000 = 4387 gm.

Water Condition

- **(d) Water + Bucket Weight = 7253 gm**

4.4 Specific Gravity and Absorption Capacity of Fine Aggregate

4.4.1 Fine Aggregate (Data Sheet)

Data Sheet

Wt. of pycnometer Filled with water to Calibration mark. **B gm**	Oven Dry Wt. in Air **A gm**	Wt. of pycnometer with Specimen and water to Calibration mark. **C gm**	Wt. of S.S.D. sample in Air **S gm**
653	290	835	300

Tests	Formula	Calculation	Results
Apparent Specific Gravity	$\frac{A}{B+A-C}$	290/ (653+290-835)	2.69
Bulk Specific Gravity (Oven Dry Basis)	$\frac{A}{B+S-C}$	290/ (653+300-835)	2.46
Absorption Capacity, D%	$\frac{(S-A)x100}{A}$	{(300-290)x100}/ 290	3.45
Bulk Specific Gravity (S.S.D. Basis), G	$\frac{S}{B+S-C}$	300/ (653+300-835)	2.54

Table 4.3 : Specific Gravity and Absorption Capacity of Fine Aggregate

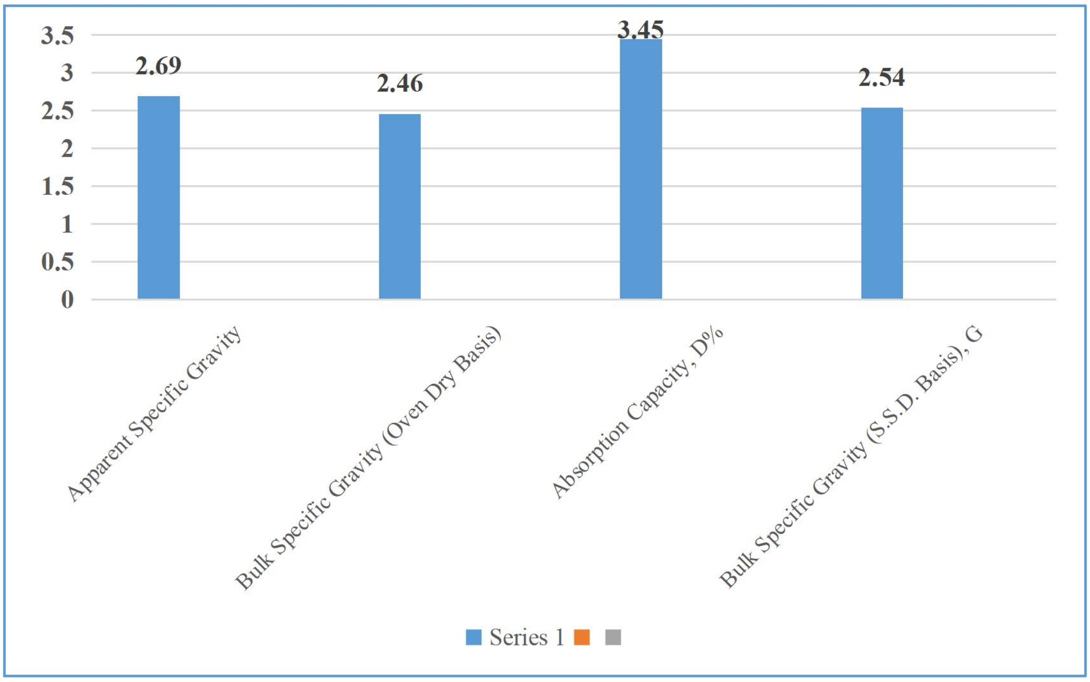

Figure 4.3 : Bar Chart of Specific Gravity and Absorption Capacity of Fine Aggregate

4.5 Specific Gravity and Absorption Capacity of Coarse Aggregate

4.5.1 Coarse Aggregate (Data Sheet)

Data Sheet

Wt. of S.S.D Sample in Air, **B** (gm)	Wt. of S.S.D Sample in Water, **C** (gm)	Oven Dry Wt. Of Sample in Air, **A** (gm)
1.850	1.115	1.815

Tests	Formula	Calculation	Results
Apparent Specific Gravity	$\frac{A}{A-C}$	1.815/ (1.815-1.115)	2.59
Bulk specific Gravity (S.S.D. Basis)	$\frac{B}{B-C}$	1.850 / (1.850-1.115)	2.52
Bulk specific Gravity (Oven dry Basis)	$\frac{A}{B-C}$	1.815 / (1.850-1.115)	2.47
Absorption capacity, D%	$\frac{(B-A)x100}{A}$	{(1.850-1.815)x100} /1.815	1.93

Table 4.4 : Specific Gravity and Absorption Capacity of Coarse Aggregate

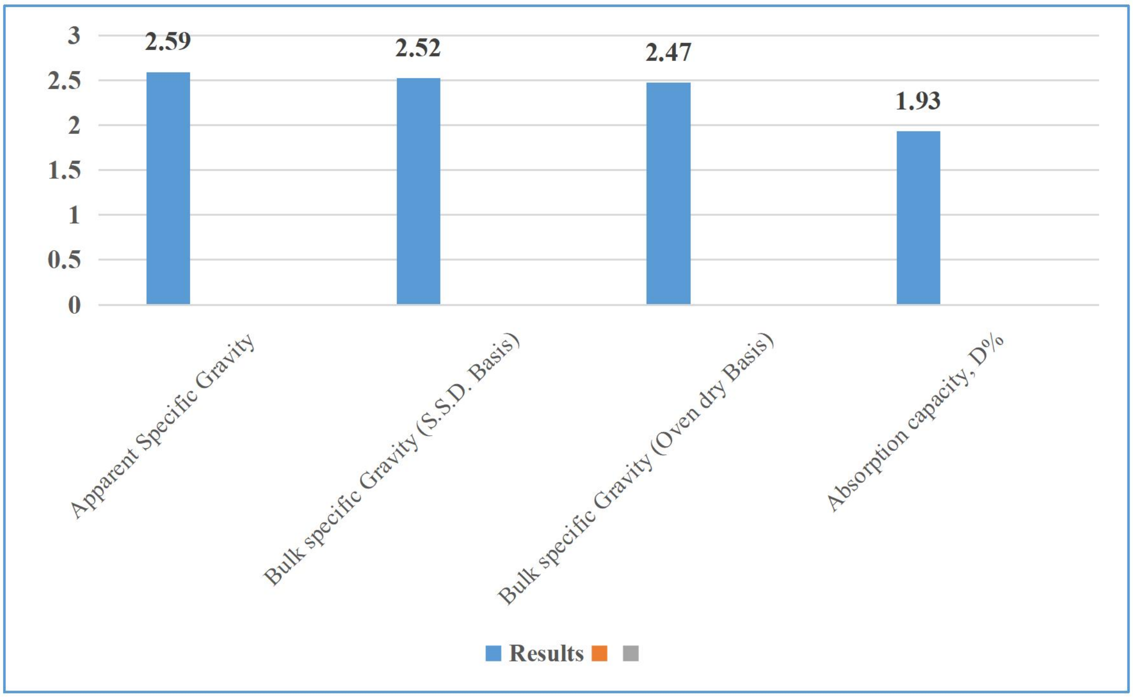

Figure 4.2 : Bar Chart of Specific Gravity and Absorption Capacity of Coarse Aggregate

4.6 Flexural Strength of Normal Concrete

Data Sheet

Description	Mix Ratio	Load, P (kN)	Load, P (b)	Area of Slab,A (sqin.)	Flexural Strength, (MPa)
7 Days Flexural strength	1:1.5:3	28	6294.4	432	2.31
14 Days Flexural strength	1:1.5:3	40	8992	432	3.31
28 Days Flexural strength	1:1.5:3	60	13488	432	4.96

Table 4.5 : Flexural Strength of Normal Concrete

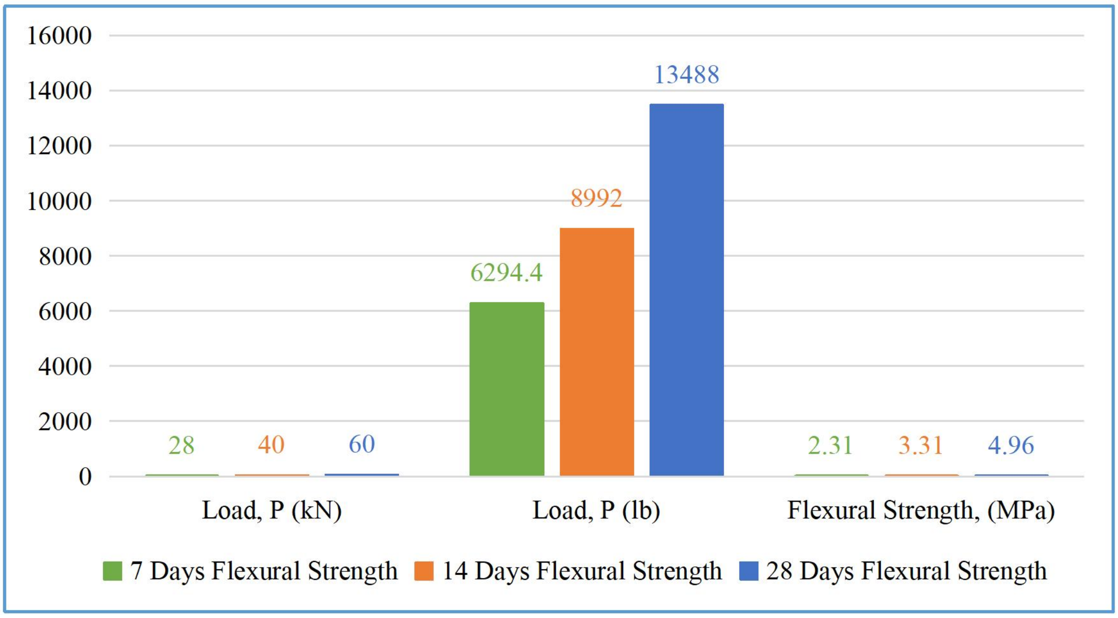

Figure 4.3 : Bar Chart of Flexural Strength of Normal Concrete

4.7 Flexural Strength of Steel Wire Mesh Concrete

Data Sheet

Description	Mix Ratio	Load, P (kN)	Load, P (Ib)	Area of Slab,A (sqin.)	Flexural Strength, (MPa)
7 Days Flexural strength	1:1.5:3	85	19108	432	7.03
14 Days Flexural strength	1:1.5:3	97	21805.6	432	8.02
28 Days Flexural strength	1:1.5:3	110	24728	432	9.09

Table 4.6 : Flexural Strength of Steel Wire Mesh Concrete

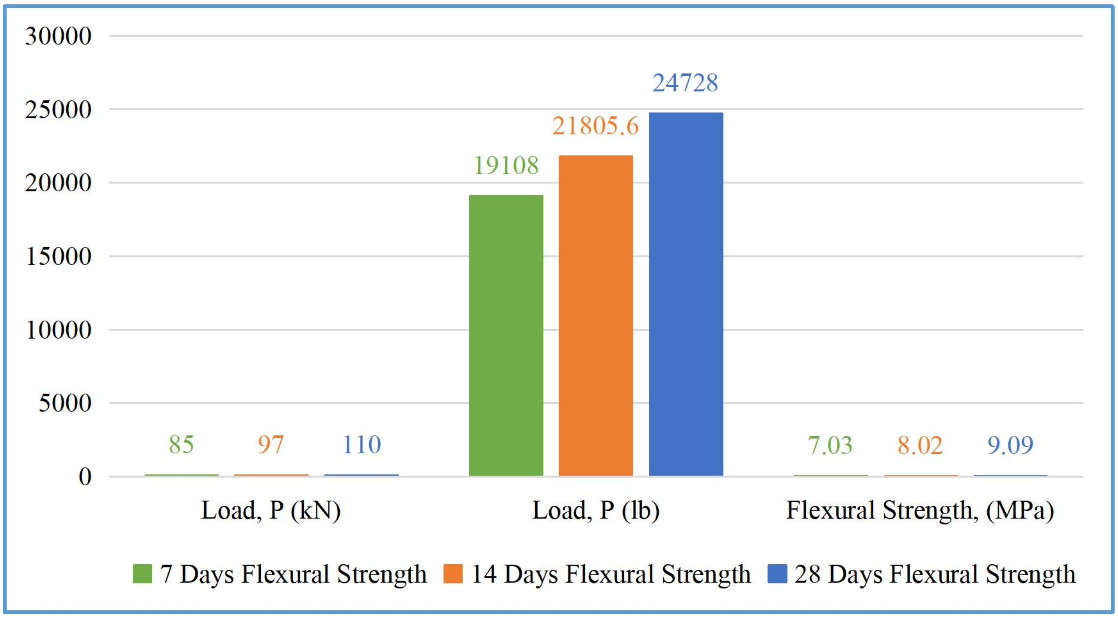

Figure 4.4 : Bar Chart of Flexural Strength of Steel Wire Mesh concrete Slab

4.8 Result analysis

By using steel wire mesh, the strength increase was about 204.3% at 7 days, 142.2% at 14 days and 83.3% at 28 days.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

5.1 General

In the present study, an experimental study on the Normal Concrete slab and Steel wire mesh concrete slab is carried out. Effects of Normal Concrete slab and steel wire mesh concrete slab were compared under both static loading condition and Flexural Strength test.

5.2 Conclusion

Two layer steel wire mesh reinforcement had been proved to be effective in enhancing concrete flexural resistance, and due to the reduction or elimination of coarse aggregate in the concrete, this reinforcement scheme showed promising future. In the present study, it showed that concrete with steel wire mesh reinforcement could fail under shear rather than energy absorbing flexure mode. Steel wire mesh reinforcement can effectively enhance the shear resistance leading to more ductile material behaviour.

Flexural strength measures a paver's ability to resist breaking when pressure is applied. The result helps to ascertain the products application suitability and longevity as well as the end user's safety.

Flexural strength—UHPC can deliver more than 2,000 psi in flexural strength; traditional concrete normally has a flexural strength of 400 to 700 psi.

Hence the results shows that compressive behavior and helps the properties of Normal concrete. Flexural strength after 7 days are 335.7psi and flexural strength results increases after 14 days is 479.57psi and flexural strength after 28 days is 719.36psi respectively.

Hence the results shows that it increases the compressive behavior and helps in improving the properties of Steel wire mesh concrete. Strength after 7 days is 1019.09psi, and flexural strength after 14 days is 1162.97psi**,** and flexural strength after 28 days is 1318.82psi respectively.

5.3 Limitations and Recommendations for Future Works

5.3.1 Limitations

- We could not experiment with more than 2 layers of steel wire mesh due to time constraints. If more layers steel wire mesh are used, the strength will be higher.

- Due to unavailability of fiber we could not do the experiment on that and unable to provide another possible solution to enhance strength.

5.3.2 Recommendations for Future Works

- For future more steel wire mesh layers can be used in the slab for better strength. For example using 4 layers and 6 layers steel wire mesh may provide the strength better.

- Slab or beam casting using other fibers like polyethylene fiber, steel fiber may enhance strength.

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