INVESTIGATION OF THE EFFECT OF BAMBOO FIBER ON THE COMPRESSIVE AND SPLIT TENSILE STRENGTH OF CONCRETE

By

MEHEDY HASAN

MUZAMMEL HAQUE

MEHEDE HASAN

MD. SAYFULLAH

MD. REFATH ALAM

SIRAZAM MONIRA

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

Department of Civil Engineering

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By

MEHEDY HASAN	BCE1903018076
MUZAMMEL HAQUE	BCE1903018035
MEHEDE HASAN	BCE1903018129
MD. SAYFULLAH	BCE1903018058
MD. REFATH ALAM	BCE1901016200
SIRAZAM MONIRA	BCE1703012113

Supervisor

Md. Abu Saleh Sagor

Assistant Professor,

Department of Civil Engineering

Sonargaon University

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BOARD OF EXAMINERS

The thesis titled **"Investigation of the effect of bamboo fiber on the compressive and split tensile strength of concrete."** submitted by Mehedy Hasan; ID: BCE1903018076, Muzammel Haque; ID: BCE1903018035, Mehede Hasan; ID: BCE1903018129, Md. Sayfullah; ID: BCE1903018058, Md. Refath Alam; ID: BCE1901016200, Sirazum Monira; ID: BCE1703012113 has been accepted as satisfactory in partial fulfillment of the requirement for the degree of Bachelor of Science in Civil Engineering on 09-05-2023.

……………………………………

1.Md. Abu Saleh Sagor — Chairman
Assistant Professor
Sonargaon University

……………………………………

2.Internal / External Member — Member

……………………………………

3.Internal / External Member — Member

DECLARATION

It is stated that the project work on, "Investigation of the effect of bamboo fiber on the compressive and split tensile strength of concrete" has been performed under the supervision of Md. Abu Saleh Sagor, Assistant Professor, Department of Civil Engineering, SU has been accepted for satisfactory submission in partial fulfillment of the requirements for the degree of Bachelor of Science in civil engineering. Any portion of this has not been submitted elsewhere for any degree or diploma.

STUDENT NAME	STUDENT ID.	SIGNATURE
MEHEDY HASAN	BCE1903018076	
MUZAMMEL HAQUE	BCE1903018035	
MEHEDE HASAN	BCE1903018129	
MD. SAYFULLAH	BCE1903018058	
MD. REFATH ALAM	BCE1901016200	
SIRAZAM MONIRA	BCE1703012113	

Dedicated

to

"Our Beloved Parent's"

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ABSTRACT

A series of experiments are carried out to investigate the mechanical performance of bamboo fiber reinforced concrete, including the cubic compressive strength and splitting tensile strength. The experimental results show that bamboo fibers can enhance the cubic compressive strength and remarkably improve the splitting tensile strength of concrete. In the concrete mixture, bamboo fiber is added with a percentage of 0%, 0.5% & 1% of cement. Testing was carried out at 7, 14, 28 days. Though tensile strength was determined for only at the duration of 28 days. At 28 days, for 0% fiber bamboo, the obtained strength was 18.62 MPa and a split tensile strength was 1.53 MPa. For 0.5% fiber, the obtained strength was 21.52 MPa and a split tensile strength was 2.48 MPa. For 1% fiber, the obtained strength value was 20.40 MPa and a split tensile strength was 2.59 MPa. Using fiber bamboo of the test shows an increase in compressive strength, where the use of 0.5% fiber bamboo in concrete was the most optimal value. Using bamboo fiber in concrete also showed an increase in split tensile strength, as addition of 1% bamboo fiber achieved highest value.

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CHAPTER 1

INTRODUCTION

1.1 General

The building industry indirectly plays a major role in environmental damage, so it is our responsibility to find more environmental techniques of construction for development. One of the solutions is to search for a new material that can be recycled and reused. Therefore, it is necessary to go for a new material that is naturally available such as bamboo, glass, agricultural product, coconut shell rice husk, ceramic, silica, crump rubber etc., Bamboo is one of the renewable natural resource known to us. But sufficient care has not been given to investigation and change in bamboo. Due to the beneficial physical characteristics of bamboo, research has been made of bamboo as fiber material in concrete. With the development of science and technology, new techniques are implemented for treating of bamboo to make it durable and more working in terms of construction materials. In this project bamboo will be used in concrete to study of strength characteristics.

Concrete is commonly used as the base of infrastructure in most countries. Concrete has the requisite construction properties, such as its ability to withstand large compressive stresses. Concrete is mostly used because it is cheap and readily available. Since it has low tensile strength, the use of concrete is limited. For this reason, it is strengthened and the tensile strength properties of the concrete are improved.

Many buildings are only made of concrete or mud-bricks in certain parts of the world. In the event of seismic activity, this is risky. In the case of an earthquake, these structures have no chance of standing. An ideal solution would be steel reinforcement, but cost is a major issue. For structural structures, scientists and engineers are constantly searching for new materials; the concept of using bamboo as a potential reinforcement has gained popularity.

Natural fibers consist of those prepared from the sources of plants, animals and minerals. It is possible to identify natural fibers according to their origin. Proteins are normally made of animal fibers. For e.g. wool, silk, alpaca, angora, mohair. The fibers that are taken from animals or hairy mammals are animal fur (wool or fur). Sheep fur, goat hair (cashmere, mohair), alpaca hair, horse hair etc., for example. Silk fibers are the fibers of bugs or insects which are extracted from dried saliva.

Examples involve silk from worms made of silk. Avian fibers are bird fibers, e.g. feathers and feather fiber. Mineral fibers are naturally occurring fiber or slightly modified fiber procured from minerals. The following groups are known as mineral fibers: asbestos is the only naturally occurring mineral fibers. Glass fibers (glass wood and quartz), aluminum oxide, silicon carbide, and boron carbide are made of ceramic fibers. Aluminum fibers contain metal fibers. Generally plant fibers are mostly made of cellulose.

Solid concrete is weak in tensile strength so to raise the tensile strength of the concrete steel is used to attain Tensile Strength. Corrosion the main problem when concerned about the steel. Therefore, researches are going on to utilize Bamboo fibers as reinforcement in concrete and as structural material because of its positive physical features. By the nature of conventional Concrete, it creates cracks, creep, and tensile failure and fatigue failures; to avoid these failures in the concrete bamboo fibers were added. This has been showed the mixing of fibers is raising the ductility of concrete. Such a multifaceted Fiber Reinforced Concrete (FRC) is a material. Aluminum, coir, jute, carbon, steel and so on are some of the fibers that can be used in FRC processing. Bamboo fibers are also used as natural fibers in concrete to manufacture Bamboo Fibers Reinforced Concrete (BFRC) to give concrete some desirable properties.

1.2 Objectives of the study

The main objectives of the study are:

- ✓ To determine the compressive strength of concrete for 7,14 and 28 days for addition of 0%, 0.5% and 1% bamboo fiber.
- ✓ To determine the split tensile strength of concrete in 28 days for addition of 0%, 0.5% and 1% bamboo fiber.

1.3 Outline of the Thesis

The chapter one includes the background of the thesis and the specific objectives of the thesis along with the outline of methodologies are thoroughly discussed. The scopes, significance and outline of the thesis are also included in the chapter. The chapter two is a compendium of related researches that will establish the true importance of the thesis topic. It also addresses the literature review. The chapter three presents detailed methodology of the research work. It includes description of the above all, how & where we have accomplished the research stages. Here chapter four includes with data collection, analysis and result of the study. And chapter five includes major findings, limitation of the study, conclusion and recommendation for future of the study.

CHAPTER 2
LITERATURE REVIEW

2.1 General

Compressive strength analysis is most important to select the coarse aggregate. Most importantly cement, sand and aggregate properties with mixing procedure discussed in this chapter. Water, curing, compressive strength calculation also performed.

2.2 Cement

Cement is a cementing of bonding materials and water-resistant products used in engineering construction. Portland cement was developed from natural cement made in Britain in the early part of the nineteenth century, and its name is derived from its similarity to Portland stone, a type of building stone that was quarried on the Isle of Portland in Dorset, England (Gill berg et al. 1999).

The Portland cement (Fig-1) is considered to originate from Joseph Aspdin, a British bricklayer from Leeds. It was one of his employees (Isaac Johnson), however, who developed the production technique, which resulted in a more fast-hardening cement with a higher compressive strength (Courland 2011). Portland cement (often referred to as OPC, from Ordinary Portland Cement) is the most common type of cement in general use around the world because it is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. It is a fine powder produced by grinding Portland cement clinker (more than 90%), a limited amount of calcium sulfate (which controls the set time) and up to 5% minor constituents as allowed by various standards such as the European Standard EN197.1.

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates (3CaO.Si02 and 2CaO.Si02), the remainder consisting of aluminum- and iron-containing clinker phases and other compounds. The ratio of Ca0 to Si02 shall not be less than 2.0. The magnesium oxide content (MgO) shall not exceed 5.0% by mass. ASTM C 150 defines Portland cement as "hydraulic cement (cement that not only hardens by reacting with water but also forms a water-resistant product) produced by pulverizing clinkers consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an inter ground addition."(ASTM n.d.) Clinkers are nodules (diameters, 0.2-1.0 inch [5-25 mm]) of a sintered material that is produced when a raw mixture of predetermined composition is heated to high temperature. The low cost and widespread availability of the limestone, and other naturally occurring materials make Portland cement one of the lowest-cost materials widely used over the last century throughout the world. Concrete becomes one of the most versatile construction materials available in the world.

Figure 2.1: Cement

Portland cement clinker is made by heating, in a kiln, a homogeneous mixture of raw materials to a sintering temperature, which is about 1450 °C for modern cement. The aluminum oxide and iron oxide are present as a flux and contribute little to the strength. For special types of cement, such as Low Heat (LH) and Sulfate Resistant (SR) types, it is necessary to limit the amount of tricalcium aluminates (3CaO.Al203) formed. The major raw material for the clinker making is usually limestone (CaCO3) mixed with a second material containing clay as a source of alumina-silicate. Normally, an impure limestone, which contains clay or Si02, is used. The CaCO3 content of these limestone’s can be as low as 80%. Second raw materials (materials in the raw mix other than limestone) depend on the purity of the limestone. Some of the second raw materials used are: clay, shale, sand, iron ore, bauxite, fly ash and slag. When a cement kiln is fired by coal, the ash of the coal acts as a secondary raw material.

2.3 Aggregate

Construction aggregate, or simply "aggregate", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete. Aggregates are a component of composite materials such as concrete and asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. The American Society for Testing and Materials publishes an exhaustive listing of specifications for various construction aggregate products, which, by their individual design, are suitable for specific construction purposes. These products include specific types of coarse and fine aggregate designed for such uses as additives to asphalt and concrete mixes, as well as other construction uses. State transportation departments further refine aggregate material specifications in order to tailor aggregate use to the needs and available supply in their particular locations (Nelson and Bolen 2008).

2.3.1 Physical Properties of Aggregate

1. Unit weight and voids
2. Specific gravity
3. Particle shape and surface texture
4. Absorption capacity and surface moisture

2.3.2 Coarse Aggregate

Coarse aggregates are larger size filler materials in construction. Coarse aggregates are the particles that retain on 4.75 mm sieve. Brick chips (broken bricks), stone chips (Fig-2), gravels, pebbles, clinkers, cinders etc. are used as coarse aggregate in concrete. Coarse aggregate acts as inert filler material for concrete. Coarse aggregates are mainly used in concrete, railway track ballast, etc.(Mahmud n.d.)

Figure 2.2: Stone Chips

2.3.3 Fine Aggregate

Fine aggregates are small size filler materials in construction. Fine aggregates are the particles that pass through 4.75 mm sieve and retain on 0.075 mm sieve. Sand, surki, stone screenings, burnt clays, cinders, fly ash, etc. are used as fine aggregate in concrete. The voids between the coarse aggregate are filled up by fine aggregate. Fine aggregates are used in mortar, plaster, concrete, filling of road pavement layers, etc. (Mahmud n.d.)

2.3.3.1 Sand

Sand is an engineering material in concrete work. It is usually termed as fine aggregate. Sand (Fig-3) is a naturally occurring granular material composed of finely divided rock and mineral particles. The composition of sand is highly variable, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or Si02), usually in the form of quartz.

Figure 2.3: Sand

2.3.4 Bamboo Fiber

Bamboo is a versatile replacement characterized by large ratio of strength to weight and it is easy to work due to its nature. It is one of the fast-growing natural reserves and it is also locally accessible. For building purposes, bamboo has been used since ancient times. The non-technical and technical methods of bamboo can be used. Our ancestors used Bamboo as basic material for building the structure. Because of its high strength to weight ratio, conventionally it has been used in different existing ability and tools. The bamboo has longitudinal alignment of fiber due its inherited property. Compared to any other natural fiber material bamboo fiber having higher modulus of elasticity. The lengthier the fiber advanced it gives the tensile strength. Adding of Bamboo fibers to the concrete increases the tensile and mechanical strength. The specific weight of the bamboo fiber is very low. The bamboo fiber is susceptible to the natural attack that is from toadstool, insects etc. To prevent from termites and insects a treatment was given using Timber Protector's anti-termite solution. It is necessary to fabricate the bamboo fiber after extracting the bamboo fiber from the bamboo in a controlled way.

There has been very little investment in the bamboo sector until recently, with Ethiopia having no formal bamboo economy until 2012. As African bamboo is at the forefront of this bamboo revolution, this has sparked growing interest in adding value to this abundant resource in Africa. Two bamboo varieties, low-land bamboo and high-land bamboo, occur naturally in Ethiopia. Low land bamboo, known locally as Shimel, makes up about 80 percent of the bamboo resources in the region. Highland, locally known as Kerekeha in Ethiopia, bamboo makes up 6.5 percent of the total forest cover. In Ethiopia, bamboo is primarily used for building and as a source of fuel. For this reason, many farmers harvest and sell young green bamboo culms, although they are immature and lack the strength and durability of mature culms. Natural bamboo fiber materials that were locally available were collected from different areas and properly shaped in the form of fibers. Using the cutting machine, standardized lengths of fibers were obtained.

Figure 2.4: Bamboo Fiber

Bamboo fibers are natural fibers that are extracted from the bamboo tree and are focused as one of substitution for natural plant fiber having many advantages such as low cost, low density, ecologically friendly, sustainability and biodegradability. In this study bamboo fibers extracted by using mechanical method was used. Scanning electron microscopy test has been conducted to find the micro structure of bamboo fibers and failure analysis as well as the diameter of bamboo fiber.

Figure 2.5: Different ages of raw bamboo

Figure 2.6: Longitudinal striped bamboo

Generally the specific gravity is a measure of the density of a substance and the substance specific gravity is determined as a comparison of its density to that of density of water. The specific gravity of bamboo is 0.58 depending mainly on its anatomical structure. Fresh bamboo may have hundred percent moisture content measured by oven dry weight basis and it can be as high as 140 to 155% for innermost layers.

Figure 2.7: Longitudinal striped bamboo

2.4 Water

Potable water (That which is fit for human consumption) can be used without testing. This information summarized requirements for mixing water for use in ready mixed concrete. In October 2004 ASTM approved two new standards that address mixing water for use in concrete. While the requirements for water were addressed in ASTM C 94, increased pressure on concrete producers to use process water from concrete production operations and other recycled sources created a need for a more comprehensive coverage on the standard of water

2.5 Curing of concrete

Adding water to Portland cement to form the water-cement paste that holds concrete together starts. A chemical reaction that makes the paste into a bonding agent. This reaction, called hydration, produces a stone-like substance the hardened cement paste. Both the rate and degree of hydration and the resulting strength of the final concrete, depending on the curing process that follows placing and consolidating the plastic concrete. Hydration continues indefinitely at a decreasing rate as long as the mixture contains water and the temperature conditions are favorable. Once the water is removed, hydration ceases and cannot be restarted.

Curing (Fig-2.8) is the period of time from consolidation to the point where the concrete reaches its design strength. The properties of concrete, such as freeze and thaw resistance, strength, water tightness, wear resistance, and volume stability, cure or improve with age as long as you maintain the moisture and temperature conditions favorable to continued hydration. The length of time that must protect concrete against moisture loss depends on the type of cement used, mix proportions, required strength, size and shape of the concrete mass, weather, and future exposure conditions. The period can vary from a few days to a month or longer. For most structural use, the curing period for cast-in-place concrete is usually 7, 14 & 28 days.

Figure 2.8: Curing in Lab

2.5.1 Curing Methods

Methods that supply additional moisture include sprinkling and wet covers. All of these methods add moisture to the concrete surface during the early hardening or curing period. They also provide some cooling through evaporation.

Table 2.1: Curing Methods and their advantages and disadvantages

Methods	Advantages	Disadvantages
Sprinkling with water or covering with Burlap	Excellent results if kept constantly wet	Likelihood of drying between sprinklings; difficult on vertical walls.
Straw	Insulator in water	Can dry out, blow away, or burn.
Moist earth	Cheap but messy	Stains concrete; can dry out; removal problem.
Pending on flat surfaces	Excellent results; maintains uniform temperature	Requires considerable labor.
Curing compounds	Easy to apply and inexpensive	Sprayer needed; inadequate coverage allows drying out; unless pigmented, can allow concrete to get too hot.

Waterproof paper	Excellent protection, prevents drying	Heavy cost can be excessive; must be kept in rolls; storage and handling problems.
Plastic film	Absolutely watertight, excellent protection, light and easy to handle	Should be pigmented for heat protection; requires reasonable care and tears must be patched.

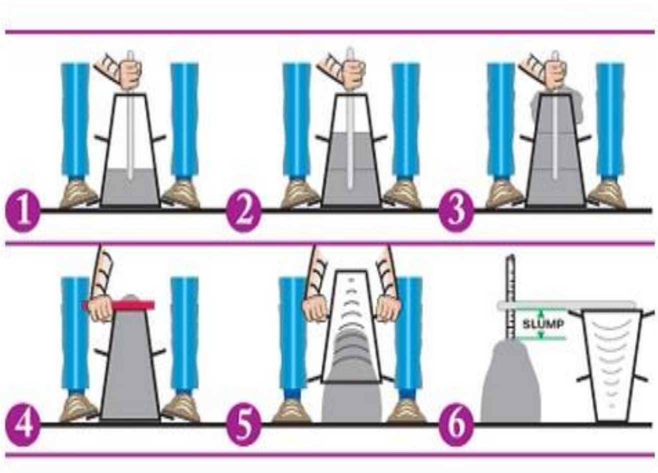
2.6 Physical tests

2.6.1 Setting of concrete

Setting of concrete is defined as the onset of rigidity in fresh concrete. It is destined from hardening, while it describes the development of useful and measurable strength. Settings precede hardening, but it should be emphasized that both are gradual changes, which are controlled by the continuing hydration of the cement. Setting is a transitional period between states of the true fluidity and true rigidity. The penetration test according to ASTM C 403 is used to determine the initial and final setting of concrete. This test method covers the determination of the time of setting of concrete with a slump greater than zero, by means of penetration resistance measurements on mortar sieved from the concrete mix. The penetration tests do not correspond to any specific change in concrete properties, although it is useful to consider that the initial set represents approximately the time at which fresh concrete can no longer be properly handled and placed, while the final set approximates the time at which the hardening begins. Fresh concrete will have lost measurable slump prior to the initial set, while measurable strength will be achieved sometime after the final set. As per ASTM 0403, the time of initial setting is the elapsed time, after initial contact of cement and water, required for the mortar sieved from the concrete to reach a penetration resistance of 3.5 Mpa (500 psi). Time of final setting is defined, in ASTM C 403, as the elapsed time, after initial contact of cement and water, required for the mortar sieved from the concrete to reach a penetration resistance of 27.6 Mpa (4000 psi).

2.6.2 Slump Test

The concrete slump test (Fig-2.9) is used for the measurement of a property of fresh concrete. The test is an empirical test that measures the workability of fresh concrete. More specifically, it measures consistency between batches. The test is popular due to the simplicity of the apparatus used and simple procedure. The slump test is used to ensure uniformity for different batches of similar concrete under field conditions, and to ascertain the effects of plasticizers on their introduction. The slump test result is a measure of the behavior of a compacted inverted cone of concrete under the action of gravity. It measures the consistency or the wetness of concrete. The slumped concrete takes various shapes, and according to the profile of slumped concrete, the slump is termed as a true slump. Shear slump or collapse slump. If a shear or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indication of too wet a mix. Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which slump test is not appropriate. Very dry mixes; having slump 0 - 25 mm are used in road making, low workability mixes; having slump 10 - 40 mm are used for foundations with light reinforcement, medium workability mixes having slump 50 - 90 for normal reinforced concrete placed with vibration, high workability concrete, slump > 100 mm.



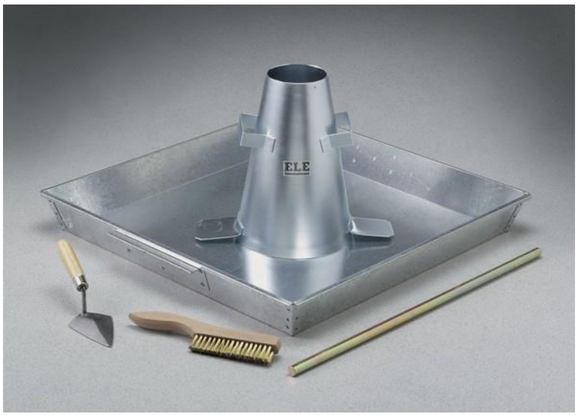


Figure 2.9: Slump Test

The slump test is suitable for slumps of medium to high workability, the slump in the range of 25 - 125 mm, the test fails to determine the difference in workability in stiff mixes which have zero slump, or for wet mixes that give a collapse slump. It is limited to concrete formed of aggregates of less than 38 mm.

Slump Value:

Figure 2.10: Slump test for 0%, 0.5% & 1% Ratio of Bamboo fiber mixed Concrete.

For,
0% = 31.75mm
0.5% =63.5mm
1% =21.4mm

2.6.3 Sieve Analysis

A sieve analysis (or gradation test) is a practice or procedure used (commonly used in civil engineering) to assess the particle size distribution (also called gradation) of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as a fraction of the whole mass.

The size distribution (Fig-2.11) is often of critical importance to the way the material performs in use. A sieve analysis can be performed on any type of non-organic or organic granular materials including sands, crushed rock, clays, granite, feldspars, coal, and soil, a wide range of manufactured powders, grain and seeds, down to a minimum size depending on the exact method. Being such a simple technique of particle sizing, it is probably the most common (McGlinchey 2009)

Figure 2.11: Sieve analysis

The results are presented in a graph of percent passing versus the sieve size. On the graph the sieve size scale is logarithmic. To find the percent of aggregate passing through each sieve, first, find the percent retained in each sieve. To do so, the following equation is used,

$\%Retained = (W_{Sieve}/ W_{Total})*100\%$

Where W_{Sieve} is the mass of aggregate in the sieve and W_{Total} is the total mass of the aggregate.

The next step is to find the cumulative percent of aggregate retained in each sieve. To do so, add up the total amount of aggregate that is retained in each sieve and the amount in the previous sieves. The cumulative percent passing of the aggregate is found by subtracting the percent retained from 100%.

%Cumulative Passing = 100% - %Cumulative Retained.

The values are then plotted on a graph with cumulative percent passing on the y-axis and logarithmic sieve size on the x-axis.

2.6.3.1 Types of gradation

A Dense gradation

A dense gradation refers to a sample that is approximate of equal amounts of various sizes of aggregate. By having a dense gradation, most of the air voids between the materials are filled with particles. A dense gradation will result in an even curve on the gradation graph.

Narrow gradation

Also known as uniform gradation, a narrow gradation is a sample that has aggregate of approximately the same size. The curve on the gradation graph is very steep and occupies a small range of the aggregate.

Gap gradation

A gap gradation refers to a sample with very little aggregate in the medium size range. This results in only coarse and fine aggregate. The curve is horizontal in the medium size range on the gradation graph.

Open gradation

An open gradation refers to an aggregate sample with very little fine aggregate particles. This results in many air voids, because there are no fine particles to fill them. On the gradation graph, it appears as a curve that is horizontal in the small size range.

Rich gradation

A rich gradation refers to a sample of aggregate with a high proportion of particles of small sizes. (Mamlouk and Zaniewski n.d.)

2.6.4 Compressive strength test

Compressive strength of concrete is the Strength of hardened concrete measured by the compression test. The compression strength of concrete is a measure of the concrete's ability to resist loads which tend to compress it. It is measured by crushing cylindrical concrete specimens in the compression testing machine.

The compressive strength of concrete (Fig-9) can be calculated by the failure load divided with the cross-sectional area resisting the load and reported in pounds per square inch in US customary units and mega Pascal (MPa) in SI units. Concrete's compressive strength requirements can vary from 2500 psi (17 MPa) for residential concrete to 4000psi (28 MPa) and higher in commercial structures. Higher strengths up to and exceeding 10,000 psi (70 MPa) are specified for certain applications. (Jamal 2017).

Figure 2.12: Compressive strength test

2.6.4.1 Importance of Determining Compressive Strength:

Compressive strength results are primarily used to determine that the concrete mixture as delivered on-site meets the requirements of the specified strength, fc', in the job specification. Cylinders tested for acceptance and quality control are made and cured in accordance with procedures described for standard-cured specimens in ASTM C-31 (which is the Standard Practice for Making and Curing Concrete Test Specimens in the Field). For estimating the in-place concrete strength, ASTM C-31 provides procedures for field-cured specimens. Cylindrical specimens are tested in accordance with ASTM C-39 (which is the Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens).

A test result is the average of at least two standard-cured strength specimens made from the same concrete batch and tested at the same age. In most cases, strength requirements for concrete are at 28 days.

2.6.4.2 Data Acquirement from Compression Strength:

Design engineers use the specified strength to design structural elements. This specified strength is incorporated in the job contract documents and is the called design strength of concrete. The concrete mixture is designed to produce an average strength fc' higher than the specified strength such that the risk of not complying with the strength specification is minimized. To comply with the strength requirements of a job specification, the following acceptance criteria apply:

The average of three consecutive tests should equal or exceed the specified strength fc'.

No single strength test should fall below fc' by more than 500 psi (3.45MPa) or by more than 0.10fc' when fc' is more than 5000 psi (35 MPa).

It is important to understand that an individual test falling below fc' does not necessarily mean that the test has failed and specifications were not as per requirement. When the average of strength tests is as per the required average strength fc', the probability that individual strength tests will be less than the specified strength is about 5% and this is accounted for in the acceptance criteria.

When strength test results indicate that the concrete fails to meet the requirements of the specification, it is important to recognize that the failure of concrete may also be due to the testing procedure. This is especially true if the fabrication, handling, curing and testing of the cylinders are not conducted in accordance with standard procedures.

2.6.5 Tensile strength test

Tensile strength is one of the important mechanical properties of concrete, but it is difficult to measure accurately due to the brittle nature of concrete in tension. The three widely used test methods for measuring the tensile strength of concrete each have their shortcomings: the direct tension test equipment is not easy to set up, particularly for alignment, and there are no standard test specifications; the tensile strengths obtained from the test method of splitting tensile strength (American Society for Testing and Materials, ASTM C496) and that of flexural strength of concrete (ASTM C78) are significantly different from the actual tensile strength owing to mechanisms of methodologies and test setup. The objective of this research is to develop a new concrete tensile strength test method that is easy to conduct and the result is close to the direct tension strength. By applying the strut-and-tie concept and modifying the experimental design of the ASTM C78, a new concrete tensile strength test method is proposed. The test results show that the concrete tensile strength obtained by this proposed method is close to the value obtained from the direct tension test for concrete with compressive strengths from 25 to 55 MPa. It shows that this innovative test method, which is precise and easy to conduct, can be an effective alternative for tensile strength of concrete.

2.6.5.1 Existing Concrete Tensile Strength Testing Method

2.6.5.1.1 Direct Tension Test

In a direct tension test, both ends of the specimen are clamped firmly, which causes local stress concentration and possible eccentricity of loading. Due to the heterogeneous behavior of the concrete, getting damage to the specimen on both sides and other unexpected locations is also possible. Some kinds of direct tension test were proposed before, including the Three Jack Solution, Embedded Threaded Rod Method, Gluing and Gripping Test, and Triangular Loading Frame Method. However, the complex structures of the mold, labor-intensive processes and difficulty in convincing the no eccentricity of loading makes the above tests hard to be used in materials laboratories. These above factors affect the experimental results and cause large deviations. Therefore, there are no standard specifications released by American Society for Testing & Materials (ASTM) for measuring the tensile strength of concrete directly. Academicians and researchers are mostly preferring to use splitting tensile test and flexural test over direct tension test for measuring the tensile strength of concrete.

2.6.5.1.2 Splitting Tensile Test (ASTM C496)

The split tensile test is an indirect way of evaluating the tensile test of concrete. In this test, a standard cylindrical specimen is laid horizontally, and the force is applied on the cylinder radially on the surface which causes the formation of a vertical crack in the specimen along its diameter. The experimental setup for this test is shown in Figure 10. Tensile stress increases with the increase in radial compressive force and specimens deteriorate along the direction of the applied force. This test is relatively simple and needs only a standard cylindrical test specimen and a loading assembly.

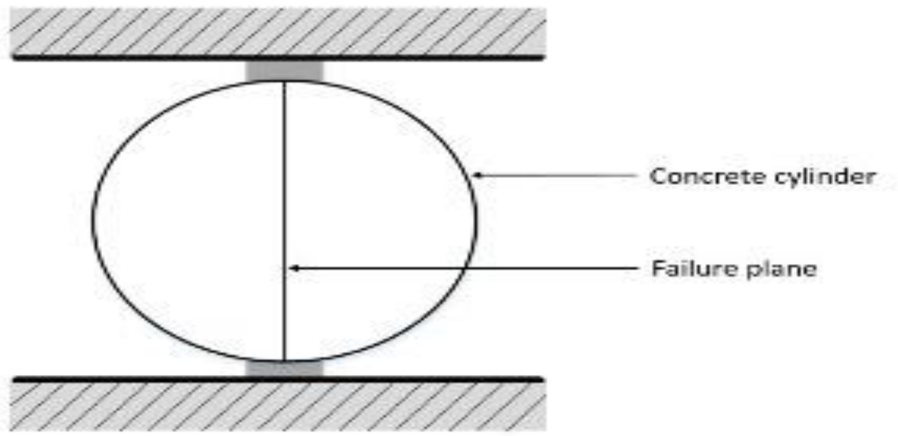


Figure 2.13: Specimen arrangement of splitting test

Uneven distribution of stress under radial compressive force makes this method disadvantageous. It can be followed from Figure 11 that, the intensity of the compressive stress is greater on the top and bottom surface of the cylinder. Initially, the tensile crack appears in the central part of the cylindrical specimen and it further penetrates until the specimen reaches the maximum tensile stress. Also, as the specimen in this test is under compression therefore, the tensile test results obtained from this test are overestimating as compared with the direct tension test. Splitting tensile test overestimates the tensile strength of concrete by 10–15%. Also, different maximum size of aggregates leads to the miscellaneous stress distribution.

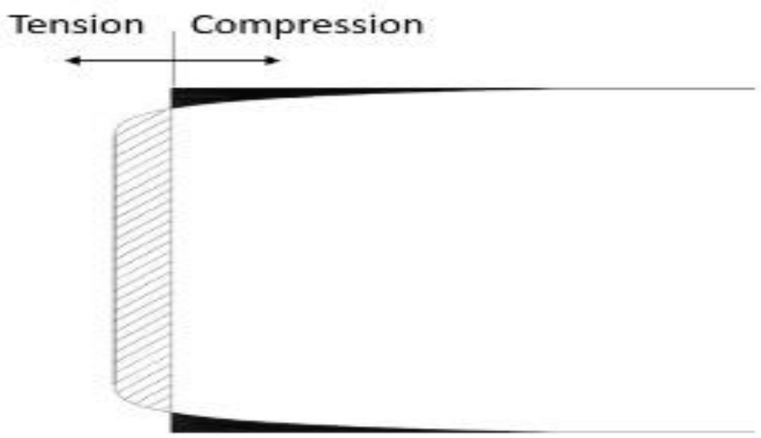
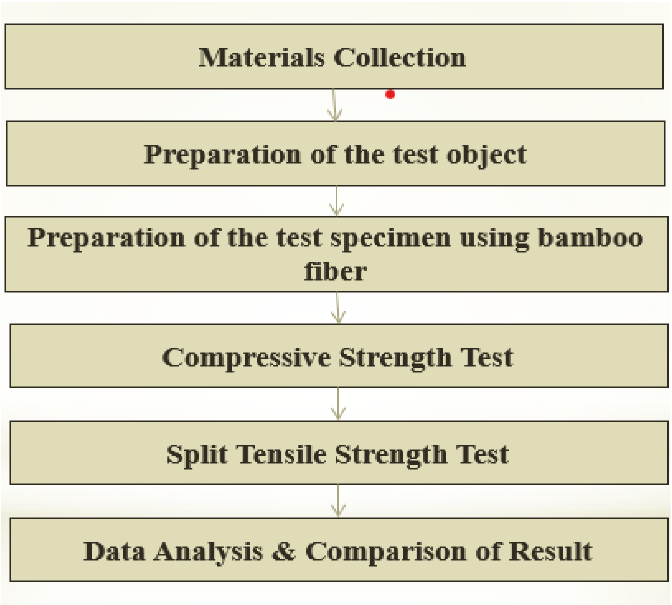


Figure 2.14: Stress distribution on vertical specimen diameter in splitting test

CHAPTER 3
METHODOLOGY

3.1 General

The compressive & tensile strength analysis will give the clear concept about the selection of aggregate before construction .Before the compressive strength test the below mentioned physical test have to perform.



3.2 The scope of work of Bamboo Fiber

The work presented in this paper reports an investigation on the behavior of concrete produced from using Sawdust as Sand. The physical properties of these materials were investigated first then compared it to ordinary Fine aggregate. In this investigation Sawdust are used in percentage of 0%, 2.5%, 5%, &7.5% in place of Sand and was developed with a characteristic compressive strength of 20MPa, with a mixing proportion of 1:1.5:3 and with W/C ratio of 0.45. A total of thirty specimens were casted and tested to evaluate the strength and durability properties of concrete.

3.3 Physical Tests

3.3.1 Physical tests for coarse aggregate

- Sieve analysis
- Specific gravity and water absorption capacity

3.3.2 Physical tests for fine aggregate

- Sieve analysis
- Specific gravity and water absorption capacity

3.4 Coarse aggregate investigation and preparation

Stone chips were collected from local market.

3.4.1 Sieve Analysis

This experiment was done to find the fineness modulus of coarse aggregate; sieve grading is given in the below table:

Table 3.1: Sieve analysis of coarse aggregate

Sieve Number	Sieve Opening (mm)	Weight Retained (gm)	% Retained	Cumulative % Retained	FM
3 inch	76.2	0	0	0	
1.5 inch	38.1	0	0	0	
¾ inch	19.05	2193	73.1	73.1	
3/8 inch	9.525	799	26.63	99.73	
#4	4.75	8	0.2667	100	
#8	2.36	0	0	100	7.73
#16	1.19	0	0	100	
#30	0.60	0	0	100	
#50	0.30	0	0	100	
#100	0.15	0	0	100	
Pan	-	-	-	-	
Total		3000	100	772.83	

3.4.3 Specific Gravity and Absorption Capacity

This experiment was done to find the Bulk Specific Gravity and Absorption Capacity of coarse aggregate; values are given in the below :

The weight in g of the saturated aggregate in water, A = 2500 gm
The weight in g of the saturated surface-dry aggregate in air, B =2565gm
The weight in g of the oven-dried aggregate in air, C =1554gm

Bulk Specific Gravity=A/ (B-C) =2500/ (2565-1554) =2.47
Bulk SSD Specific Gravity=A/ (A-C) =2500/ (2500-1554) =2.64
Apparent Specific Gravity=C/ (A-C) =1554/ (2500-1554) =1.64
Water absorption in %= (B-A) /A *100 = (2565-2500) /2500 *100 =2.6%

3.5 Fine aggregate investigation and preparation

Sand was collected from the local market, and Sylhet sand was used.

3.5.1 Sieve Analysis

This experiment was done to find the fineness modulus of fine aggregate; sieve grading is given in the below table:

Table 3.2: Sieve analysis of Fine aggregate

Sieve Number	Sieve Opening (mm)	Weight Retained (gm)	% Retained	Cumulative % Retained	FM
#4	4.75	0	0	0	
#8	2.36	7	1.4	1.4	
#16	1.19	31	6.2	7.6	
#30	0.60	146	29.2	36.8	2.126
#50	0.30	162	32.4	69.2	
#100	0.15	142	28.4	97.6	
Pan	-	12	2.4	-	
Total		500	100	212.6	

Specific Gravity and Absorption Capacity

This experiment was done to find the Bulk Specific Gravity and Absorption Capacity of Fine aggregate; values are given in the below :

SSD Weight (S) = 559 gm
Weight of Pycnometer filled with water (B) = 1353gm
Weight of Pycnometer with specimen & water to calibration mark (C) =1654gm
Weight of Oven dry Specimen in Air (A) =500gm

Bulk Specific Gravity, Dry = S/ B-(C-A) = 500/ 1353-(1654-559) =1.94
Bulk SSD Specific Gravity=A/ B- (C-A) = 559/ 1353-(1654-559) =2.80
Apparent Specific Gravity=S/ B-(C-S) = 500/ 1353-(1654-500) =2.51
Water absorption in %= (S-A) / A *100= (559-500)/ 559 *100 =11.8%

3.6 Cement

Cement is collected from the local market and its initial setting time and final setting time were 30 and 600 minutes respectively. The unit weight of the cement was approximately 1350 kg/m^3.

3.7 Water

Water that was used in the concrete mixing and the curing of the specimens was normal tap water, which has a Unit weight of 1000kg/m^3. (Approximately) In general, the air percent of the mix design was assumed 2%. The cement content of the ratio was 0.45 for the workability of the concrete.

3.8 Mix Design

Mix design can be defined as “the process of choosing the ingredient of concrete and determining their quantities with the object of producing as economically as possible of certain concrete of certain minimum properties such as consistence, strength, and durability(Neville, 1995, Ghasemi n.d.)

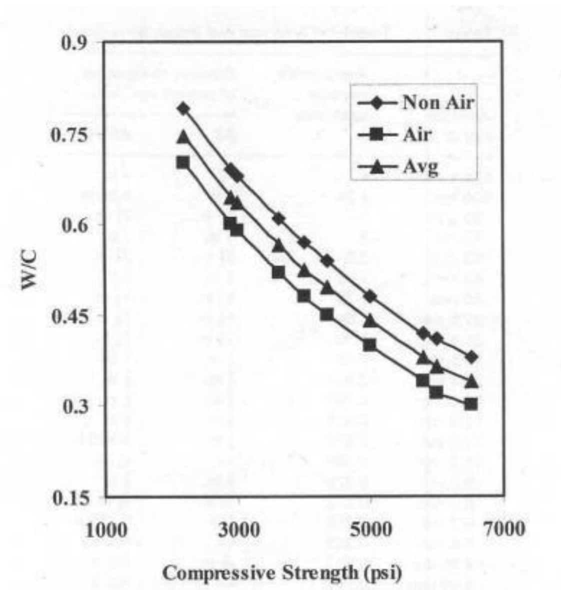


Figure 3.1: W/C versus Compressive Strength (for stone chips)

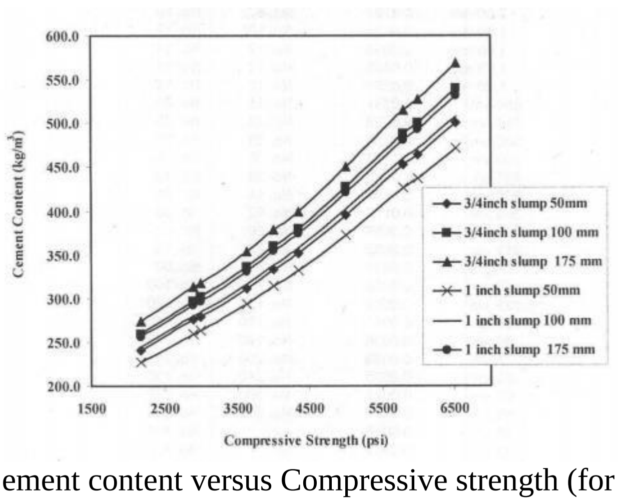


Figure 3.2: Cement content versus Compressive strength (for stone chips)

From the above graph and our calculation, we get the ratio of water- cement is 0.45 and the mixture ratio is

Cement: Fine aggregate: Coarse aggregate = 1: 1.5: 3 (M20)

3.8.1 Mix proportion for concrete

Volume of concrete for 1 Cylinder:

Cement – 1.078 kg
Sand – 1.618 kg
Stone – 3.237 kg
Water – 0.4851 kg
Bamboo Fiber
For
0.5%- 0.00538 kg
1%- 0.01078 kg

3.9 Molds preparation

Our mold cylinder size was 4in on diameter and 8in in height. The molds were prepared and cleaned properly before putting the concrete mix into these molds. All the molds were properly lubricated inside before casting of concrete specimens.

Figure3.3: Molds preparation

3.10 Casting

Concrete mixture was prepared by hand. Trial mix was done for every case before the final mix. At construction sites all the elelPment, such as cement, sand, stone and water put together in the mixture machine to produce concrete mix. But in fact, it is not a good way to gain the good strength of concrete. To ensure the quality strength in the matrix, the following procedure was followed for mixing concrete.

At first, all the coarse aggregate sand and cement putted together and mixed properly with the help of Towel. After that one third of the water was mixed with the mixed aggregate. Then after mixing that properly, the rest of the water was putted into the mixture and mixed properly. After that casting was done of the specimens. For water-cement ratio we have used 0.45, this is found from the mix design calculation.

Figure 3.4: Casting

3.11 Compaction of the concrete

The concrete mixture was compacted properly before completing the mold. Every cylinder specimen was compacted by three layers. In each layer, there were total 25 blows. After the proper compaction of these mixtures, hammering and scaling were done to get a void free surface and cylinder of the specimen.

Figure 3.5: Compaction of the concrete

3.12 Curing of Concrete

After all the casting was done, curing was ensured properly. Normal tape water was used for curing. We have used a water drum for the curing procedure. All the specimens are putted into the water in the drum. Before crashing these cylinders, all of them were putted under water in the drum for 14 & 28 days.

Figure 3.6: Curing of Concrete

3.13 Destructive Test by Universal Testing Machine (UTM)

The universal testing machine had used to do destructive tests for all the concrete specimens. Before the destructive tests of the cylinder, the entire cylinder specimen was carried out of the curing drum and left for drying. Before the test all the specimen were capped properly to get a smooth and uniform surface for concentrated load. Loading was 4kN/sec applied by the Universal Testing Machine to the specimen. Stresses were measured for each case.

Crashing patterns and the entire crack surface picture were taken for every specimen. Generally speaking, concrete used for residential purposes is around 2500 psi, for commercial uses is 4000psi, and as high as 10000psi for other specified application.

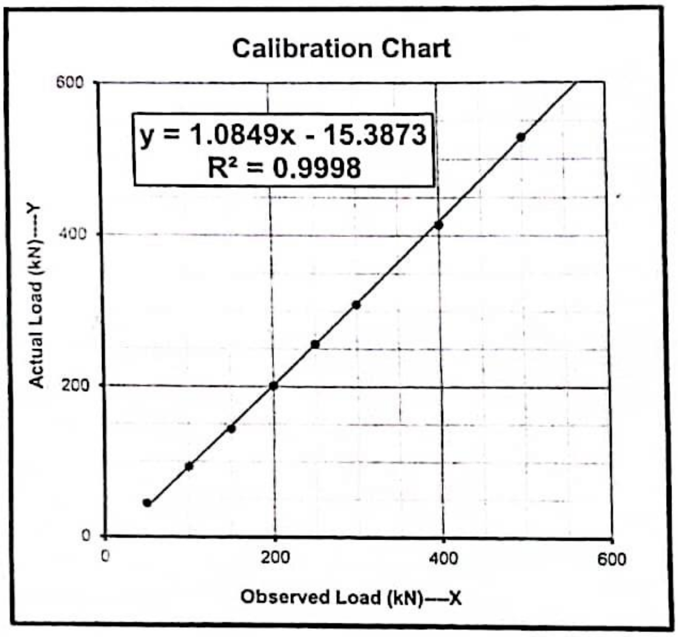
CHAPTER 4
RESULTS AND DISCUSSION

4.1 General

Our natural resources are limited, but the rapidity of our infrastructure development is very fast. Our recent development scenario indicates that we need to utilize our land by replacing the old low rise building with new and high rise building. Recycling these old building makes huge mass of demolished concrete, and that can harm our environment in many ways. By using these waste demolished materials as recycled aggregate we can save both our environment and our construction cost at a time.

4.2 Results

We got compressive and tensile cylinder test result from crashing the specimen concrete cylinder by Universal Testing Machine (UTM). We got the result in KN from the test and converted that to psi format. [Cylinder size (4” * 8”) & Ratio 1: 1.5: 3]. The calibration equation:



Observed Load (kN)	Actual Load (kN)	Calibrated Load (kN)
50.0	44.0	38.9
100.0	92.8	93.1
150.0	143.5	147.3
200.0	201.2	201.6
250.0	256.4	255.8
300.0	309.0	310.1
400.0	414.3	416.6
500.0	528.5	527.0
600.0	638.2	635.5

Note: Calibration equation is valid upto 600 kN

Table 4.1: Compressive strength of concrete (7 Days)

Materials Ratio	Bamboo Fiber Ratio	Load (KN)	Average Load (KN)	Load (lb)	Area (in^2)	Compressive Strength (psi)	Compressive Strength (Mpa)
1:1.5:3	0%	103.95	98.53	22149.02	12.57	1762.05	12.15
		93.10					
		98.53					
1:1.5:3	0.5%	115.30	115.47	25956.91	12.57	2064.99	14.38
		118.50					
		112.60					
1:1.5:3	1%	107.20	110.40	24817.92	12.57	1974.38	13.71
		110.60					
		113.40					

Table 4.2 Compressive strength of concrete (14 Days)

Materials Ratio	Bamboo Fiber Ratio	Load (KN)	Average Load (KN)	Load (lb)	Area (in^2)	Compressive Strength (psi)	Compressive Strength (Mpa)
1:1.5:3	0%	131.07	125.65	28246.05	12.57	2247.10	15.50
		125.65					
		120.23					
1:1.5:3	0.5%	131.07	140.12	31497.86	12.57	2505.80	17.28
		141.92					
		147.35					
1:1.5:3	1%	125.65	131.07	29465.48	12.57	2344.11	16.17
		131.07					
		136.50					

Table 4.3 Compressive strength of concrete (28 Days)

Materials Ratio	Bamboo Fiber Ratio	Load (KN)	Average Load (KN)	Load (lb)	Area (in^2)	Compressive Strength (psi)	Compressive Strength (Mpa)
1:1.5:3	0%	158.20	150.96	33936.71	12.57	2699.82	18.62
		141.92					
		152.77					
1:1.5:3	0.5%	179.89	174.47	39220.90	12.57	3120.20	21.52
		169.05					
		174.47					
1:1.5:3	1%	174.47	165.43	37188.52	12.57	2958.51	20.40
		158.20					
		163.62					

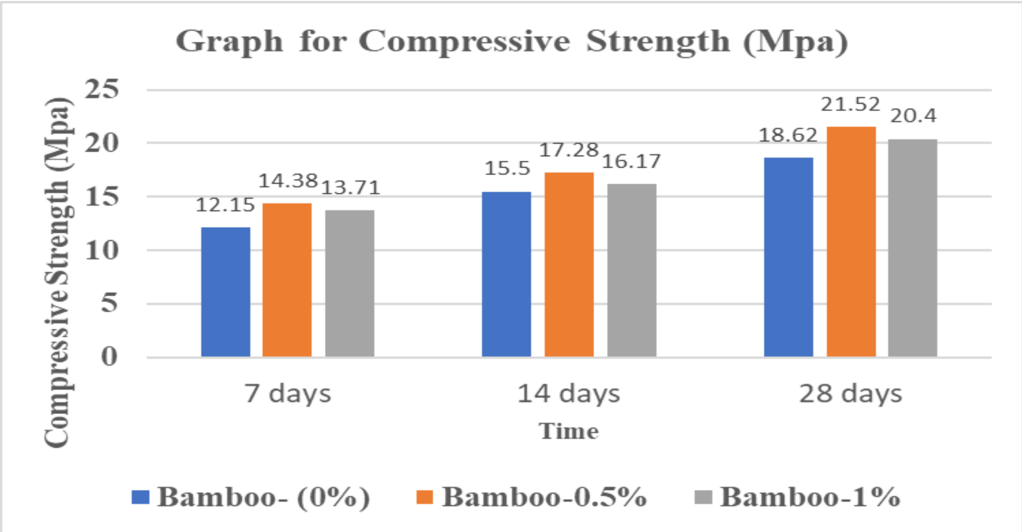


Figure 4.1 Comparison of Compressive Test

From the graph it is seen that, adding 0.5% of bamboo fiber achieved the highest number of compressive strengths. In 28 days, 21.52 Mpa of strength was resulted with an increase of 15.57 % in comparison with no bamboo fiber added.While addition of 1% fiber also escalated strength with an increase of 9.56 % with 20.4 Mpa.

Table: 4.4 Split Tensile strength of concrete (28 Days)

Materials Ratio	Bamboo Fiber Percentage	Load (KN)	Average Load (P) (KN)	Load 2P (lb)	πDL (in^2)	Split Tensile Strength (psi)	Split Tensile Strength (MPa)
1:1.5:3	0%	44.28	60	26976	100.53	268.33	1.53
		55.13					
		49.71					
1:1.5:3	0.5%	82.25	88.33	39713.17	100.53	395.04	2.48
		87.68					
		71.40					
1:1.5:3	1%	71.40	91.67	41214.83	100.53	409.97	2.59
		82.25					
		98.52					

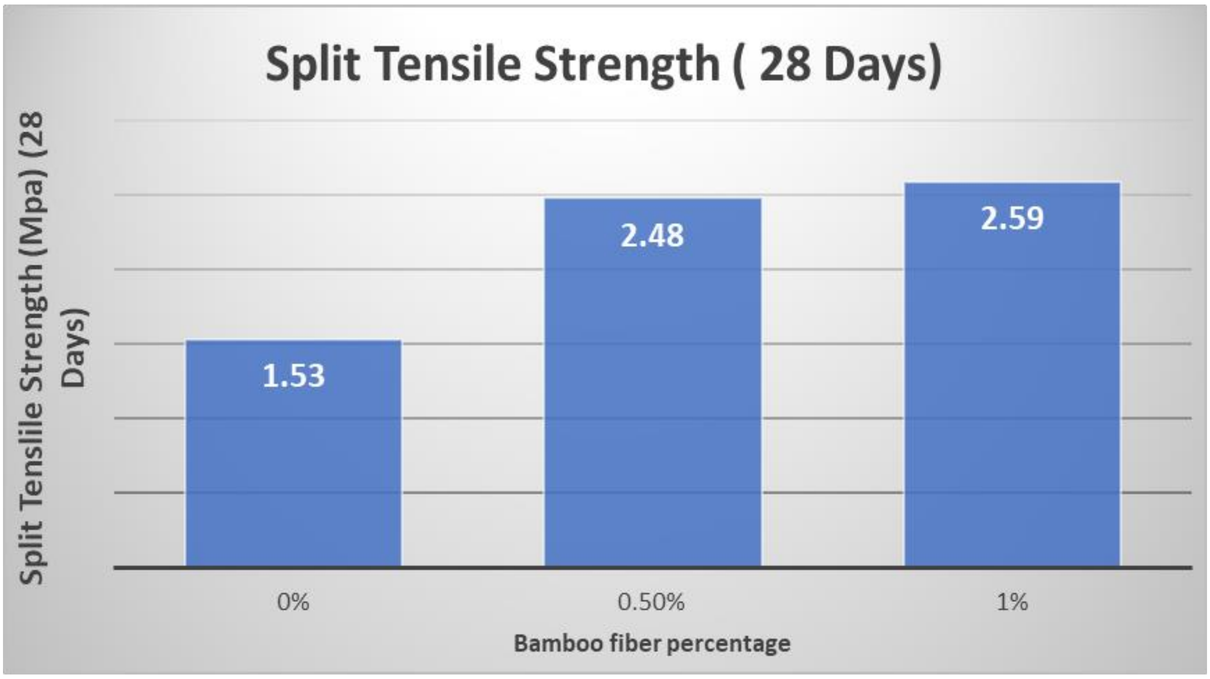


Figure 4.2 Comparison of Split Tensile Strength

At 28 days, addition of 1% of bamboo fiber, increased 69.28% of split tensile strength at 2.59 Mpa. From this it can be concluded that addition of bamboo fiber helps to increase tensile strength in which generally concrete is weaker.

4.3 Cost

Table: 4.5 Cost for 1 cylinder without bamboo fiber

Cement	12/-
Fine Aggregate (Sylhet Sand)	21.5/-
Coarse Aggregate (Stone Chips)	4.5/-
Total	**38/-**

Table: 4.6 Cost for 1 cylinder with 0.5% bamboo fiber

Cement	12/-
Fine Aggregate (Sylhet Sand)	21.5/-
Coarse Aggregate (Stone Chips)	4.5/-
Bamboo	5/-
Total	**43/-**

Table: 4.7 Cost for 1 cylinder with 1% bamboo fiber

Cement	12/-
Fine Aggregate (Sylhet Sand)	21.5/-
Coarse Aggregate (Stone Chips)	4.5/-
Bamboo	10/-
Total	**48/-**

CHAPTER 5
CONCLUSIONS AND RECOMENDATIONS

5.1 General

The research was aimed to study compressive and tensile strength analysis of concrete made using by Bamboo fiber. Another aim was to find the results of compressive strength; if it is within the allowable limit then it can be used in new construction. From the results we get that it cannot be used in high rise and high priority buildings, bridges and other important construction work. But it can be easily used in low priority constructions and low rise buildings, and less important construction work like sidewalk of road, road of rural areas, benches of park, drainage etc. It is found satisfactory results from the strength test which indicates waste materials like Sawdust can be used in concrete as aggregate. After some physical test we can find the quality of these aggregates. By compressive strength analysis the final condition of concrete produced by these waste material aggregates was found. By using these waste materials as aggregate, we can reduce the construction waste, and it will help us from environmental pollution and landfill by this type of wastes. And finally it can reduce our construction cost of new construction requiring nominal strength of concrete.

5.2 Specific Conclusion

- ✓ From the results it is observed that the compressive strength of concrete increases with the addition 0.5% of bamboo fiber but decreases for addition of 1 % bamboo fiber.
- ✓ In split tensile strength test, addition of bamboo fiber increases tensile strength of concrete. Highest split tensile has been found for 1% addition of bamboo fiber.

5.3 Recommendation

- ✓ Effect of addition of different percentages of bamboo fiber should be tested.
- ✓ Effect of addition of treated bamboo fiber should be studied.
- ✓ Addition of different length of bamboo fibers should be also studied.

5.4 Limitations

- ✓ Due to time limitation only one mixing proportion was selected to carry out the study.
- ✓ Split Tensile strength test on 7 and 14 days could not be implanted.
- ✓ Bamboo fibers could not be treated.

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