VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"Jnana Sangama", Belgaum-590 014

A Dissertation Project Report on

"AN EXPERIMENTAL STUDY ON EFFECT OF STEEL WOOL FIBER AND GLASS FIBER ON STRENGTH ENHANCEMENT OF CEMENT MORTAR"

A final project report submitted in partial fulfillment of requirement of 8th semester of Bachelor of Engineering course during the year 2019-20

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Certificate

This is to certify the project work entitled **"AN EXPERIMENTAL STUDY ON EFFECT OF STEEL WOOL FIBER AND GLASS FIBER ON STRENGTH ENHANCEMENT OF CEMENT MORTAR"** has been successfully completed by **Ms. SHALINI K V (1CR16CV057), Mr. MITHUN N (1CR17CV408), Mr. NAGARAJU B S (1CR17CV411), Mr. NAVEEN H S (1CR16CV042),** bonafide students of **CMR Institute of technology** in partial fulfillment of the requirement for the award of degree of Bachelor of Engineering in Civil Engineering of the **"VISVESVARYA TECHNOLOGICAL UNIVERSITY",** Belgaum during the academic year 2019-20. It is certified that all corrections indicated for internal assessment has been incorporated in the Report. The project report has been approved as it satisfies the academic requirements in respect of project work prescribed for the said Degree.

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DECLARATION

We, **Ms. SHALINI K V, Mr. MITHUN N, Mr. NAGARAJU B S, Mr. NAVEEN H S**, bonafide students of CMR Institute of Technology, Bangalore, hereby declare that dissertation entitled **"AN EXPERIMENTAL STUDY ON EFFECT OF STEEL WOOL FIBER AND GLASS FIBER ON STRENGTH ENHANCEMENT OF CEMENT MORTAR"** has been carried out by us under the guidance of **Mr. ShivaKumara M J (Assistant Professor)**, Department of Civil Engineering, CMR Institute of Technology, Bangalore, in partial fulfillment of the requirement for the award of degree of Bachelor of Engineering in **Civil Engineering** of the Visvesvaraya Technological University, Belgaum during the academic year 2019-2020. The work done in this dissertation report is original and it has not been submitted for any other degree in any university.

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ABSTRACT

An experimental program was carried out to evaluate the mechanical properties and to develop an economical, structurally effective, and practically applicable steel wool fiber mortar and glass fiber mortar. Compressive strength test and split-tensile strength test were performed and the results were analyzed statistically. According to the results of this study, the designed direct tensile testing method was a suitable method to estimate the tensile strength of fiber cement- based composites (cement mortar). Steel fibers and glass fibers can greatly increase the mechanical properties of cement-based composites (cement mortar). Specimens containing steel fiber of 0.5%, 1%, 1.5% and glass fibers of 1%, 2%, 3% and cement partially replace fly ash of 20%, 30%, 40% by weight of cement are prepared and tested in this work. It is demonstrated that certain amount of fibers enhances the compressive and split tensile capacity of the fiber reinforced cement mortar. From this experimental study, the optimum percentage of glass fiber, steel wool fiber, optimum amount of fly ash is obtained. The 1% of steel wool fibers used by weight of cement and 2%of glass fibers used by weight of cement and 20% partial replacement of cement by fly ash gives better compression strength and split tensile strength of cement mortar.

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CHAPTER 1

1.1 INTRODUCTION

Cement-based composites (cement mortar) have been used for civil structures such as highways, bridges and buildings. However, reinforcement has led to the improvement of durability of mortar. Traditionally, the constituents of cement-based composites include design of steel fiber cement mortar in structural applications. Cementitious- material, water, aggregate Fiber has been added in cement-based composites since 1960's to enhance concrete and cement mortar properties, particularly tensile strength, abrasion resistance and energy absorbing capacity. The presence of fiber would refrain the growth or propagation of internal cracks and helps to transfer load.

The specimen with fiber has much higher ductility than the specimen without fiber, for which fiber reinforced composites (FRC) also demonstrates a significant increase in energy absorption or toughness. Lower fiber volume fraction is usually preferred as far as material cost and workability are concerned. It was also reported that glass fiber and steel wool fiber would effectively enhance the compressive strength, splitting tensile strength, abrasion resistance and impact resistance and be beneficial for fiber dispersion in cement-based composites.

This study was aimed to evaluate the effect of steel fiber and glass fiber on the mechanical properties of cement-based composites (cement mortar).

This investigation is aimed at generating information on the overall response of Compressive as well as tensile behavior of cement composite reinforced with different fiber percentage of steel fibers, also with partial replacement of cement with fly ash, and also fiber percentage of glass fibers. Compression and split tensile tests on cement mortar cubes of size 70.6 x 70.6 x 70.6 mm containing steel fiber of 0%, 0.5%, 1%, 1.5% by weight and glass fiber of 1%, 2%, 3% by weight and partial replacement of cement by fly ash of 20%, 30%, 40% carried out. Results of compression and split tensile strength were studied and depicted in tabular and graphical form for the sake of convenient design of steel fiber cement mortar and glass fiber cement mortar and partial replacement of fly ash in cement mortar in structural applications.

1.2 RESEARCH SIGNIFICANCE

Dimensional hybrid and amount of steel wool fibers and glass fibers in cementitious-composites can be effective in arresting cracks at both macro and micro levels. The problem of failure mechanism and bearing capacity of fiber reinforced cement mortar under various loading conditions has been studied quite extensively in the past. In spite of the volume of information available, relatively very little or no research work is reported in the technical literature on the split tensile strength of thin cementitious-composites containing steel wool and glass fibers with varying quantities although it presents considerable versatility towards the development of cementitious-composites for structural applications. The purpose of this research is to investigate the split tensile and compressive behavior of fiber-reinforced cementitious composites and to identify synergistic effects of quantities.

1.3 EXPERIMENTAL PROGRAM

In order to study the effects of steel-wool fibers and glass fibers on the behavior of cement composites in terms of compressive strength and split tensile strength, tests were carried out on specimens with plain cement mortar, with the addition of steel-wool fibers and glass fibers. For the case of cement composite with fiber, it was steel-wool fibers of length of 5mm, 20 mm and diameter of 0.3mm and glass fibers is of diameter 0.014mm and length of 12mm. The variable percentage of fiber content, chosen for this investigation were 0.5%, 1%, 1.5% of steel-wool fiber and 1%, 2%, 3% of glass fiber by weight of cement is used and whereas the size of the test cubes was kept constant to 70.6 x 70.6 x 70.6 mm for all the specimens to investigate the effectiveness of amount of fibers in cement composites.

CHAPTER 2

2.1 OBJECTIVES

- To enhance the compressive strength of cement mortar.
- To enhance the split tensile strength of cement mortar.
- To study the strength behaviour of cement mortar with the replacement of fly ash .

2.2 MATERIALS USED

Cement, sand and steel-wool fibers, glass fibers, fly ash with water are used to prepare plain cement mortar cubes and cement mortar cubes with steel-wool fibers, glass fiber and with partial replacement of cement by fly ash.

The properties of these materials are discussed below.

- CEMENT
- SAND
- WATER
- FLY ASH
- STEEL WOOL
- GLASS FIBER

2.2.1 CEMENT

Cement is a powdery ingredient of mortar, and is made up of lime, silica, alumina, iron, and gypsum. In this study, the cement used is OPC 53 grade. Tests were conducted on the cement like Fineness of cement, Specific gravity, Initial Setting time, Final setting time, Consistency, Compressive Strength in N/mm^2 at 7days and 28 days.

Table 2. 1: The physical properties of OPC are given in below table

Sl No	DESCRIPTION	TEST RESULT (OPC)
1	Fineness	2% (by weight)
2	Standard Consistency	29%
3	Specific gravity	2.97
4	Initial setting time	60 minutes
5	Final setting time	291 minutes
6	Compressive strength	54 MPa

Figure 2. 1- OPC 53 grade cement

2.2.2 SAND (FINE AGGREAGTE)

Sand is a granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarser than silt. Sand can also refer to a textural class of soil or soil type. Those fractions from 4.75 mm to 150 microns are termed as fine aggregate. The river sand is used as fine aggregate conforming to the requirements of IS: 383. The river sand is washed and screens, to eliminate deleterious materials and oversize particles.

Table 2. 2:The properties of fine aggregate are given in table below

Sl No	DESCRIPTION	TEST RESULT (OPC)
01	Specific gravity	2.54
02	Sieve analysis	Zone-I
03	Silt content	4.59%

Figure 2. 2- River sand

2.1.3 WATER

Water is an important ingredient of cement mortar as it actually participates in the chemical reaction with cement. Since it helps to form the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully. Water used for making and curing mortar should be free from injurious substances such as oil, acid, alkali, salt, sugar, organic materials & other elements which deleterious to cement mortar & steel.

Figure 2. 3- Water

2.1.4 FLY ASH

Fly ash is a fine powder that is a by-product of burning pulverized coal in electric generation power plants. Fly ash is a pozzolan, a substance containing aluminous and siliceous material that forms cement in the presence of water. When mixed with lime and water, fly ash forms a compound similar to portland cement. The fly ash (Class F) is procured from Tuticorin, Tamil Nadu. The chemical constituent of fly ash is given below as per IS: 3812 (Part- I) - 1966 [8]. At molecular level, fly ash is spherical in shape and its size range from micrometer to nanometer.

Table 2. 3: The properties of fly ash are given in table below

Sl No	**DESCRIPTION**	**CLASS (F)**
1	Specific gravity	2.03
2	Silica	85.3
3	Alumina	10
4	Iron oxide	0.15
5	Calcium oxide	0.15
6	Magnesium oxide	1.86
7	Sodium oxide	1.12
8	Potassium oxide	0.05
9	Sulphuric anhydride	0.68
10	Loss of Ignition	0.62

Figure 2. 4- Fly ash

2.1.5 STEEL WOOL FIBERS

The steel-wool fibers used in this research work are commercially available in India. The fibers are generally sized by either cutting or by chopping, and therefore it is also known as chopped steel fiber. Common length of chopped steel fiber is 10 mm. Fibers with straight fibers used in mortar enhances the bonding strength.

Table 2. 4: The properties of steel fibers are given in below table:

Sl No	DESCRIPTION	STEEL-WOOL FIBER
1	Length (mm)	20 & 5
2	Diameter (mm)	0.3
3	Density	7.95
4	Tensile strength (GPa)	1.1
5	Elastic modulus	193
6	Softening point ˚c	1350
7	Elongation %	40

Figure 2. 5- Steel-wool fiber

2.1.6 GLASS FIBER

Glass fiber also called fiberglass. It is a material made from extremely fine fibers of glass. Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using moulding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.

Table 2. 5: The properties of glass fiber are given in below.

Sl No	**DESCRIPTION**	**GLASS FIBER(KDM)**
1	Size	12mm length, 0.014mm diameter
2	Colour	White
3	Brand	KDM
4	Type	Alkali resistant
5	Tensile strength	1700 MPa
6	Modulus	73 GPa
7	Dispersion	High dispersion
8	Softening point	775̊c
9	Elongation %	2.4

SOURCE—Naturo Protect, Surat, Gujarat

Figure 2. 6- Glass fiber

CHAPTER 3

3.1 LITERATURE SURVEY:

Tungce Sevil, Mehmet Baran, Turhan Bilir, Erden Canbay - use of steel-wool fiber reinforced cement mortar for seismic strengthening (1 April 2020) :

The objective of this research was to develop an economical, structurally effective and practically applicable steel-wool fiber reinforced mortar. In this research, the 2% of addition of steel-wool fibers by volume was found out as optimum content to be used. It is observed that the specimen strengthened with optimum mortar mix satisfied the target objectives of this study.

Damyanti G Badagha, Chetan Kumar D Modera- study on harden properties of mortar using steel wool fibres (6 June 2013) on steel wool fibres

According to the researcher in this study they came across the results as follows: Steel fibre can greatly increase the mechanical properties of the cement mortar with specimens containing fibres of 0, 0.3, 0.4, 0.5, 0.6, 0.8, and 10%. The optimum usage of the steel fibres enhances the compressive strength and split tensile capacity of the cement mortar. They found out that optimum usage of fibres increased compressive strength to 43.62% @ 3days, 62.29% @ 7days, 22.62% @ 28 days & split-tensile strength increased by 105.26% @ 7days, 29.17% @ 28 days.

Md Mahmud Sazzad, Nazia Nowshin Sudipta, Saleha Akhter Poly - strength behaviour of cement mortar reinforced with steel fibres at elevated temperature:

The aim of this research is to study and investigate the effect of steel fibres on the compressive strength of cement mortar at elevated temperatures. The researcher have found out steel fibres with 4% of usage in cement mortar shows greater results in compressive strength, tensile strength and also help in crack arresting, and they found out compressive strength of mortar increases as the cooling time increases.

Divyesh Kumar D Paradava, Prof Jayesh Kumar Pitroda (may 2014)- experimental studies on mortar using glass fibre:

The addition of glass fibre in cement mortar accordingly in the range of 0.1%, 0.2 %, 0.3%, by weight of 1:6 proportion of mortar. Compressive strength of mortar was increased 111.78% at 7days, 28.46 at 28 days and split-tensile strength that was increased by 115.15% at 7days, 40% at 28 days.

Praveen Kumar Goud. E , Praveen K S- optimization of percentage of steel and glass fibre reinforced cement mortar composites:

This study was concerned with the optimisation of the fibre reinforced cement composites mixes at fresh states and other than assessing the mechanical behaviour of this mixture at hardened state. The addition of fibers randomly distributed in these materials improves the resistance to cracking, sustainability. In this research, they found that the optimum percentage of steel fibre is 1.5% and 1% for glass fibre provides great compressive strength and spliy-tensile strength.

Swamy RN-Experimental investigation on the flexural of concrete by using small short fiber published in 1974:

The objective of this research concludes that the first crack strength is significantly improved. He also derived the equation to determine the first crack flexural and ultimate flexural strength of the composite based on experimental and previous investigations.

Rasha Salah Mahadi -Experimental study on effect of using glass fiber on cement mortar ''A journal from Babylon university vol (22) 2014:

According to this study the researcher selected % of glass fibre in ratio of 1, 1.5, 2% by the weight of cement and tests used to study the material characteristics where compressive strength and flexural strength. He concluded that the mortar mixed with 1% of fibre gave higher compressive strength and flexural strength than the mortar with 2%of fibre content.

P Chindaprasirt, C. Jaturepittakal & T. Siri, Sivakumar Naganathan & Tan Linda-replacement of cement with fly ash :

Strength increases with the increase in fly ash content up to an optimum value, beyond which strength values start decreasing with further addition of fly ash. Percentile increases for 50% of fly ash is high when compared to mix design and 20% replacement.

Yogesh Ravichandran, Dr. Mahalinga Balasubramanian- an effective replacement of cement with fly ash in cement mortar :

Compressive strength -As fly ash content increases, the amount of tri-calcium silicate C_3S in the mix reduces, which in turn reduces the heat of hydration and hence reduces durability at early stages. Tensile strength- tensile strength increases with the increase in fly ash content up to an optimum value, beyond which strength values start decreasing with further addition of fly ash and 20% was the optimum strength. Surface morphology, elemental analysis, economic feasibility has also been studied in this journal.

CHAPTER 4

4.1 METHODOLOGY

4.1.1 TESTS ON MATERIALS:

TESTS ON CEMENT

The standard consistency of the cement using Vicat apparatus:

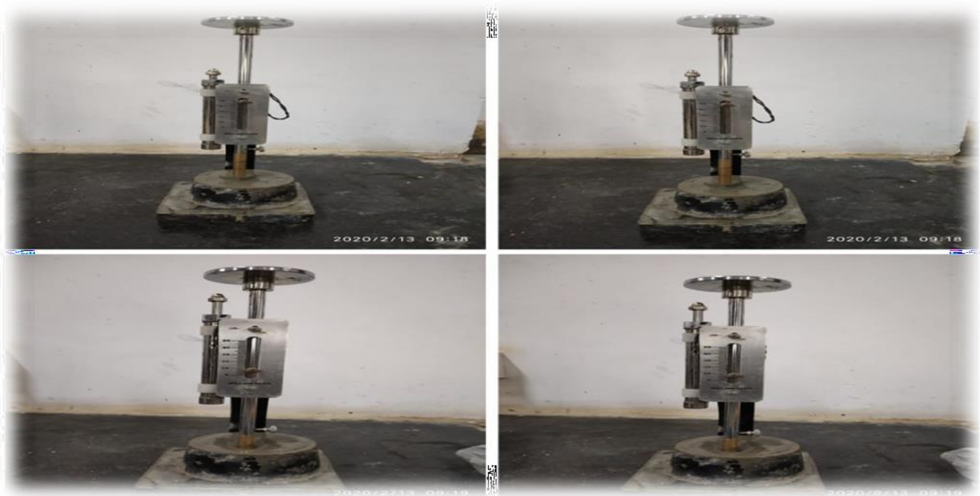

Figure 4. 1- Vicat apparatus

Procedure:

- Take about 500grams of cement.

- Prepare a paste with a weighed quantity of water (say 24% by weight of cement).
- Paste is prepared in standard manner and filled in Vicat mould within 3-5 minutes.
- After completely filling the mould, shake the mould to repel the air.
- Standard plunger is used (10mm diameter & 50mm long).
- Take the reading by noting the depth of penetration.

Increase the percentage of water in each trial till the depth of penetration is 33-35mm.

Tabular column:

Table 4. 1: Standard consistency

Sl no	W/C RATIO in %	DEPTH OF PENETRATION(mm)
01	23	37
02	26	20
03	29	06

RESULT:

The standard consistency of a given sample of cement is 29% of water equivalent of cement.

INITIAL AND FINAL SETTING TIME OF CEMENT

Aim: To determine the initial and final setting time of cement.

Apparatus: balance, vicat apparatus, stop watch

Theory:

The **initial setting time** refers to the time that cement turns into paste by mixing with water and begins to lose its plasticity.

The **final setting time** refers to the time that cement completely loses its plasticity by mixing with water and begins to have a certain structural strength.

Figure 4. 3- Final setting time

Figure 4. 2- Initial setting time

Procedure:

- Unless otherwise specified this test shall be conducted at a temperature of 27 + 20 C and 65 + 5% of relative humidity of the Laboratory.
- Prepare a paste of 300 grams of cement with 0.85 times the water required to a give a paste of standard consistency IS: 4031 (Part 4) 1988.

- The time of gauging in any case shall not be less than 3 minutes not more than 5minutes and the gauging shall be completed before any sign of setting occurs.
- Count the time of gauging from the time of adding water to the dry cement until commencing to fill the mould. Fill the vicat mould with this paste making it level with the top of the mould.
- Slightly shake the mould to expel the air.
- In filling the mould the operator hands and the blade the gauging trowel shall only be used.

INITIAL SETTING TIME

- Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle.
- Lower the needle and quickly release allowing it to penetrate in to the mould.
- In the beginning the needle will completely pierce the mould.
- Repeat this procedure until the needle fails to pierce the mould for 5 + 0.5mm.
- Record the period elapsed between the time of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time.

FINAL SETTING TIME

- Replace the needle of the Vicat apparatus by the needle with an annular ring lower the needle and quickly release.
- Repeat the process until the annular ring makes an impression on the mould.
- Record the period elapsed between the time of adding water to the cement to the time when the annular ring fails to make the impression on the mould as the final setting time.
- Replace the needle of the Vicat apparatus by the needle.
- Release the needle gently to the surface of the test.

RESULTS:

The initial and final setting time of cement is 60minutes and 291 minutes respectively.

SPECIFIC GRAVITY OF CEMENT

Aim: To determine the specific gravity of cement.

Apparatus used: Le Chatelier flask, weighing balance, vibrating tools.

Materials used: cement, kerosene.

Figure 4. 4- Le Chatelier flask

Procedure:

- Take a Le Chatelier flask and fill kerosene to a point on the stem between 0-1ml mark.
- Note down the initial reading.
- Weigh 59 gm quantity of cement.

- Introduce 59 gm of cement to the flask care should be taken to avoid splashing of cement inside the flask.
- After cement is fully introduced the stopper shall be place in flask and roll flask gently in horizontal circle until no air bubbles rise to the surface of kerosene.
- After the rolling of flask, the kerosene level will be in its final position and finial reading will be taken.

$$\text{Specific gravity} = \frac{\text{Density of cement}}{\text{Specific gravity of water}}$$

$$\text{Density of cement} = \frac{\text{Mass of cement}}{\text{Volume of cement}}$$

Tabular column

Table 4. 2: Specify gravity of cement

SL NO	DESCRIPTION	TRIAL
1	Mass of cement	59 gm
2	Initial level of kerosene in flask ,h_1	0.9
3	Final level of kerosene in flask, h_2	19.7
4	Volume of kerosene displace by cement $h_2 - h_1$	18.8

Results:

The specific gravity of given cement is found to be = **3.138.**

FINENESS OF CEMENT

Aim: to determine the fineness of cement.

Apparatus used: is 90-micron sieve, weighing balance.

Materials used: cement

Figure 4. 5- Fineness of cement

Procedure:

- Take 100 gm of cement.
- Add 100gm of cement to 90micron standard sieve.
- Continuously sieve the sample for 10 minutes.
- Weigh the residue left after 10 minutes.

$$\text{FINENESS OF CEMENT}=\frac{\text{WEIGHT OF SAMPLE RETAINED ON SIEVE}}{\text{TOTAL WEIGHT OF SAMPLE}}\times 100$$

The permissible fineness of cement is only 10%.

Tabular column:

Table 4. 3: Fineness of cement

SL NO	DESCRIPTION	TRIAL
1	Total weight of cement	100gm
2	Weight of sample retained on 90 micron sieve	2gm

Results:

The fineness of given cement is found to be = **2%.**

TESTS ON SAND:

THE SILT CONTENT DETERMINATION

Aim: to determine the silt content of fine aggregate

Apparatus used: 500ml measuring cylinder, tray

Materials used: fine aggregate, water, salt

Figure 4. 6- Silt content

Procedure:

- First, we have to fill the measuring cylinder with 1% solution salt and water up to 50ml.
- Add sand to it until the level reaches 100ml, then fill the solution up to 150ml level.
- Cover the cylinder and shake it well.
- After 3 hours the silt content settled down over the sand layer.
- Now note down the silt layer alone volume as v1 ml.
- Then note down the sand volume as v2 ml.
- Repeat the procedure two more times to get the average.

Silt content= $\frac{V1}{V2}\times100$

The permissible silt content in sand is only 6%.

Tabular column:

Table 4. 4: Silt content

SL NO	DESCRIPTION	SAMPLE 1	SAMPLE 2	
1	Volume of sample (v1) ml	290	273	
2	Volume of sample (v1) ml	15	11	
3	% of silt content (v1÷v2)×100	5.17	4.02	Avg=4.60%

RESULTS: The silt content of given fine aggregate is found to be = **4.60%.**

SPECIFIC GRAVITY OF FINE AGGREGATE

Aim: To determine the specific gravity of fine aggregate.

Apparatus used: Pycnometer, weighing balance.

Materials used: fine aggregate, water.

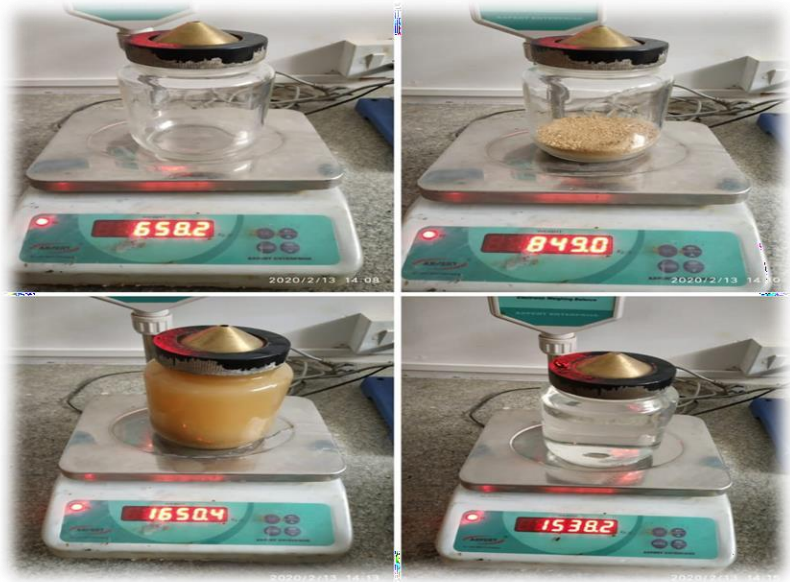

Figure 4. 7- Pycnometer

Procedure:

- Take the pycnometer and weigh it and note as (W_1).
- Now take 500 gm of sad which is of 1/3rd of height of pycnometer and weight and note it as (W_2).
- Fill the pycnometer with water till apex of cone. Eliminate the entrapped air by rotating the pycnometer on its side the in the apex of cone being covered with a finger wipe out the outer surface of pycnometer and weigh it (W_3).
- Transfer the content of the pycnometer into the tray.
- Refill the pycnometer with distilled water to the same level. Find out the weight (W_4).

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

Tabular column

Table 4. 5: Specific gravity of fine aggregate

SL NO	DESCRIPTION	TRIAL 1 grams	TRIAL 2 grams
1	Empty weight of pycnometer w1	658.2	658.2
2	Weight of pycnometer +sand w2	849	850.4
3	Weight of pycnometer +sand +water W3	1650.4	1650.6
4	Weight of pycnometer +water W4	1538.2	1538.2

Results:

The specific gravity of given fine aggregate is found to be = **2.54**

4.1.2 QUANTITY ESTIMATE

Estimate of quantity of materials:

Cube mould size 70.6mm x 70.6mm x 70.6mm

Volume of mould =0.00035189m^3

Mix ratio =1:4

Dry volume of mortar = wet volume x 1.44 (Assume)

=0.00035189 x 1.44

=0.00050672 m^3

Quantity of cement $= \frac{\text{Dry volume of mortar} \times \text{cement ratio}}{\text{Sum of ratios}}$

$= \frac{0.00050672\ X\ 1}{(1+4)}$

= 0.000101345m^3

- Density of cement = 1440kg/m^3
- Weight of cement = 1440 x 0.000101345

=0.1459kg

Quantity of sand = Quantity of cement x 4

= 1.01345x10^{-4} x 4

=4.0538x10^{-4}m^3

Density of sand = 1920kg/m^3

Weight of sand = 4.0538x10^{-4} x 1920

=0.7783kg

Quantity of water =$\frac{P}{4}$+3×weight of sand+ weight of cement

= [$\frac{29}{4}$+3]×[145+778]

= 94 ml

Quantity of materials required for 6 cubes:

- Cement =0.145x 6 = 0.870kg
- Sand = 0.778 x 6 =4.668kg
- Water = 94 x 6 =0.564 litre

4.2 PREPARATION OF TEST SPECIMEN

4.2.1 MORTAR FIBER MIXTURE

In this study, ordinary Portland cement of 53 grade, river sand, steel wool fiber and glass fiber were used. The water to cement ratio and cement to sand ratio were kept as 0.405 and 0.33 by weight in all the mixes. In each casting, three cubes of plain mortar of size 70.6 x 70.6 x 70.6 mm were casted and tested to find out the compressive strength and split tensile strength of the mortar. The details of the proportion of mortar mix are given in below table. The required amount of sand, cement, glass fibers, steel fiber and cement is partially replaced by flash were dry mixed manually on a glass plate in such a way that the procedure involves several passes of scoop through the dry mix to ensure an even distribution of cement and fiber in the mixture. The calculated amount of water to be necessary to obtain a water-cement ratio of 0.405 was added gently to the dry mix and finally, the components were mixed thoroughly. Nearly 3–5 min was required to obtain a homogeneous mortar–fiber mixer.

Figure 4. 8- Mixing

Table 4. 6: Proportion of cement mortar mix by steel wool fiber

INDEX	CEMENT (grams)	SAND (grams)	WATER (ml)	STEEL-WOOL % BY WIEGHT OF CEMENT
M1	145	778	94	0
M2	145	778	94	0.5
M3	145	778	94	1
M4	145	778	94	1.5

Table 4. 7: Proportion of cement mortar mix by glass fiber.

INDEX	CEMENT gram	SAND gram	WATER ml	GLASS FIBER % WEIGHT OF CEMENT
M1	145	778	94	0
M2	145	778	94	1
M3	145	778	94	2
M4	145	778	94	3

Table 4. 8: Proportion of cement mortar mix by partial replacement of fly ash with steel wool fiber and glass fibers

INDEX	**CEMENT** grams	**SAND** grams	**WATER** ml	**PARTIAL REPLACEMENT OF FLY ASH IN %**	**FIBERS IN %**
M1	116	778	93.5	20	0
					SF-1
					GF-2
M2	101	778	93	30	0
					SF-1
					GF-2
M3	87	778	92.5	40	0
					SF-1
					GF-2

PROCEDURE FOR CASTING OF MORTAR CUBE:

- Take steel moulds with open tops of size 70.6 x 70.6 x 70.6 mm of the four side-walls and the base of the mould were detachable to facilitate the demoulding process after its initial setting
- Fix the mould using bolts in correct position and apply the oil inside the plates.
- Prepare the mixture and place the mix in the mould by tamping it using tamping rod for 25 blows to avoid the voids.
- Remove the mould after 24 hrs.
- Keep the cube for curing 28-days in water.
- Repeat the same procedure for next cube and curing is done for 7, 28days.

Figure 4. 9- Casting of cubes

CURING

The specimens were air-dried for 1 day for initial setting and then immersed in water for curing. After 28 days of curing the specimens were air-dried in room temperature at about 25ºC.

Figure 4. 10- Curing

COMPACTING THE MORTAR CUBES USING VIBRATING MACHINE:

Figure 4. 11- Compaction of mortar cubes.

TESTING OF CUBES

Compressive strength- Compressive strength tests were performed on compression testing machine using cube samples. Three samples per batch were tested with the average strength values reported in this project. The loading rate on the cube is 2 KN per one division. The comparative studies were made on their characteristics for cement mortar ratio of 1:4. Three cube samples were cast in the mould of size 70.6 x 70.6 x 70.6 mm for test.

The Compressive strength testing machine shown below.

Figure 4. 12- Compressive strength testing machine

SPLIT TENSILE STRENGTH

The splitting tensile strength test will be carried out on the specimens at the end of 7 days and 28 days of curing. The procedure to be followed is as given below. Tensile strength is an important property of a mortar because mortar structures are highly vulnerable to tensile cracking due to various kinds of effects and applied loading itself. However, tensile strength of mortar is very low in comparison to its compressive strength. In splitting tensile strength test same machine is used which are used in compressive strength test, the concrete block will be placed at an angle of 45. The axes of the specimen are to be carefully aligned with the centre of the lower pressure plate of the testing machine. Then an upper pressure plate is to be lowered till the distance between the pressure plate and the top surface of the specimen achieved. No packing used between the face of the pressure plates and block. The load will be applied without shock and increased gradually at the rate of 2 KN per one division until the specimen was crushed.

The splitting tensile strength testing machine shown below.

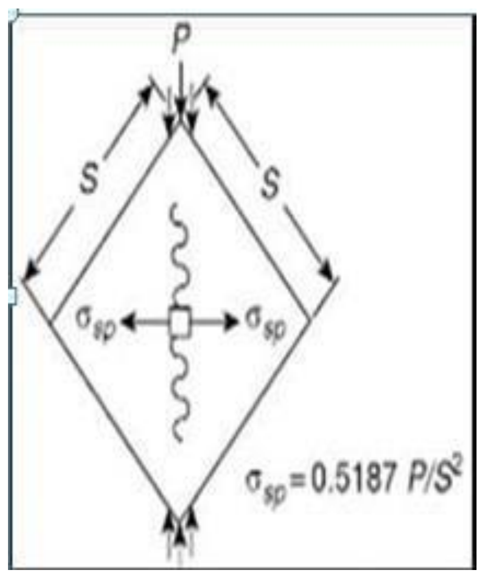

Figure 4. 13- Split-tensile test in CTM

CHAPTER 5

5.1 RESULTS AND GRAPHS

Results of test on sand:

- **Specific gravity** of sand 2.54 (2.47-2.58, it is clay).
- **Silt content** of sand is 4.59%.

Results of tests on cement OPC 53 grade:

- The **standard consistency** of a given sample of cement (OPC 53)is **29%** of water equivalent of cement.
- **Fineness** of cement is **2%.** (Specific limit < 10% by weight.)
- **Specific gravity** of cement is **2.97**.
- **Initial setting time** is **60 minutes**
- **Final setting time** is **291minutes**

RESULTS OF COMPRESSIVE AND SPLIT-TENSILE STRENGTH OF MORTAR CUBES:

1. Cement mortar cubes:

Table 5. 1: Compressive strength of cement mortar cubes

Sl No		DURATION	AVG COMPRESSIVE STRENGTH(MPa)
01	Cement mortar cubes	7days	12.5
		28days	14.8

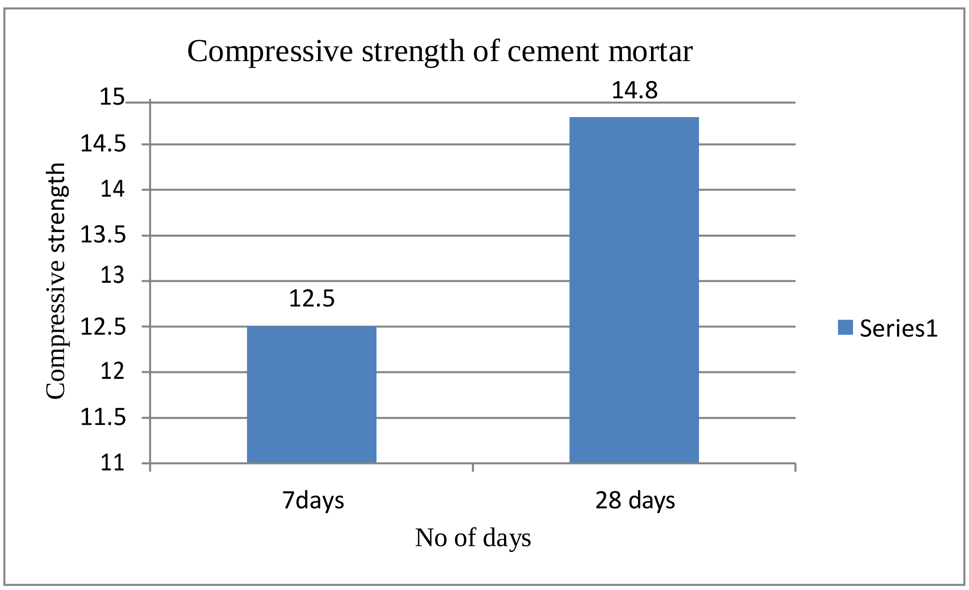

Figure 5. 1- Compressive strength of cement mortar cubes

Table 5. 2: Split tensile strength of cement mortar cubes

Sl No		DURATION	AVG SPLIT-TENSILE TEST
01	Cement mortar cubes	7days	12.5
		28days	14.8

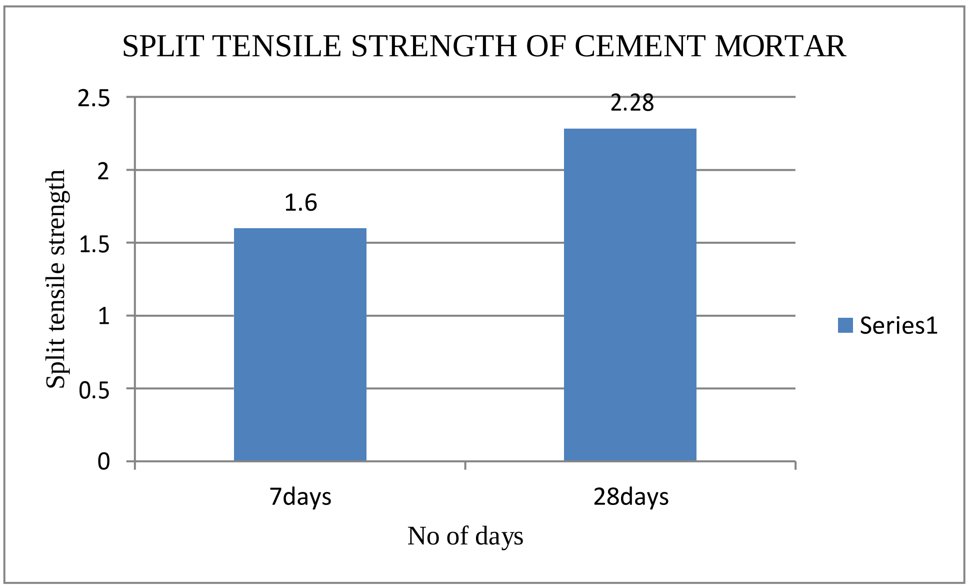

Figure 5. 2- Split tensile strength of cement mortar cubes

2. Cement mortar cubes with glass fibre:

Table 5. 3: Compressive strength of cement mortar cubes with glass fiber

Average compressive strength(MPa)			
Duration \ Percentage	1%	2%	3%
7days	18.05	19.66	16.85
28days	24.07	25.28	21.46

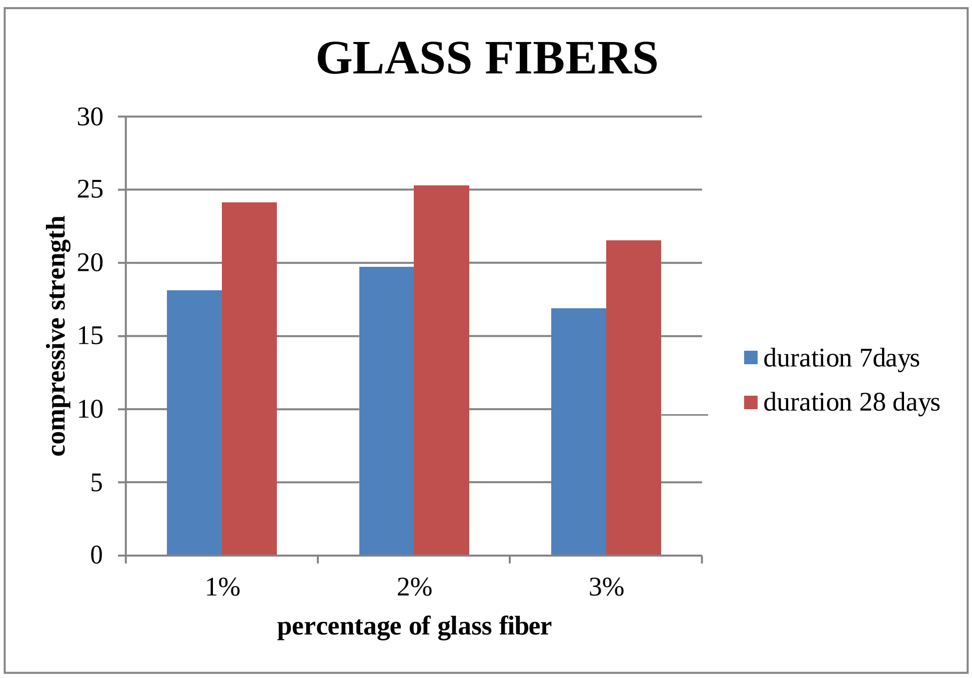

Figure 5. 3- Compressive strength of cement mortar cubes with glass fiber

Table 5. 4: Split tensile strength of cement mortar with glass fiber

Average split-tensile strength(MPa)			
Percentage / Duration	1%	2%	3%
7days	2.59	2.18	2.50
28days	3.12	3.23	2.39

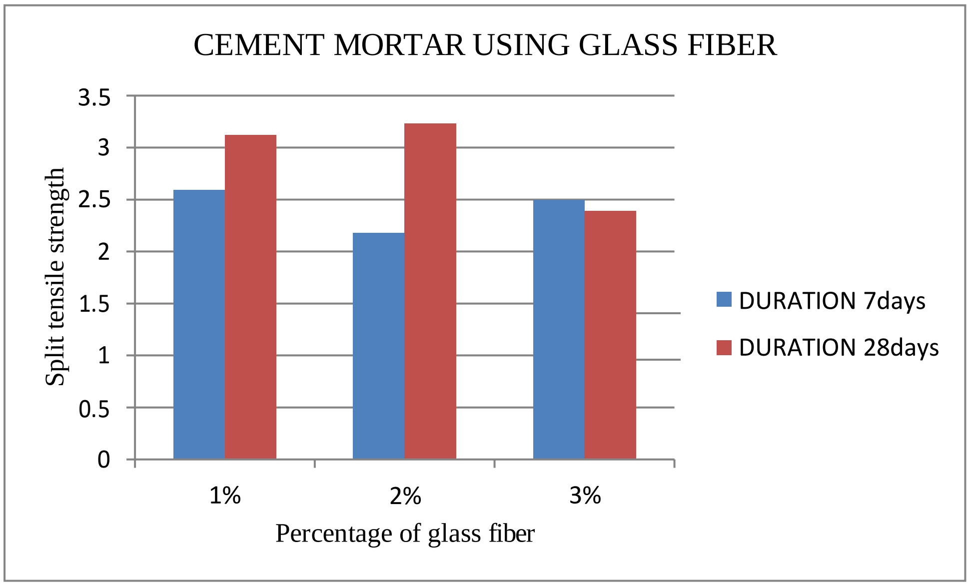

Figure 5. 4- Split tensile strength of cement mortar with glass fiber

3. Cement mortar with steel-wool fibres(l=2cm):

Table 5. 5: Compressive strength of cement mortar with steel-wool fiber(l=2cm)

Average compressive strength(MPa)			
Percentage / Duration	0.5%	1%	1.5%
7days	21.66	22.06	17.65
28days	23.26	25.87	22.86

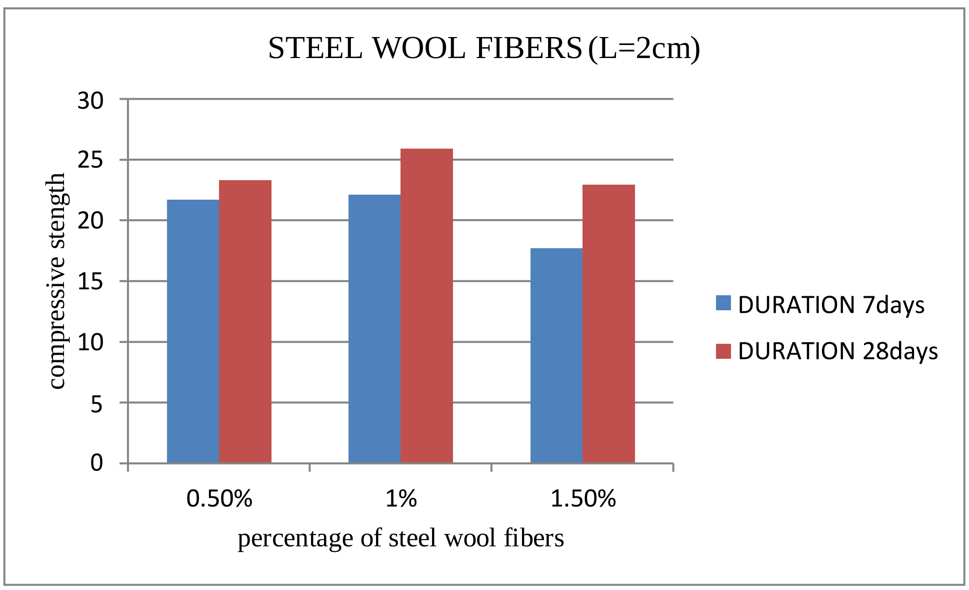

Figure 5. 5- Compressive strength of cement mortar with steel-wool fiber(l=2cm)

Table 5. 6: Split tensile strength of cement mortar with steel-wool fiber(l=2cm)

Average split-tensile strength(MPa)			
Percentage / Duration	0.5%	1%	1.5%
7days	2.29	2.70	2.18
28days	2.97	3.17	2.60

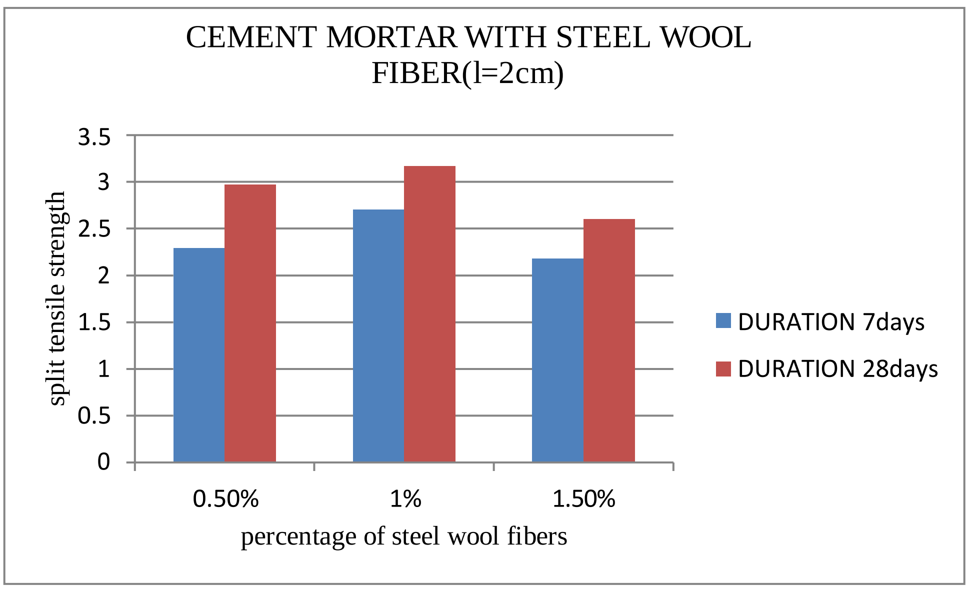

Figure 5. 6- Split tensile strength of cement mortar with steel-wool fiber(l=2cm)

4. Cement mortar with steel-wool fibres(l=0.5cm):

Table 5. 7: Compressive strength of cement mortar with steel-wool fiber(l=0.5cm)

Average compressive strength(MPa)			
Percentage / Duration	0.5%	1%	1.5%
7days	20.06	21.67	18.05
28days	24.47	26.68	23.06

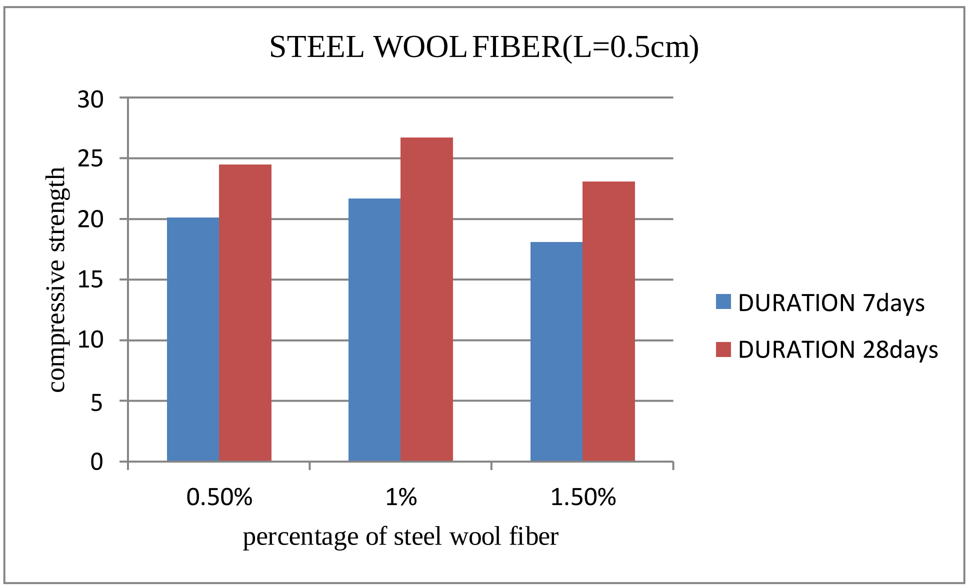

Figure 5. 7- Compressive strength of cement mortar with steel-wool fiber (l=0.5cm)

Table 5. 8: Split tensile strength of cement mortar with steel-wool fiber (l=2cm)

Average split-tensile strength(MPa)			
Percentage / Duration	0.5%	1%	1.5%
7days	2.49	2.91	2.49
28days	2.85	2.96	2.65

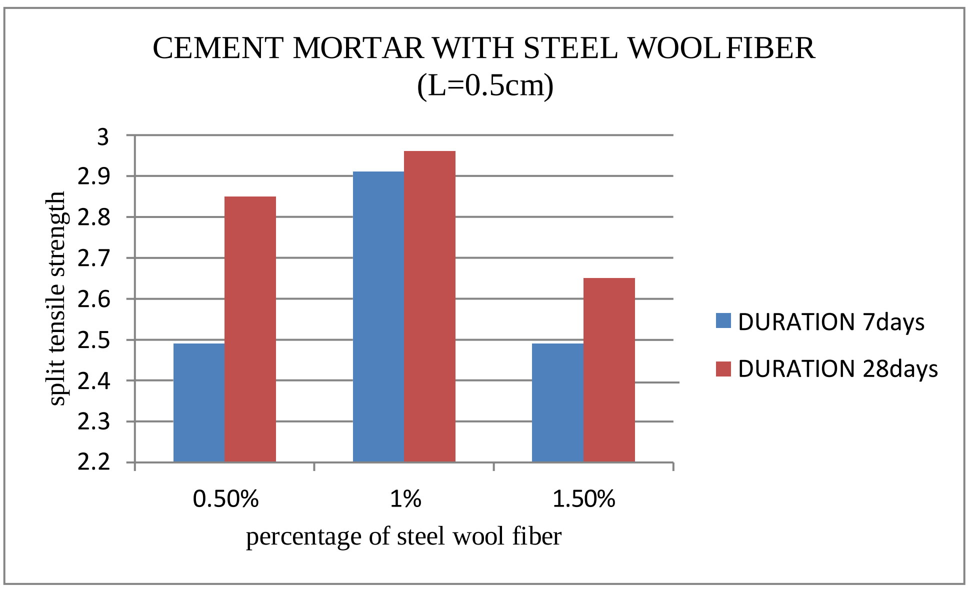

Figure 5. 8- Split tensile strength of cement mortar with steel-wool fiber (l=2cm)

5. Replacement of cement with fly ash:

Table 5. 9: Compressive strength of cement mortar (fly ash)

Average compressive strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	20.06	14.64	8.42
28days	-	-	-

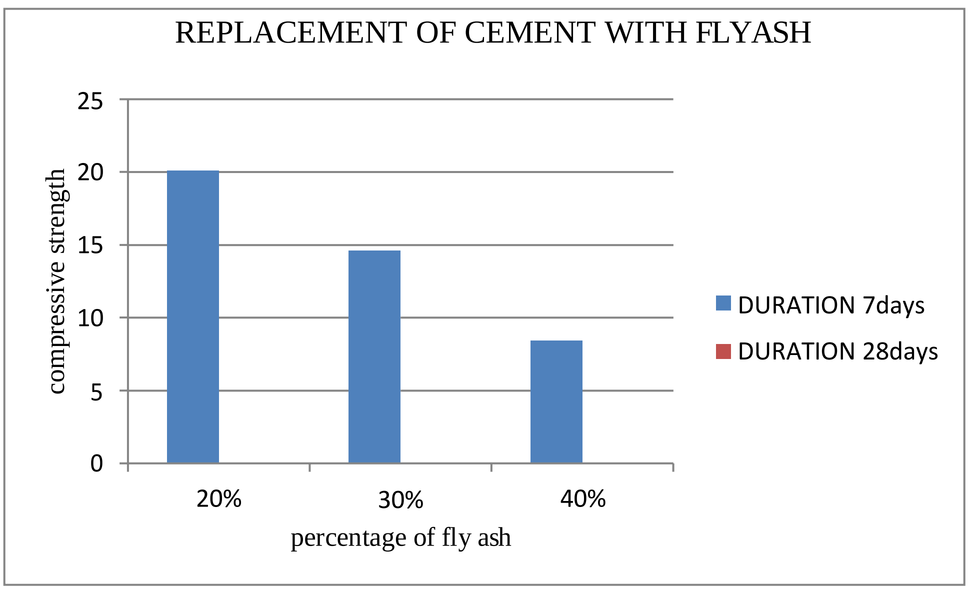

Figure 5. 9- Compressive strength of cement mortar (fly ash)

Table 5. 10: Split tensile strength of cement mortar (fly ash)

Average split-tensile strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	1.87	1.45	1.66
28days	-	-	-

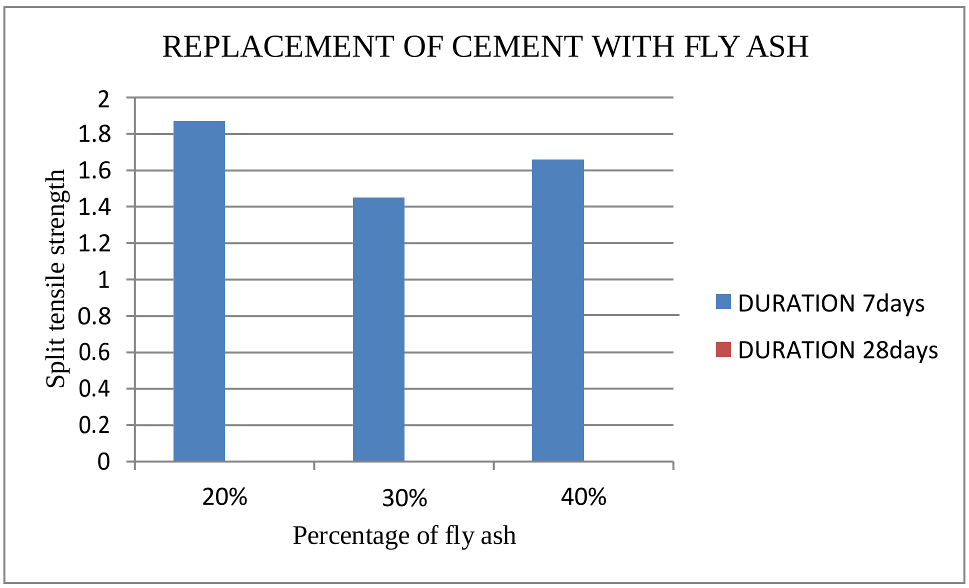

Figure 5. 10- Split tensile strength of cement mortar (fly ash)

6. Replacement of cement with fly ash & addition of glass fibres (2%)

Table 5. 11: Compressive strength of cement mortar (fly ash) with glass fiber(2%)

Average compressive strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	16.85	12.04	09.63
28days	-	-	-

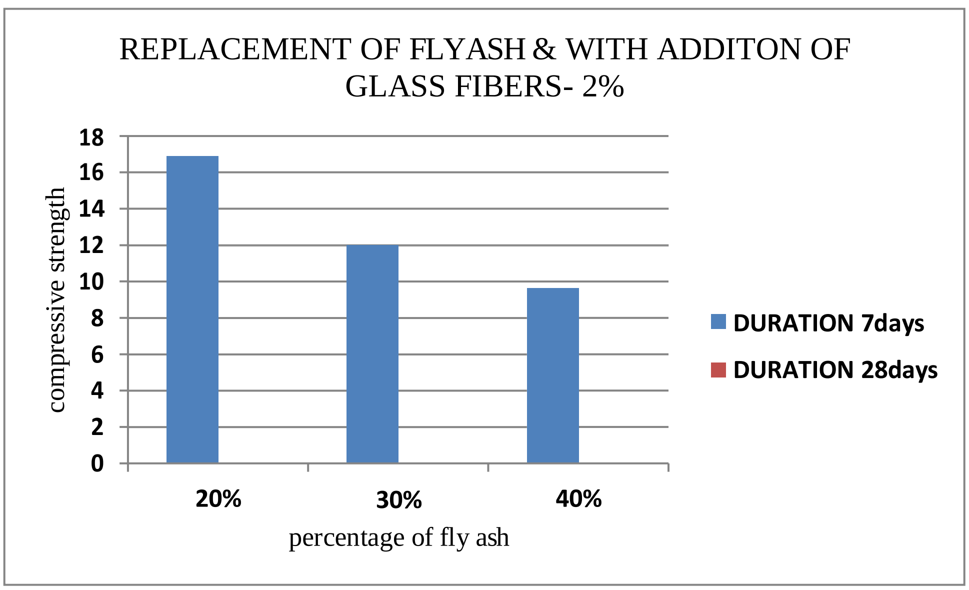

Figure 5. 11- Compressive strength of cement mortar (fly ash) with glass fiber (2%)

Table 5. 12: Split tensile strength of cement mortar (fly ash) with glass fiber (2%)

Average split-tensile strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	1.97	1.76	1.66
28days	-	-	-

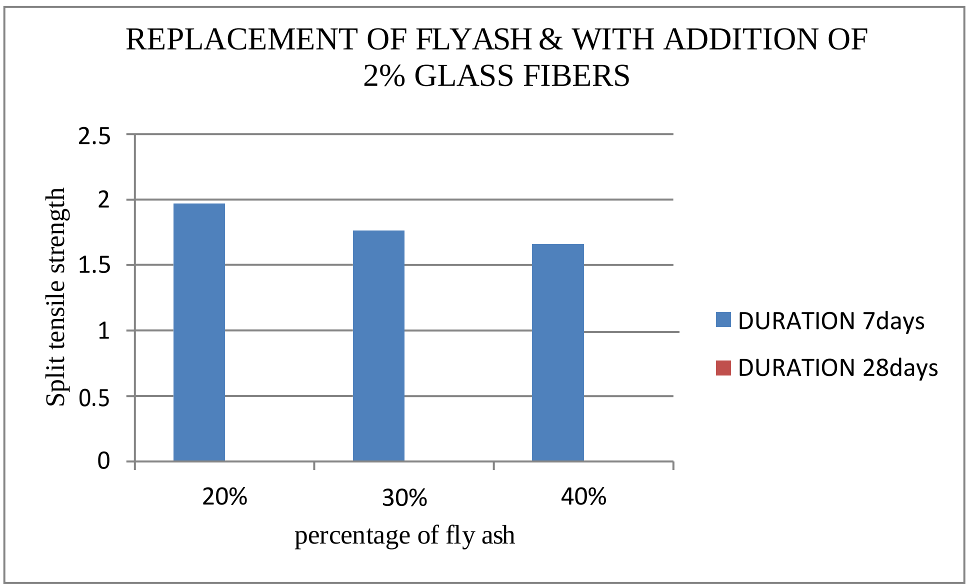

Figure 5. 12- Split tensile strength of cement mortar (fly ash) with glass fiber (2%)

7. Replacement of fly ash & addition of 1% steel-wool fibres (l=2cm)

Table 5. 13: Compressive strength of cement mortar(fly ash) with 1% steel-wool fiber(l=2cm)

Average compressive strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	15.24	14.44	10.23
28days	-	-	-

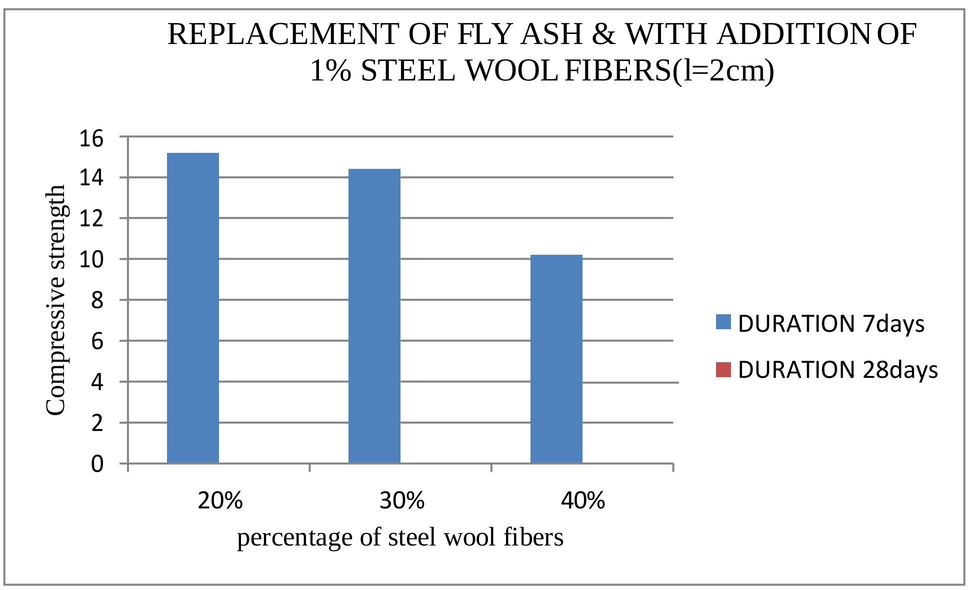

Figure 5. 13- Compressive strength of cement mortar(fly ash) with 1% steel-wool fiber(l=2cm)

Table 5. 14: Split tensile strength of cement mortar (fly ash) with 1% steel-wool fiber(l=2cm)

Average split-tensile strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	1.97	1.87	1.56
28days	-	-	-

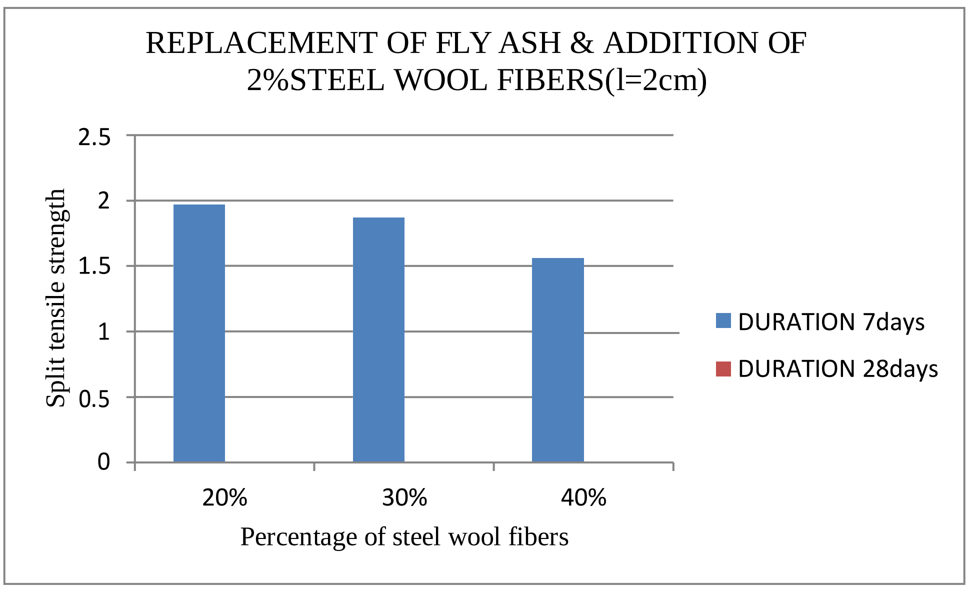

Figure 5. 14- Compressive strength of cement mortar(fly ash) with 1% steel-wool fiber(l=2cm)

8. Replacement of fly ash and addition of 1% steel-wool fibre (l=0.5cm):

Table 5. 15: Compressive strength of cement mortar (fly ash) with 1% steel-wool fiber (l=0.5cm)

Average compressive strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	18.05	10.43	10.03
28days	-	-	-

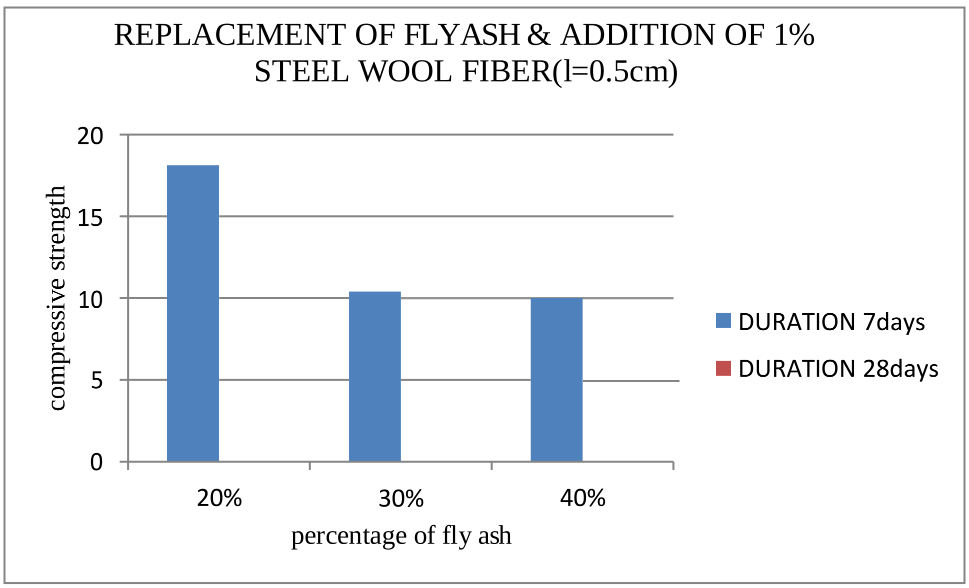

Figure 5. 15- Compressive strength of cement mortar (fly ash) with 1% steel-wool fiber (l=0.5cm)

Table 5. 16: Split tensile strength of cement mortar (fly ash) with 1% steel-wool fiber(l=0.5cm)

Average split-tensile strength(MPa)			
Percentage / Duration	20%	30%	40%
7days	2.29	1.98	1.66
28days	-	-	-

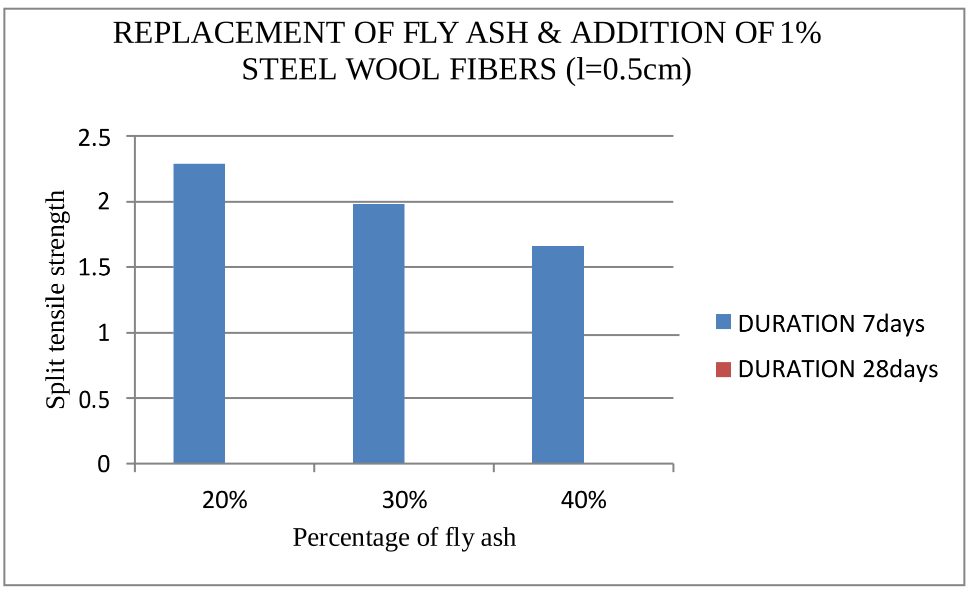

Figure 5. 16- Split tensile strength of cement mortar (fly ash) with 1% steel-wool fiber (l=0.5cm)

CHAPTER 6

6.1 CONCLUSION

From test, we conclude that

- Cement mortar with glass fiber:

➢ The addition of 2% glass fibers has greater strength when compared to 1% & 3% of glass fibers.

- Cement mortar with steel-wool fiber of 2cm & 0.5 cm:

➢ The addition of 1% steel-wool fibers has greater compressive strength as well as tensile strength when compared to 0.5% & 1.5% of steel-wool fibers.

➢ Cement mortar cubes with partial replacement of fly ash: **20% replacement of fly ash** shows greater compressive strength & tensile strength when compared with the replacement of 30% & 40% fly ash.

➢ Even with the addition **of 2% glass fiber 20% of fly ash** shows greater compressive strength & tensile strength when compared with 30% & 40%.

➢ For **1% steel wool fiber (l=2cm & l=0.5cm)also, 20 % of fly ash** shows greater compressive strength & tensile strength when compared with 30% and 40% replacement of fly ash.

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