RESEARCH REPORT

on

"EFFECT OF ORGANIC WASTE (TEFF HUSK) ON THE CONCRETE PROPERTIES"

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY – ETHIOPIA

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DECLARATION

We hereby, solemnly declare that the work carried out by us, presented in this research "**Effects of Organic Waste (Teff Husk) on The Concrete Properties**" is entirely and solely our effort. It has been carried out entirely at the facilities available in the university and it has not been submitted earlier to any other university.

By:

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ABSTRACT

In Ethiopia Teff (Eragrostis teff) is an important food grain where it is used to for the preparation of Injera which is the major food used. Teff milling generates a by-product known as Teff Husk (TH). In this research, a critical review of the influences of TH on strength of concrete is mainly presented. Based on the available and documented literature till date, it can be concluded that Teff Husk could be used as a partial replacement of sand up to certain limit due to its particle size. Proper consumption of these TH contributes to solving environmental pollution and production of cost-effective concrete; it can also play a vital role in the production of sustainable concrete. Ethiopia is a major Teff producing country in Africa continent, and the husk generated during milling is mostly used as a foodstuff for animals and fuel for the preparation of food.

This research evaluates how Teff Husk will have an impact on the concrete properties of concrete. Sample Cubes were tested with percentage variable (0 – 30%) of fine aggregate by TH in volume with constant w/c ratio 0.45. Properties like Compressive strength, split tensile strength, flexural strength, unit weight, and Water absorption properties are evaluated at different ages of harden concrete 7, 14, 21 and 28 days for concrete cylindrical strength 25 MPa

From the experimental results, the compressive strengths and unit weights of the concrete ranged between 28.76MPa and 22.38MPa and between 2296.38 and 2218.64 kg/m3 respectively. In addition, flexural strength varied between 0.48 and 0.4 MPa. In conclusion, the results revealed that the unit weight and compressive strength decreased with increase in percentage teff husk by 10 %. The research also revealed that there is a possibility of replacing fine aggregate with Teff husk in the production of structural concrete for the same grade of concrete.

From experimental work it was observed 3 percentage increase in strength of concrete up to 10% replacement of sand by volume hence the concrete produced can be used for all construction purpose.

CONTENTS

List of Abbreviations

Teff Husk	=	TH
C-25	=	Grade of concrete
FA	=	Fine aggregate
CA	=	Coarse aggregate
M1-M7	=	Different mix Proportions for TH
SP 430	=	Super Plastiser
F_c	=	Cube compressive strength
P	=	Cube compressive causing failure
A	=	Cross-sectional area of specimen
Tsp	=	Split tensile strength
D	=	Diameter of the specimen
L	=	Length of the Specimen
M	=	Bending moment at the section
Z	=	Section modulus
I	=	Moment of Inertia of the section
Y	=	Depth of neutral axis
SWA	=	Saturated Water Absorption in percentages
W_s	=	Weight of the specimen at fully saturated condition in kg
W_d	=	Weight of oven dried specimens in kg
Dc	=	Density of the concrete, kg/m^3
M_c	=	Weight of the measure holding the concrete
M_m	=	Weight of the empty concrete measure (base of air meter)
V_m	=	Volume of the measure

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CHAPTER-1

INTRODUCTION

1.1 Background of study

Teff is a primary food source for millions of people in Ethiopia, according to food and agriculture organization of the Ethiopia data shows that the production of Teff is increasing annually by 10.42 % on an average [1]. Generally, the Teff husk will be used for feeding the animals / burned in open air or being sent to landfill but both methods are creating enormous CO_2 emission to the atmosphere.

Increasing demand of the building materials had come into the concern of public and related industries. The issue is not only the chronic shortage of building materials but also the great impact to the environment and land degradation in search of virgin construction materials like sand.

One of the solutions to the environmental problems can be reuse of by-product produced from agricultural activities. Agro-waste generated from agricultural sources are rice husk, jute fiber, coconut husk, Teff husk [2, 3]. Reuse of such agro-waste is not only overcome the pollution to the environment but also the disposal problem of agro-waste. Ethiopia has a great potential to reuse the agro-waste to reduce the environmental issues generated from the cement industry and usage of agro-waste materials will be the objective for sustainable development.

1.2 Problem Statement

Fine aggregate is a common material used as a filler material used in the concrete as a construction material. The practices of using fine aggregate for the longer period of time diminishes natural resources.

The demand of food source is increasing due to the rapid growth of population in Ethiopia. The massive expansion of plantation in Ethiopia has generated a large amount of agro-waste and huge environmental concerns. Teff is the major food source of Ethiopia, 22 % [4] of Teff husk is generated after going through Teff milling process.

Historically, agricultural and industrial wastes have created waste management and pollution problems. However, the use of agricultural and industrial wastes to complement other traditional materials in construction provides both practical and economic advantages. The wastes have generally no commercial value and are locally available. The use of waste materials in construction contribute to conservation of natural resources and the protection of the environment

Researchers are finding a solution to minimize the usage of fine aggregate and retain natural resources. From previous studies, barley husk, sugar cane husk, are used in terms of fibers to increase the tensile strength of concrete [5].

1.3 Research objectives and Aims

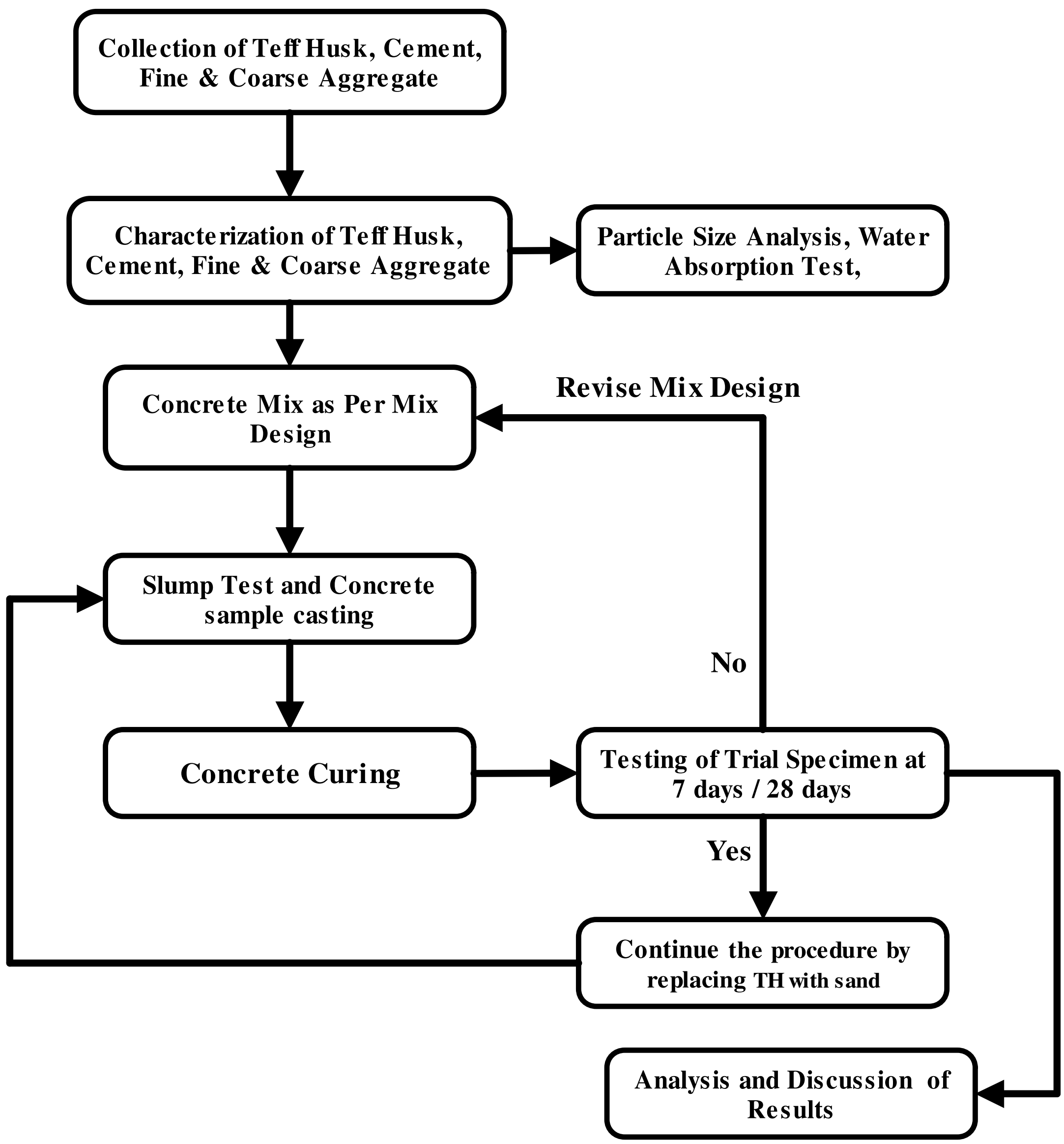


Fig 1: Experimental flow chart.

1.3.1 General Objective:

The general objective of this research is to study the effect of Teff Husk on mechanical and physical properties of concrete with partial replacement of fine aggregate for C-25 grade concrete.

1.3.2 Specific Objectives

1. To evaluate the physical materials properties of concrete.
2. To determine the workability of concrete with different percentage of Teff husk.
3. To assess the effect of Teff husk (TH) on Density of Concrete.
4. To investigate the effect of Teff husk on Compressive Strength, split tensile strength and Flexural strength of concrete.
5. To determine the effect of Teff Husk on water absorption of concrete.

1.4 Scope of research

In this research work mechanical properties of concrete such as compressive strength, split tensile strength, flexural strength and other properties such as water absorption and unit weight of concrete were also studied with partial replacement sand by teff husk with 5% increase up to 30% at different age of concrete 7, 14, 21 and 28 days, All specimens had identical mix ratio. Only sand was replaced by Teff Husk in-terms of volume with constant w/c ratio by 0.45 to achieve C 25 grade concrete for the standard specimen, the notations were used as M1 –M7, example M1 is used for the standard specimen and M7 for 30% replacement. The experimental work was carried out at Adama Science and Technology of Civil Engineering department Concrete Laboratory from Jan 2016 – Dec 2017.

CHAPTER-2

LITERATURE REVIEW

History of development.

Several factors have to be consider in building construction. Material selection is one of the most important factor. The proper selection of the construction materials will assist to ensure that the building functions as expected in economic construction. Isolation and low-cost construction are particularly key for agricultural and villa or impermanent building constructions.

The experimental work was carried out **[Ajay Kumar & Susheel Kumar]** [6] to study the workability, compressive strength and water absorption of concrete using the coconut shell as a replacement for fine aggregate in concrete. They found that Concrete using coconut shell resulted in high strength and impact resistance compared to conventional concrete. Water absorbing capacity of coconut shell was found to be increased with compared to other conventional aggregates used in concrete.

Another study was carried out on using Coconut Husk Fibre for improving compressive and flexural strength of concrete **[Anthony Nkem Ede et. al.]** [7] The fibres were used in different percentages 0%, 0.25%, 0.5%, 0.75%, and 1.0% of the weight of the fine aggregate to study compressive strength and flexural strength for 28 days. The results show that the compressive and tensile strength of coconut fiber-reinforced concrete up to 0.5% is increased.

Study on using rice husk was carried out [Akinwumi et. al.] [8] To study the effect on workability, water absorption and strength of concrete. The workability of the concrete was improved with an increase in the quantity of rice husk also unit weight and compressive strength of the concrete was found to be decreased with increase in the percentage of rice husk content. The water absorption was high compared to standard specimens and has high air content. Rice husk cannot be used more than 12.5% replacement of sand.

An investigation into the use of groundnut shell as a fine aggregate replacement was carried out by **[B.H. Sada et.al]** [9]. Groundnut shells were used to replace fine aggregate at 0, 5, 15, 25, 50 and 75% replacement levels. The effects of the groundnut shells on the fresh and harden concrete properties such as workability, compressive strengths and density were determined at 28 days with different percentage replacement by fine aggregates, Results showed replacement of groundnut shells by 25% can produce lightweight concrete compared to conventional concrete and can be used where low stress in concrete is required.

Study on groundnut shell **[Dr. Kimeng Henry et.al]** [10] to produce lightweight concrete. with groundnut shell replacements by 0%, 10%, 20%, 30%, 50%, 70%, 100% a by fine aggregates and samples were tested for different age of concrete up to 28 days. They observed the density of the cubes ranged from 830 kg/m3 to 2160kg/m3. The compressive strength was 10 MPa at 28 days, while moisture absorption increased from 0.47 to 2.04%. The strength results indicate that groundnut shell panels cannot be used for structural purposes.

Wen-Ten Kuo et.al [11] has done the experimental to study the behavior of harden concrete properties using study on oyster shells. It was observed by them that there was no reduction in concrete compressive strength up to 20% replacement by sand.

Experiments were conducted to study the tensile strength of polyester resin and composite pineapple leaf fibers (PALF) in Brazil **[Gabriel Oliveira Gloriaa et. al.]** [12] PALF used was of 0.09 to 0.30 mm diameter and 35 mm length. The fibers were up to 30% by volume with a composite of lingo-cellulosic fibers with 10% increment gradually and fibers were placed parallel to the tensile axis. The tensile strength and elastic modulus were increased by 2.70 and 5.41 times respectively for 30 % composite.

Studied the compressive strength and split tensile strength of concrete for 28 days with partial replacement of cement by Rice Husk Ash (RHA), Fly Ash and Eggshell **[Jayasankar.R et. al.]** [13] Up to 20 % each with 5 % increment gradually with seven different combinations to achieve the mean target strength of concrete 20, 25 and 30 MPa concrete. The results obtained by them was 60% increment in strength with RHA alone at 5 % replacement. The strength was not changed when concrete was done with different combinations. For M20 and M25 grade concrete. Whereas for M30 grade there was a slight decrease in the strength level in respect of compressive strength.

Studied the mechanical and thermal properties of concrete at 28 days experimentally **[Can Burak Sisman]** [14] using zeolite as coarse aggregate and organic waste material rice husk as lightweight aggregate with percentage 5% varying successively up to 20 % for 300 and 400 cement content, The unit weights produced were 1507 to 1406 kg/m3 and 1604 to 1559 kg/m3 for 300 & 400 cement content respectively and compressive strengths of the samples ranged from 13.03-14.30 MPa and from 18.88-16.39 MPa for 300 & 400 cement content respectively. The water absorptions of the samples varied between 6.17 and 14.19 % and between 4.44 and 7.46% for 300 & 400 cement content respectively. The use of RH as a lightweight aggregate replacement increased the water absorption. The thermal conductivity decreased with increasing RH content.

Oriyomi M. Okeyinka, David A. Oloke, Jamal M. Khatib[15] Has reviewed a paper on use of solid waste in building materials, the materials were broadly classified into two categories as organic and inorganic (paper, plastic, glass, metal and others), it has stated that organic waste was 46%. The organic and inorganic materials can be used in a various form in concrete as partial replacement of aggregates, cement or in terms of reinforcing steel with fibers to increase the tensile strength of concrete.

Jnyanendra Kumar Prusty, Sanjaya Kumar Patro, S.S. Basarkar [3] Has done the review on agro-waste materials groundnut shell, oyster shell, cork, rice husk ash and tobacco waste can be used to improve the workability of concrete also Agro-waste material such as bagasse ash, sawdust ash, and oyster shell can also be used to improve the compressive, flexural and tensile strength of concrete by 20% addition of the bagasse ash as fine aggregate in concrete mortar will increase the durability properties of concrete such as resistance of chloride, better thermal resistance and fatigue resistance.

S. P. Zhang and L. Zong [16] Conducted the experiment on harden concrete to study the relationship between compressive strength and water absorption of concrete under different curing under six different conditions with varying temperature and RH. The results showed a reduction in compressive strength with higher water absorption and strength of concrete depends on the internal and external surface of water absorption.

Experimental work on concrete was done **[Tanvir Hossain et.al]** [17] with partial replacement of cement by RHA with 0 – 15% to study the compressive strength and split tensile strength on harden concrete on 28 days and consistency, setting time test on fresh concrete. The results presented by the increase in consistency, setting time and water absorption with the percentage increase of RHA but decrease in compressive strength and split tensile strength after 7 days.

R.K.Kolisetty and H.S.Chore [18]. Discussed regarding the optimum utilization of waste materials from industrial plants, powerhouses, colliery pits, demolition sites and household in some construction activities as a green concept. Waste materials such as plastic, fly ash, recycled aggregates, GGBS, silica fume, rubber waste can be used as partial replacement of cement or aggregates to improve the internal structure of concrete which can be used for the construction of buildings or road pavements.

Md. Safiuddin et.al [19] has discussed utilization of solid waste material from various industry in the construction industry. The organic waste such as bagasse, wheat husk, groundnut shell, sisal, cotton stalk, vegetable residues can be used in construction industry for cement boards, particle boards, insulation boards, acid proof cement, polymer composite cement, bricks. The inorganic waste materials such as combustion residues, steel slag, bauxite red mud construction debris can also be used as coarse aggregate, fine aggregates, cement and in the manufacturing of ceramic products. Hazardous and non-hazardous wastes such as gypsum, lime sludge, broken glass, and residue from marble processing, kiln dust, metallurgical residues, and sludge from wastewater treatment plant can be used in manufacturing different types of cement, bricks, ceramic tiles and fibrous gypsum boards.

Evi Aprianti et.al. [20] Has done a review on supplementary cementitious materials origin from agricultural wastes. The agricultural wastes such as rice husk ash, palm oil fuel ash, sugar cane bagasse ash, wood waste ash, and bamboo leaf ash and corn cob ash can be used in the construction industry as a supplementary cementitious material (SCM). This ashes from various agricultural wastes contain silica which helps in the reaction of cement when added with water to form CSH. By using this ashes in different percentages strength of concrete can be increased and used up to achieve 61 MPa at 90 days.

In this research report, the use of agricultural waste of different types will be considered, since we are interested to use locally available agricultural waste. Coconut shell was replaced by sand [6] coconut fiber was used to increase tensile strength [7]. Rice husk studies on fresh and harden concrete was studied [14] groundnut shell replacement by fine aggregate [10]. Oyster shells replacement by sand [11]. Pineapple leaf fibers can be used to improve tensile strength [12]. Rice husk ash, fly ash, eggshell on compressive strength and water absorption were studied by [13]. Lightweight aggregate with RHA on concrete properties was done [14]. Papers were also reviewed on solid waste materials from agricultural waste and industrial waste [19] Bamboo, jute coir can also be used for increasing tensile strength of concrete [20]. From the above, we observed that there was a change in concrete properties by adding various agricultural and industrial waste and attempt were not made on Teff husk concrete. Henceforth in this research, an attempt was made to use locally available material teff husk (agricultural waste) to replace the fine aggregate in different percentage by volume for cylindrical compressive strength C 25 mix.

CHAPTER-3
RESEARCH METHODOLOGY

3.1 Experiment

The experimental work was carried out (as per ASTM standards) in Civil Engineering Laboratory at ASTU to study the properties of fresh and hardened concrete such as slump cone test, compressive, split tensile and flexural strength, water absorption and unit weight of concrete. To achieve cylindrical strength 25 MPa basic material properties were studied such as sieve analysis for aggregates, bulk density for fine and coarse aggregate and the trail mix was done.

The experimental work includes casting and testing of 189 Cubes (150 mm x 150 mm x 150 mm), 168 Cylinders (150 x 300 mm) and 21 Prisms (500 x 100 x 100 mm). Seven groups of specimens were cast by replacing sand by Teff husk up to 30 % with 5% increment. All the specimens have identical mix ratio and only sand was replaced by Teff Husk in-terms of volume with constant w/c ratio. The number of specimens casted for each case is shown in Table 1.

Table 1. Number of samples casted to study the properties of Standard and TH concrete.

Sl. No.	Particular	Code	Number of Specimen	Curing period in days
1	Cube Cylinder Prism	M1 (0%)	27 24 3	7, 14,21,28 7, 14,21,28 28
2	Cube Cylinder Prism	M2 (5%)	27 24 3	7, 14,21,28 7, 14,21,28 28
3	Cube Cylinder Prism	M3 (10%)	27 24 3	7, 14,21,28 7, 14,21,28 28
4	Cube Cylinder Prism	M4 (15%)	27 24 3	7, 14,21,28 7, 14,21,28 28
5	Cube Cylinder Prism	M5 (20%)	27 24 3	7, 14,21,28 7, 14,21,28 28
6	Cube Cylinder Prism	M6 (25%)	27 24 3	7, 14,21,28 7, 14,21,28 28

7	Cube Cylinder Prism	M6 (30 %)	27 24 3	7, 14,21,28 7, 14,21,28 28

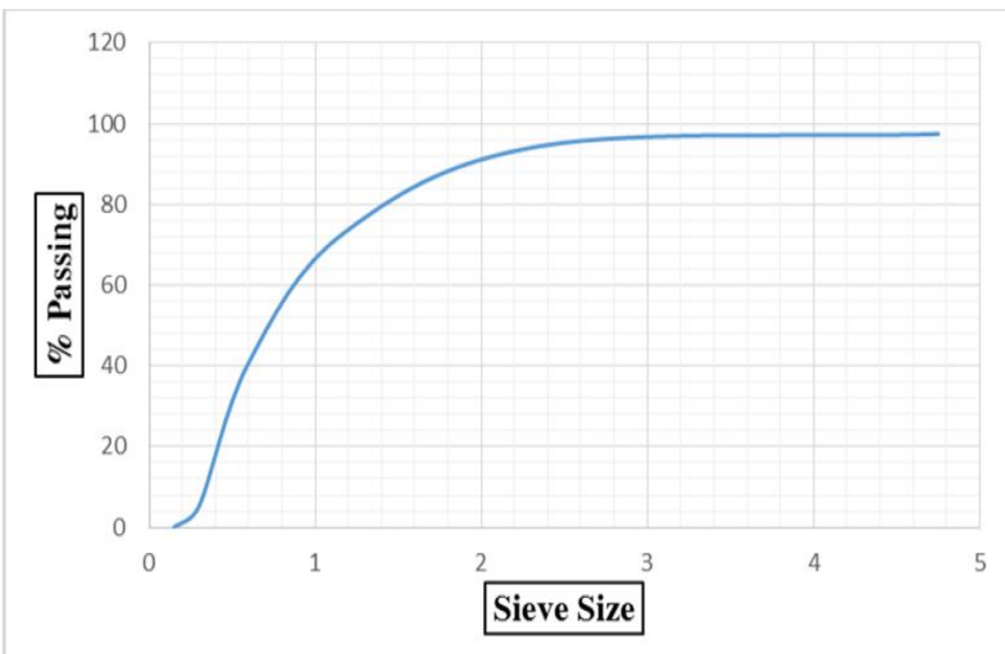
3.2 Material Properties:

3.2.1 Cement:

Ordinary Portland Cement of 43 Grade was used in this work.

3.2.2 Fine Aggregate (FA):

The Aggregate which is passing through 4.75mm sieve is known as a fine aggregate. Air dried fine aggregates passing through 4.75mm sieve and retained on 150 micron BS sieve sample of 1000 grams was used to study the size distribution of fine aggregate. It was observed that particles size are concentrated from 1.18 - 0.3 mm and not uniformly distributed to fill the voids in the concrete. The physical properties of fine aggregate are listed in Table 2 and grain size distribution with percentage passing are presented in graph 1



Graph:1. Grain size distribution of fine aggregate .

Table 2: Sieve analysis of fine aggregate

S.NO	SIEVE SIZE (mm)	Weight retained (gm)	Correction	Corrected weight	Cumulative weight retained	Cumulative percentage weight retained	Cumulative percentage passing
1.	4.75	25	+0.5	25.5	25.5	2.55	97.45
2.	2.36	29	+0.58	29.58	55.08	5.508	94.50
3.	1.18	209	+4.18	213.18	268.26	26.826	73.18
4.	0.6	317	+6.34	323.34	591.60	59.16	40.84
5.	0.3	350	+7.0	357	948.60	94.86	5.16
6.	0.15	50	+1.0	51.0	999.6	99.96	0.04

Properties of Fine Aggregate:

Fineness modulus = 2.88

Specific gravity = 2.68

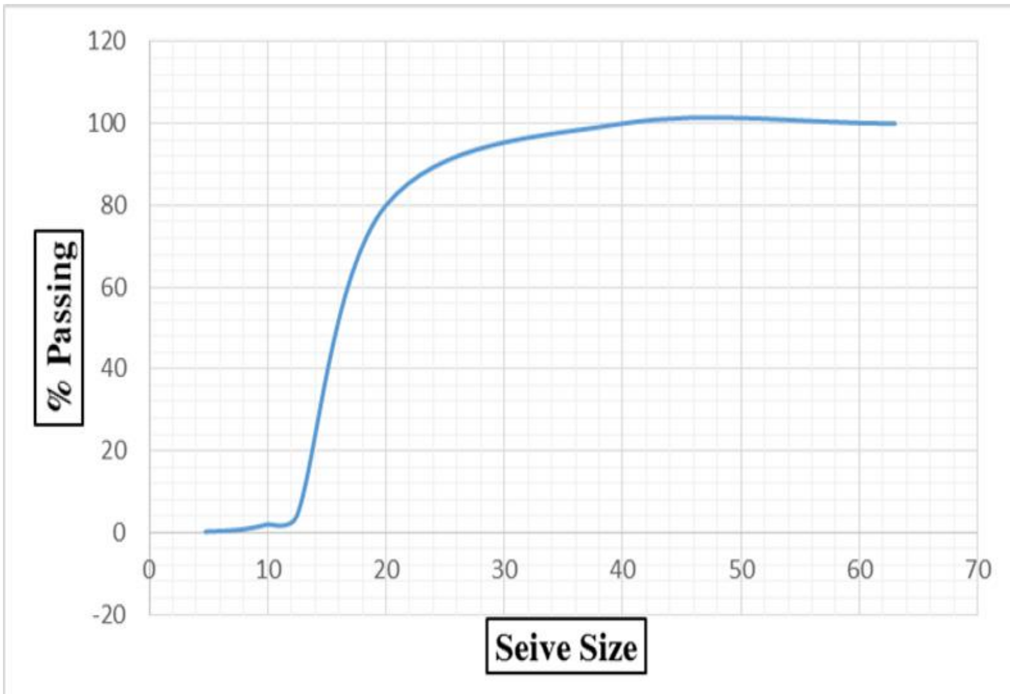
Water absorption = 0.86%

Silt or clay content = 0.5%

Bulk density = 1520 kg/m^3

3.2.3 Coarse Aggregate (CA):

The coarse aggregate 10 kg sample of grade two (10-20 mm aggregate size) had been used to study the grain size distribution, physical properties of coarse aggregate are listed in table 3 and grain size distribution with percentage passing are presented in graph 2



Graph:2. Grain size distribution of coarse aggregate.

Properties of Coarse Aggregate:

Fineness Modulus	=	5.12
Specific gravity	=	2.7
Water absorption	=	1.12%
Impact value	=	11.76%
Bulk density	=	1440kg/m³.

Table 3: Sieve analysis of coarse aggregate

S.No	Sieve size	Weight retained (gms)	Cumulative weight retained	Cumulative percentage weight retained	Cumulative percentage passing.
1.	20.00	2000	2000	20.00	80.00
2.	12.50	7580	9580	95.80	4.20
3.	10.00	220.0	9800	98.00	2.00
4.	8.00	120.0	9920	99.20	0.80
5.	6.30	40.00	9960	99.60	0.40
6.	4.75	20.00	9980	99.80	0.20
7.	pan	20.00	10,000	-	0.00

3.2.4 Water:

Portable tap water from laboratory is used for mixing and curing of water used for both mixing and curing.

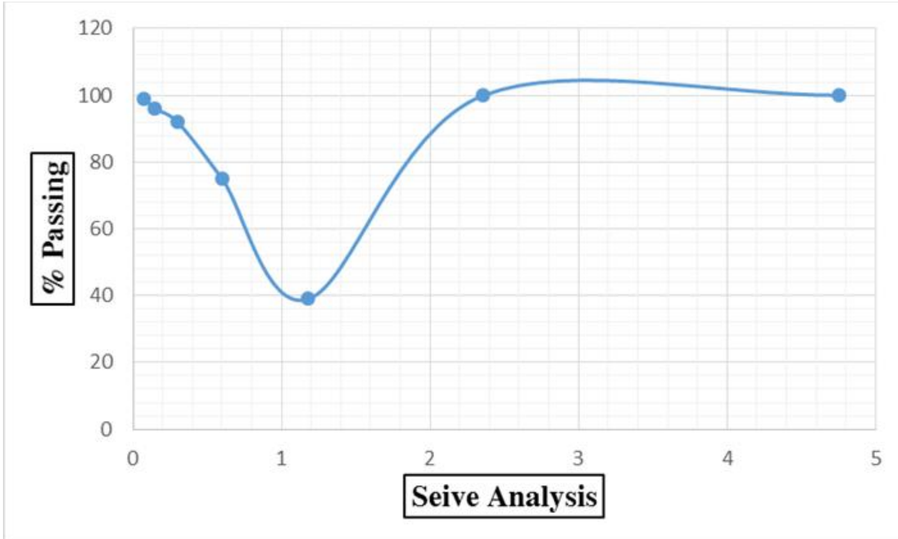
3.2.5 Teff Husk (TH):

The Teff husk color varies from ivory to dark reddish- brown purple, the grain is oval shaped with size 0.9–1.7 mm (length) and 0.7–1.0 mm (diameter). The individual grain mass is generally in the range of 0.2–0.4 mg [21]. The chemical composition of teff seeds [22]. 100 grams teff husk sample were taken to study the properties such as grain size, specific gravity, and water absorption. Fig 2 shows the teff Husk and Table 4 shows the grain size distribution and grain size distribution with percentage passing are presented in graph 3

Fig 2: Teff Husk

Table 4. : Sieve analysis of teff husk

S.NO	SIEVE SIZE	Weight retained (gms)	% weight retained	Cumulative % weight retained	% Passing
1	4.75mm	0	0	0	100
2	2.36mm	0	0	0	100
3.	1.18mm	61	61	61	39
4.	600µ	25	25	86	75
5.	300µ	8	8	94	92
6.	150µ	4	4	98	96
7	75 µ	1	1	99	99



Graph:3. Sieve analysis for teff husk

The Teff husk size ranges from 0.6 – 1.18 mm

Dry density Teff husk 0.151 kg/cm^3,

Specific gravity of Teff husk 0.15

Water absorption= 90 % for 3 hours

3.2.6 Super-plasticizer:

To achieve the slump for mix design High range water-reducing admixture (HRWA) from Fosroc Chemicals India Limited, Bangalore of type Conplast SP-430 has been used. Using this super plasticizer reduction of water was up to 25%.

3.3 Mixing method:

Teff husk is organic material hence absorbs water; hence it was soaked for 3 hours before using it in the dry mix for concrete. Mix proportion for one cubic meter is shown in table 5. The quantity of materials required for different mix proportions is shown in table 6.

Table 5: Mix proportion for cylindrical strength 25 MPa

Water	Cement	FA	CA
193.77 Kg/m^3	425.78 Kg/m^3	544.01 Kg/m^3	1296.71 Kg/m^3
0.45	1.00	1.27	3.04

Table 6:- Quantity of materials required for casting of samples

Code	Volume of Concrete (m^3)	Cement (Kg)	Coarse Aggregate (Kg)	Water (Litters)	Sand (Kg)	Teff Husk (Kg)	Admixture
M1	0.16052	68.34	208.15	23.328	87.32	0	820ml
M2	0.16052	68.34	208.15	23.328	82.97	0.245	820ml
M3	0.16052	68.34	208.15	23.328	78.61	0.484	820ml
M4	0.16052	68.34	208.15	23.328	74.25	0.729	820ml
M5	0.16052	68.34	208.15	23.328	69.89	0.974	820ml
M6	0.16052	68.34	208.15	23.328	65.53	1.219	820ml
M7	0.16052	68.34	208.15	23.328	61.17	1.464	820ml

3.4 Casting and Curing

The ingredients of cement, coarse aggregate, fine aggregate and teff husk was mixed in the dry state until uniform color mix as per the mix design requirements admixture and water was added.

The moulds are greased with lubricant material to the inner surface of the mould to prevent the sticking of cement concrete to mould, the fresh concrete was casted by tamping the materials in three layers using the tamping rod of 25 mm at a height of 50 mm. These specimens are allowed to set in the moulds for 24 hours and these specimens are de-molded, immersed in curing tank at the different age of concrete. For determining the various parameters of concrete are shown in fig 3-5.

Figure 3: Mix of fresh concrete

Figure 4: Casting of cube and cylindrical specimens

Figure 5: Curing of specimens

3.5 Mechanical Test

3.5.1 Slump Cone Test:

Slump test was used to study the workability of the fresh concrete. The apparatus of slump test consists of a base plate, compacting rod and mould. The steel mould was in a cone shape with 200mm diameter of the bottom base, 100mm diameter of top and height of 300mm. The mould and base plate must be damped before testing workability. Then the fresh concrete mixture was filled into the mould in three layers and each layer was compacted by using compacting rod for 25 times. After filling up to the top surface, the mould was lifted upward gradually with no lateral or torsional motion. The difference between the height of the mould and the highest point of the sample was measured and recorded as slump height.

Figure 6: Slump cone test apparatus

3.5.2 Compressive Strength of Concrete:

The compressive strength of concrete is determined by specimen size 150 mm × 150 mm × 150 mm cubes and 150 mm x 300 mm. Cylinders. The compressive strength of concrete is determined by the compressive testing machine of capacity 2000 KN in a concrete laboratory. Setup for compressive strength is shown in fig 7, the specimen is loaded up to failure at a rate of 40 KN/s. The weight of the concrete sample was recorded before conducting the test for reference in order to determine the unit weight of concrete. Compressive strength is calculated using:

$$F_c = P/A \qquad \text{--------------} \ \mathbf{3.1}$$

where,

F_c = cube compressive strength in N/mm^2

P = cube compressive causing failure in N.

A = cross-sectional area of cube in mm^2

Figure 7: Set up for compressive strength for cube and cylinders.

3.5.3 Split Tensile Strength for concrete:

The tensile strength of concrete is determined by casting cylindrical concrete specimens by placing the specimens as shown in Fig.8. The load was applied at a uniform rate of 40 KN/ sec till the specimen is failed along the vertical diameter.

The load at which the specimen ultimately fails is noted and split tensile strength is calculated by:

$$Tsp = 2P / \Pi DL \quad \text{--------------} \; \mathbf{3.2}$$

where, Tsp. = Split tensile strength in N/mm²

P = Applied compressive for at failure in N.

D = Diameter of the cylinder in mm

L = Length of the cylinder in mm.

Figure 8: Setup for split tensile strength test

3.5.4 Test for Flexural Strength:

Plain concrete prism of size 100 x 100 x 500 mm are casted to determine the flexural strength of concrete for single point load. The modulus of rupture is computed by:

$$F = M/Z \quad \text{--------------} \; \mathbf{3.3}$$

where:

M = Bending moment at the section where rupture occurs.

Z = Section modulus (I/Y)

I = Moment of Inertia of the section

Y = Distance from neutral axis = d/2

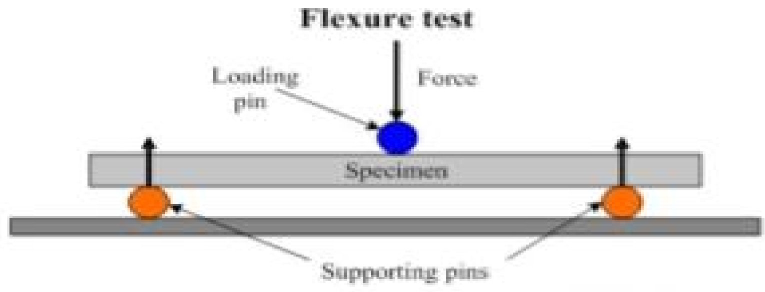


Figure 9: flexural strength test

1.5.5 Water Absorption

The water absorption values for various mixtures of concrete were determined on 150mm x 150mm x 150mm cubes. The specimens were taken out of curing tank after 28 days to record the water saturated weight (W_s).The drying was carried out in an oven at a temperature of 105°C. The drying process continued till the difference between the two successive measurements is found to be very close. Oven-dried specimens were weighed after they cooled to room temperature (W_d). Using these weights, saturated water absorption (SWS) was calculated. The formula used to find water absorption value of concrete specimens is given by:

$$SWA = [(W_s - W_d) / W_d] \times 100 \quad \text{-------------- } \mathbf{3.4}$$

where:

SWA - Saturated Water Absorption in percentages

W_s - Weight of the specimen at fully saturated condition in kg

W_d - Weight of oven dried specimens in kg.

1.5.6 Unit weight of concrete

The density of concrete is calculated by:

$$\mathbf{Dc = (M_c - M_m) / V_m} \quad \text{-------------- } \mathbf{3.5}$$

where :

Dc = Density of the concrete, kg/m^3

$\mathbf{M_c}$ **=** Weight of the measure holding the concrete.

$\mathbf{M_m}$ **=** Weight of the empty concrete measure (base of air meter).

$\mathbf{V_m}$ **=** Volume of the measure.

CHAPTER-4

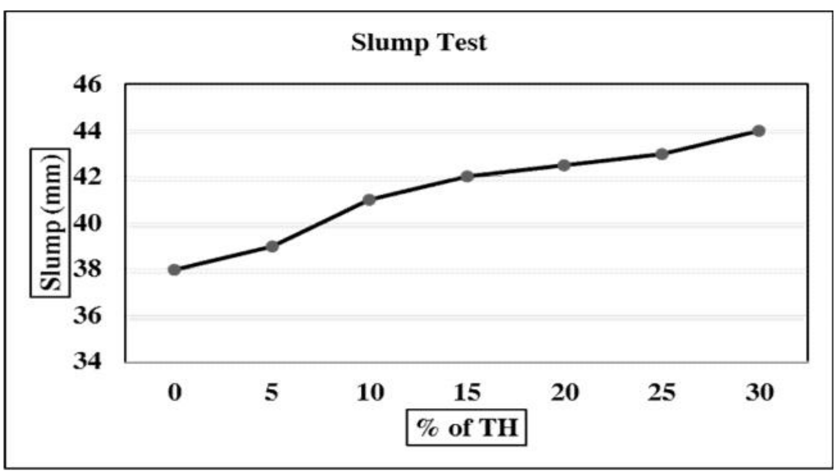
RESULTS AND DISCUSSIONS

4.1 Slump Test.

The slump values for different percentage of replacement for teff husk is shown in Table 7 and in graph 4

Table No. 7: Slump values for percentage variation of Teff husk

Mix design codes	W/c	Slump in mm.
M1-MIX (Controlled concrete)	0.45	38
M2-MIX (5% Teff Husk)	0.45	39
M3-MIX (10% Teff Husk)	0.45	41
M4-MIX (15% Teff Husk)	0.45	42
M5-MIX (20% Teff Husk)	0.45	42.5
M6-MIX (25% Teff Husk)	0.45	43
M7-MIX (30% Teff Husk)	0.45	44



Graph No: 4: Workability of fresh concrete (Slump Cone Test in mm)

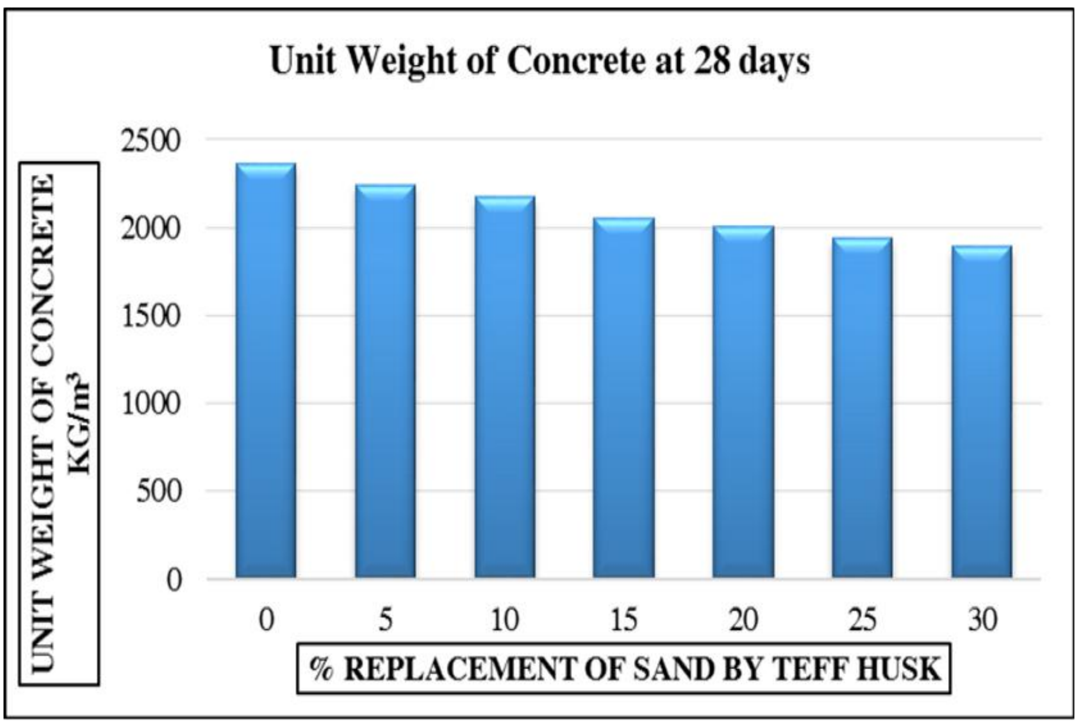
Form the results, we observe that the slump value increases with the increase in the percentage of Teff husk. This is due to the smooth surface of teff husk and low specific surface area.

4.2 Unit Weights of Samples:

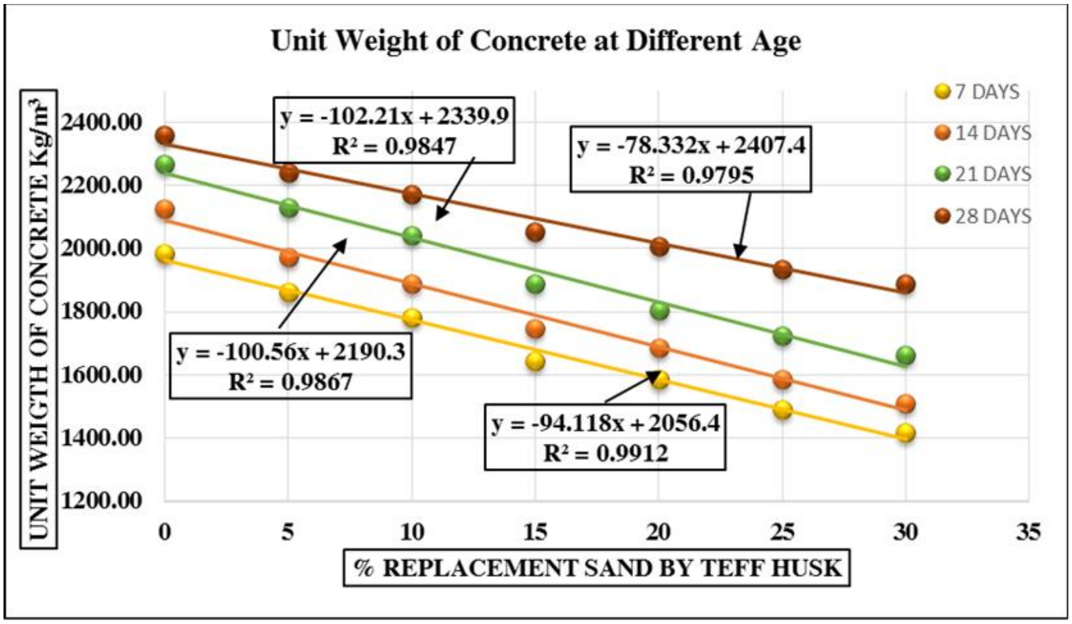
Table 8 and graph 5 gives the details about variation in unit weight of samples for different percentage of Teff Husk.

Table 8: Unit weights of controlled and TH specimens

Mix	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Teff Husk (%)	0	5	10	15	20	25	30
Test age (days)	3-3 SAMPLES ; UNIT WEIGHTS (KG/m^3)						
7;Avg	1982.50	1860.95	1780.47	1642.64	1584.82	1490.18	1416.07
14;Avg	2124.11	1973.06	1889.04	1745.31	1685.13	1586.94	1510.48
21;Avg	2265.72	2130.01	2041.03	1889.04	1805.49	1722.42	1661.52
28;Avg	2360.12	2242.35	2171.64	2053.87	2006.54	1935.92	1888.34



Graph:5. Unit weight of concrete at 28 days



Graph:6. Unit weight of concrete at different age

From the results obtained, it was observed that the unit weight of concrete for 28 days was found to be decreased with the increase in the percentage of TH as the specific gravity of TH is lower than fine aggregate and voids in the cement matrix at a microscopic level. The relationship between unit weight and amount of TH is shown in graph 6. It was observed that there are reductions in weight by 8 % and 20% with compared to the standard specimen in partial replacement of 10% and 20% teff husk with respectively. The weight is 2360 kg/m3 for 0% and 1888.34 kg/m3 for 30%.

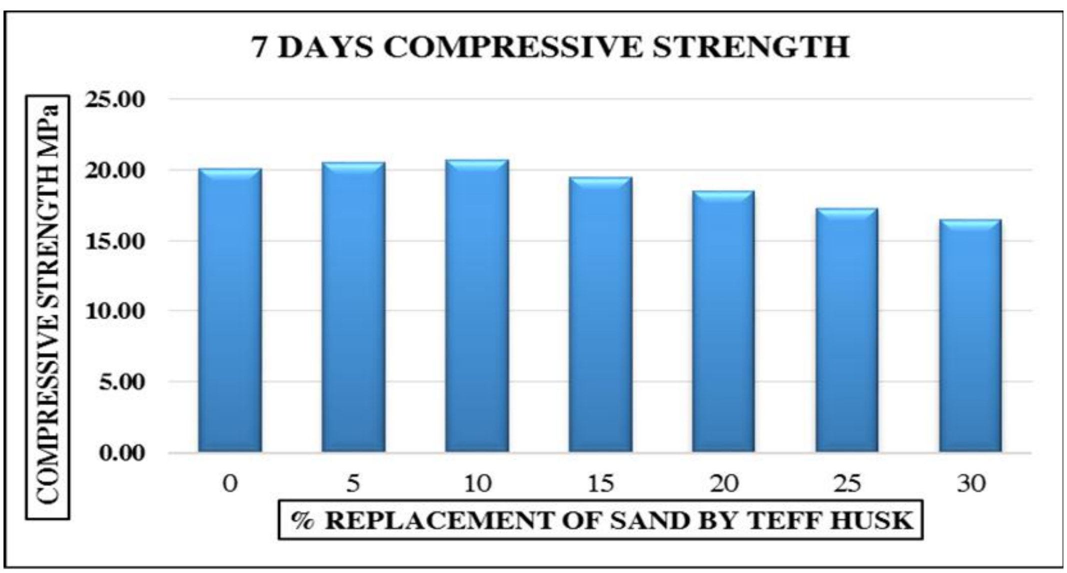
4.3 Cube Compressive strength.

The compressive strength of concrete mixes made with and without Teff husk was determined on 7th, 14th, 21st and 28 days of curing. Table 9 gives the details about variations in the compressive strength of concrete samples for different percentage of Teff Husk.

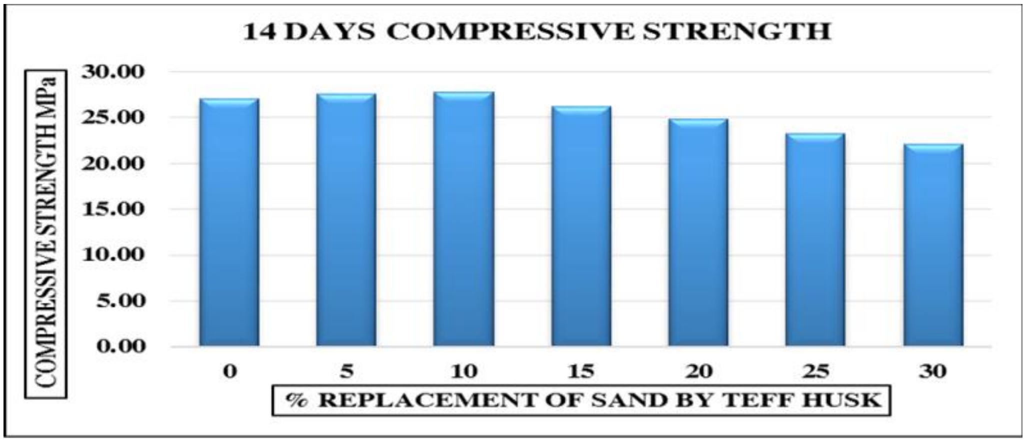
Table 9: Cube Compressive Strength of controlled and TH specimens

Mix	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Teff Husk (%)	0	5	10	15	20	25	30

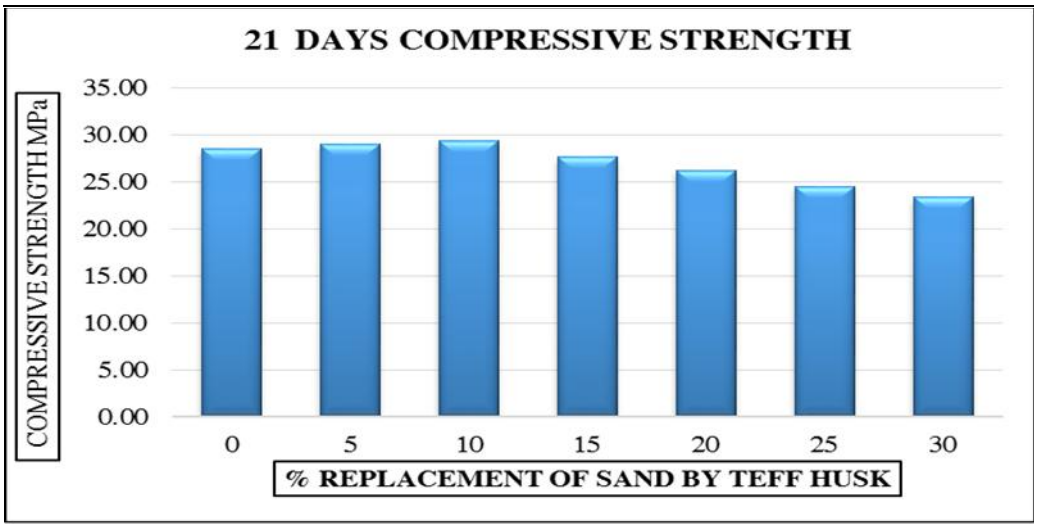
Test age (days)	3-3 SAMPLES COMPRESSIVE STRENGTH (N/mm²)						
7	20.18 21.32 18.50	20.60 19.05 21.85	21.37 20.53 20.20	20.18 17.47 20.85	19.46 18.75 17.26	18.24 17.49 16.14	17.26 15.82 16.36
Avg	**20.10**	**20.50**	**20.70**	**19.50**	**18.49**	**17.29**	**16.48**
14	26.48 28.42 26.10	28.74 26.35 27.53	28.54 28.36 26.53	25.89 26.33 26.34	25.64 24.90 23.98	23.88 22.68 23.10	21.86 22.48 22.08
Avg	**27.00**	**27.54**	**27.81**	**26.19**	**24.84**	**23.22**	**22.14**
21	28.84 28.43 28.23	28.98 29.10 29.04	29.82 28.62 29.64	27.98 26.54 28.43	26.82 23.52 28.32	25.32 24.37 23.84	23.68 21.61 24.82
Avg	**28.50**	**29.07**	**29.36**	**27.65**	**26.22**	**24.51**	**23.37**
28	32.68 27.95 29.82	31.28 30.88 29.64	31.28 29.94 31.48	29.60 28.76 28.94	27.42 26.42 28.96	26.64 25.48 25.28	23.94 25.62 24.28
Avg	**30.15**	**30.60**	**30.90**	**29.10**	**27.60**	**25.80**	**24.60**



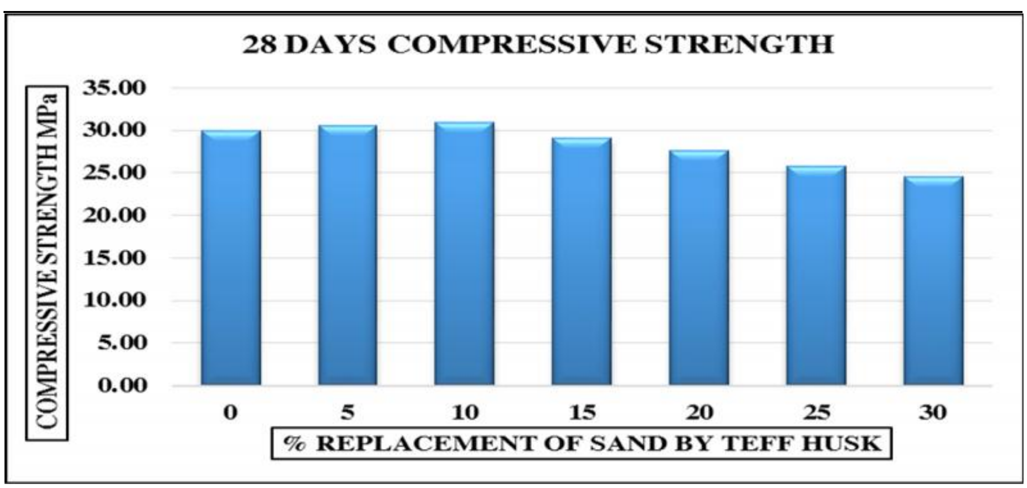
Graph:7. Compressive strength of cube for concrete 7 days



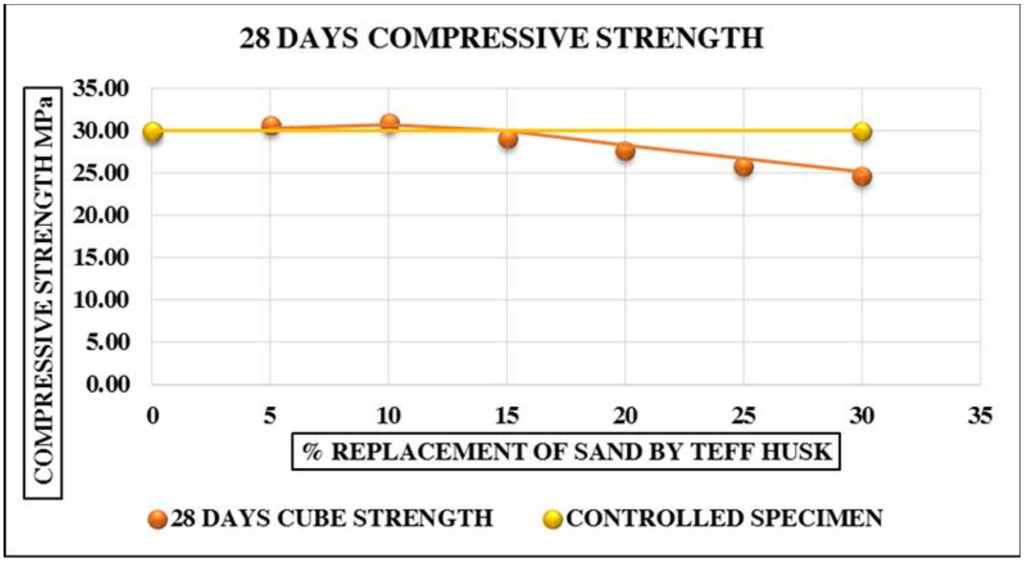
Graph:8. Compressive strength of cube for concrete 14 days



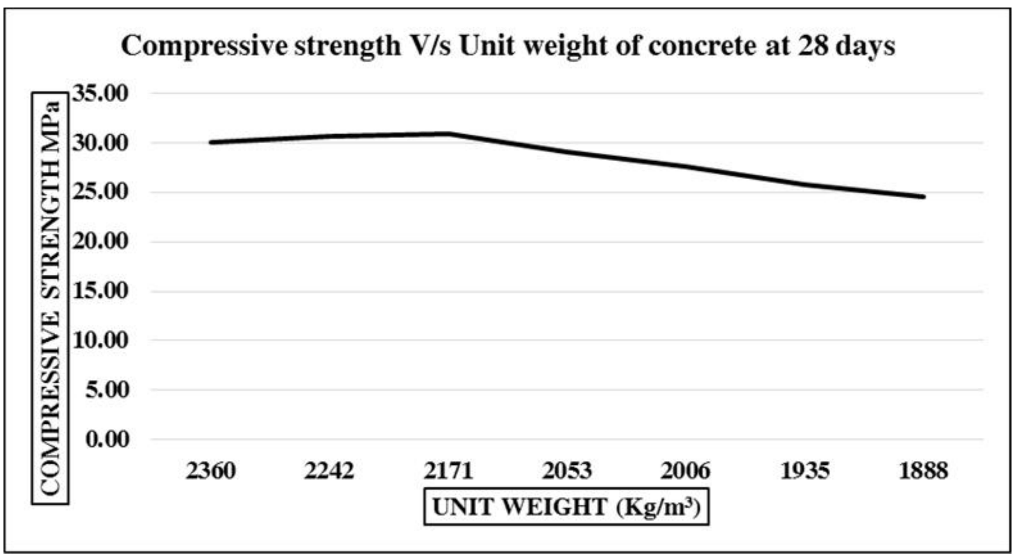
Graph:9. Compressive strength of cube for concrete 21 days



Graph:10. Compressive strength of cube for concrete 28 days



Graph:11. Comparrision of compressive strength of teff husk concrete and conctrolled specimen at 28 days strength



Graph:12. Compressive strength with unit weight of concrete at 28 days

Graph 10-12 show the cube compressive strength at the different age of concrete. The compressive strength of the cube specimens for 28 days was found to be 30 MPa and 25.8 MPa for the controlled specimen and for 30% replacement. From results, we observed that compressive strength of concrete increased up to 3% for 10% replacement of teff husk. This increase in strength is due to finer particle size and water absorption of teff husk during the curing period. It was also observed that there is a decrease in strength up to 14 %.

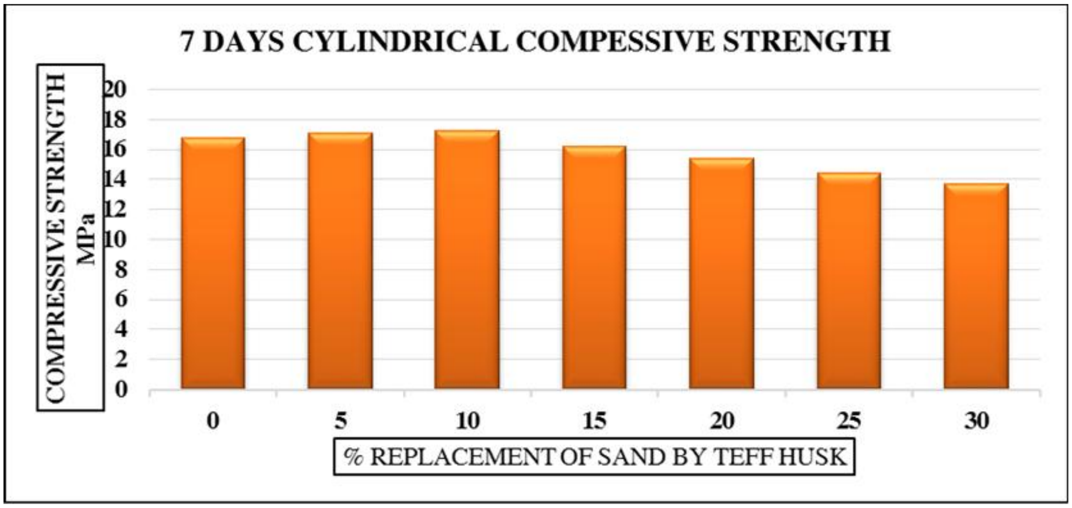
Experimental work was also carried to study the behavior of concrete with compressive strength and unit weight of concrete on 28 days. It was observed that the compressive strength of concrete was decreased up to 18% with the replacement of teff husk at 30 %.

4.4 Cylindrical Compressive strength of concrete.

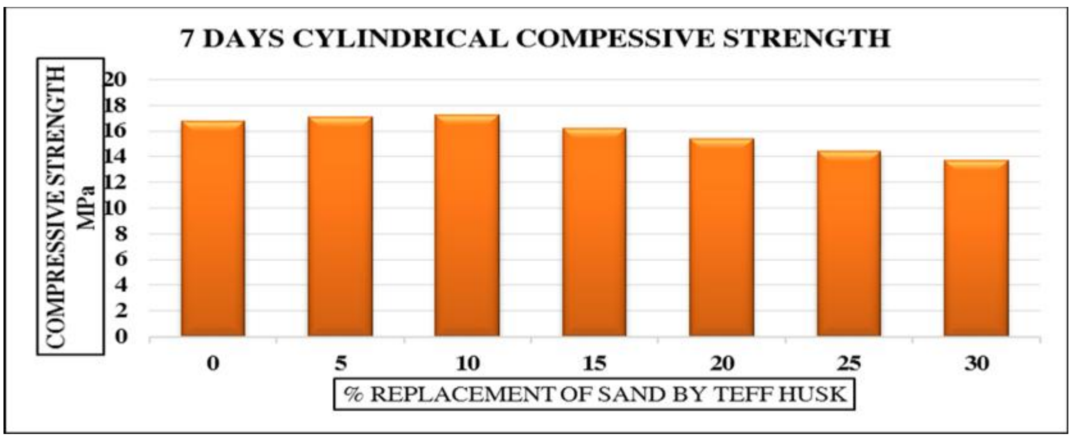
The cylindrical Compressive strength of concrete was also studied at 7th, 14th, 21st and 28 days of curing. Test results are shown in table 10 and same are represented in a graph (13 - 16).

Table No-10: Cylindrical Compressive Strength controlled and TH specimens.

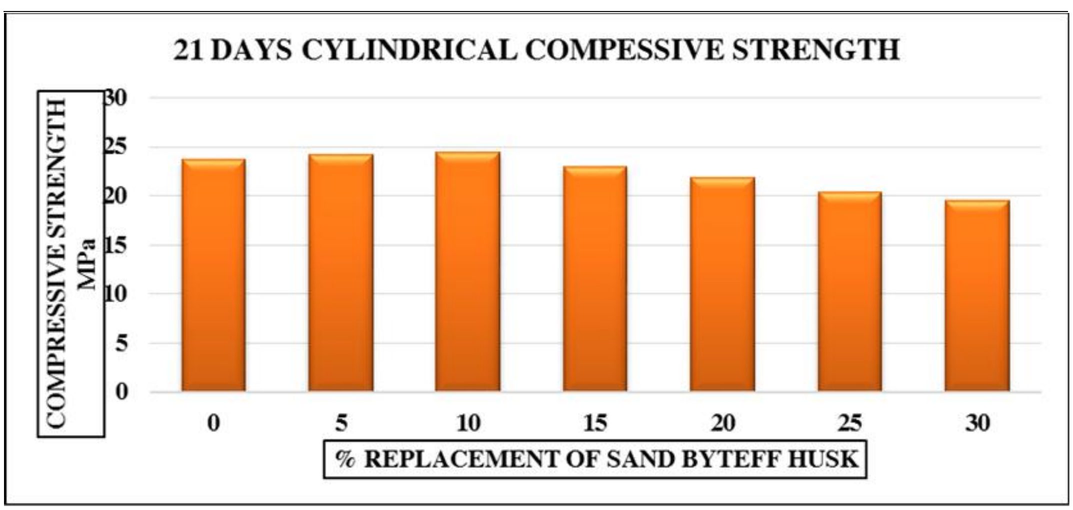
Mix	**M-1**	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**
Teff Husk (%)	0	5	10	15	20	25	30
Test age (days)	**3-3 SAMPLES COMPRESSIVE STRENGTH (N/mm²)**						
7	16.98 17.99 15.28	15.75 17.24 18.25	16.98 17.71 17.06	16.82 14.82 17.08	15.68 14.37 15.21	14.82 13.98 15.02	12.98 15.13 13.08
Avg	**16.75**	**17.08**	**17.25**	**16.24**	**15.41**	**14.40**	**13.73**
14	21.69 23.77 22.04	21.67 23.36 23.82	23.54 22.85 23.12	21.22 20.82 23.42	19.68 22.18 20.24	20.17 18.52 19.36	19.62 17.71 18.02
Avg	**22.5**	**22.95**	**23.17**	**21.82**	**20.7**	**19.35**	**18.45**
21	22.98 25.22 23.05	24.16 24.62 23.88	24.88 24.28 24.22	23.98 21.69 23.42	21.38 21.72 22.45	20.86 20.54 19.86	21.32 18.14 18.95
Avg	**23.75**	**24.22**	**24.46**	**23.03**	**21.85**	**20.42**	**19.47**
28	25.85 24.17 25.13	25.69 25.59 25.34	25.98 24.99 26.28	24.26 22.53 25.96	22.54 23.68 22.96	22.64 19.91 21.95	22.80 21.38 17.35
Avg	**25.05**	**25.54**	**25.75**	**24.25**	**23.06**	**21.50**	**20.51**



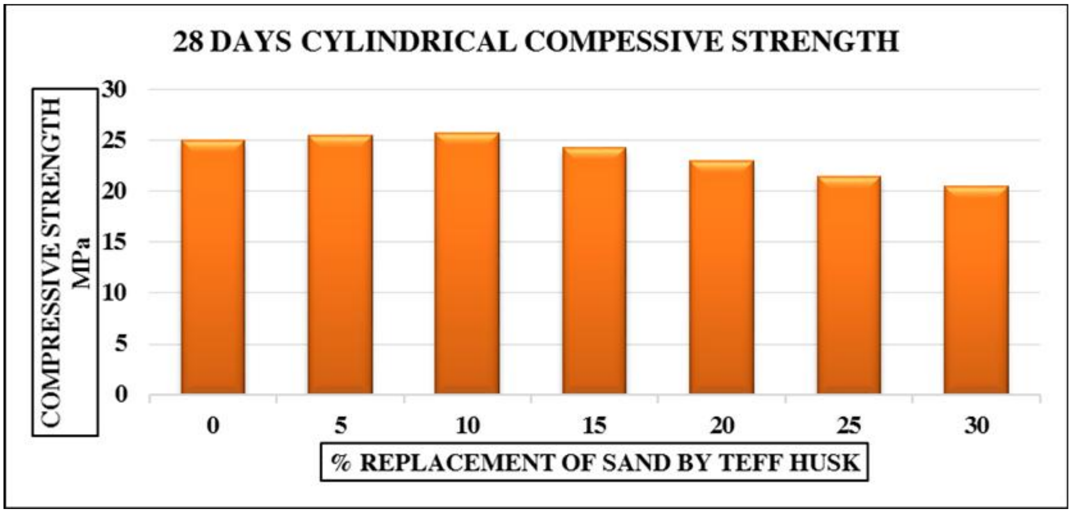
Graph:13. Cylindrical compressive strength for 7 days



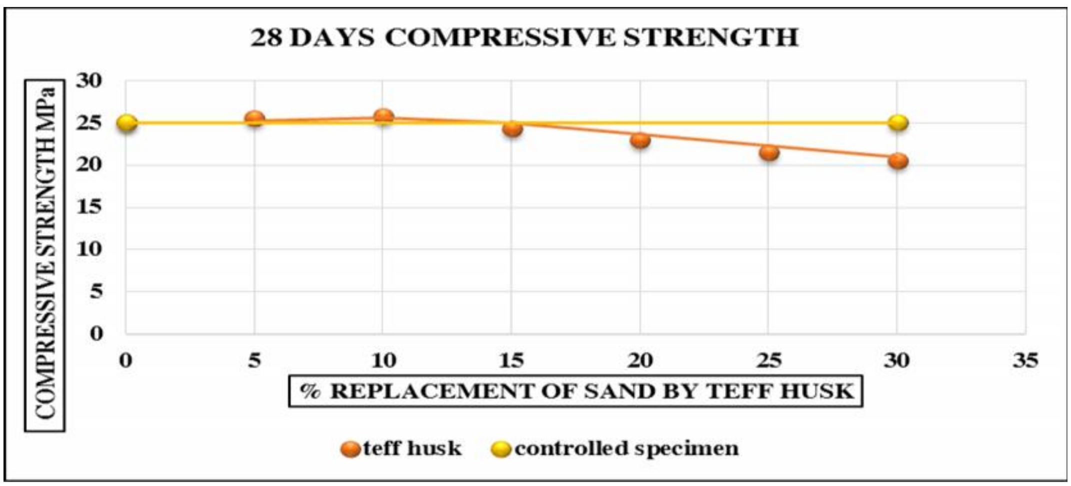
Graph:14. Cylindrical compressive strength for 14 days



Graph:15. Cylindrical compressive strength for 21 days



Graph:16. Cylindrical compressive strength for 28 days



Graph:17. Relationship between cylindrical strength and Teff Husk at 28 days

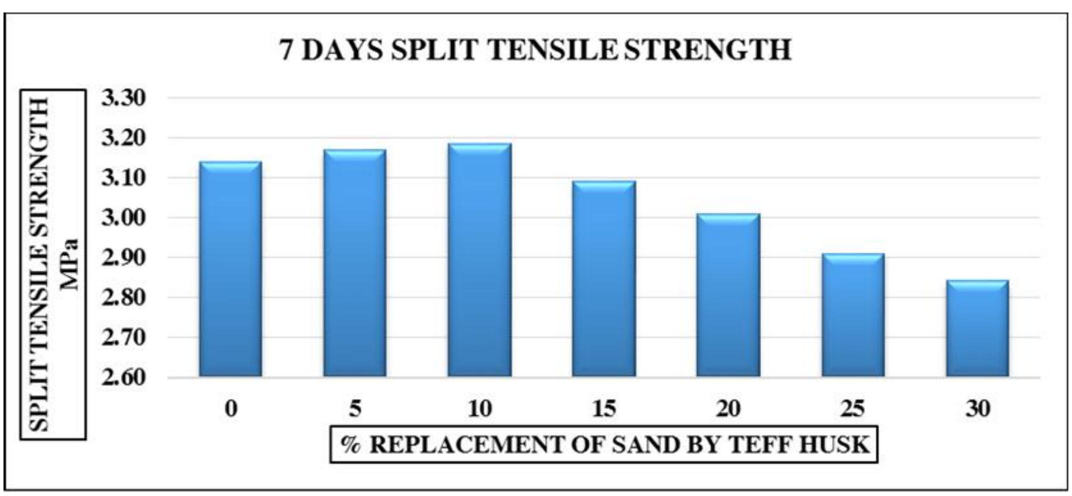
The relationship between compressive strength and percentage replacement of TH at different age of concrete is shown in graph 17. Cylindrical compressive strength results show that there is an increase in strength up to 3% for 10% replacement of teff husk and a decrease in strength up to 18 percent for 30 percent replacement.

4.5 Split tensile Strength

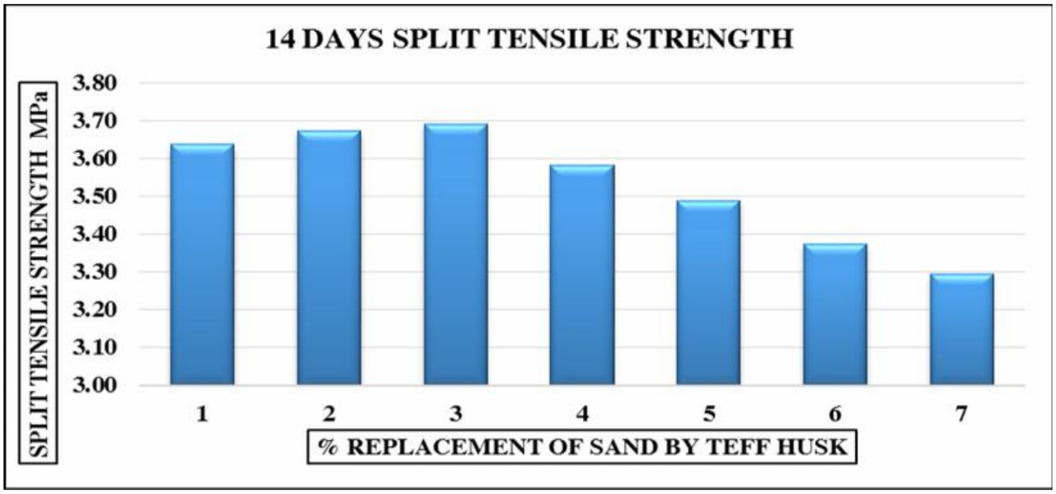
The splitting tensile strength of concrete results is tabulated in Table 11 at different age of concrete as shown below. Graph 18- 21 shows the result for 7 – 28 days age of concrete.

Table 11: Split tensile strength of controlled and TH specimens

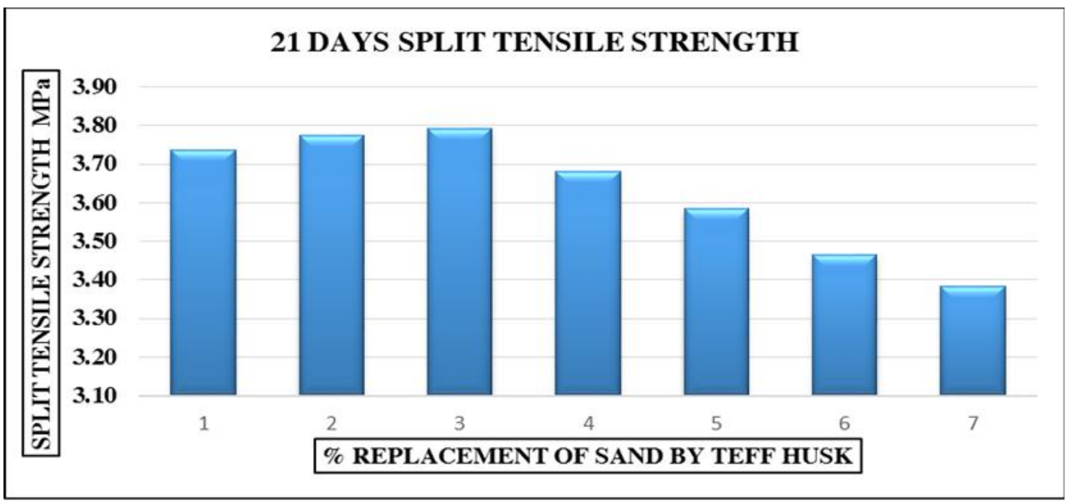
Mix	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Teff Husk (%)	0	5	10	15	20	25	30
Test age (days)	**3-3 SAMPLES SPLIT TENSILE STRENGTH (N/mm²)**						
7	2.97 3.33 3.12	3.19 3.34 2.98	3.04 3.35 3.18	3.16 3.03 3.08	3.14 2.95 2.94	2.74 3.04 2.95	3.08 2.79 2.95
Avg	**3.14**	**3.17**	**3.19**	**3.09**	**3.01**	**2.91**	**2.84**
14	3.98 3.66 3.28	4.10 3.24 3.67	3.89 3.65 3.53	3.68 3.45 3.61	3.36 3.54 3.57	3.38 3.68 3.05	3.24 3.25 3.38
Avg	**3.64**	**3.67**	**3.69**	**3.58**	**3.49**	**3.37**	**3.29**
21	3.89 3.79 3.54	3.99 3.68 3.64	3.84 3.69 3.84	3.50 3.96 3.58	3.66 3.52 3.56	3.68 3.25 3.48	3.48 3.41 3.25
Avg	**3.74**	**3.77**	**3.79**	**3.68**	**3.58**	**3.47**	**3.38**
28	3.98 3.67 3.84	3.95 3.82 3.84	3.95 3.85 3.87	3.82 3.76 3.76	3.52 3.66 3.86	3.54 3.58 3.56	3.49 3.38 3.54
Avg	**3.83**	**3.87**	**3.89**	**3.78**	**3.68**	**3.56**	**3.47**



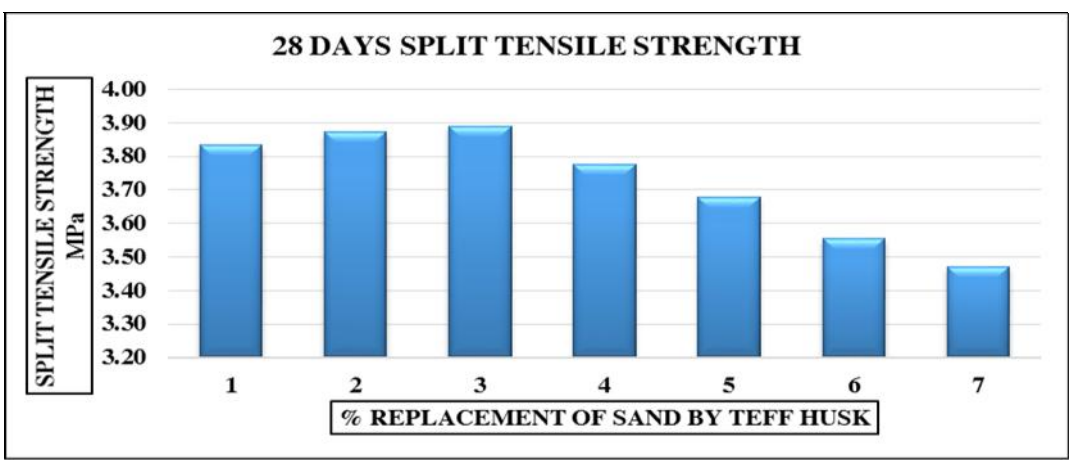
Graph:18 . Split tensile of concrete for 7 days



Graph: 19 . Split tensile of concrete for 14 days



Graph: 20 . Split tensile of concrete for 21 days



Graph: 21 . Split tensile of concrete for 21 days

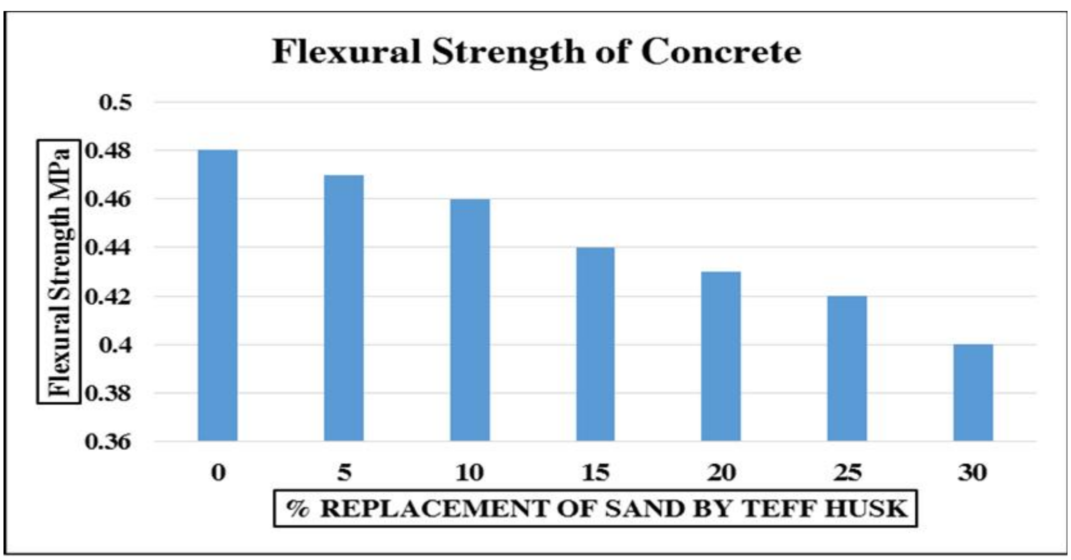
The maximum value of split tensile strength obtained is 2.56 MPa for the controlled specimen. However, it was observed that for 10 percent replacement there was increment by 1.5%. There was a reduction of 10 percent in tensile strength for 30% replacement.

4.6. Flexural Strength

The flexural strength test results of controlled and teff husk concrete at 28 days are tabulated in table 12 and also presented in graph 22.

Table No.12: Flexural Strength of Grade controlled and TH specimens

Mix	**M-1**	**M-2**	**M-3**	**M-4**	**M-5**	**M-6**	**M-7**
Teff Husk (%)	0	5	10	15	20	25	20
Test age (days)	**3-3 Samples Flexural Strength (N/mm²)**						
28	0.49 0.42 0.42	0.47 0.48 0.45	0.4 0.49 0.49	0.37 0.51 0.43	0.49 0.42 0.40	0.4 0.43 0.42	0.4 0.42 0.4
Avg	**0.48**	**0.47**	**0.46**	**0.44**	**0.43**	**0.42**	**0.4**



Graph No-22: Flexural strength of for different % replacement of TH.

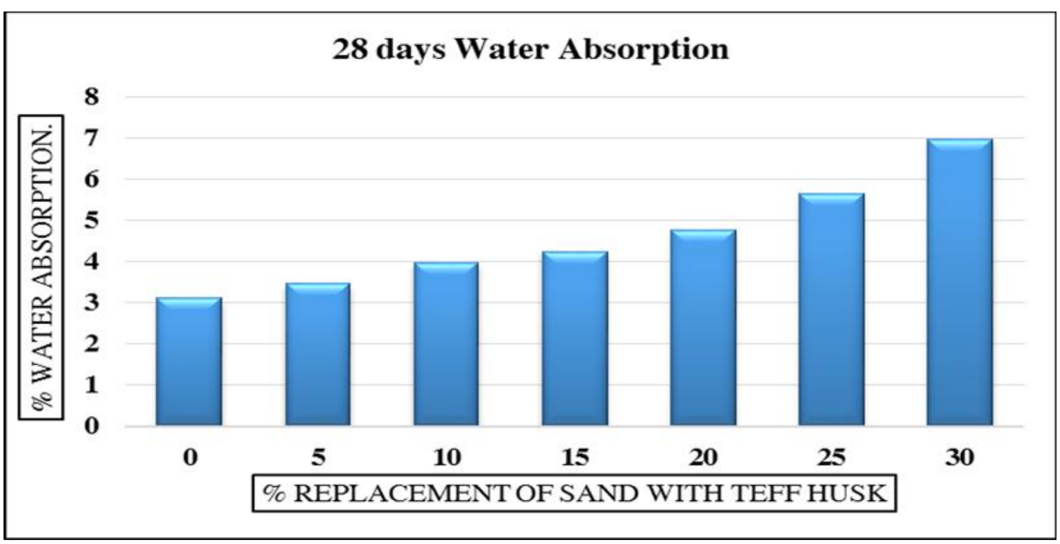
The maximum flexural strength obtained for teff husk concrete was 0.48 MPa for zero reference sample but for teff husk concrete specimen was found to be lower with an increase in the percentage of teff husk.

4.7 Water Absorption:

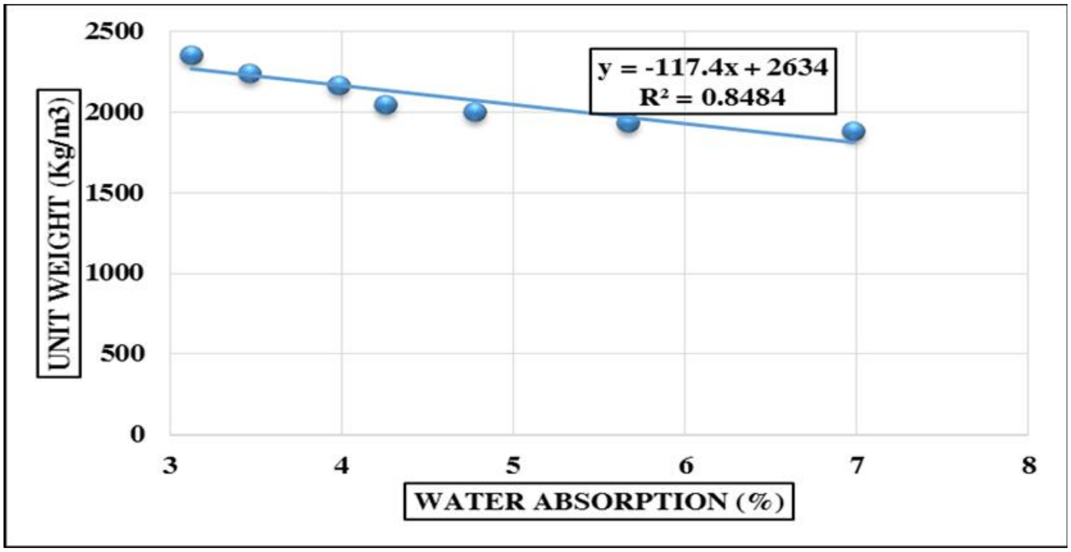
Water absorption test was done with controlled and Teff husk concrete for 28 days is given in table 13 and also presented in graphs 23 and 24. The graph shows a variation of the unit weight of concrete with the percentage of water absorption.

Table 13: Water Absorption of controlled and TH specimens

Mix	M-1	M-2	M-3	M-4	M-5	M-6	M-7
Teff Husk (%)	0	5	10	15	20	25	20
Test age (days)	**3-3 Samples Water Absorption (Percentage)**						
28	3.22 3.18 2.96	3.36 3.52 3.50	3.94 3.98 4.02	4.34 4.26 4.15	4.86 4.82 4.63	5.80 5.52 5.66	6.98 7.26 6.70
Avg	**3.12**	**3.46**	**3.98**	**4.25**	**4.77**	**5.66**	**6.98**



Graph No-23: Percentage of water absorption with different percentage of TH



Graph No-24: Percentage of water absorption with unit weight

The water absorption of the samples on 28th day ranged between 3.12% and 6.98% for the controlled specimen and for 30 percent replacement. The water absorption was within the permissible limits as per ASTM. But compared to controlled specimen the percentage of water absorption was increased by 55%. It was also observed that unit weight of concrete decreased with the increase in the percentage of TH.

CHAPTER – 5
CONCLUSIONS

The experimental work was conducted with sand replacement by volume up to 30% with linear increment by 5 percent from zero percent. Studies were carried on the structural properties of concrete in terms of compressive strength, flexural strength, unit weight and water absorption by casting cube, cylinder and beams specimens. Based on the results, the following conclusions are drawn:

1. The workability of concrete was increased up to 13 % with increase in TH up to 30% replacement of sand by TH.
2. Unit weight of concrete was decreased with increase in the percentage of TH up to 20% but the compressive strength of concrete was reduced parallel.
3. Test results showed positive response up to 10 % replacement with an increase in compressive strength up to 3 % for 28 days.
4. Split tensile strength and flexural strength of concrete was also found to be lower than controlled specimen for 28 days by 9% but was found to be increased up to 1.5 % for 10% replacement of TH and negligible difference in flexural strength of concrete.
5. Water absorption was high in TH concrete up to 55 % with 30% replacement of sand by TH as compared to that of controlled concrete.

The overall behavior of Teff Husk concrete with that of controlled specimen closely resembles that of equivalent strength up to 10 % replacement by Teff Husk.

Overall, the study revealed that using TH as a replacement of sand up to 10% by volume contributes an increase in strength of concrete relatively. The study pointed out that the possibility of using TH as an alternative material for construction purposes. This also creates a possibility of commercializing TH as an economic advantage for the farmers. Besides using TH as a replacement of sand in concrete production has an environmental advantage by reducing the depletion of a natural resource like sand and land degradation. In search of it in rural areas. Hence, it is possible to use TH as an alternative material replacing fine aggregate, particularly where sand is scarce and TH is abundant.

SCOPE FOR FURTHER STUDY / RECOMMENDATIONS

1. The research can be further extended to study the durability properties such as permeability, hydrochloride, and sulfuric acid of concrete for 90 / 120 days.
2. The chemical composition and crystalline phase of the TH should be performed.
3. Research can be carried out to investigate the compressive strength of the combination of more types of husk.
4. The research can be further conducted using Teff husk ash as a partial replacement of cement.

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APPENDIX

Casting of specimens

Curing of specimens

Failure of Cube Samples

Failure of Compressive Strength of Cylinder