Experimental Investigation on Concrete with Partial Replacement of Cement by Gram Flour

T.Subramani[1], M.Senthil kumar[2], Alen V Aloysius[3], Najeemsha Salahudeen[4], Swathi Shree Yesodha[5]

[1]Professor & Dean, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, India

[2] Associate Professor, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation
(Deemed to be University), Salem, India

[3,4,5]UG Student, Department of Civil Engineering, VMKV Engineering College, Vinayaka Missions Research Foundation (Deemed to be University), Salem, India

ABSTRACT

In the recent time, attempts are vigorously made to enhance the fresh state and hardened properties of concrete. Hence to get high strength concrete with good rheology, natural admixtures are progressively used to the concrete during mixing stage. Use of chemical admixtures in concrete is a common practice in modern construction. Although chemical admixtures improve properties of concrete but also create leaching problem. Our project, the various experiments performed to identify the influence of natural organic materials as admixture on durability of concrete. In this study, the influence of natural admixture Gram-flour on the engineering properties of concrete has been investigated for different w/c ratios. In hardened concrete the specimens are casting with different percentage of Gram – flour that is cube 150mm x 150mm x 150mm and the cylinder is 150mm x 300mm. The strength of hardened concrete is predicted with respect to the following Strength tests such as Compressive strength, split tensile strength test and durability tests such as water absorption and water permeability tests are studied under 7, 14 and 28 curing days were assessed in order to enumerate the effect of Gram - flour on the concrete. Finally, the fresh and hardened concrete properties are compared to conventional concrete.

Keywords: Concrete, Partial Replacement, Cement, Gram Flour.

1. INTRODUCTION

a. General

Concrete is a most commonly used building material which is a mixture of cement, sand, coarse aggregate and water. It is used for construction of multi-story buildings, dams, road pavement, tanks, offshore structures, canal lining. The method of selecting appropriate ingredients of concrete and determining their relative amount with the intention of producing a concrete of the necessary strength durability and workability as efficiently as possible is termed the concrete mix design. The compressive strength of harden concrete is commonly considered to be an index of its extra properties depends upon a lot of factors e.g., worth and amount of cement water and aggregates batching and mixing placing compaction and curing. The cost of concrete prepared by the cost of materials plant and labour the variation in the cost of material begins from the information that the cement is numerous times costly than the aggregates thus the intent is to produce a mix as feasible from the practical point of view the rich mixes may lead to high shrinkage and crack in the structural concrete and to development of high heat of hydration is mass concrete which may cause cracking. The genuine cost of concrete is related to cost of materials essential for produce a minimum mean strength called characteristic strength that is specific by designer of the structures. This depends on the quality control measures but there is no doubt that quality control adds to the cost of concrete.

Usage of chemical admixtures in concrete is a common practice in modern construction. Use of chemical admixtures in concrete reduce water demand and improve properties of concrete. Although use of chemical admixtures provides better concrete properties but also responsible for environmental pollution. Impact of chemical admixture on environmental can occur when chemical admixtures are expose to environment or when dumping concrete granulate containing admixtures after demolition of structure or when concrete granulate is used as gravel replacement in construction, as the concrete admixtures are very readily soluble in water, hence create environmental problem due to leaching. So, it is desired to find alternative admixtures that provide better concrete properties, also don't produce adverse effect on environment. In the ancient period various natural organic materials were used with concrete and mortar. Organic admixtures (herbs) are locally available plants and animal derivative and the major content in these materials are proteins. The organic materials like black gram, potato starch, egg white, cactus gluey liquid etc. These organic materials improve workability, compressive strength, tensile strength, plasticity etc.Due to deprive transportation services, lack of storage space and lack of maintenance, wastage of food grains is high in India. According to United Nations Development program (UNDP) almost 40% of the total food production is wasted in India due to Poor transportation facilitiesand lack of storage space.So, these waste food grains can be utilizing as natural organic admixture in concrete.

The level of quality control is often an inexpensive cooperation and depends on the size and type of job nowadays engineers and scientists are trying to enhance the strength of concrete by adding the several other economical and waste materials as a partial substitute of cement or as a admixture gram-flour. Thismaterial isgenerally by-product from Gram Company.

1.2 Importance of Admixtures

Concrete admixtures are not the essential component of the mix, but nowadays their use in concrete is increasing very rapidly and their importance is becoming more valuable. A concrete mix without admixtures is an exception in this real world and United Kingdom is the maximum consumer of concrete admixtures.

1.3 Admixtures Benefits

The use of admixtures is increasing very rapidly, because concrete admixtures provide physical as well as economic benefits. Admixtures benefit the concrete in following possible ways.

- Admixtures reduce the required quantity of cement and make concrete economical.
- They enhance the workability of concrete.
- Admixtures impart early strength in concrete.
- Admixtures reduce the early heat of hydration and overcome thermal cracking problem in concrete. If there is a more heat of hydration then cracks can propagate in fresh concrete.
- Admixtures improve the resistance against freeze-thaw effect on concrete.
- Concrete admixtures maximize the sustainability by bringing waste products in use.
- Concrete admixtures can accelerate the setting time as well as there are admixtures that decelerate concrete setting time.
- There are some admixtures that act as anti-bacterial agents.
- There are concrete admixtures that decrease initial strength, but increase the hardened concrete strength more than the normal concrete strength.
- If concrete admixtures are used properly then these are very beneficial to concrete. Otherwise, there is no repair for poor quality of concrete mix ingredients

1.4 Objective

- To study the strength and durability characteristics of concrete made with Gram – flour as natural admixture.
- To find out the optimum percentage of Gram – flour that can be used in concrete.
- The strength and durability test results are compared with the conventional concrete.

2. METHODOLOGY

Figure 1 shows the methodology of the study.

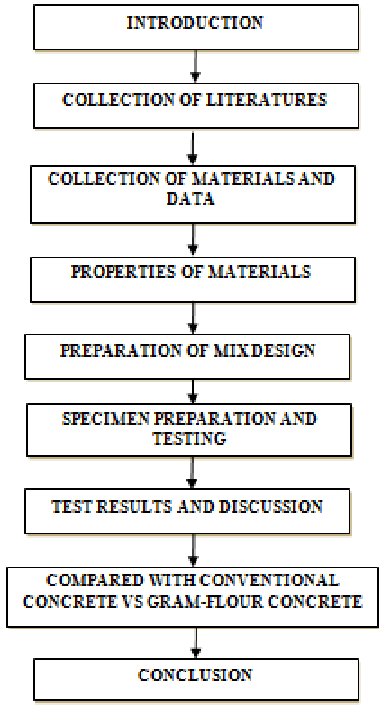

Figure 1 Methodology

3. MATERIAL COLLECTION

a. Cement

Ordinary Portland cement is the most common type of cement in general use around the world as abasic ingredient of concrete, mortar, stucco, and most non-specialty grout. It developed from other types of hydraulic lime in England in mid-19th century and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker, we will add small amounts of remaining ingredients.

b. Aggregate

Aggregate are the most important constituents in concrete and the aggregate occupy nearly 70-80% of concrete volume. They give body to the concrete, reduce shrinkage and stiffened the concrete. One of the most important factors for producing workable concrete is a good gradation of aggregates. Good grading implies that as ample fraction of aggregates in required proportion contains minimum voids requirements to use as concreting materials.

i. Fine Aggregate

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica(silicon dioxide, or SiO_2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete Fine aggregates are termed as “filler” which fills the voids in concrete. The reactions of aggregates less then4.75mm are known as fine aggregates. The river sand is used as fine aggregate conforming to requirements of IS:383-1970 comes under zone II.

ii. Coarse aggregate

Aggregates fractions larger than 4.75mm are termed as coarse aggregates. The fraction of aggregates used in the experimental work passed in 20mm sieve and retained on 10mm IS sieve comes under Zone II aggregates conforming to IS: 383-1970.

c. Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Since it helps to from the strength giving cement gel, the quantity and quality of water are required to be looked into very carefully.

- Role of Water in Cement Concrete.
- Requirements of water used in concrete.
- The permissible limits for solids in water.
- Solids Permissible Limits (Max).
- Organic 200 mg/lit.
- Inorganic 3000 mg/lit.
- Sulphates (SO_4) 500 mg/lit.
- Chlorides (Cl) 500 mg/lit.
- Suspended matter 2000 mg/lit Water/Cement Ratio and Strength.

d. Gram Flour

- Addition of gram flour provided better durability. Electrical resistivity increased for both w/c ratios up to 26.65%. Even after applying 70% loading, electrical resistivity was more than control concrete. Up-to 31.98% increase in electrical resistivity was observed over control concrete. After applying 70% loading, percentage drop in electrical resistivity was lesser than control concrete.
- UPV increased for both w/c ratios up-to 0.8%. Even after applying 70% loading, UPV was more than control concrete. Up-to 2.75% increase in UPV was observed over control concrete. After applying 70% loading, percentage drop in ultrasonic pulse velocity (UPV) was lesser than control concrete.
- Carbonation depth decreased for both w/c ratios up-to 4.84%. Even after applying 70% loading carbonation depth was lesser than control concrete. Up-to 11.63% decrease in carbonation depth was observed over control concrete. After applying 70% loading, percentage drop in carbonation depth was more than control concrete. Since addition of gram flour improve properties of concrete hence gram flour can be recommended to use in concrete as natural organic admixture.

Figure 2 shows the gram flour.

Figure 2 Gram flour

Made from a grounded mixture of chickpeas, chickpea or gram flour is a chief condiment in Indian, Pakistani and Bangladeshi cuisines. The flour is powdery yellow and has an earthy flavor adding savor to various dishes. Chickpea flour makes a tasty and crispy coating for deep-fried vegetable pakoras. The variety of chickpea flour depends on the kind of chickpea used to ground.

4. MATERIAL PROPERTIES

a. Cement

Ordinary Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete, mortar, stucco, and most non specialty grout. It developed from other types of hydraulic lime in England in mid 19thcentury and usually originates from limestone. It is a fine powder produced by heating materials to form clinker. After grinding the clinker, we will add small amounts of remaining ingredients. Many types of cements are available in market. When it comes to different grades of cement, the 53 Grade OPC Cement provides consistently higher strength compared to others.

As per the Bureau of Indian Standards (BIS), the grade number of a cement highlights the minimum compressive strength that the cement is expected to attain within 28 days. For 53 Grade OPC Cement, the minimum compressive strength achieved by the cement at the end of the 28^{th} day shouldn't be less than 53Mpa or 530 kg/cm2. The color of OPC is grey color and by eliminating ferrous oxide during manufacturing process of cement we will get white cement also. Ordinary Portland Cement of 53 Grade of brand name Ultra Tech Company, available in the local market was used for the investigation. Care has been taken to see that the procurement was made from single batching in air tight containers to prevent it from being affected by atmospheric conditions. The cement thus procured was tested for physical requirements in accordance with IS: 169-1989 and for chemical requirement in accordance IS: 4032-1988. Table 1 shows the properties of cement.

Table 1: Properties of Cement

S.no	Properties	Test results
1	Normal consistency	0.32
2	Initial setting time	50min
3	Final setting time	320min
4	Specific gravity	2.96
5	Fineness	5%

b. Fine Aggregates

Sand is a natural granular material which is mainly composed of finely divided rocky material and mineral particles. The most common constituent of sand is silica (silicon dioxide, or SiO2), usually in the form of quartz, because of its chemical inertness and considerable hardness, is the most common weathering resistant mineral. Hence, it is used as fine aggregate in concrete. River sand locally available in the market was used in the investigation. The aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity in accordance with IS: 2386-1963.The sand was surface dried before use. Table 2 shows the properties of fine aggregate.

Table 2: Properties of Fine Aggregate

Properties
Specific gravity
Bulk density, kg/m^3
Porosity, %
Grading zone
Fineness modulus
Water absorption

c. Coarse Aggregates

Crushed aggregates of less than 12.5mm size produced from local crushing plants were used. The aggregate exclusively passing through 12.5mm sieve size and retained on 10mm sieve is selected. The aggregates were tested for their physical requirements such as gradation, fineness modulus, specific gravity and bulk density in accordance with IS: 2386-1963. The individual aggregates were mixed to induce the required combined grading. Table 3 shows the properties of Coarse Aggregates

Table 3: Properties of Coarse Aggregates

Properties	Coarse aggregate
Particle shape	Angular
Particle size	20mm
Specific gravity	2.98
Bulk density	1340 kg / m^3
Fineness modulus	4.18

d. Water

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete.

Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding take place, so that the concrete becomes weak, but most of the water will absorb. Hence it may avoid bleeding. If water content exceeds permissible limits, it may cause bleeding. If less water is used, the required workability is not achieved. Potable water fit for drinking is required to be used in the concrete and it should have pH value ranges between 6 to 9.
Gram flour contains high quantity of carbohydrate and no gluten. However, compared to other flours, gram flour is high in protein content.

e. Gram-Flour

- Rich in vitamins and minerals
- Chickpea flour is loaded with important nutrients.
- One cup (92 grams) of chickpea flour contains (1Trusted Source):
- Calories: 356
- Protein: 20 grams
- Fat: 6 grams
- Carbs: 53 grams
- Fiber: 10 grams
- Thiamine: 30% of the Reference Daily Intake (RDI)
- Folate: 101% of the RDI
- Iron: 25% of the RDI
- Phosphorus: 29% of the RDI
- Magnesium: 38% of the RDI
- Copper: 42% of the RDI
- Manganese: 74% of the RDI
- Plus, it's an excellent source of several minerals, including iron, magnesium, phosphorus, copper, and manganese.

5. MIX DESIGN

a. Design Stipulations

- Grade Designation M-40
- Type of cement O.P.C-53grade
- Fine Aggregate Zone-I
- Sp. Gravity Cement 2.96
- Sp. Gravity Fine Aggregate 2.98
- Sp. Gravity Coarse Aggregate 2.98

6. TESTING PROCEDURE

a. Absorption Tests

Water absorption is one of the important parameters, which affects the durability of the structure due to the corrosion of steel reinforcement. The test specimens of 150mm x 150mm x 150mm cubes were dried at a temperature of 105°c for a period of 24 hours with the help of an oven. The dried specimens were cooled at the room temperature and the corresponding dry weight was noted. The dried specimens were immersed in water for a period of 24 hours. After 24 hours the weight of the concrete cubes was taken. The water absorption of the concrete was calculated in percentage by the given formula:

Water absorption (%) = (Saturated weight - Dry weight)/ Dry weight X 100

b. Water Permeability Test

The durability of concrete depends on the permeability of concrete which is defined as the property that governs the rate of flow of a fluid into a porous solid. The test was conducted as per IS: 3085 (Part 7) – 1965. The permeability test set up

is shown in Figure 6.5. Standard cubes of 150mm size were cast, cured for 28 days and the four faces of the cubes were painted to prevent the penetration of water from sides. The top surface was effectively
sealed to achieve water tightness. Pressure was applied to the water column. The quantity of water passing through the cube was collected at the bottom, in the glass bottle through the funnel. The operating pressure, quantity of water collected and time of observation were recorded. The co-efficient of permeability was calculated using the given formula:

$$K=QL/ATH$$

K = Co-efficient of permeability in cm/sec.
Q = Quantity of water percolating over the entire period of test.
A = Effective area of specimen in cm^2 .
T = Time in seconds over which 'Q' is measured.
H = Pressure head in cm.
L = Length of specimen in cm.

c. Compression Test

Compressive strength test IS: 516 - 1959 covers tests for the determination of compressive strength of concrete. Test specimens cubical in shape shall be 150 × 150 × 150mm. At least three specimens should be cast for testing. The cubes should be cured up to the specified date of testing and after the particular date, the cubes are removed from the curing tank and tested immediately. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area and shall be expressed to the nearest N/mm^2. Average of three values shall be taken.

$$\text{Compressive Strength} = \frac{Load}{Area}\ N/mm^2$$

d. Split Tensile Strength

Cylinders are cast to determine the split tensile strength of the concrete. The dimension of the cylinder height is 300mm and diameter is 150mm. At first, the cylinder mould is prepared by connecting it properly with nuts and bolts. Then, it is thoroughly applied with grease in all the nuke and corner of the mould. Now, the dry mix consisting of the cement, fine aggregate, coarse aggregate and the replacements are added and mixed thoroughly. Now water is added slowly to the dry mix and the concrete is prepared. Now the prepared concrete is kept in three layers. For each layer, compaction is done by ramming it with proctor compactor for 25 times. The last layer is alone rammed by using the tamping rod. Finally, levelling is done in the mould. It is allowed to set for 24 hours and then de-molded. Now the tensile test is carried out.

$$\text{Tensile Strength}= \frac{2P}{\pi dl} N/mm^2$$

7. RESULTS & DISCUSSION

a. Water Absorption Test

Water absorption of M40 grades of concrete with 5%, 10% and 15% of gram flour is tabulated in table 4.

Table 4: Water Absorption of Concrete

S. No	Mix Id	Initial weight (Kg)	Oven Dry Weight W1(Kg)	Weight After Immersion W2(Kg)	%Of Water Absorption
1	CC	8.30	8.25	8.58	4.0
2	5GF	8.35	8.30	8.52	2.65
3	10GF	8.34	8.29	8.53	2.89
4	15GF	8.32	8.27	8.48	2.53

Figure 3 shows the water absorption for gram flour concrete cube.

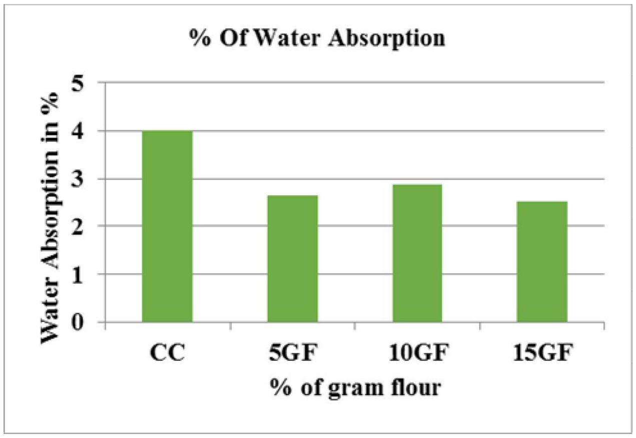

Figure 4 Water Absorption For gram flour concrete cube

Figure 3 explains that the concrete with gram flour has less water absorption, when compared to the conventional concrete. This is due to the less voids of better packing and it also becomes evident that the absorption of water is reduced for higher grade concrete due to the less voids in it.

b. Water Permeability Test

Water Permeability The permeability coefficient of M 40 grades of concrete with 5%, 10% and 15% natural sand of gram flour are revealed. Table 5 shows the permeability of concrete.

Table 5: Permeability of Concrete

S. No	Mix ID	Permeability x 10^{-7} cm/sec
1	CC	11
2	5GF	12
3	10GF	10
4	15GF	13

Figure 5 shows the water permeability for gram flour concrete.

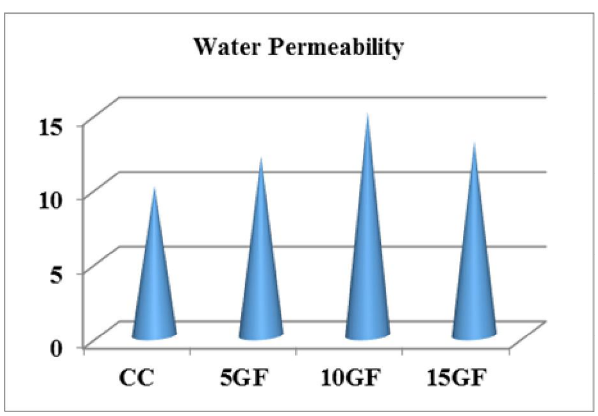

Figure 5 Water Permeability For gram flour concrete

Figure 5 expresses the fact that the coefficient of permeability is decreased while using the gram flour. It was found that the coefficient of permeability is less for 70% manufactured sand. This is due to the presence of a small amount of micro fines in it. It was also noted that the permeability of water is reduced for higher grade concrete. This exhibits that there is less water penetration, due to the better interlocking between the particles.

c. Compressive Strength Test

The cubes are tested in a load controlled universal testing machine to obtain the compressive strength at 7 days, 14 days and 28 days. The compressive strengths of all the specimens are presented in Table 8.3. It can be observed from the table that as the concentration increases the compressive strength at both 7 days, 14days and 28 days increases initially and then decreases. It can be seen that the maximum percentage increase in compressive strength. The variation of the compressive strength at 7-day, 14 day and 28 day is also expressed graphically in Fig. 8.30. The maximum strength at 28 days is 42.6 MPais high compared to other concrete mixes.

Table 6: Compressive Strength of Concrete

S. No	Mix ID	Compressive Strength (MPa)		
		7 days	14 days	28 days
1	CC	21.5	34.2	40.4
2	5GF	23.6	33.8	41.8
3	10GF	25.80	35.5	42.6
4	15GF	23.20	30.8	38.5

Figure 6 shows the compressive strength for gram flour concrete cube.

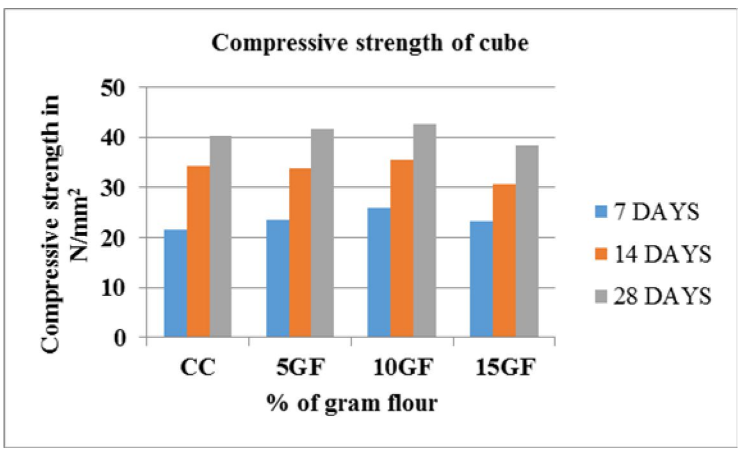

Figure 6 Compressive strength for gram flour concrete cube

d. Split Tensile Strength Test

Tensile splitting strength of gram flour concrete for selected dosages is presented in Fig. 8.4 This figure shows that as the GF dosage increases the tensile splitting strength increasesgradually to reach a maximum valueof 2.76MPa at a dosage of 10%. It can be seen that the strength reduces for further increase of GF content. The increase in tensile splitting strength is about 10%. Table 7 shows the tensile strength of concrete.

Table 7: Tensile Strength of Concrete

S.	Mix ID	Split Tensile Strength (MPa)

No		7 days	14 days	28 days
1	CC	1.32	2.12	2.55
2	5GF	1.48	2.15	2.60
3	10GF	1.55	2.28	2.76
4	15GF	1.35	1.96	2.15

Figure 7 shows the split tensile for gram flour concrete cube.

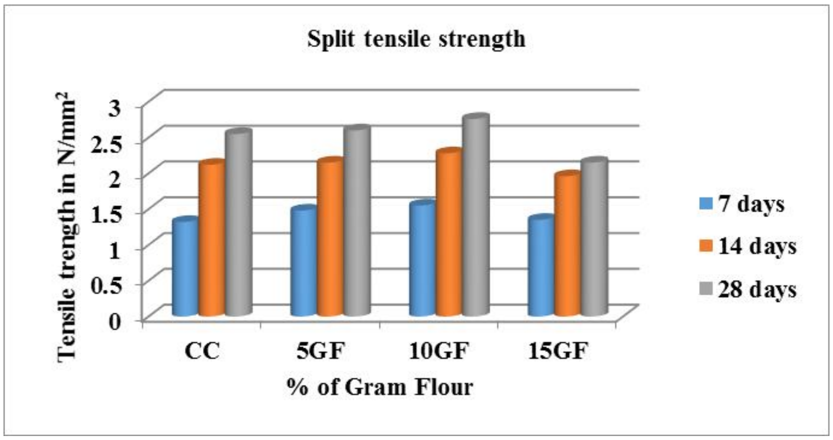

Figure 7 Split tensile for gram flour concrete cube

8. CONCLUSION

This study worked on the mechanical properties of gram flour concrete. The following conclusions could be drawn from the present investigation.

- Optimum percentage of Water Absorption is 2.89% for gram flour 10% replacement in concrete.
- Water permeability of gram flour concrete is 10 x 10-7 cm/sec was predicted from replacement of 10% of gram flour.
- Max compressive strength for M40 grade of concrete is 42.6Mpa was obtained by replacement of 10% of gram flour at 28 days curing.
- Max split tensile strength for M40 grade of concrete is 2.76Mpa was obtained by replacementof 10% of gram flour at 28 days curing.
- The paper concluded that the replacement of gram flour at 10% by volume of concrete improve strength on concrete.

References

[1] T.Subramani., S.Krishnan. S.K.Ganesan., G.Nagarajan "Investigation of Mechanical Properties in Polyester and Phenyl-ester Composites Reinforced With Chicken Feather Fiber" International Journal of Engineering Research and Applications Vol. 4, Issue 12(Version 4), pp.93-104, 2014.

[2] T.Subramani, J.Jayalakshmi , " Analytical Investigation Of Bonded Glass Fibre Reinforced Polymer Sheets With Reinforced Concrete Beam Using Ansys" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 105-112 , 2015

[3] T.Subramani, D.Latha , " Experimental Study On Recycled Industrial Waste Used In Concrete" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 113-122 , 2015
[4] T.Subramani, V.Angappan , " Experimental Investigation Of Papercrete Concrete" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 134-143 , 2015
[5] T.Subramani, V.K.Pugal , " Experimental Study On Plastic Waste As A Coarse Aggregate For Structural Concrete" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp.144-152 2015
[6] T.Subramani, B.Suresh , " Experimental Investigation Of Using Ceramic Waste As A Coarse Aggregate Making A Light Weight Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 153-162 , 2015
[7] T.Subramani, M.Prabhakaran , " Experimental Study On Bagasse Ash In Concrete" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 163-172 , 2015
[8] T.Subramani, A.Mumtaj , " Experimental Investigation Of Partial Replacement Of Sand With Glass Fibre" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 254-263 , 2015
[9] T.Subramani, S.B.Sankar Ram ***Experimental Study on Concrete Using Cement With Glass Powder, IOSR Journal of Engineering,****Volume 5 , Issue 5, Version 3, pp43-53, 2015*
[10] T.Subramani, S.Kumaran , " Experimental Investigation Of Using Concrete Waste And Brick Waste As A Coarse Aggregate " , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 294-303 , 2015
[11] *T.Subramani, G.Ravi,* ***"Experimental Investigation Of Coarse Aggregate With Steel Slag In Concrete", IOSR Journal of Engineering,*** *Volume 5,Issue 5, Version 3, pp64-73, 2015*
[12] T.Subramani, K.S.Ramesh , " Experimental Study On Partial Replacement Of Cement With Fly Ash And Complete Replacement Of Sand With M sand" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5 , pp. 313-322 , 2015
[13] T.Subramani, G.Shanmugam , " Experimental Investigation Of Using Papercrete And Recycled Aggregate As A Coarse Aggregate " , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 4, Issue 5, pp. 323-332 , May 2015
[14] T.Subramani, P.Sakthivel , " Experimental Investigation On Flyash Based Geopolymer Bricks" , International Journal of Application or Innovation in Engineering & Management (IJAIEM) , Volume 5, Issue 5, pp. 216-227 , 2016 .
[15] T.Subramani, R.Siva, "Experimental Study On Flexural And Impact Behavior Of Ferrocement Slabs" International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 5, Issue 5, pp. 228-238 , 2016
[16] T.Subramani, A.Anbuchezian , " Experimental Study Of Palm Oil Fuel Ash As Cement Replacement Of Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 001-005 , ISSN 2319 - 4847.
[17] T.Subramani, A.Anbuchezian , " Experimental Study Of Mineral Admixture Of Self Compacting Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 006-010 , ISSN 2319 - 4847.
[18] T.Subramani, A.Anbuchezian , " Experimental Test On Bitumen With Addition Of 35% Of Plastic Fibre " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 017-022 , ISSN 2319 - 4847.
[19] T.Subramani, A.Anbuchezian , " Stabilization Of M30 Concrete Pavement By Partially Replacing Cement By 20% Of Flyash And Sodium Silicate " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 023-031 , ISSN 2319 - 4847.
[20] T.Subramani, A.Anbuchezian , " Experimental Investigation On Flexural Behavior Of Folded Ferro Cement Panels " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 045-049 , ISSN 2319 - 4847.
[21] T.Subramani, A.Anbuchezian , " Experimental Study On Replacement Of Concrete Material By Water Treatment Plant Waste Sewage " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 050-057 , ISSN 2319 - 4847.

[22] T.Subramani, A. Fizoor Rahman , " An Experimental Study On The Properties Of Pet Fibre Reinforced Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 3, March 2017 , pp. 058-066 , ISSN 2319 - 4847.

[23] T.Subramani, M.Meganathan, S.Priyanka , " Experimental Study On Strength Properties Of Diaphanous Concrete With Vermiculite " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 5, May 2017 , pp. 229-238 , ISSN 2319 - 4847.

[24] T.Subramani, T.Anandavel, S.Priyanka , " Experimental Investigation Of Waste Plastic Fiber In Reinforced Cement Concrete Using Recycled Coarse Aggregate " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 5, May 2017 , pp. 239-250 , ISSN 2319 - 4847.

[25] T.Subramani, S.Priyanka , " Experimental Test On Carbon Nano Powder On The Properties Of Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 5, May 2017 , pp. 294-303 , ISSN 2319 - 4847.

[26] T.Subramani, P.Babu, S.Priyanka , " Strength Study On Fibre Reinforced Concrete Using Palmyra Palm Fibre Using Fem Software " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 6, Issue 3, May - June 2017 , pp. 198-207 , ISSN 2278-6856.

[27] T.Subramani, G.Unni Krishnan, R.Arumugam, A.Godwyn Michael Cornelies, H.Gopu , " Experimental Study Of Quarry Sand And Rice Husk Replacing In Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 5, May 2017 , pp. 312-319 , ISSN 2319 - 4847.

[28] T.Subramani, R.Sengottaiyan, K.Roop Kumar, V.Arun Kumar , S.S.Shanjay Sundara Sood , " An Expremental Investigation On Mineral Admixture For High Perfomence Of Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 6, Issue 5, May 2017 , pp. 320-326 , ISSN 2319 - 4847.

[29] T.Subramani, M.Senthilkumar, V.Ashok Kumar, Pawan Kumar Singh, R.Silambarasan , " Experimental Study On M-Sand With Addition Of Sugar As Admixture In Concrete " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 100-107 , ISSN 2278-6856.

[30] T.Subramani, A.Fizoor Rahman, K.M.Mohamed Irfan, G.Ramajayam, Shubram Mohan , " Experimental Study Of Applying Translucent Concrete In Green House Building Concrete Using M-Sand " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 116-125 , ISSN 2278-6856.

[31] T.Subramani, M.Senthilkumar, G.Gopinathan, A.S.Kabil, R.Naveen Kumar , " Experimental Study On Pervious Concrete Using Different Size Of Coarse Aggregate " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 126-133 , ISSN 2278-6856.

[32] T.Subramani, S.Sekar, Kuriakose saji, Syam gopalakrishnan, A.Arul prakash , " Experimental Study On Pollution Control Concrete " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 149-157 , ISSN 2278-6856.

[33] T.Subramani, N.Liyamin Ahad, Eldhose Jolly, Manuel Cheriyan, S.Priyanka , " Experimental Study On Mechanical Behavior Of Roof Panel Using Steel Fibre With Alkaline Solution " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 169-176 , ISSN 2278-6856.

[34] T.Subramani, S.Gunalan, Hari Prasath, K.Vasantha Sethupathi , S.Priyanka , " Experimental Investigation Of Concrete Using Peengan Waste " , International Journal of Emerging Trends & Technology in Computer Science (IJETTCS), Volume 7, Issue 2, March - April 2018 , pp. 208-215 , ISSN 2278-6856.

[35] T.Subramani, V. Karthick, A. Mohammed Asif, Mohammed Salman, S.Priyanka , " Experimental Study on Hybrid Fiber Concrete With Banana And Sugarcane Fiber " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 200-209 , ISSN 2319 - 4847

[36] T.Subramani, Akshay Vijayan, P.Mohammed Fayas, Jestin Thomas, S.Priyanka , " Experimental Study on Flyash and Lime With Gypsum in Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 257-268 , ISSN 2319 - 4847.

[37] T.Subramani, J.Karthick Rajan, F.Mohamed Ibrahim, K.Mano Vikaram, P.M.Rajesh , " Experimental Study on Hybrid Fiber Concrete (Polypropylene Fiber with Basalt Fiber) " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 269-278 , ISSN 2319 - 4847.

[38] T.Subramani, Febin Skaria Jacob, Limil Antoney, Rahul Pillai Suresh, S.Priyanka , " Experimental Study On Concrete With Plastic Waste And Master Gelinium " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 288-296 , ISSN 2319 – 4847

[39] T.Subramani, S.Priyanka , " Experimental Study on Research of Bricks with Copper Tailing Waste " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 329-334 , ISSN 2319 – 4847

[40] T.Subramani, S.Priyanka, K.Thirunavukkarasu , " Experimental Investigation of Concrete using Basalt Fibre And GFRP Sheet " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 335-340 , ISSN 2319 - 4847.

[41] T.Subramani, J.Karthick Rajan , " Experimental Study on Hybrid Fibre Concrete " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 349-356 , ISSN 2319 - 4847.

[42] T.Subramani, J.Karthick Rajan , " Experimental Investigation Paver Block Natural Fiber " , International Journal of Application or Innovation in Engineering & Management (IJAIEM), Volume 8, Issue 3, March 2019 , pp. 357-364 , ISSN 2319 - 4847.