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Study on Partial Replacement of Cement Using Pertile Powder and Chalk Powder with Sugarcane Fiber in Concrete

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Abstract:** Concrete is a vital part of the construction industry. The expansion in population has placed a massive want for more and more infrastructure and it keeps growing. The result of this demand is that the increase in production of cement. This has in turn led to exploitation of natural resources in addition as emission of pollutants that cause damage to our environment. As a result, waste management has become an enormous problem for our environment. Chalk is the most popular material it is used is a fine whitish colored powder composed of calcium carbonate (CaCO3), a form of limestone and is obtained by fine grinding of limestone. Chalk powder can used as partial replacement of cement because of the fact it has some of the binding properties. Volcanic glass is the source of the lightweight, porous material known as perlite powder. It is produced by heating raw perlite ore quickly to a temperature of around 1600°F (870°C), which causes the ore to expand and produce a large number of small bubbles. Perlite's characteristic lightweight and porous structure are attributed to these bubbles. Sugarcane fiber, also known as bagasse fiber, is the fibrous residue left after extracting juice from sugarcane stalks. It is a natural, biodegradable material rich in cellulose, hemicellulose, and lignin. In concrete technology, sugarcane fiber is gaining attention as a sustainable additive that can improve certain mechanical properties of concrete. The research work here deals with the partial replacement of cement with CP and PP together with addition of sugarcane fiber. After mixing, casting and curing the characteristic strength of this new concrete are compared with standard concrete of M35 grade. The experimental investigations are administered for compressive strength, split tensile and flexural strength for curing period of 7, 14, 28 days. Workability gets reduced at higher replacement of materials and the experimental results shows test are satisfactory up that the combined replacement percentage of 14%, which has 7% CP and 7% PP, and 0.6% SCF the values of compressive strength, flexural strength and split tensile strength were higher compared to alternative replacement percentages.
***Keywords:** CP (Chalk Powder), PP (Pertile powder), SCF (Sugarcane fiber) workability, compressive strength, Split Tensile strength, Flexural strength*

I. INTRODUCTION

Concrete is the second most consumed substance in the world and it is the most commonly used construction material. Major volume of concrete is contributed by aggregates. About 70–80% volume of the structural concrete is occupied by the aggregates, in which coarse aggregate (CA) contributes 40–50% and fine aggregate contributes 25–30%. Conventionally, naturally available materials like crushed rocks and river sand are used as coarse and fine aggregate respectively. Nowadays scarcity of resources is a major problem resulted by the excessive depletion of natural aggregates. In other hand with relatively recent rapid industrial development as well as the improvement of people’s living standards, the volume of domestic and industrial waste is increasing, and much of this waste is not recycled. over the last few years, This leads to the destruction of natural environment and construction of artificial environment in the society. The protection of environment is one of the major challenges in today’s world. We can aid to this problem by reusing and recycling the waste products, reducing the use of natural materials and using environmentally friendly materials. In order to have sustainable development one must focus on these environmental problems. Minimizing the waste can be achieved by using waste products as aggregates and other materials in construction practices. This will not only minimize the waste but also preserve our natural resources. This will help in increasing its life span and thus reducing dumping of waste, space for landfill disposal and extracting natural resources.

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A. PERLITE POWDER

Volcanic glass is the source of the lightweight, porous material known as perlite powder. It is produced by heating raw perlite ore quickly to a temperature of around 1600°F (870°C), which causes the ore to expand and produce a large number of small bubbles. Perlite's characteristic lightweight and porous structure are attributed to these bubbles, which also make it a very adaptable material with a wide range of applications.Perlite reduces the density of concrete, making it suitable for non-load-bearing structures, roof decks, and partition walls.Fine perlite powder improves workability and water retention, which can help with curing and hydration.

B. CHALK POWDER

Chalk powder acts as an inert filler, filling the micro-voids in concrete.Its fine texture helps in increasing the lubrication in the concrete mix, making it more workable.chalk powder can be used to partially replace cement, reducing overall costs and environmental impact.

This improves particle packing density, leading to a denser and potentially less permeable concrete matrix.

C. SUGARCANE FIBER

Sugarcane fiber, also known as bagasse fiber, is the fibrous residue left after extracting juice from sugarcane stalks. It is a natural, biodegradable material rich in cellulose, hemicellulose, and lignin. In concrete technology, sugarcane fiber is gaining attention as a sustainable additive that can improve certain mechanical properties of concrete. When properly processed and added in suitable proportions, it helps reduce plastic shrinkage cracks, enhances tensile and flexural strength, and contributes to better energy absorption and toughness. As an agricultural waste product, sugarcane fiber offers an eco-friendly alternative to synthetic fibers, supporting efforts to produce greener and more sustainable construction materials. However, due to its high water absorption and potential biodegradability, the fiber often requires chemical treatment, such as alkali soaking, before use to ensure better durability and compatibility with the cement matrix. Overall, sugarcane fiber presents a promising option for developing sustainable concrete, particularly in regions where agricultural waste management and green construction are high priorities.

II. LITERATURE REVIEW

V. Sathiyapriya et.al. 2023 his study explores the use of chalk powder as a partial replacement for cement to address material scarcity and environmental concerns. Various samples with different proportions (25%, 50%, 75%, and 100%) were tested for compressive, flexural, and tensile strength after curing periods of 7, 14, and 28 days. The findings indicate that chalk powder can enhance workability and durability while reducing costs and carbon emissions.

Matheus R. Carbraletal . (2018) The authors treated Sugarcane bagasse fibre was 5.9%while for non-treated Sugarcane bagasse fibre it was 67.3% were used. The authors concluded thatthe Sugarcane bagasse fibre characterization decreased of extractives and impurities in indicated bychemical and morphological analysis. Physical analyzed to reduce the hydrophobicity of treated sugarcane bagasse fiber content angle increased from 60.60for non- treated sugarcane bagasse fibre to 90.40 for treated sugarcane bagasse fibre. The author also concluded that the non-treated and treated sugarcane bagasse fibre and the indexes were 67.3% (high) and 5.9% (low) respectively.

Nancy T. Hussien 2022 This research explores the utilization of sugarcane bagasse fibers in concrete to assess their impact on mechanical properties. The study involved adding untreated bagasse fibers to concrete mixes and evaluating compressive strength, splitting tensile strength, and flexural strength. The findings revealed that a 5% replacement of cement with sugarcane bagasse ash (SCBA) enhanced splitting tensile strength by 33.2% compared to the control mix. However, the addition of untreated bagasse fibers led to a reduction in flexural strength, attributed to improper fiber treatment. The study suggests that while sugarcane waste can improve certain mechanical properties of concrete, proper treatment of fibers is crucial for optimal performance.

R. Manojsuburam et. al. 2023 To make concrete a fire-resistant material, it is necessary to examine how concrete behaves when exposed to high temperatures. In the current investigation, perlite powder was utilized in three different percentages—10%, 20%, and 30% by weight of cement, respectively—to partially substitute cement. The compressive strength of the concrete cubes was evaluated in two distinct scenarios. Itemized specimens stored at room temperature; b) specimens heated to 100°C, 200°C, or 300°C. Additionally, a comparison is made between the specimens' compressive strength test results and those of the control group. Comparing the specimen with 20% perlite powder and exposed to a higher temperature, the specimen's compressive strength performed better than the others resilience to high temperatures since there are less noticeable changes in weight loss percentage and compressive strength.

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In addition, the specimens that were exposed to a higher temperature and included 30% perlite powder had the lowest strength of all the specimens.

Sabria Malika Mansour et al. 2021 This study assesses the use of natural perlite as a 50% aggregate replacement and as a 10–20% cement substitute in self-compacting concrete (SCC). Results indicated that 50% perlite aggregate replacement or 10% cement substitution enhanced workability and improved compressive, flexural strength, and elastic modulus at 28 days. The findings suggest that perlite can reduce cement consumption and CO_2 emissions while maintaining mechanical performance.

III. MATERIALS

1) CEMENT:

Ordinary Portland Cement (OPC) of 43 grade would be used throughout the experimental investigation. Various tests such as consistency, fineness and initial and final setting time will be conducted on cement samples in order to match the requirement of OPC 43 grade as per IS:8112-1989.

2) COARSE AGGREGATES:

Aggregate which has a size larger than 4.75 mm or which retrained on 4.75 mm IS Sieve are known as Coarse aggregate. Materials which are large to be retained on 4.75 mm IS sieve and contain only that much of fine material as is permitted by the specifications are termed as coarse aggregates. The graded coarse aggregate is described by its nominal size i.e., 40 mm, 20 mm, 16 mm and 10 mm. Since the aggregates are formed due to natural disintegration of rocks or by the artificial crushing of rocks or gravel, they derive many of their properties from the parent rocks.Grading of coarse aggregate was done according to IS:383-1970. Aggregates of Nominal size 20mm & 10mm to form a graded aggregate. The concerned lab provided the properties of coarse aggregate.

3) FINE AGGREGATES:

Fine aggregate consists of crushed sand particles or natural river sand passing through a 4.75mm sieve. In general, river sand is used as a fine aggregate having a particle size of 0.07mm. The extraction is done from rivers, lakes or seabeds. Fine aggregate that was present at the site was extracted from Jammu. Sieve analysis would be done to find out the zone conforming IS: 383-1970. The physical properties of sand were provided by the concerned lab.

4) PERLITE POWDER

Volcanic glass is the source of the lightweight, porous material known as perlite powder. It is produced by heating raw perlite ore quickly to a temperature of around 1600°F (870°C), which causes the ore to expand and produce a large number of small bubbles. Perlite's characteristic lightweight and porous structure are attributed to these bubbles, which also make it a very adaptable material with a wide range of applications. They were crushed by hammer and sieved from 90 micron sieve.

Table no. 1 Properties of perlite powder

Chemical Compound	Percentage Composition
Silicon Dioxide (SiO2)	70-75%
Aluminum Oxide (Al2O3)	12-15%
Sodium Oxide (Na2O)	3-4%
Potassium Oxide (K2O)	2-4%
Iron Oxide (Fe2O3)	0.5-2%
Calcium Oxide (CaO)	0.5-1.5%
Magnesium Oxide (MgO)	0.2-0.7%
Titanium Dioxide (TiO2)	0.1-0.5%
Other Oxides (trace elements)	<0.5%

5) Chalk Powder

Chalk Powder is white in color and mainly derived from line stone. The quantity of lime present in chalk is higher than other constituents. Chalk being a base can be used as an antacid, because of the huge properties it can be used in number of ways. Chalk powder acts as an inert filler, filling the micro-voids in concrete. Its fine texture helps in increasing the lubrication in the concrete mix, making it more workable. chalk powder can be used to partially replace cement, reducing overall costs and environmental impact.

Table no. 2 Properties of CP

Particular	Proportion
Silicon Dioxide (SiO_2)	6.50
AluminumOxide(Al_2O_3)	0.11
Ferric Oxide (Fe_2O_3)	0.06
Titanium Dioxide (TiO_2)	0.01
Calcium Oxide (CaO)	86.94
Magnesium Oxide (MgO)	0.04
Sulphur Trioxide (SO_3)	1.20
Potassium Oxide (K_2O)	0.72

6) SUGARCANE FIBER

Sugarcane fiber, also known as bagasse fiber, is the fibrous residue left after extracting juice from sugarcane stalks. It is a natural, biodegradable material rich in cellulose, hemicellulose, and lignin. In concrete technology, sugarcane fiber is gaining attention as a sustainable additive that can improve certain mechanical properties of concrete. When properly processed and added in suitable proportions, it helps reduce plastic shrinkage cracks, enhances tensile and flexural strength, and contributes to better energy absorption and toughness.

Table no. 3 Properties of WBA

Property	Typical Value/Range
Color	Light brown to off-white
Fiber Length	10–30 mm (adjustable)
Diameter	100–300 microns
Density	~1.2–1.3 g/cm³
Water Absorption	High (can be >200%)
Tensile Strength	100–250 MPa (varies)
Young's Modulus	1–10 GPa
Aspect Ratio	50–200
Moisture Content	8–12% (after drying)

IV. METHODOLOGY

1) MIXING CONCRETE

All the ingredients of concrete are mixed together however this mix should be homogenous and uniform in color and consistency. The mixing can either be done by hand or with the use of mixer.

2) MIXING CONCRETE

Thorough mixing of the materials is essential to produce uniform concrete. The mixing should make sure that the mass become homogeneous, uniform in consistency and colour. There are two methods adopting for mixing concrete one is hand mixing and other is machine mixing.

3) CURING

Before removing the mould, it is dried for 24 hours, and then specimens are placed in a water tank made to cure specimens. The specimens must be marked for identification so that there must not be any error. The specimens are removed from the tank and dried before putting in the testing machine. The specimens are kept in the tank for 7,14,28 days.

4) WORKABILITY TEST

It can be used in site as well as in lab. This test is not applicable for very low and very high workability concrete. It consists of a mould that is in the form of frustum having top diameter of 10cm, bottom diameter of 20cm and height of 30cm. The concrete to be tested if fitted in the mould in four layers. The each is compacted 25 times with the help of tamping rod. After the mould is completely filled it is lifted immediately in the vertically upward direction which causes the concrete to subside.

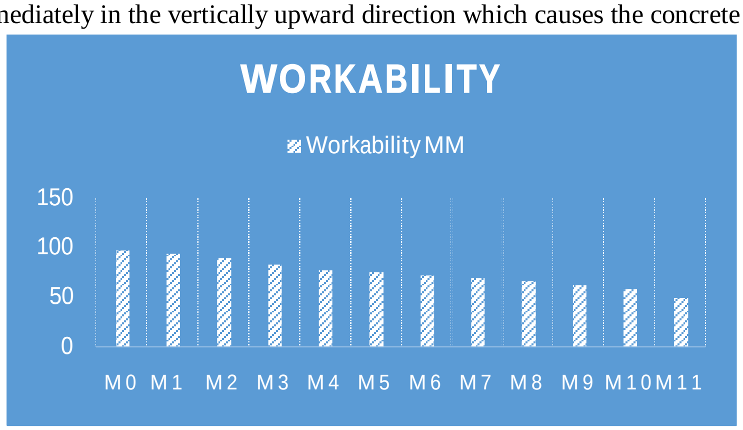

Fig -1: SLUMP CONE TEST

5) COMPRESSIVE STRENGTH TEST

Then fresh concrete is filled in mould in 4 layers and after filling each layer tamping should be done 35 times in case of cube and 25 times in case of cylinder by using standard tamping rod. Once the mould is filled then leveled top surface of concrete with trowel. After the day the mould will removed and specimen are dropped in the curing tank under standard temperature of 27±2° c. After 7,14 days and 28 days in this research.

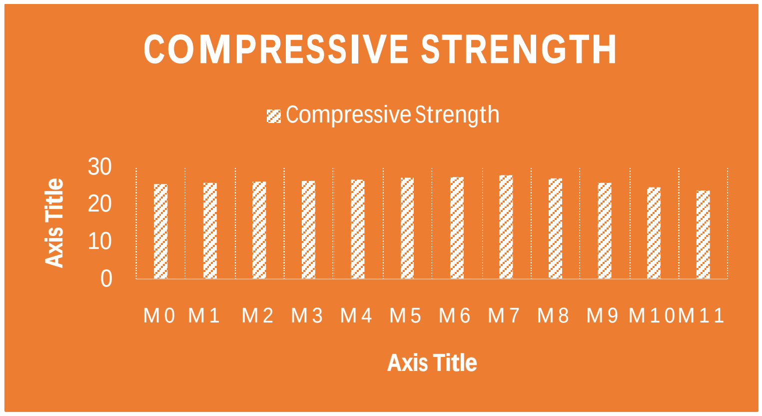

Fig -2: COMPRESSIVE STRENGTH TEST 7

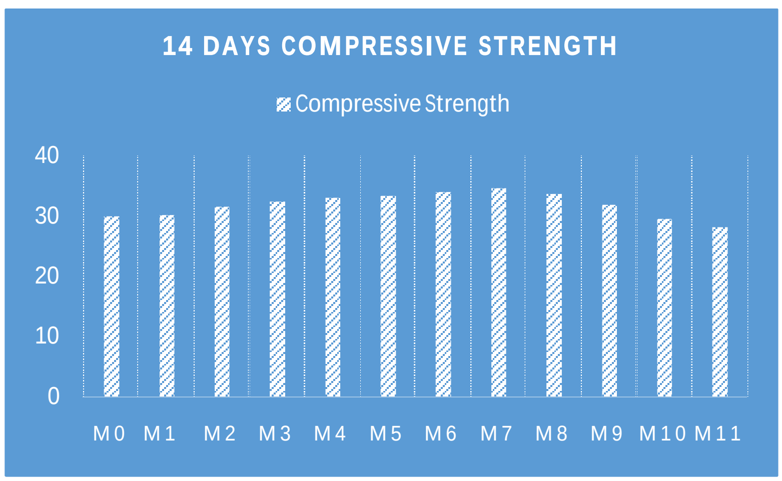

Fig -3: COMPRESSIVE STRENGTH TEST 14

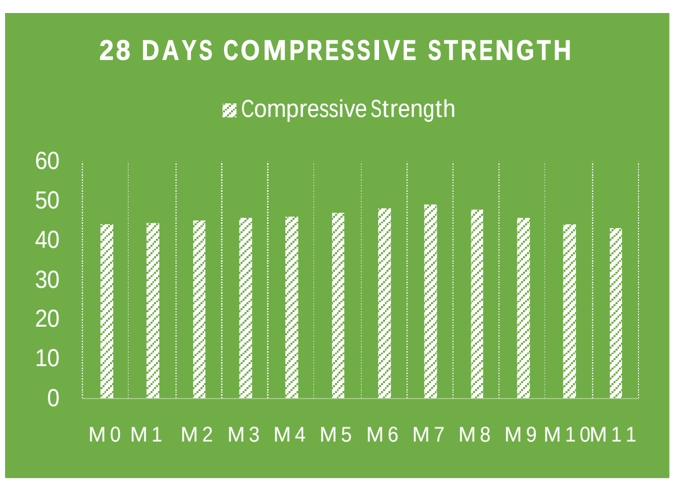

Fig -4: COMPRESSIVE STRENGTH TEST 28

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6) SPLIT TENSILE STRENGTH TEST

The specimen used for this test is cylindrical and its dimension is 150 mm in diameter and 300mm in length. The instrument used for this testing is universal testing machine. The fresh concrete is prepared in according to the required grades and respective mix proportion. The fresh concrete is filled in mould in layers and each layer is tamping with standard tamping rod with 25 blows for each layer. After the day the mould is removed and specimen is placed in the curing tank for 7,14 days and 28 days in this research at the temperature 27+ 2°c. Then draw the line on the specimen.

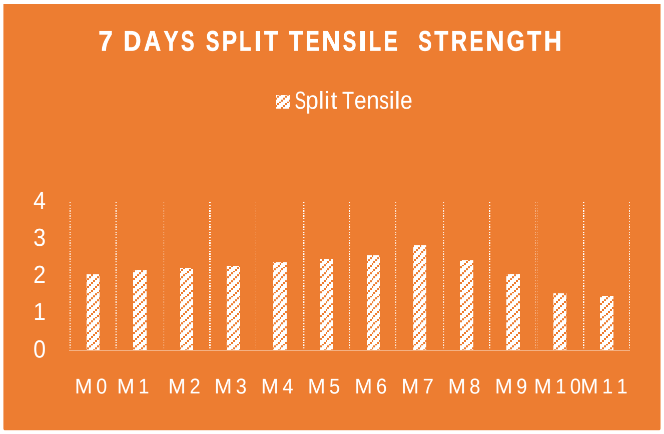

Fig -5: SPLIT TENSILE STRENGTH TEST 7

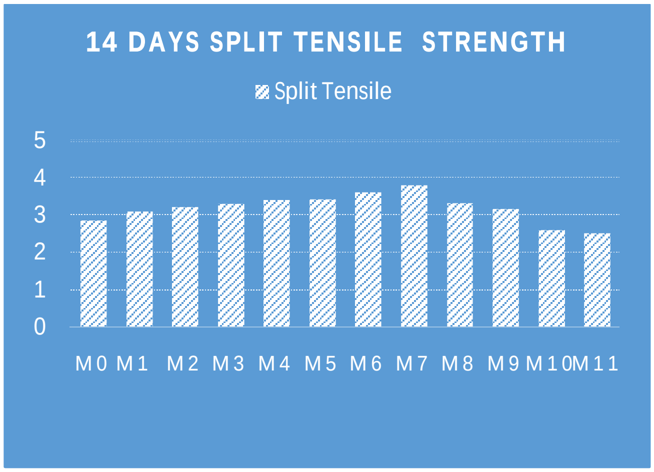

Fig -6: SPLIT TENSILE STRENGTH TEST 14

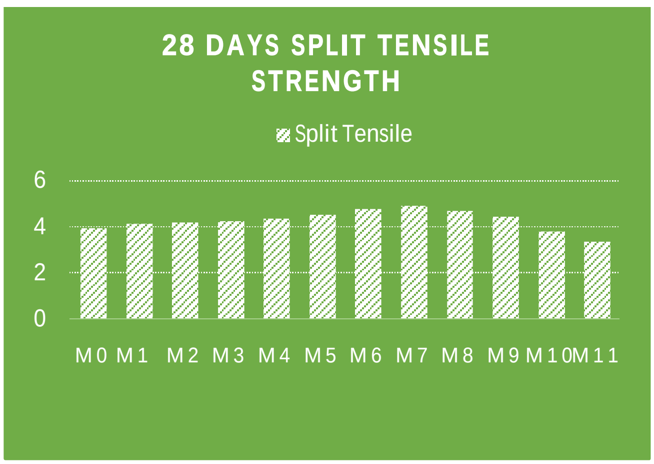

Fig -7: SPLIT TENSILE STRENGTH TEST 28

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7) FLEXURAL STRENGTH TEST

The concrete is prepared at required rate of mass element the mould is filled with concrete in layers and blows 25 times with standard tamping rod. After the day or we can say 24 hours the mould is removed and specimen placed in the water tank for curing at a temperature of 27 + 2 C. Depending upon the requirement the test specimen is removed from the water tank and wipe it properly for 7,14 and 28 days for testing.

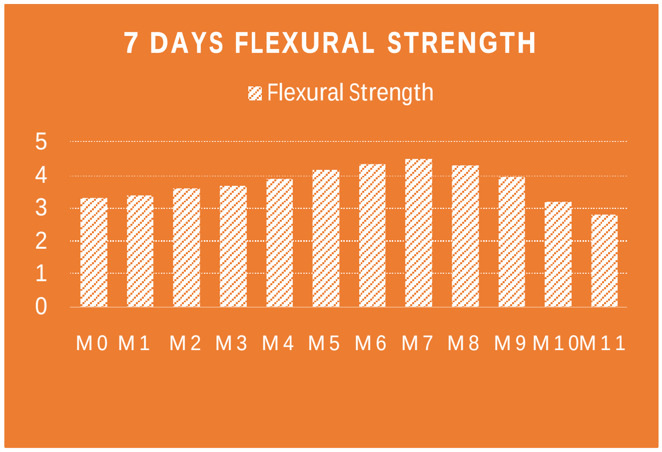

Fig -8: FLEXURAL STRENGTH TEST 7

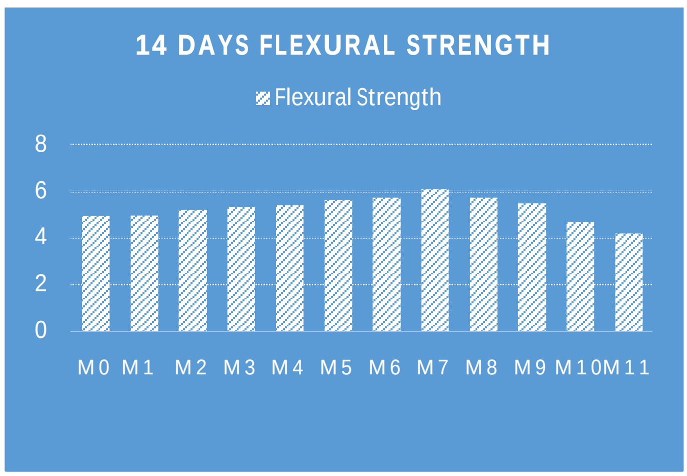

Fig -9: FLEXURAL STRENGTH TEST 14

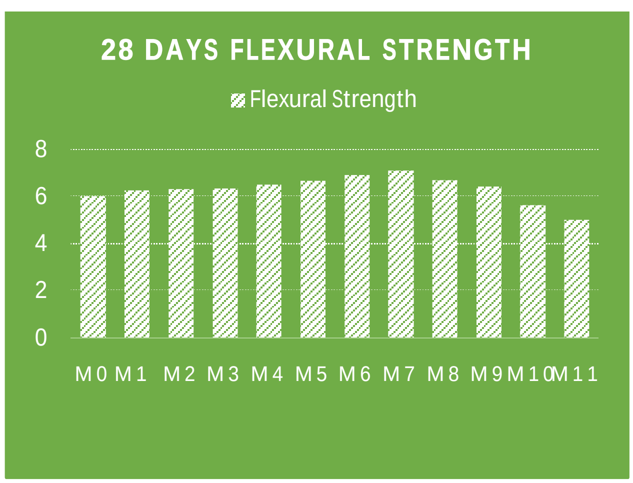

Fig -10: FLEXURAL STRENGTH TEST 28

V. CONCLUSION

Sugarcane fiber acted as a reinforcement and hence acted as resistance to the cracks, thus increasing the flexural strength. By replacing theperlite and chalk powder with the cement & Sugarcane fiber strengths get increased, also the replacement can be taken into consideration up to certain percentage workability factors gets enhanced as well. In case of compressive strength, flexural strength, tensile strengththe optimum percentage that was noticed, was at at 14% perlite and chalk powder with the replacement of cement & 0.6% Sugarcane fiber addition in the concrete mix was used.

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