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Experimental Investigation on Utilization of Shredded Waste Paper in Concrete

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Abstract: *The usage of concrete around the world has become a significant importance, same as that of water in the world. There is a ascending rise in the production of cement leads to the lot increase in the emission of greenhouse gases into the environment, contributing to about 6-8% of overall green house gas emission in the world.*
This leads to the alternative introduction of paper pulp concrete against conventional concrete and environmental friendly paper pulp concrete.
This paper deals with the study of strength properties with various mix proportion of paper pulp with the different percentage of 0%, 2.5%, 7.5%, 12.5%, 17.5%.
Compare all the various percentage of addition of combination of paper pulp with conventionalconcrete, under various tests like compression, split tensile, flexural tests for the samples ofcube, cylinders, beam respectively and justifies the advantage of paper pulp concrete the cement replaced by waste paper pulp.

Keywords: Ordinary Portland Cement (OPC), Fine Aggregate, Coarse Aggregate, Waste Paper Pulp, Compressive Strength, Flexural Strength, Split Tensile Strength

I. INTRODUCTION

Utilizing shredded waste paper in concrete is an innovative and eco-friendly approach with the potential to address environmental concerns and enhance the sustainability of construction materials. This practice involves incorporating shredded waste paper, often sourced from discarded documents or newspapers, into concrete mixtures. By doing so, it aims to reduce the consumption of traditional raw materials like sand and gravel, which can deplete natural resources and increase the carbon foot print associated with concrete production.

Paper cement pulp is created when cement and wastepaper (WP) are combined with water. Once the pulp has dried, it can be a durable building material. A concrete mixture containing WP is excellent for insulating and long shelf life because of its study nature.

It reduces the cement amount used and provides an environmentally friendly construction material. Portland cement and waste paper are the materials that make a fibrous cemented material called papercrete. Papercrete might be a material initially developed 80 years ago that has recently been rediscovered.

Using waste paper in concrete can produce new and modern construction material. It reduces the cement amount used and provides an environmentally friendly construction material. Portland cement and waste paper are the materials that make a fibrous cemented material called papercrete.

Advantages of paper pulp concrete

Incorporating shredded paper into concrete mixtures can offer several advantages, especially in terms of sustainability and certain performance characteristics. Here the some of the potential advantages:

1. **Resource Conservation:** Utilizing shredded paper in concrete reduces the demand for traditional raw materials such as sand and gravel, which helps conserve natural resources. This is particularly important in regions facing resource scarcity.
2. **Waste Reduction:** Shredded paper is often sourced from recycled or waste materials, diverting it from landfills and promoting a more sustainable waste management approach.

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3. **Improved Insulation:** Shredded paper can enhance the insulation properties of concrete, making it suitable for applications where thermal insulation is important, such as in walls and roofs.
4. **Reduced Density:** The incorporation of paper can lower the density of concrete, resulting in a lighter material that may be advantageous for certain construction projects, including those weights as a considerations of factor.
5. **Eco-Friendly:** The use of shredded paper aligns with environmentally friendly construction practices and supports a more circular economy by recycling and repurposing waste materials.

Disadvantages of paper pulp concrete

While utilizing shredded waste paper in concrete can offer several advantages, it also comes with certain disadvantages and challenges. Here are some of the potential drawbacks:

1. **Reduced Structural Strength:** Shredded paper is not as strong as traditional construction materials like sand and gravel. When used in concrete, it can compromise the structural integrity of the material, which is a critical concern in load- bearing applications.
2. **Durability Concerns:** Concrete with shredded paper may be more susceptible to environmental factors like moisture and decay. This can lead to reduced durability and longevity, especially in outdoor or high-moisture environments.
3. **Quality Control:** Achieving consistent quality in concrete with shredded paper can be challenging. Variations in the properties of the paper itself and the mixing process may result in inconsistent performance.
4. **Standards and Regulations:** The use of non-traditional materials like shredded paper in construction may not always align with existing building codes and standards. Meeting regulatory requirements can be a hurdle.
5. **Fire Hazard:** Shredded paper is flammable, which can pose a fire hazard. In applications where fire resistance is essential, such as in structural elements or certain building types, this may be a significant disadvantage.

Properties of paper pulp concrete

Paper pulp concrete, also known as papercrete or fibrous concrete, is a lightweight construction material made by mixing shredded paper or pulp with cement or a binder. Here are some properties of paper pulp concrete:

1. **Insulating properties:** Paper pulp concrete exhibits good thermal insulation properties, making it suitable for use in buildings where energy efficiency is a concern. It can help regulate indoor temperatures and reduce heating and cooling costs.
2. **Fire resistance:** Although paper pulp is a combustible material, when mixed with cement or other binders, paper pulp concrete can exhibit improved fire resistance compared to traditional wood-based materials. The cement matrix helps to protect the paper fibers from direct exposure to flames.
3. **Sound absorption**: Paper pulp concrete has good sound absorption properties, which can help reduce noise transmission between rooms or from external sources. This makes it suitable for use in buildings where acoustic comfort is important.
4. **Mold ability:** Paper pulp concrete can be molded into various shapes and forms, allowing for versatility in design and construction. It can be poured into molds or formed into blocks for use in different applications.
5. **Environmental benefits:** Paper pulp concrete is considered an eco-friendly building material because it utilizes recycled paper or pulp, reducing the demand for virgin materials and diverting waste from landfills. Additionally, its lightweight nature can contribute to lower transportation emissions.

II. LITERATURE SURVEY

1. B. A. Solahuddin, F. M. Yahaya (2023):

The environmental degradation in the vicinity of landfills or mills is caused by waste paper disposable. Each year, the industry's paper waste is increasing gradually. As a result, additional places are required for landfills, which consume energy, deplete natural resources, and increase expenditure and environmental pollution. Pollution can be reduced by adding WP to a concrete mixture in concrete production. This review paper investigates the physical and chemical properties of waste paper. Besides that, the mechanical properties of concrete containing waste paper, such as

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compressive, flexural, and splitting tensile strengths, are also studied in this review paper. All reviews of the intended studies include experimental tests. From the reviews, all strengths were increased with the inclusion of waste paper, either by addition, substitution, or replacement with fine aggregate, coarse aggregate, or cement. By using waste paper, not only would concrete have advantages and benefits, but also environmentally friendly construction materials could be produced from time to time. It has been noted in most studies that the inclusion of waste paper brings significant benefits. It can be concluded that waste paper potentially has favourable properties for concrete production. The concrete performance will improve in terms of compressive, flexural, and splitting tensile strengths with waste paper inclusion at certain percentages compared to ordinary concrete with no waste paper content.

2. B. A. Solahuddin and F. M. Yahaya (2023):

This research uses WP to investigate the effect of two types of Shredded Waste Paper (SWP) comprising Shredded Copier Waste Paper (SCPWP) and Shredded Cardboard Waste Paper (SCBWP) as additives on the properties of concrete and the structural behavior of Reinforced Concrete Beam (RCB). The slump, compressive, flexural, and splitting tensile strengths increase by 4–13% for 5–10% addition of SCPWP and decrease by 16–23% for 15% addition of SCPWP compared to 0% addition. For SCBWP, the slump, compressive, flexural and splitting tensile strengths increase by 10–23% for 5–10% addition and decrease by 15–21% for 15% addition compared to 0% addition. 15% of SCPWP and SCBWP addition records the highest effect in water absorption and efflorescence, showing 11% and 10.28% increases with 15% addition of SCBWP and SCPWP. Scanning electron microscope (SEM) analysis reveals that the crack is repaired, and the presence of calcium hydroxide (Ca(OH)2) and calcium–silicate–hydrate (C–S–H) links enhances the concrete strength. The addition of 10% SCPWP and 10% SCBWP in the concrete mixtures improves the structural behavior of RCB with stirrup spacing (SS)=100 mm (full), 150 mm and 200 mm (reduced) by increasing the load and reducing the defection. Apart from that, the concrete bending and shear strains also increase by 44.17% and 34.9%. The failure mode of the RCB changes from shear to bending. This study indicates that SCPWP and SCBWP can be used as additives in concrete at 5% and 10%, and 10% significant strength and structural improvement. Keywords Shredded waste paper, Concrete, Reinforced concrete beam, Mechanical properties, Durability properties, Structural behavior.

3. B.A. Solahuddin (2022):

Has represented Aggregate, sand, water and cement are the mixtures for concrete. Waste paper concrete (WPC) incorporates waste paper (WP) in a concrete mixture. Each year, WP production increases gradually. As a result, additional places are required for landfills, which consume energy, deplete natural resources and increase environmental pollution. The environmental pollution could be lessened by using WP in concrete. So, this comprehensive paper reviews the potential of WP by adding or substituting with fine aggregate, coarse aggregate and cement in concrete at 0%, 5%, 10%, 15% and 20%. This paper also reviews the WP's structures, physical and chemical properties. Moreover, the fresh, structural and durability properties of WPC, such as slump, modulus of elasticity, stress-strain and water absorption, are also reviewed in this paper. From this review, the concrete's fresh, structural, and durability properties increase with the incorporation of WP at 5% and 10% and decrease at more than 10%. There are some hydrated cement particles, as observed through the SEM. At 10% WP addition, the hydrated cement particles tend to increase the concrete strength more than the strength at 5% WP addition. It is apparent that the incorporation of WP brings significant desirable characteristics compared to ordinary concrete, which has no waste paper contents. WP can potentially have favorable properties to be used in concrete production by improving its properties and performance.

4. B A Solahuddinand F M Yahaya (2021):

Cement, sand, coarse aggregate and water are the materials to make a concrete mixture. The waste paper has been dumped as waste and causes environmental pollution behind the mill or landfill. The industry paper wastage for every year is increasing gradually. More spaces are being needed for landfills, uses energy loss of natural resources and increase of expenditure and various types of pollutions. Utilizing waste paper as an addition in concrete production will reduce environmental pollutions. This research is conducted to investigate the effect of shredded waste paper using copier and cardboard waste paper as additions to the compressive and flexural strengths and water absorption of

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hardened concrete. All specimens are subjected to water curing at 7 and 28 days. The results of compressive and flexural strengths increase at 5% and 10% additions of shredded copier and cardboard waste paper at 7 and 28 days of water curing. The finding shows that concrete containing 10% addition of shredded copier and cardboard waste paper exhibit the highest compressive and flexural strengths. For concrete water absorption, the higher water absorption is caused by the higher addition of shredded copier and cardboard waste paper. Furthermore, the results also show that shredded cardboard waste paper has higher strength and water absorption than shredded copier waste paper for all percentages of addition. This study indicates that shredded copier and cardboard waste paper can be used as additional materials in concrete production.

5. B A Solahuddinand F M Yahaya (2020):

Cement, sand, coarse aggregate, water and reinforcing bar are the materials to make a reinforced concrete beam. The waste paper has been dumped as waste and causes environmental pollution behind mill or landfill. The industry paper wastage for every year is increasing gradually. More spaces are being needed for landfills, uses energy loss of natural resources and increase of expenditure and various types of pollutions. Utilizing waste paper as an addition in concrete and reinforced concrete beam productions will reduce environmental pollutions. This research investigates the load-strain behavior of reinforced concrete beam containing shredded waste paper using 10% copier and 10% cardboard waste paper as additions in the concrete mixture to the concrete shear strain and concrete bending strain of reinforced concrete beam. There are three types of beam shear reinforcements with stirrup spacing (SS)=100 mm, 150 mm, and 200 mm. All specimens are subjected to air curing at 28 days. The result of concrete bending and shear strains are higher by 10% shredded copier waste paper (SCPWP) and 10% shredded cardboard waste paper (SCBWP) with reducing shear reinforcements (SS=200 mm) and (SS=150 mm) compared to full shear reinforcement (SS=100 mm). This research shows that 10% SCPWP and 10% SCBWP improves the concrete bending and shear strains with reducing reinforcements. Furthermore, the results also show that 10% SCBWP has higher concrete bending and shear strains than 10% SCPWP for full and reduce shear reinforcements. This study indicates that shredded copier and cardboard waste paper can be used as additional materials in reinforced concrete beam production.

III. MATERIALS AND METHODOLOGY

CEMENT

Fig No 1: Cement

OPC grade of 53 having specific gravity of 3.08 was used for carrying out experiments. Various tests were carried out to determine the properties of the cement. It acts as a bonding material which unites different materials used in the project and forms a compacted assembly. It acts as a bonding material which unites different materials used inthe project and forms a compacted assembly. Cement is actually a good precipitate, which previously assorted with water experiences chemic variation and thereafter permitted to set and harden is actually proficient of binding masses or fragments of sound stuff in concert to yield mechanically difficult concrete. Cement could be cast off as binding considerable with H_2O, for bonding tough devices of several sizes as bricks, aggregate orstones to develop a monument. Cements used in construction of buildings as well as civil company functions enclose mixtures of lime, alumina and silica as their chief ingredients and could be called as composite substances. Portland cement is regarded as the public form of cement in over all usage. It's a fundamental part of concrete, plaster and putty.

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PAPER PULP

Fig No 2: Paper pulp

Paper is the main ingredient of papercrete and so its properties depend on paper's microstructure. Wood fragments are thermometrically or mechanically treated to dissolve the lignin binder and to free the cellulose fibers. Paper is then made by pressing the pulp to remove excess water. Paper is an anisotropic material andth equality and strength of its fibers differs depending on several factors. They are: the type of wood, the percentage of recycled paper, the amount of water in the pulp, the way of pulping(chemical or mechanical) and the speed of drying. Today, half of the paper fiber utilized in current production comes from recovered fibers. Yet, recovered fibers are inherently less strong and moving the pulp means orienting the fibers.

FINE AGGREGATE

Fig No 3: Fine Aggregate

Sand is night around or angular grain in shape with a choice of grading of fineness at special zones. Fine aggregate is the portion of the aggregate passing through the 2 mm sieve for bituminous concrete or passing 4.75 mm sieve for Portland cement concrete.

COARSE AGGREGATE

Fig No 4: Coarse Aggregate

Coarse Aggregate which is retain on 4.75 mm sieve. The occupation of coarse aggregate is the main load bearing component of the concrete. Coarse aggregate consists of normal stones, gravels and sand and also admixture of combination of these materials. It should be hard, strong and durable. They should be solid, plain and free from any coating. They should not be supposed to contain flaky and elongated pieces. They should not be supposed to contain any material label to attack Steel reinforcement in care of reinforced concrete.

WATER

Fig No 5: Coarse Aggregate

Concrete is produced by mixing binding materials and inert material with water. Does the water and its quality plays an vital role in determining the quality of concrete. Strength and durability of the concrete is to a large extent resolute by its water to cementatious material ratio. This is the slightest costly universally available material, however most essential element of cement. Drinking water is utilized as a part of every solid blend and in the curing the greater part of

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the tests examples. The water, which is utilized for making concrete and for relieving, ought to be perfect and free from destructive pollutions. Water is used to make the mix, for fluidity condition in order to pass workability.

SUPER PLASTICIZERS

Fig No 6: Super plastcizers

Super plasticizers have a property of high water reducing agents then the ordinary reducing chemical admixtures, hence these superplasticizers are known as the Super water reduces. Even the super plasticizers are able to decrease the water requirementby about 30% when compared to the normal water reducing admixtures.The addition of water reduces like superplasticizers will show good workability and slump with high strength.

IV. METHODOLOGY

The desired paper pulp concrete can be developed based on the accessible journalism and to realize the strength by addition of certain paper pulp with variation in the percentage of mix proportion.

METHODOLOGY

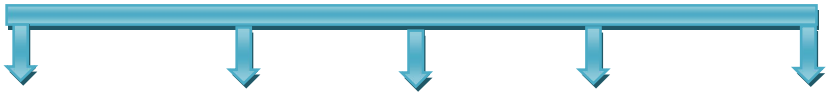
↓

MIX DESIGN M25

↓

OPC

↓



Mix / Materials	Mix 1 0%	Mix 2 2.5%	Mix 3 7.5%	Mix 4 12.5%	Mix 5 17.5%
Cement	100%	97.5 %	92.5%	87.5%	82.5%
Paper pulp	0%	2.5%	7.5%	12.5%	17.5%
Fine aggregate	100%	100%	100%	100%	100%
Coarse aggregate	100%	100%	100%	100%	100%
water	100%	100%	100%	100%	100%

V. MIX DESIGN

Mix Design For M25

Step -1: Target strength for mix proportioning

F'ck = Fck + 1.65 S

= 25+1.65X5

= 33.25N/mm²

Step-2: Selection of Water cement ratio

From table – 5 of IS 456:2000, maximum water cement ratio = 0.45 Based on experience, adopt water cement ratio as 0.40.

0.40< 0.45, Hence ok.

Step – 3: Selection of water content

Maximum water content for 20mm aggregate = 186 lit (for 25 – 50mm slump range) Water content for 100 mm slump

= 186+(6/100) x 186 = 197.16 lit

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Water content reduces at 30% (as a super plasticizer used)
Water content = 197 x 0.71 = 140 lit

Step – 4: Calculation of cement and fly ash content

Cement and pulp content Water cement ratio = 0.40
Cement + pulp content = 140/ 0.4 = 350 kg/ cm² Minimum cement content for
Severe exposure condition = 320 kg/ cm² (table – 5, IS 456 – 2000)
350 kg/ cm²> 320 kg / cm²
Hence ok.
10% cementitious material content = 350 x 1.10 = 385 kg / cm²
Water content = 140 kg /cm²
So w/c ratio = 140/385 = 0.364
Paper pulp at 30% of total cementitious material content = 385 x (30/100)
= 115.5 kg/cm² Cement OPC
= 385 – 115 = 270 kg / cm²
Saving of cement while using paper pulp = 350 – 270 – 80 kg/cm²
Paper pulp being utilized among 5 kg/cm²

Step – 5: Proportion of volume coarse aggregate and fine aggregate content

For pumpable concrete these value should be reduced by Reduced 10% Volume of coarse aggregate = 0.62 x 0.9 = 0.56
Volume of fine aggregate = 1 – 0.56 = 0.44

Step - 6: Mix calculations

a) Volume of concrete = 1 m³
b) Volume of cement = (Mass of cement / sp.gr. Of cement) x (1/1000)
= (270/3.15) x (1/1000)
= 0.086 m³
c) Volume of paper pulp = (mass of paper pulp / sp.gr. Of paper pulp) x (1 / 1000)
= (115/1) x (1/1000)
= 0.052 m³
d) Volume of water = (mass of water / sp. Gr. Of water) x (1 / 1000)
= (140/1) x (1/1000)
= 0.140 m³

Step – 7: Mix proportions

Cement =270 kg/m³
Paper pulp = 115 kg/m³
Water = 140 kg/m³
Fine aggregate = 862kg /m³
Coarse aggregate = 1097 kg/m³

VI. RESULTS AND DISCUSSIONS

Compressive Strength Test

Compressive strength is done mainly to know the properties and characteristics of concrete. Compressive strength of the concrete depends up on factors like water cement ratio, cement strength, nature of concrete material, quality control during making of concrete etc.

Here in this project concrete, the compressive strength depends upon paper pulp, which we know the strength of concrete. Major test to be carried out is compressive strength test. It is done using compressive testing machine. Presently put the solid blocks into the testing machine (Centrally). The blocks to be put accurately on the machine plate (check the hover blemishes on the machine). Precisely adjust the example to the roundly situated plate. The load will be applied to example pivotally. Gradually apply the load at the rate of 140 kg/cm² till the cube cracks. 7 days, 14 days and

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28 days strength are calculated and tabulated accordingly. The percentage used for this experiment is 0%, 2.5%, 7.5%, 12.5%, and 17.5%.

Table No 1: Compressive Strength for Cubes

STRENGTH TEST	AGE IN DAYS	MIX PROPORTIONS				
		0%	2.5%	7.5%	12.5%	17.5%
COMPRESSIVE STRENGTH IN Mpa	7	20.1	13.33	7.55	2.66	1.99
	14	26	20.44	11.9	2.88	3.33
	28	27.92	16.88	19.5	4.88	4.22

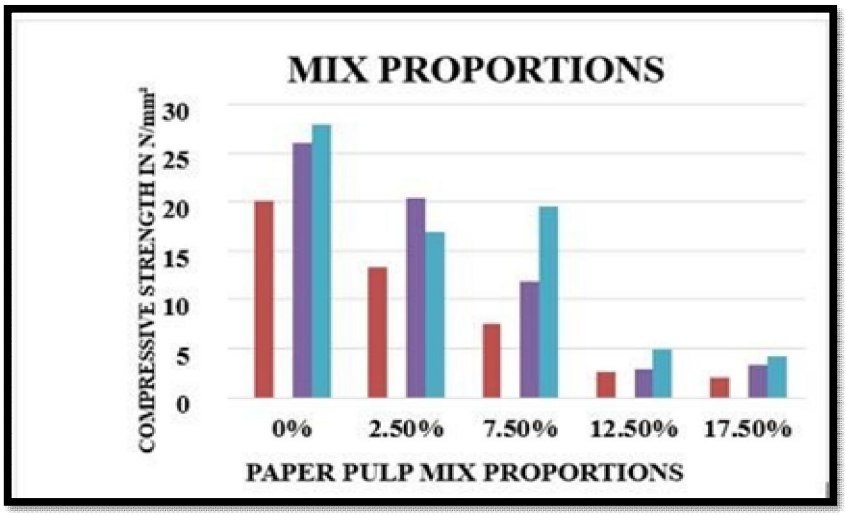

Fig No 7: The Combined Compressive Strength test results of mix Proportions

SPLIT TENSILE TEST

One more important strength of concrete to be calculated is tensile strength. The tensile strength test is carried out in the same machine which is used for compressive strength calculation. The specimen is placed along its length between the plates placed centrally. There are five types of mix with percentage of 0%, 2.5%, 7.5%, 12.5%, and 17.5% for 28 days. There are 3 layers for each layer is tamped by 3 to 4 times due to compact well. This test is conducted only for 28 days and total number of cylinders tested is 11 mould. Therefore 11 cylinders for 28 days therefore, 11 cylinders specimens are prepared.

Split Tensile Test for Cylinder:

Opinion on test results for 28 days Split Tensile Test results.

Table No 7: Split Tensile Test for Cylinder

STRENGTH TEST	AGE IN DAYS	MIX PROPORTIONS				
		0%	2.5%	7.5%	12.5%	17.5%
SPLIT TENSILE TEST IN Mpa	28	1.87	1.31	1.0	0.61	0.7

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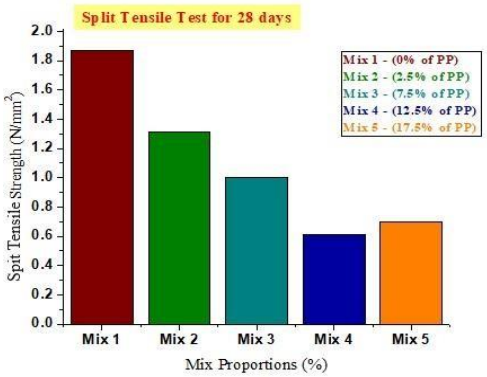

Fig No 8: The Split Tensile test results

FLEXURAL STRENGTH TEST

Another required test to find tensile strength is flexure test. Specimens used in this test are called prisms. The prisms are casted for required dimensions. The test is performed according to the codal mentions. Simple beam is tested for its flexure nature. Universal testing machine is used for the test. Prisms are placed according to the figure. Loading is applied at one third distance from supports. Gradually loading is applied till the cracks are formed in the middle portions. The change in flexure strength of beam due to the variations in percentage. There are five types of mix with percentage of 0%, 2.5%, 7.5%, 12.5%, and 17.5% for 28 days. There are 3 layers for each layer is tamped by 3 to 4 times due to compacted well. This test is conducted only for 28 days and total number of beams tested is 11 mould, therefore 11 cylinders specimens are prepared.

Flexural Strength Test for Beams:

Opinion on test results for 28 days Flexural Strength Test results.

Table No 8: Flexural Strength for Beams

STRENGTH TEST	AGE IN DAYS	MIX PROPORTIONS				
		0%	2.5%	7.5%	12.5%	17.5%
FLEXURAL STRENGTH TEST IN Mpa	28	0.25	0.19	0.155	0.105	0.045

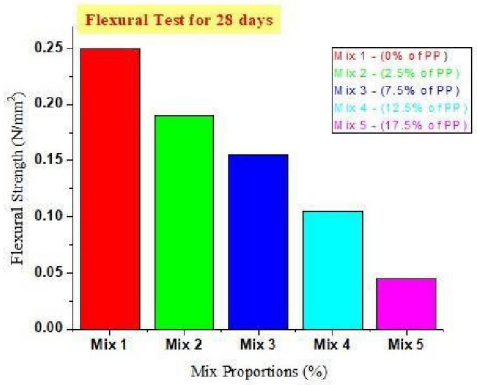

Fig No 9: The Flexural strength test results

VII. CONCLUSION

- In this project we were intended to manufacture concrete by partially replacing cement with waste paper to achieve an economical and environmental friendly concrete.

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- The Compressive Strength for mix 1 (0% of PP) increases in number of days like 7, 14, 28 days with increases in the percentage of paper pulp with replacing cement in concrete.
- The 7 days compressive strength of mix 2 (2.5% of PP) is increases when compared with mix 3(7.5% of PP) is about 27%.
- The 14 days compressive strength of mix 2 (2.5% of PP) is increases when compared with mix 3(7.5% of PP) is about 25%.
- The 28 days compressive strength of mix 3 (7.5% of PP) is increases when compared with mix 2 (2.5% of PP) is about 7%.
- Remaining mix 4 and mix 5 (12.5% & 17.5% of PP) of compressive strength for 7, 14, 28 days on gradually decreases when compared with mix 2 and mix 3 (2.5% & 7.5% of PP).
- Flexural strength of mix 2 (2.5% of PP) is 81% and mix 4 is gradually decreases.
- Split tensile strength of mix 5 (17.5% of PP) is gradually increases compared with mix 4 (12.5 of PP).
- As a fact that there are no specific guidelines and standard for manufacturing of papercrete, it is observed that it can be used in dry areas and areas with not much rainfall.
- It can ideally be used for reduction in dead load but its application is restricted to non-load bearing walls or inner partition walls only as it take up small loads.
- As the failure was brittle, it is ideal for areas prone to earthquakes and can be used as dampers in earthquake resistant buildings.
- As huge amount of paper waste around the world does not get recycled and hence can be used for manufacturing of papercrete.
- The project can be extended even further to produce more strength and durability by more significant amount of research.

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