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RESEARCH ARTICLE

INVESTIGATION OF USING PAPERCRETE MATERIAL.

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Abstract

The concrete we use today has the one main ingredient and that is aggregate. Approximately 75% of the total for any concrete mix is covered by aggregate. The strength of the concrete mostly depends on the quality of aggregates than on other factors. The aim of this paper is to find the proper strength and durability characteristics of structural concrete by using paper as a coarse aggregate, which will give us better and proper understanding of the properties of concrete having paper as an ingredient.Papercrete is made up of cement and waste paper. The people have been utilizing papercretefor a decade now by not even having proper knowledge about the structural properties. Although, the properties of papercrete varies with paper mixing ratio[1]. Accordingly, different mixing ratios were used in this study to understand the mechanical properties of each mix. To obtain proper results, many laboratory tests were performed. The detailed strength and durability related tests such as compressive strength test of cubes, flexural strength of beam were carried out for experimental investigation. It was found out that papercrete could be properly used for low load bearing structures and for aesthetics only.

Introduction:-

As there is a great demand in the industry for the building materials especially due to this largely increasing population which has created a paucity of these materials, the civil engineers all around the world are being challenged to find new alternatives or convert the industrial waste as an alternative to this paucity age. This study involves experimental investigation of potential uses of waste paper for producing very low coast and light weight concrete as a building material. The concrete in this study is prepared using waste paper as one of the ingredient. In any construction there are several materials required like steel, brick, stone, glass, clay, mud, wood etc., but utilizing paper in concrete opens many gates for innovation. Today, cement remains the main ingredient to be used for binding the materials, although aggregate and other materials remain to act just a filler material where paper can also be utilized. For the suitability and adaptability, the paper is the best material to be used in construction industries as it is eco-friendly, conserve resources, economic, protect the environment and proper utilization of energy[1]. The paper has a very sluggish life as from the day it is manufactured; it is stored and utilized either for academic or educational purpose or for packaging purpose. After the usage it is recycled or filled in landfills or burnt as a fuel, but only 60% of the papers are recycled, mostly are burnt. Using the other 40% as coarse aggregate is the best possible option for paper industry as its demand will increase, for construction industry as a cheap alternative is available and for environment.

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I. HISTORY OF BRICKS[2]

- Bricks are the most commonly used construction materials for the construction of any structure mostly buildings.
- The bricks are made using the moulds and the clay is used as the main constituent as only one shape and mould of is used all bricks are of uniform shape and size, after the moulding the bricks are dried and burned.
- The bricks are uniform in size and shape, they can be properly placed and arranged.
- The brick is one of the oldest building materials and it is exhaustively a leading material in construction.
- The process making the bricks has not changed from many centuries except some minor changes.
- There is effort being put by the people of industry to enhance the quality of bricks.
- Bricks have two drawbacks one is its self-weight and the other being its brittleness.

II. INNOVATION OF PAPER CRETE[2]

Papercrete was discovered 80 years ago as a construction material and is currently being emphasized. Papercrete consists of waste paper which are fibrous in nature and Portland cement. Both the constituents are mixed thoroughly and well blended to create a paper cement pulp, which can shaped using a mould and dried to get a proper papercrete brick which can be used as a durable building material. Papercrete being rediscovered is relatively as new concept and has limited scope in construction. Papercrete can be further divided categorising according to the uses, like Fibrous Cement, Padobe and Fidobe. The fibrous concrete is prepared by mixing fibrous paper, portland cement and water. There are non-harmful by-products or excessive energy use in the production of Papercrete- Fibrous Cement.Padobehas no Portland cement and is a mix of waste paper, water and earth clay, clay is the binding material. Rather than using thecement, earth is used in this type of bricks.This earth musthave clay more than 30%.As in regular brick, if the clay content is too high the brick may crack while drying, but adding fibrous paper to the earth mix strengthens thedryingblock.It gives flexibility which helps to prevent cracking.Fidobe is similar to padobe, but it may contain other fibrousmaterial rather than paper.

Materials & Properties[2]

The constituents used in preparation of the Papercrete and their properties.For proper results, ingredients were collected from various sources. Collecting Material is the basic and important step in any project. Yet, the material that is used in any project should not cause any harm or damage to the environment.
The various materials include:

- ORDINARY PORTLAND CEMENT
- FLYASH
- FINE AGGREGATE
- COARSE AGGREGATE
- WASTE PAPER
- WATER

4.1. Ordinary Portland Cement (53 GRADE)

- The invention of Portland cement was done by John Aspidin as finegrey powder.
- Cement is just a mixture of chalk or limestone powder and clay.
- Cement canbe seldomused solely, but is majorly used to bind sand and gravel (aggregates) together.
- Fine aggregate used with cement makes mortar and the same mortar used with coarse aggregate forms concrete.
- In India, there are three grades of OPC, namely 33grade, 43 grade and 53 grademanufactured. As per the standard testing procedure, the compressive strength of cement will be obtained after 28days.

Figure.1-CEMENT FLYASH[2]

4.2. Fly Ash

- Fly ash, being known as fuel-ash, is one of the wasteful residues generated in combustion, and contains fine particles from the flue gasses.
- From industrial point of view, fly ash is just a waste generated during combustion of coal.
- Collection of fly ash is mostly done by electrostatic precipitators before the flue gases reaches the chimneys of the coal-fired power plant, and composed with bottom ash removed from the bottom of the furnace is in this case conjointly known as coal ash.
- As there are n number of coal mines around the world, the coals vary in their chemical constituent but all fly ash includes substantial amounts of silicon dioxide (SiO_2) and calcium oxide (CaO), both being endemically common ingredients in many coal-bearing rock strata.
- Fly ash is mostly replaced with Portland cement up to 30%, but can be replaced in higher dosages in certain applications.
- Fly ash can be addedso as it increases the concrete's final strength and increases its chemical resistance and durability. .
- Experimentally it is revealed that up to 40 to 50% cement can be replaced and designed strengths can be achieved

Figure.2-FLYASH[2]

4.3.Fine Aggregate

- Concrete made by mixing water, cement and fine aggregate that is sand and coarse aggregate, and mortar is also made by mixing water, cement, and fine aggregate. Hence, sand is an essential part of any construction.

- The sand particle generally contains small grains of silica (SiO_2). These are formed during the decomposition od sandstone due to various forms of weathering.
- A disadvantage of fine aggregate is the great consumption of binder leading to shrinkage and creep.
- The quantity of binder in the concrete can be reduced by adding plasticizers or by pulverising the sand or by autoclaving.
- The locally available sand is passed through a sieve of 4.75mm and the passed sand is used for construction as per IS.
- According to the source the sand is obtained, it is termed as Pit sand, River sand and Sea sand.

Figure.3.Sand[2]

4.4.Coarse Aggregate

- The locally available crushed blue granite stonesconfining of 12.5 mm size are used for construction as per IS:383-1970.
- Stones having specific gravity of 2.77 and which passes through 4.75 mm sieve are mostly used for casting specimens.
- Several experimental investigation reveal that the size of aggregate must be limited to the strength od composite.
- The cement to aggregate ratio influence the strength of concrete.

Figure.4 – Coarse Aggregate[2]

4.5.Paper

- Paper is the natural fibrous polymer which is made of wood cellulose, which is the most abundant organic compound on the planet.
- Cellulose is a polymer made up of units of monomer glucose (polysaccharide). The linking is done by a type of sugar called ß-D-glucose. Regardless of containing several hydroxyl groups, cellulose is a water insoluble compound.The reason to this stiffness of the chains is the hydrogen bonding between two -OH groups on the adjacent chains.
- When the networks or matrices of fibres and fibrils dry, they interweave and adhere together with the power of the hydrogen bond.

Figure 5-Paper [2]

4.6. Water

- Water is an important ingredient in any kind of concrete, papercrete also requires water as it vigorously participates in the chemical reaction with the cement.
- The water used must be free from organic matter and the pH value of the water must be between 6 and 7.

Figure 5-Water [2]

Papercrete Properties	
Physical properties	
Mass m [Kg/m²]	56.5
Density ρ [Kg/m³]	382.6
Shrinkage [%]	6.00
Available and processibility	Waste paper is widely available material. Easy to process after hardening.
Cost [€/Kg]	0.02 pure mix 0.04 adding colorants and additives
Mechanical properties	
Compressive strength [MPa]	1.12
Flexural strength [MPa]	0.318
Young's Modulus E [GPa]	8
Fracture toughness K_{1c} [MPa-$m^{1/2}$]	0.2
Brittleness	Brittle behaviour
Hardness	Soft material
Creep	Oooh damn, yes
Functional properties	
sound Insulation	Good
Thermal conductivity λ [W/mK]	0.08
Specific heat capacity C_p [J/kgK]	1000
Thermal diffusivity α [m^2/s]	$2{,}1 \times 10^{-7}$
Thermal Expansion Coefficient a [μstrain/K]	10
Enviromental properties	
Embodied energy per volume [MJ/m3]	4700

Table 1-Papercrete Properties

III. PAPERCRETE BRICKS

The objective of the study is to investigate the properties of Papercrete bricks that were prepared out of waste paper, quarry dust and Fly Ash in varying proportions of 25%, 40% and 55%. The following properties were studied and a comparative study with conventional bricks was done:

- Mechanical properties
- Weight comparison
- Quality Standards like hardness, soundness and fire resistance
- Environmental compatibility

5.1 Experimental Procedure
5.1.1 Specific Gravity Test for Fine Aggregate and Paper Pulp

• A clean and dry pycnometer with its cap is taken and weighed in grams (W1).About 200g of dry sample (quarry dust or paper pulp) passing through it was put in it and gross weight of the pycnometer and the sand was again taken (W2).
• The pycnometer was then filled with distilled water up to the hole in the conical cap and shaken gently until all the air bubbles escaped. Then the weight of the pycnometer with the sand and water was taken in grams (W3).
• The pycnometer was then emptied and cleaned thoroughly. The clean pycnometer was then filled with distilled water up to the hole in the conical cap and weighed in grams (W4).

5.1.2 Sieve Analysis

About 1 kg of dry sample of fine aggregate was taken and sieved on IS sieve number: 470, 240, 60, 30 and 15. This operation was continued until number particles passed through the sieves finally. Then the material retained in each sieve was collected and weighted. The results were tabulated and the percentage of fine aggregate of varying size that passes through each sieve was calculated and recorded. The value obtained was compared with grading limit chart for fine aggregate and the actual zone, to which particular fine aggregate comes under, was determined. [11]

5.1.3 Determination of Bulk Density
To find, the bulk density of quarry dust, the following procedure was employed. The empty weight of the container was taken as Wc. The container was filled with aggregates sample for about one third height and was tamped evenly with 25 blows. Similarly same quantities of aggregates were added as second layer and were tamped with 25 blows. A third layer of aggregate was added until it overflows and was tamped with 25 blows. Using tamping rod as a straight edge, the surplus aggregate was struck off. Measure the weight W1.

The container was emptied and it was filled again until it over flows using a shovel, aggregates being poured from a height not exceeding 5 cm above the top of the container. Surface was levelled and the weight was taken as W2. [11]

5.1.4 Specific Gravity of Fly-Ash and Cement
The procedure to find the Specific Gravity of Fly-Ash/Cement is as follows . Having taken a clean and dry Le Chatlier Flask with its stopper, its weight was measured as W1. Filling half the flask with test specimen (fly ash/cement) the weight was measured as W2. Following which kerosene was added until it is partially filled. The mixture was mixed using a glass rod to remove entrapped air. Stirring was continued and more kerosene was added up to the graduation mark. The weight W3 was measured. Emptying the flask and refilling it with clean kerosene up to the graduation mark the weight W4 was measured.

Specific gravity of fly-ash/cement was then calculated by using the formula given in Eq. (1):

$$\text{Specific gravity} = W3 - W1 / [(W4 - W2) - (W3 - W1) \times 0.79] \quad (1)$$

Here 0.79 is the specific gravity of kerosene [11]

5.1.5 Quality Standard Tests on Papercrete bricks
This involves the study of various qualities of Papercrete bricks. The presence of soluble salts was determined by efflorescence test. In which the fibrous concrete brick was immersed in water for 24 hours.

Following which they are kept in shade to dry. Having taken all the three proportion bricks, the hardness of the brick was determined by making a scratch on the brick surface. To study the soundness property of the brick, two bricks of same proportion were struck with each other. By setting a few bricks to fire, it enabled the study on the fire resistive nature of the bricks. In projects we prefer a simple and easy test that can be conducted in a very short span of time for certain specifications and to control the quality. The very thought is that we can make use of rapid chloride permeability test (RCPT). By observing the quantity of flow of electrical current through a 50 mm thick by 100 mm in diameter sample for duration of 6 hours, the rapid chloride permeability test was performed. The sample was cut as a slice of a core or cylinder. Throughout the test a potential difference of 60V DC was sustained across the electrodes. One lead was immersed in a 0.3 Mcaustic soda (NaOH) solution and the other in a 3.0% salt (NaCl)

solution. A conditional ranking was madefor the concrete's permeability based on the charge that passes through the sample. Finally, in compression testing machine the brick was tested for cracking pattern under different loads. [11]

5.2 Results and Discussions

A number of tests were carried out to study the properties of the brick as per the given procedure, results of which are as follows –

- Specific gravity test- on conducting this test on fine aggregates for three different samples the specific gravity was determined as 2.52.
- Sieve analysis– performed on quarry dust, displays a fineness modulus of 2.8.
- Determination of bulk density - conducted on quarry dust, assisted in calculating the bulk density of compacted quarry dust as 1.7 kg/l and 43% for loaded quarry dust.
- Specific gravity of fly ash and cement – by le chatelier method the specific gravity of cement was determined as 3.13 and that of fly ash was 2.33.

QUALITY STANDARD TESTS-

- Efflorescence test – this test resulted in no white or grey surface deposits on the bricks, thus the bricks are clear from soluble salts.
- Hardness test – the outcome of this test shows that the brick is hard enough with a less impression due to scratch.
- Soundness test – the clear ringing sound produced shows that the bricks are good.
- Fire resistance- in an open flame the papercrete bricks did not burn. They burnt slowly similar to charcoal. Although they would be reduced to ashes if kept flaming for several hours. With the provision of interior plaster and exterior stucco, the papercrete bricks will not burn. Also application of plaster without any holes or leakage in the bricks and absence of oxygen, will prevent burning on the inside.

We are aware that corrosion of the reinforced steel which is held within the concrete as a result of chloride intrusion is a major factor that guides to the downturn of the concrete structures.

This is the followed by high cost of repairs which is why this longevity issue has received widespread awareness recently.

- Rapid chloride permeability test (RCPT)– results noted for chloride permeability as per ASTM C1202 is HIGH. As compared to conventional bricks, which are highly brittle in nature and fail as soon as load is applied breaking into multiple pieces, the papercrete bricks never failed miserably, instead they just compress like squeezing rubber. Thus, for test conducted under full compression, even at higher load the structure experiences outer face cracks and peels out without any structural fail, although papercrete brick failed. Reason being the high elastic nature at failure which compresses like rubber. The roof collapse as a result of compression under heavy loading, thus resulting its application for non – load bearing partition walls alone.

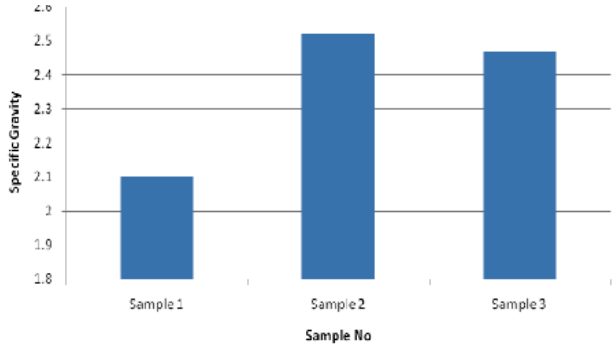

Figure5:- Specific gravity test of fine aggregate [11]

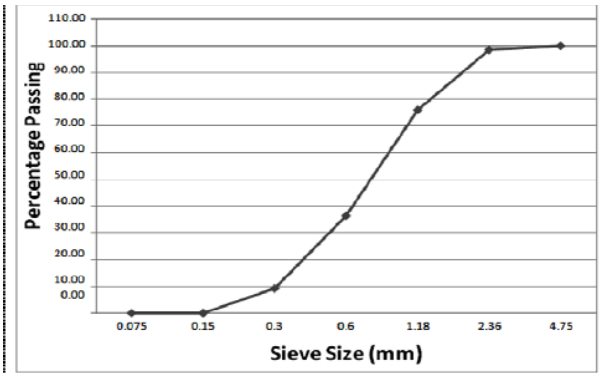

Figure6:- Graph of sieve analysis for fine aggregates. [11]

Figure7:-Papercrete Bricks during and after fire test [11]

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