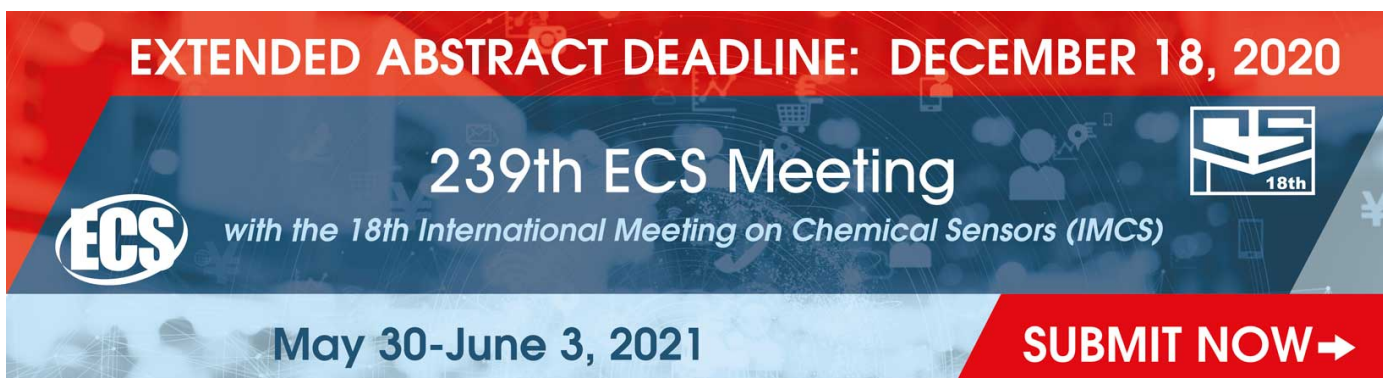


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Research Analysis of Paper Sludge and Paper Ash Bricks

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RESEARCH ANALYSIS OF PAPER SLUDGE AND PAPER ASH BRICKS

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Abstract: Construction sector is found to be the largest consumer of non-renewable resources at any age of development. Among the total cost of construction, 80% of cost is only due to the construction materials and the rest is due to the hands and brains behind it. In order to reduce the consumption rate of resources, alternative sources of materials are being investigated. With this note, the use of recycled paper in nominal brick began. Among 3.04 trillion trees around the world, 4 billion trees are being consumed for paper each year. i.e. 15 full grown trees for a single ton of paper. Recycling of such paper can be done by adding them into the brick by ratio less than 50%. They have good chemical bonding with concrete. While maintaining the strength to the required limit. This concept makes the system more sustainable and cheap to produce.

Keywords: Papercrete, recycling paper waste, compressive strength, water absorption.

1. Introduction:

All around the world, it was estimated that nearly 450-550 million tons of paper waste was produced every year. Here, the pulp was the third largest pollutant of all air, water and land environments. Even the well developed countries have only 45% as their recycling rate of paper waste. i.e. 55% is being dumped un mindly. The need of materials or increased demand in construction materials made use of this scenario. The term called 'papercrete' evolved as a result. Though it was found about 80-90 years ago, only now it is being put into the fields of study. Only very less amount of study has been done in this area.

1. Papercrete - paper + OPC
2. Padobe. - paper + clay binder
3. Fidobe. - padobe + other fibrous material

It serves as the tool to meet the increasing demand, along with the way to reduce the dumping of waste. It's the best way to retreat because reuse of paper involves chloride bleach causing water pollution and the methane gas is emitted when it is left to rot in the field. In India only 12% waste is recycled and 88% waste is landfilled. The manufacture of brick can be done by following methods: Hydraulic press method, Paper sludge method, Paper ash method. The method of manufacturing also depends on the type of binder being used. There are different varieties of binders, among which cement can also be used. In case of usage of other binders, the aim of obtaining low cost cannot be achieved, due to cost of the binder. Also the properties of binder should be studied carefully.



2. Hydraulic press method:

Scinduja M et al [2014], explained that it was the most economical method of producing paper brick. Though it was easy to manufacture, it contributes less durability and low strength when tested. No proper research and study was done in it, as it was a failure method. It is less in weight and has lots of voids in it. It gets demolished by peeling of strip by strip.

3. Paper sludge method:

Hypo- sludge contains maximum calcium chloride and minimum amount of silica. Lime sludge behaves like a cement, because of the presence of silica and magnesium properties. This silica and magnesium improve the setting of the Mortar. Paper fibbers can be recycled only for a limited number of times, before they become too short or weak to make high quality paper. It means the broken, low-quality paper fibbers become the waste sludge; this waste sludge is known as Hypo- sludge. To reduce disposal and pollution problems emanating from these industrial wastes, it is essential to develop profitable building materials from them. Keeping this in view, investigations were undertaken to produce low-cost Bricks by blending various ratios of bricks with hypo- sludge.



Figure 1. *Hypo sludge*

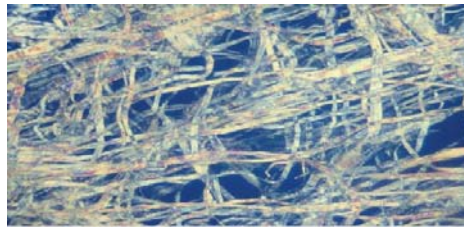


Figure 2. *Microscopic view of bonding*

3.1. Properties:

Table: 1 Properties of paper sludge

Parameters	Value(in percentage)
pH	12.20
Specific gravity	2.23
Lime	68.08
Silica	2.25
Alumina	1.17
Magnesium	0.73

3.2. Making of bricks:

Priyanka V et al [2019], followed the steps of manufacturing as follows,

3.2.1. Sludge preparation:

Paper is collected as sludge form and it is sun dried. After drying under sun, the sludge is crushed and sieved with 2.36mm IS sieve and used as ingredients.

3.2.2. Moulding of bricks:

Brick contains Fly ash, Lime, Water and P-sand. With the control brick, i.e. 5%, 10%, 15%, and 20% of the lime is replaced with Hypo sludge. Bricks were cast of size 230x110x70mm.

3.2.3. Drying and curing of bricks:

Bricks are allowed to dry under shadow in open air for 15 days and bricks are cured with water for the next 15 days.

3.3. Compressive strength:

Kulkarni A et al [2013], on experimenting fly ash bricks by partial replacement of hypo sludge by weight with lime with a permutation of (5%, 10%, 15% and 20%) for performing the experiments to determine compressive strength, to make economical, green bricks and to avoid a problem such as ash disposal and unbalanced environment, till 10% replacement the compressive strength was under desired limits. But as the percentage replacement was increased the values of compressive strength started declining[14]. Kulkarni A et al[2014],while experimenting with hypo sludge and fly ash to manufacture bricks in the Indian context. The replacement of hypo sludge was done from 5% to 20% with an increment of 5% at every time. These bricks turned out to be green bricks[15].



Figure 3. Compression test



Figure 4. Papercrete bricks

The compressive strength increased when 5% and 10% hypo sludge was used but as the percentage replacement increased up to 15% and 20% gradually the strength started decreasing. Navaneetha B et al[2019] while utilising hypo sludge and sugarcane waste in fly ash bricks, the 2.5% and 5% replacements the compressive strength at 21 days increased but on increasing the content up to 7.5%

and 10% the compressive strength started decreasing gradually[16]. Saktival D et al, on usage of sludge and pulp production residue to manufacture the bricks by 5% and 10% respectively the compressive strength was under the desired limit, but when 15% replacement of waste products was done the compressive strength decreased rapidly.

3.4. Water Absorption:

Dr.Nagarajan N et al[2019],at the time of using the sludge to manufacture the fly ash bricks, it was found out that the water absorption capacity of the fly-ash bricks is reduced from 20%(clay bricks) to 11.20% (Hypo- sludge bricks)[17]. Navaneetha B et al[2019]meanwhile using hypo sludge and sugarcane waste to manufacture fly ash bricks, the study shows water absorption values for the bricks is less than 4%. So the brick required very less amount of water for curing[16]. Prabhat kumar Prasad et al [2019] While increasing the hypo sludge content and reducing the fly ash ratio, the initial rate of absorption is decreasing in 15%, 20% hypo sludge content, but for 25% and 30% quantity of hypo sludge, it was increased[9].

3.5. Weight and Density:

Dr.Nagarajan N et al[2019],while using sludge to manufacture the fly ash bricks, the Fly-ash bricks reduce the density of brick masonry from 2000 kg/m³ (clay bricks) to 1509.91kg/m³ (Hypo sludge bricks)[17]. Prabhatkumar Prasad et al [2019] said that, density is varying between 1880 to 1922.5 kg/m³ for the 10%, 15%, 20%, 25% and 30% hypo sludge respectively[9]. Arya R K et al[2016]found that while using paper pulp with cement and sand the weight of the brick was approximately 50% lesser than conventional clay brick. Therefore papercrete bricks will decrease the dead weight of the structure in a significant amount. So it can change our design and building cost as in an economical point of view. The large deviation in each data is due to the different degree of compaction for different bricks manufactured. Explaining that higher the compaction higher the density of bricks[6].

3.6. Soundness:

Prabhat kumar Prasad et al [2019] observed that the soundness value is best for 25% and 30% hypo sludge content and it produces good metallic sound without breaking of brick, when they struck to each other[9]. Navaneetha B et al[2019] while using hypo sludge and sugarcane waste to manufacture, it was concluded that bricks of good quality should not break and produce a ringing sound. Bricks sufficiently passed soundness test[16].

3.7. Effect on Environment:

Navaneetha B et al[2019] concluded that the usage of hypo sludge and sugarcane waste to manufacture fly ash bricks will reduce the environmental effects and disposal problems of waste by this research and being protected from the emission of CO₂. It's also a better measure as an innovative construction material. It was found that those bricks are eco-friendly and thus solving the consistent problem of environmental issues like disposing off hypo-sludge waste from paper industries which pollutes the land and air[16].



Figure 5. Waste paper dump



Figure 6. Soil pollution

4. Paper sludge ash method:

Table: 2 Chemical composition of waste paper sludge ash

Element	Percentage Content
O	15.83
Ca	14.94
Si	60.57
Al	2.06
Mg	3.59
S	1.07
K	0.16
Fe	0.92
Na	0.22

4.1. Compressive strength:

Fontes et al[2004], Corinaldesi et al[2010], Sajad Ahamad et al[2013], on 5% replacement of cement by waste paper sludge ash showed 10% increase in compressive strength at 7 days and 15% increase in compressive strength at 28 days[1][2][4]. Mymrin V et al[2009], found that obtained materials on the 28th day have uniaxial resistance strength up to 15.7MPa (for respective mix ratio)[3]. Balwaik et al[2011], said that the splitting tensile, compressive and flexural strength increased up to 10% addition of waste paper pulp and further increased in waste paper pulp reduces the strengths progressively[5].

4.2. Water absorption:

Sajad Ahamad et al[2013], during the increase in waste paper sludge ash content, percentage water absorption increases. The water absorption of WPAA(waste paper ash aggregate) and normal coarse aggregate was recorded to have 18.92% and 2.94%, respectively and percentage difference between these two aggregate is 84.46%. Then, if WPAA is compared with fly ash aggregate studied by cold-bonded process were noted 10.33%, 25.80% and 13.37% at different cases[1].



Figure 7. Water absorption test



Figure 8. Slump test for workability

4.3. Weight:

Sajad Ahamad et al[2013], during the increase in waste paper sludge ash content, average weight decreases by 4.58% for mixture with 20% waste paper sludge ash content thus making waste paper sludge ash concrete light weight[1]. Siva Prasad G V S et al[2015], Light in weight compared to conventional clay bricks and very good surface finish can be achieved. The weight of this brick is 2/3rd to 3/5th lesser than conventional clay bricks[7]. Ismail M et al[2010], computed that Paper sludge-POFA brick has about 26.1% weight reduction when compared with normal brick[8].

4.4. Workability:

The workability test of the fresh concrete was tested by using slump test equipment, by measuring the height of slump. The height of slump was determined and classified the concrete under true slump condition with the range of slump of 40-60 mm. As a result the slump condition was decreased when increasing the amount of WPAA in concrete. Low workability of the concrete will affect the strength development and durability. Normally rounded aggregate will promote the better in workability because of less in surface area and voids when compared with normal coarse aggregate. But in the study, the rounded shape of WPAA contributed for low workability because of the high water absorption.

4.5. Split tensile strength:

Sajad Ahamad et al[2013], computed splitting tensile strength decreases with increase in waste paper sludge ash content and is more than reference concrete at 5% replacement[1]. Balwaik et al[2011], found that average weight decreases by 4.58% for mixture with 20% waste paper sludge ash content when increase in waste paper sludge ash content[5].

4.6. Environmental effect:

Khalili et al[2000], Lu et al[1996] stated that the activated carbons can be produced from municipal wastewater treatment of sludge. The conversion of paper mill sludge to activated carbon delivers an innovative, environmentally safe, and economically realistic solution, to the problem of sludge supervision[10]. Oikari et al[1982], on study with both bleached and unbleached Kraft pulp mill effluents(KME) and showed evidence of impaired liver function in fish exposed to these effluents[11]. Logan et al[1985]and workers have found increases in soil pH and organic matter content following the addition of paper mill sludge(PMS) to land[12]. Sahu et al[1987]stated that only positive is the calcium carbonate content of PMS yield increases for a range of crops on acid soils[13].

5. Cost analysis:

Sajad Ahamad et al[2013], Taking a regular brick, which cost at Rs: 5.00 per unit, cost of brick material required for a regular brick wall of 3000x3000mm is around Rs: 2250/-and for the four walls it costs up to Rs: 9000/-. Alternatively, paper brick costs a little less than Rs: 2.00 per unit reducing the material costs up to Rs: 3600/- with the difference of Rs: 5400/-.(About60% of cost required for a regular brick material)[1].

6. Conclusion:

On adding the sludge or ash at considerable quantities (5-10%) all the strength and stability factors of brick improves. It also reduces the water absorption deducing the chance of efflorescence and reduction in weight of bricks reduces the dead load of the structure. Due to the fineness of paper the finishing would be more excellent and can be used for facing also. Addition of sugarcane waste will deduct water absorption extremely and adding of pofa will make it still less in weight. The ash content in bricks will make it fireproof. The reduced cost will make it more economical. This research contributes to useful disposal of paper waste and leads to sustainable development.

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