THE IMPACT OF WASTE PAPER ASH AS A CEMENT REPLACEMENT MATERIAL ON C-25 CONCRETE'S PROPERTIES

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Abstract
Concrete is one of the versatile and widely used building materials in the world construction industry. It is known that cement is one of the basic materials used in the production of concrete. However the production of cement is both environmental unfriendly and uneconomical as compared to the other constituents of concrete, showing that the cement industry has sustainability problems. In order to alleviate these problems of the cement industry, the use of different cement replacing materials which have lower cost of production, lower emission of CO_2, and lower energy consumption, were being implemented. On the other hand, more waste paper ends up in landfill or dump sites than those recycled.

Paper is a natural polymer which consists of wood cellulose, which is the most abundant organic compound in the planet. This study is therefore focuses on investigating the technical feasibility of using waste paper ash as cement replacement material in concrete production.
In this study experimental investigations are carried out to evaluate the improvement of the fresh and hardened properties of C-25 concrete incorporating waste paper ash .Initially, waste paper ash samples were collected from different office and converted to ash. Secondly chemical compositions of paper ash were investigated. And then cement has been replaced by waste paper ash in the rangeof 0%, 5%, 10%, 15%, 20% and its effects on both fresh and hardened properties of C – 25concrete was studied.

Keywords: Compressive strength, Partial replacement, Waste Paper Ash, Concrete, Construction, Paper

Introduction - Concrete is one of the versatile and widely used building materials in the world construction industry. In Kosmatka, *et al.,* (2003) concrete is described as a composition of aggregates, a Portland or blended cement, water, and contains other cementitious materials and/or chemical admixtures. It will contain some amount of entrapped air and may also contain purposelyentrained air obtained by use of an admixture or air-entraining cement. The annual production of concrete is rapidly increasing. This is because many developing countries are experiencing rapid urbanization and population growth, making the demand for housing and infrastructure development greater than ever before.

It‘s known that cement Is the most”Impo’tant Ingredient of concrete. But it is the very expensive and environmentally unfriendly material. Therefore, a requirement for economical and more environmental-friendly leads the way to search for supplementary cementing materials in concrete that can be used as partial replacement of the normal Portland cement. As a result, the use of different cement replacing materials has become a common practice in the construction industry.

Currently several supplementary pozzolanic materials are being utilized as partial replacement of cement. Savita D., *et al.* (2016) reviewed the cement replacement materials. They concluded various cement replacement material such as ceramic waste, paper pulp, Ground Granulated blast furnace slag, silica fume, Hypo sludge, fly ash, paper sludge, Waste glass powder, Waste paper sludge ash.

Objectives

In light of the issues raised, the following particular aims will be investigated during the course of this study:

1. To investigate the chemical compositions of waste paper ash.
2. to examine how ash from used paper can affect the fresh characteristics of concrete.
3. to explore the influence that waste paper ash has on the characteristics of concrete after it has been hardened.
4. To identify the ideal proportion of discarded paper ash that can be used in place of cement in the manufacturing of concrete.

Literature Review

1.Mehta, et al., (2001).by Concrete is the material that is utilized in modern construction the majority of the time. It is the fundamental component of the contemporary building method. The buildings in which we live and work, the roadways on which we drive, and the dams from which we derive water and electricity are all examples of the many ways in which our activities are influenced, either directly or indirectly, by concrete structures. The ability of concrete to be cast into any shape or size desired, its excellent resistance to water, and the fact that it is the material that is both the least expensive and the most readily available on the job are some of the reasons why concrete is used so frequently.

2. Kosmatka et al. (2003), concrete is fundamentally composed of a combination of two different components: aggregates and paste. The aggregates, which are often composed of sand, gravel, or crushed stone, are held together in the form of a rock-like mass by the paste, which is composed of Portland cement and water. As the paste dries, the cement and water undergo a chemical reaction that causes the paste to harden. It is possible for the paste to also contain supplementary cementitious ingredients and chemical admixtures.

3.Ali Hussein Hameed (2012) Self-compacting concrete has an enhanced ability to flow. It is known to result in an increased segregation and bleeding potential. This paper discusses the results of an experimental investigation into the properties of self-compacting concrete mixes having varying dosage of high-performance superplasticizer (Glenium 51) (0.5%-3.0%) L per 100 kg of cement material. The properties investigated are workability on the fresh state of concrete by using one mix with five superplasticizer dosage (0.5%,1.0%,1.5%,2.5% and 3.0%) is used. The workability was assessed using

three tests according to the specification of self compacted concrete (slump flow,L- box differential height and V-funnel tests. The three dosage (1.0%,1.5% and 2.5%) comply with requirement for production of SCC while 0.5% and 3.0% don't comply with specification requirement .Dosage of superplasticizer need to produce self compacted concrete range between (1.0%-2.5%) L/100 kg of cement according to the condition and material used in this paper.

4.**Oriyomi M. Okeyinka (2014)** This research work investigates the potential applicability of waste paper in the production of ceiling boards with focus on achieving: environmental sustainability, safe disposal of waste paper and more cost effective production of materials. The main view was to provide an alternative to the conventional asbestos ceiling boards that are costly and also pose health risks. Three mix designs were formulated and used for the casting (1:1, 1:1.5 and 1:2), varying in regards of the weight of the waste paper components. CaCO3 was added to the mix as an additive as well as starch bond glue to aid binding. Laboratory experiments were conducted to determine the properties and suitability of the produced boards.

5.Shivangni, K., Kishan, L. P., & Mukul, K. (2015) Concrete is one of the versatile and widely used building materials in the world construction industry. Cement being the main binder in concrete, its production process is both uneconomical and environmental unfriendly. In order to alleviate these problems, the use of alternative materials which have lower cost of production, lower emission of CO2, and lower energy consumption, were being implemented. Therefore, the aim of this study is to investigate the effects of waste paper ash as cement replacement material in concrete production. Accordingly, chemical compositions of waste paper ash were investigated and cement was replaced by waste paper ash in a range of 0%, 5%, 10%, 15%, and 20%. To examine the suitability of paper ash for concrete production, its' effect on both fresh and hardened properties of C – 25 concrete was studied. From result of this study, it was observed that, the chemical compositions of waste paper ash were not fulfill the requirements of Pozzolanic material. Paper ash has lengthened the setting times of blended cement paste and its normal consistency was increased. The cement paste with replacement up to 10% showed a normal consistency with in standard range.

6.**Muhsen Salem (2016)** The use of chemical admixtures in concrete is a common solution to achieve full compaction particularly where reinforcement congestion and shortage of skilled workers. The past researchers have been underscored the use of chemical admixtures imparts the desirable properties to concrete in both fresh and hardened state. This paper has been made an attempt to study the influence of superplasticizer dose of 400ml, 600ml, 800ml, 1000ml and 1200ml/100 kg of cement on performance of Concrete.

7.Aseel B. al Zubaid (2018) The Waste materials need to be recycled in some method to avoid ground contamination. One of the methods to reuse such materials is to include in concrete materials. This will decrease pollution and encourage sustainable development in environment conservation. In this work ash wastepaper was partially replaced as 0%, 5%, 7% and 10% in place of cement in concrete for M-25 mix (i.e. concrete design mix of 1: 1.60 : 2.37 cement , sand and aggregate as per ASTM C 94 : 2007) with 0.48 w\c ratio was used. About 4 mixes with ash wastepaper were prepared. Strength properties were determined by compressive strength, splitting tensile strength and flexural tensile strength at (7, 14 and 28) days. From The results showed that the replacement of ash wastepaper increases the compressive strength and splitting tensile strength and flexural tensile strength by (22.129%) , (4.160%) and (34.783%) respectively, at (28) days of curing when (5%) 0f ash wastepaper was added by weight.

8.**Bikila Meko Kejela (2020)** Concrete is one of the versatile and widely used building materials in the world construction industry. Cement being the main binder in concrete, its production process is both uneconomical and environmental unfriendly. In order to alleviate these problems, the use of alternative materials which have lower cost of production, lower emission of CO 2 , and lower energy consumption, were being implemented. Therefore, the aim of this study is to investigate the effects of waste paper ash as cement replacement material in concrete production. Accordingly, chemical compositions of waste paper ash were investigated and cement was replaced by waste paper ash in a range of 0%, 5%, 10%, 15%, and 20%. To examine the suitability of paper ash for concrete production, its' effect on both fresh and hardened properties of C-25 concrete was studied.

9.Bikila Meko **(2020**) The aim of this study was to investigate the properties of concrete with waste paper ash (WPA) as cement replacing material. The chemical composition of WPA was reported, and Portland cement was partially replaced with 0%, 5%, 10%, 15%, and 20% of WPA to explore its effect on both fresh and hardened properties of C—25 concrete. The result of this study indicated that the chemical compositions of WPA were not classified as Pozzolanic material. Setting times of blended cement paste with WPA were lengthened and its consistency was also increased. The cement paste with replacement up to 10% showed a normal consistency within the standard range. The workability of concrete was tested immediately after preparing the concrete mix, whereas the compressive strength was tested after 7 and 28 days of curing. The results indicated that the workability of concrete containing WPA decreases as the WPA content increases.

10.Bahiru Bewket Mitikie (2022) An investigation was conducted to study the viability of using waste paper pulp ash as an alternative material applied as a partial replacement of cement in the manufacturing of concrete and its effect on the properties of concrete, and also, the cost and environmental advantage of using waste paper were examined. Four concrete mixes with 0%, 5%, 10%, and 15% waste paper pulp ash replacement of OPC and PPC for 25 MPa concrete were prepared. Based on the results obtained from the

research, the highest compressive strength obtained at all test ages, i.e., 3, 7, and 28 days, were, 24.36, 28.35, and 36.83 MPa, respectively, with 5% replacement of waste paper pulp ash for OPC, and for PPC, all percentage replacements showed reduction in compressive strength than the control mix.

Material : The following material used

Cement**,** Aggregates, Waste Paper Ash, Water

(i).Cement - The cement used in this study was Dangote Ordinary Portland Cement (OPC) of grade 42.5, which is obtained commercially. This cement complies with the requirements of Indian Standards, ES C. D5 201. The chemical and physical property of the cement is as shown in Table1.0 Sealed bags of cement were stored in the laboratory on a platform above floor and were covered with plastic covering. Thus it was free from any exposure to moisture. Bags were unsealed immediately before mixing.

Table 1.0: Chemical composition of cement (Dangote OPC 42.5)

Chemical composition in %	*Dangote OPC 42.5*
Silicon Oxide (SiO_2)	20.00 Min
Aluminium Oxide (Al_2O_3)	6.00 Max
Iron Oxide (Fe_2O_3)	6.00 Max
Calcium Oxide (CaO)	-----
Magnesium Oxide (MgO)	6.00 Max
Sulphur Trioxide (SO_3)	3.00 Max
Loss on Ignition (LOI)	3.00 Max
Insoluble Residue (I.R)	0.75 Max

(ii).Aggregate- aggregate, in building and construction, material used for mixing with cement, bitumen, lime, gypsum, or other adhesive to form concrete or mortar. The aggregate gives volume, stability, resistance to wear or erosion, and other desired physical properties to the finished product.

Figure No. 1. Aggregate

Commonly used aggregates include sand, crushed or broken stone, gravel (pebbles), broken blast-furnace slag, boiler ashes (clinkers), burned shale, and burned clay. Fine aggregate usually consists of sand, crushed stone, or crushed slag screenings; coarse aggregate consists of gravel (pebbles), fragments of

broken stone, slag, and other coarse substances. Fine aggregate is used in making thin concrete slabs or other structural members and where a smooth surface is desired; coarse aggregate is used for more massive members.

(a)Fine Aggregate

The river sand, passing through 4.75 mm sieve was used as a fine aggregate. The sand is free from clay, silt and organic impurities. In order to investigate its properties for the

Figure No. 2. Fine aggregate

required application different tests were carried out, which includes gradation and fineness modules, specific gravity and absorption capacity, moisture content, silt content and unit weight. Physical properties-

Description	Fine aggregat
Specific gravity	2.6
Water absorption	1.57%
Fineness modulus	3.1 (zone II)
Surface moisture	Nil
Bulk density	1450 kg/m^3

Table No. 1 Fine Aggregate

(b)Coarse Aggregates

Coarse aggregates used in this research were crushed granite, supplied from a local quarry, with maximum size of 20 mm. In a similar manner like the fine aggregate, the coarse aggregate was tested for its physical requirements such as gradation, fineness modulus, specific gravity and bulk density etc.

Property	Result
pecific Weight	2.61
ulk Density (t/m^3)	1.56
/ater Absorption %	2.05
lay and Fine Dust Content %	2.4
lakiness Index %	36.8
longation Index %	9.6
brasion Index %	17.8
npact Value %	12.66

Table No. 2. Coarse aggregate

(iii)Water Fresh portable water free from organic matter is used in mixing the concrete. Water in required quantities were measured by graduated jar and added to the concrete. The rest of the material for preparation of the concrete mix was taken by weigh batching. The same water was also used to cure the concrete samples after casting.

(iv).Waste Paper Ash - Paper is a natural polymer which consists of wood cellulose, which is the most abundant organic compound in the planet. It is a versatile material with many uses, including writing, printing, packaging, cleaning, and a number of industrial and construction processes. The waste paper used in this study was collected from office of jiwaji University, and anther offices.

The papers, which were collected, cannot be used directly. It should be made into paper ash before mixing with other ingredients. In order to have paper ash the collected paper was burnedin open flame. Finally it was added to the cement as replacement in the percentages of 5, 10, 15, and 20, ratio.

Methods

Several research methods were considered, taking into account the aims and objectives of the research. This study is a descriptive research which employs a quantitative research approach. And experimental research design was selected to meet the objectives of this study. Thus this research involved series of laboratory works to measure the strength of concrete produced with waste paper ash as a partial replacement of cement.For the development of concepts for the study, the concepts and problems are stated and reviewed. Problem identification has been done through a preliminary literature review and informal discussion with colleagues. Contextual and conceptual literature reviews was done once the problem is identified to have an in depth understanding on the research topic. The review includes books, journal articles, internet sources and archival document. Then, laboratory experimentations were carried out. So, in order to obtain the final results, first concrete ingredient is prepared and tests were performed. Then, based on the test results concrete ingredients proportioning was executed and mix-design is prepared for C-25

concrete grades.

After that, concrete sample preparations at different dosages of Waste paper ash were performed.Then, the prepared concrete samples were tested both in the fresh and hardened states. For the fresh state workability property of concrete was checked and for hardened concrete compressivetests and density were carried out. For compressive strength tests concrete samples have been checked at the age of 7 and 28 days.

Sample Preparation- In order to produce concrete samples weight measurement was used for the preparation of the ingredients. The paper ash was sieved through Standard sieves to have a fined powder and that retained on sieve size of 150µm was used to replace cement in sample production. The cast iron moulds whit sizes of (15cm x 15cm x 15cm) are cleaned of dust particles with mineral oil on all sides. The moulds are placed on a level platform. The specimens were casted immediately using the freshly mixed concrete. All the mould was filled in three layers. After pouring each layer, the concrete was compacted by vibrator. The time of vibration is monitored so that the concrete does not get segregated due to over vibration.

Normal consistency test

This test is carried out to determine the amount of water required to prepare a standard cement paste. Therefore, the normal consistency was measured by a vicat apparatus. It measures the resistance of the paste to the penetration of a plunger or needle of 500gm released at the surface of the paste. Different pastes both control i.e. without paper ash and blended were prepared by replacing part of the Portland cement with paper ash. The water content was varied for each of the pastes produced until a normal consistent paste is obtained.

Figure No. 3 Normal consistency of blended cement test

Setting time test

The objective of this test is to determine the initial setting time and final setting time of cement paste with normal consistency. The initial setting time of the paste was determined by the duration of 25mm penetration of vicat needle into the paste in 30 seconds after it has been released while the final setting time was determined by measuring the time related to zero penetration of the needle into the paste.

Figure No. 4 Setting time of blended cement test

Test Methods for Fresh and Hardened Concrete

Workability test

In order to determine the workability of the fresh concrete the slump test was conducted according to ASTM C 143. As specified by this method, concrete was placed in the slump conein three approximately equal layers and consolidated by rodding each layer 25 times with a smooth, straight steel tamping rod. After the top layer was compacted, the excess concrete was struck off and the mold was removed slowly. Then the Slump was determined by measuring the difference in level between the height of inverted cone and that of highest point of the subsided concrete and reported as slump.

Figure No. 5 Workability of the fresh concrete (slump test)

RESULTS

Properties of Fine Aggregate

Silt content

The material in fine aggregates which is finer than 75µm is generally regarded as silt. This silt in the sand has a severe effect on the quality of the concrete. It mainly affects the workability of theconcrete, and also results in the reduction of strength. From the silt content test performed on the sand, it was found that the original silt content was 4.54% and it was within the acceptable limit of the Indian standard which restricts the silt content to a maximum of 6%.

Gradation of fine aggregate

This is a procedure for the determination of the particle size distribution of the aggregate. It is also used to determine the fineness modulus, coarseness and uniformity of aggregates. These properties of the aggregate greatly affect the property of the concrete.The grading requirement for fine aggregate according to ASTM 33 and the grain size distribution of the fine aggregate used in this study was as shown in Table 3 and Figure No.6 Table No. 3 Sieve analysis results and standard for fine Aggregate.

Standard Sievesize (SSS)	Weight Retained	% Retained	% Cum. Retained	% Passing	ASTM33 % Pass	Comparing Result with ASTM 33
9.5 mm (3/4‘)	0.00	0%	0%	100%	100	In Range
4.75 mm (No.4)	0.07	3.5%	3.5%	96.5%	95 to 100	In Range
2.36 mm (No.8)	0.11	5.5%	9%	91%	80 to 100	In Range
1.18 mm(No.16)	0.28	14%	23%	77%	50 to 85	In Range
600 µm (No.30)	0.67	33.5%	56.5	43.5%	25 to 60	In Range
300 µm (No.50)	0.66	33%	89.5	10.5%	05 to 30	In Range
150 µm (No.100)	0.19	9.5%	99	1%	0 to 10	In Range
Pan	0.02	1%	100	0%		In Range
Total weight	2kg	Zone two				

$$\text{Finess Moduless} = \frac{\text{tatol Cumulative Retain}}{100} \times \frac{280.5}{100} = 2.8$$

The Table 3 showed that the grading of fine aggregates was within the limits of ASTM 33. According to the principle out lined in ASTM C 33, Standard specification of concrete aggregate, the fine aggregate shall have not more than 45% passing any sieve and retained on the next consecutive sieve and its fines modulus shall be not less than 2.3 no more than 3.1.

Gradation of fine aggregate

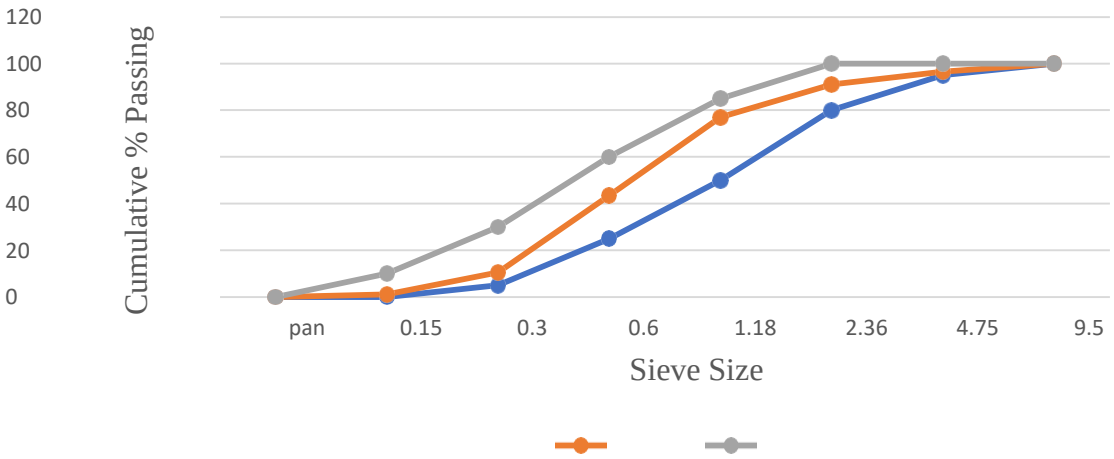

Figure No. 6 Gradation of Fine Aggregate

Conclusion:

The primary objective of this research was to study the effects of waste paper ash content on both fresh and hardened properties of concrete mixes when used as additive in concrete. These objectives were achieved by conducting a series of laboratory test such as chemical composition of paper ash, setting time and consistency of blended cement paste, workability, density, and compressive strength of concrete cubes incorporating Waste Paper Ash as cement replacing material. From the experimental investigations, it is concluded that:

(i).Waste paper ash cannot be as classified as pozzolanic material. As prescribed by ASTM C 618, in order to classify particular material as pozzolanic materials, its chemicalcomposition (SiO_2+ Al_2O_3+ Fe_2O_3) have to be greater than 70% but that of paper ash is less than 70%.

(ii)Higher replacement of cement by waste paper ash resulted in higher normal consistency (implying higher water demand for certain workability) and longer setting time.

(iii)The workability of concrete containing waste paper ash decreases as the waste paper ash content

increases.

(vi) Significant improvement was seen in compressive strength of concrete.Replacing of ordinary Portland cement with 5% to 10% of waste paper ash results in a better compressive strength than that of the conventional concrete for all curing ages. But beyond 10% replacement that there is a gradual reduction in compressive strength.

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